NEW CONCEPTS AND ADVANCED STUDIES IN HEALTH SCIENCES

All Sciences Academy

NEW CONCEPTS AND ADVANCED STUDIES IN HEALTH SCIENCES

Editor
Prof. Dr. Fatih HATİPOĞLU

New Concepts and Advanced Studies in Health Sciences
Editor: Prof. Dr. Fatih HATİPOĞLU

Design: All Sciences Academy Design
Published Date: October 2025
Publisher's Certification Number: 72273
ISBN: 978-625-5794-49-9

www.allsciencesacademy.com
allsciencesacademy@gmail.com

CONTENT

Intercultural (Transcultural) Nursing and its Reflections on Child Health

Çiğdem Müge HAYLI[1*]

Mehmet Zeki AVCI[2]

Dilek DEMİR KÖSEM[3]

1* Associate Professor Doctor, Hakkari University, Faculty of Health Sciences, Department of Nursing, Hakkari, Türkiye, Orcid number:0000-0001-7630-9619 Mail: mugehayli@hakkari.edu.tr
2 Professor Doctor, Cyprus Sciences University, Faculty of Health Sciences, Department of Nursing, Hakkari, Kyrenia, Cyprus, Orcid number: 0000-0001-6614-9447, Mail: mehmetavci@cau.edu.tr
3 Associate Professor Doctor, Hakkari University, Faculty of Health Sciences, Department of Nursing, Hakkari, Türkiye, Orcid number: 0000-0001-9914-8299, Mail: dilekdemir@hakkari.edu.tr

ABSTRACT

The World Health Organization defines health in three dimensions: physical, social, and spiritual. Accordingly, health and wellness are defined as a state of complete well-being that represents the coexistence of these three elements. Culture is a concept with a wide variety of definitions. Generally speaking, it is a dynamic concept that encompasses unwritten rules, is passed down from generation to generation, and is also influenced by the processes it influences. Culture affects the quality of care. The quality of care is an interdisciplinary issue and can be shaped by culture, society, and individual nurses. Therefore, the purpose of this study, "Transcultural Nursing and Its Reflection in Child Health," is to examine how health is addressed.

Keywords – Intercultural, nursing, child, health, reflection

INTRODUCTION

Culture is the shared values, beliefs, attitudes, and behaviors learned, taught, and passed down from generation to generation. By transmitting these shared values, which ensure the continuity of human life, culture has served as an important tool for humankind to shape and interpret its environment in order to protect its health, ensure its well-being, and sustain its existence (Bolsoy and Sevil, 2006).

Today, nurses from different cultures provide intercultural care services by providing care to individuals, families, and communities from different cultures in their own countries, as well as by providing nursing services in countries where people from different cultures live (Bayık Temel, 2008). The term “Transcultural Nursing” (TCN) was first used by Leininger in 1979 (Tortumluoğlu, 2004) and defined TCN as “a branch or sub-branch of nursing that provides cultural universality and culture specificity in nursing care, is based on comparative research and analysis of different cultures, analyzes differences in subcultures and cultures around the world, and focuses on comparative study, while respecting health-illness, care, beliefs, and values” (Hotun Şahin, Onat Bayram, Avci, 2009; Leininger, 1999). Transcultural nursing models also serve as a guide for nurses in understanding and evaluating the cultural structure of society and creating a common language (Tanrıverdi and Söylemez, 2018). Nurses, as the determinants of care, should plan care for pediatric patients by carefully analyzing the care to increase its effectiveness (Sönmez et.al., 2024).

What is Culture?

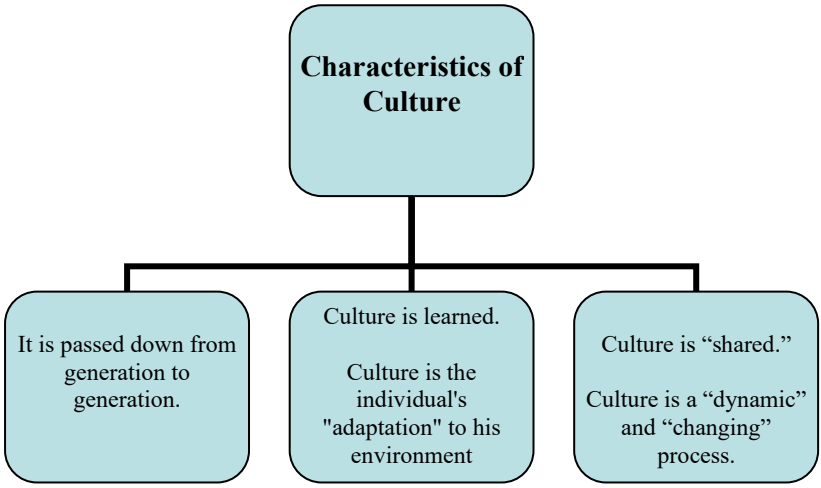
It is suggested that the word "culture" comes from the Latin word "ederecultura," meaning agriculture, cultivation, etc. (Demirkan, 2007; Mejuyev, 1987). Similar to this view, another study suggests that the root of the word "culture" is "cultura," derived from the Latin root "colere," meaning "to inhabit, cultivate, protect" (Williams, 2016). Considering that plants grown under various conditions are still called cultivated plants today, it appears that the Turkish term "ekin," used as the equivalent of the term "kültür," also derives from the verb "colere." It has been explained that the word "kültür" interacted with other meanings and uses later attributed to its root meaning related to agriculture (Doğan, 2012).

Edward Tylor defined culture, the main field of study for anthropologists, in the 19th century as "the complex whole that includes knowledge, art, law, morality, custom and all other abilities and habits exhibited by human beings in its broadest sense in ethnography" (Tanrıverdi et.a., 2012).

As social beings, humans exist within the framework of traditions, values, beliefs, attitudes, and behaviors that are passed down from generation to generation. This dynamic environment, in which they are shaped and through which their environment continues to shape them, constitutes culture (Abbas, 2023). It is a concept that has been shaped by human existence, has been passed down from the past to the present and will be passed down from today to the future, is unwritten, varies from society to society, and has a significant impact on the concepts of health/disease (Sönmez et.al., 2024; Öztürk and Öztaş, 2012).

Characteristics of Culture

Characteristics of culture are shown in Figure 1 (Güvenç, 2015).



Elements of Culture

The fundamental elements of culture are as follows:

a. Material cultural elements: These are the material values possessed by a society.

b. Language: This is the fundamental element of communication and the most important carrier of culture.

c. Religion and belief systems: These are the values by which people make sense of their situations and guide their behavior.

d. Attitudes, values, and norms: The most important elements that distinguish cultures from one another and are also determinative are their rules and values.

e. Art and aesthetics: These are the aesthetic perceptions and values unique to each culture.

f. Social and political organizations: These are the institutions and organizations that regulate the relationships of individuals in every society, shape social organizations such as marriage, family, and education, and bring order to the behavior and lifestyles of people within a community.

g. Education: This is the function of individuals learning their cultural achievements through education within the society where they socialize, first within the family, then within groups such as the immediate environment, school, workplace, etc. (Sönmez et.al., 2024; Aksoy, 2013; Güney, 2000).

Health and Culture

Health is a significant value imparted by culture. Therefore, care is not only related to illness and health, but also to culture. In fact, care can be

considered a culture-based approach. The characteristics inherent in culture are crucial in nursing approaches. Culture, in a sense, is the common language of a society comprised of diverse individuals. Nurses, who form the closest interaction group with individuals in all processes, have over time strived to develop common languages actively used within the healthcare system and developed models to be used in care. Transcultural nursing models also serve as a guide for nurses in understanding and evaluating the cultural structure of society and in creating a common language (Tanrıverdi et.al. 2018).

The relationship between health and culture can be examined from many different perspectives. First, it can be said that the meaning-making practices associated with health and illness can vary across cultures. As stated, "culture influences people's perception of health" (Bolsoy and Sevil, 2006). Health perception, in conjunction with cultural norms, involves an individual's subjective assessments of health. Therefore, it is important to "understand how individuals' beliefs about their health status relate to their personal circumstances, the society they live in, and their culture" (MacLachlan, 2006).

In addition, as lifestyles and cultural values change, the kind of body structure and lifestyle that constitutes good health has become a topic of debate. Physical, social, and psychological wellness can evolve over time, influenced by social changes. For example, even eating habits, a basic need, can emerge as a cultural and social issue. Food and eating habits, which can also be seen as a reflection of lifestyle, are considered much more than just a source of nutrition, as Helman emphasizes. Accordingly, eating habits are deeply ingrained in the social, religious, and economic aspects of daily life and carry numerous symbolic meanings from a societal perspective. Even "what you eat or refuse to eat" carries cultural and social implications (Helman, 2007).

In conclusion, it is possible to say that cultural differences have an impact on many areas such as the definition of health, treatment methods, the meaning attributed to health, perspectives on bodily experiences, eating and drinking practices, and body image (Bolsoy ve Sevil, 2006).

Intercultural (Transcultural) Nursing

The transcultural nursing approach emerged from the need to care for individuals with diverse cultures within societies. M. Leininger, a nurse anthropologist, first defined transcultural nursing in 1959 as "a branch or sub-branch of nursing that provides cultural, universal, and cultural

specificity in nursing care, focusing on comparative research and analysis of different cultures, analyzing differences in subcultures and cultures around the world, respecting health, illness, care, beliefs, and values." (Sönmez et.al., 2024; Öztürk and Öztaş, 2012).

During her research, Leininger primarily examined how culture influences the concepts of health and illness and the care process (Serrant-Green et al., 2001; Price & Cortis, 2000). Later, the concept of "CH" began to gain increasing interest worldwide, was nurtured through collaboration with various disciplines in the 1960s, and was explained as a concept in the 1970s (Serrant-Green et al., 2001). Leininger first used the term CH in 1979 (Tortumluoğlu, 2004), and transcultural nursing; It is defined as "a branch or sub-branch of nursing that focuses on comparative study and analyzes differences in subcultures and cultures around the world, ensuring cultural universality and culture specificity in nursing care, based on comparative research and analysis of different cultures, and respecting health and illness, care, beliefs, and values." (Yüksel Kaçan, 2018; Hotun Şahin et al., 2009).

There are 4 basic concepts in transcultural nursing;

- Nurses are intercultural care providers.
- Individuals are cultural beings and cannot be considered separate from their cultural background.
- The environment is the cultural context.
- The nature and meaning of health vary from culture to culture. Intercultural care is nursing care that is sensitive to the needs of individuals and families from diverse cultural groups within a society (Bekar, 2001).

Cultural Care

To ensure adequate cultural care in nursing, Leininger and other expert nurses are continuing their efforts to develop and simplify numerous cultural theories, models, and assessment guides that can be used internationally. An important point to emphasize in culturally-oriented nursing care is to answer the question, "How different is this group from my group?" It should also be considered that the characteristics of human groups are not uniform (Duffy 2001).

Emphasizing the importance of intercultural care, Leininger emphasized that culturally compatible care can only be provided when the patient's cultural expressions, practices, and patterns are known (Soyanıt and Altay, 2023). It has been determined that nurses make significant

contributions to understanding, analyzing, and addressing individual behaviors in nursing care (Sönmez et.al., 2024; Tanrıverdi, 2017).

Cultural differences can occur within ethnic groups as well as between them. Furthermore, cultural differences can occur between different generations and subgroups (Andrews and Boyle, 2002). Healthcare professionals must understand the characteristics of individuals from different cultures (Duffy 2001). However, it is impossible for nurses to know the cultural background and characteristics of every individual, and it is unnecessary to conduct a complete cultural diagnosis for every patient. Instead, it is important and necessary for nurses to adequately collect basic cultural data for diagnosis (Andrews and Boyle, 2002). With the understanding of the necessity of a cultural approach in nursing care, the importance of transcultural nursing services has been highlighted.

Intercultural (Transcultural) Nursing and its Reflections on Child Health

Nursing is a profession where interpersonal communication and interaction are experienced at the highest level. In providing care services that are culturally appropriate, individuals should adopt approaches that prioritize high levels of empathy and health beliefs and values, increasing participation in care (Abbas, 2023). Therefore, providing services in line with a holistic approach requires a thorough understanding of the recipient group. An individual's culture, including their age, gender, family structure, social characteristics, values, traditions, and customs, should be recognized (Özsezer et.al., 2020).

Hospitalization is a challenging and stressful experience for children and their families (Boztepe, 2009). Behaviors such as regression, disability, sadness, separation anxiety, apathy or withdrawal, fears, loneliness, hyperactivity, and aggression have been reported to be common in hospitalized children (Başay et.al., 2022).

Individuals' beliefs, attitudes, and treatment methods regarding health and illness are influenced by their cultural background (Prosen, 2021; Giger, 2017). In this context, children, in particular, are more affected by the cultural characteristics of the society in which they live and are exposed to cultural practices (Pekyiğit et.al., 2022; Perry et.al. 2016) While some of these cultural practices do not harm children, others are known to have fatal consequences (Açıkgöz et.al. 2019). Pediatric nurses, in particular, must be aware of the importance of culturally appropriate care to provide better nursing care due to their advocacy role and must consider race, ethnicity,

culture, and cultural heritage to provide culturally specific care (Tutar and Karol, 2023; Hockenberry et.al., 2022).

Child health nurses providing transcultural nursing care;

It is recommended that they collect cultural data to understand the behaviors of the communities they serve, to cope with their problems, and to promote and protect their health.

• Based on the data they collect, they determine whether their culture can be changed.

• They base their health policies and initiatives not only on scientific and epidemiological evidence, but also on people's life and health experiences, and their own priorities and needs.

• They protect and embrace health practices inherent in the public's culture.

• They perceive individuals within their own cultural patterns, examine them within their own cultures, and consider these in their nursing approach.

• They identify similar and different behaviors across different cultures, develop educational programs, and integrate these programs into curricula.

Pediatric nurses should be aware of their own cultural orientations, be sensitive to the cultural differences of the children and parents they care for, and provide culture-specific individualized nursing care using cultural diagnostic models/theories (Öztürk and Ayar, 2018). When evaluated from this perspective, health professionals aim for a good life for the individual based on cultural care (Nazan, 2015).

CONCLUSION

The care provided by health professionals should be planned in line with the needs of the individual. Children's health should be considered, respected, and understood, and the health-supportive aspects of this culture should be utilized. If there are any health-impairing aspects, appropriate intervention should be made. In all of these, nurses may be culturally conditioned. It is believed that in clinical practice, it would be beneficial to include families in the process to improve the quality and competence of care provided to children with diverse backgrounds, and to develop a service approach shaped by these models. The active use of care models based on cultural differences is recommended.

REFERENCE

- Abbas, N.K.(2023). Hemşirelik Öğrencilerinin Kültürel Farkındalık ve Kültürlerarası Duyarlılık Düzeylerinin İncelenmesi. Kırşehir Ahi Evran Üniversitesi, Sağlık Bilimleri Enstitüsü. Master's Thesis.

- Acikgoz, A., Orsal, O., Orsal, O., Balci-Alparslan, G. (2014). Traditional practices used by Turkish mothers in the care of their babies. Holistic Nursing Practice;28(3): 198-207.

- Aksoy, Z. (2013). Kültürel Zaka ve Çokkültürlü Ortamlardaki Rolü. İzmir Ege Üniversitesi.

- Andrews, M. M., Boyle, J. S. (2002). Transcultural Concepts in Nursing Care. Journal of Transcultural Nursing, 13(3), 178– 180.

- Başay, B.K., Başay, Ö., Ürüt, A., Hasmercan, B., Uysal, M., Usul, B.E. (2020). Hastanede yatarak tedavi gören çocuklar: psikososyal uyumu etkileyen faktörler üzerine bir araştırma [Hospitalized children: A study on the factors affecting psychosocial adjustment]. Klinik psikiyatri Dergisi;23(4): 402-13.

- Bayık Temel, A. (2008). Kültürlerarası (Çokkültürlü) Hemşirelik Eğitimi. Journal of Anatolia Nursing and Health Sciences;11(2): 92–101.

- Bekar, M. (2001). Kültürlerarası (Transkültürel) Hemşirelik. Toplum ve Hekim; 6(2): 135-141.

- Bolsoy, N., Sevil, Ü. (2006). Sağlık-Hastalık ve Kültür Etkileşimi. Atatürk Üniversitesi Hemşirelik Yüksekokulu Dergisi, 9(3): 78-87.

- Boztepe, H. (2009). Pediatri hemşireliğinde aile merkezli bakım [Family centered care in pediatric nursing: review]. Türkiye Klinikleri Hemşirelik Bilimleri Dergisi;1(2)88-93

- Demirkan, E. (2007). Çokuluslu İşletmelerde Kültürel Farklılıkların Örgütsel İletişim Üzerine Etkileri. İstanbul Yıldız Teknik Üniversitesi.

- Doğan, Ö. (2012). Kültür Bilimleri ve Kültür Felsefesi (6th ed.). İstanbul: Notos Kitap. Retrieved from http://www.idefix.com/Kitap/Kultur-Bilimleri-ve-Kultur- Felsefesi/Dogan-Ozlem/Felsefe/Felsefe Bilimi/urunno=0000000405895.

- Duffy, M. E. (2001). A critique of cultural education in nursing. Journal of Advanced Nursing, 36(4), 487–495.

- Güney, S. (2000). Davranış Bilimleri (2nd ed.). Ankara: Nobel Yayın Dağıtım.

- Giger, J.N. (2017). Transcultural nursing-e-book: Assessment and intervention. Elsevier Health Sciences: 2-121.

- Güvenç, B. (2015). Kültürün abc'si (7th ed.). İstanbul: Yapı Kredi Yayınları.Retrieved from http://www.dr.com.tr/Kitap/Kulturun-Abcsi/BozkurtGuvenc/ArastirmaTarih/Sosyoloji/urunno=0000000058242.

- Helman, C. (2007). Culture, Health and Illness. CRC Press.

- Hockenberry, M.J., Wilson, D., Rodgers, C.C. (2021). Wong's Essentials of Pediatric Nursing-E-Book. Elsevier Health Sciences; :1-38.

- Hotun Şahin, N., Onat Bayram, G., Avci, D. (2009). Kültürlere Duyarlı Yaklaşım: Transkültürel Hemşirelik. Hemşirelikte Eğitim ve Araştırma 80 Dergisi; 6(1): 2–7.

- Leininger, M. (1999). What is transcultural nursing and culturally competent care? J Transcult Nurs;13(3): 189–192.

- MacLachlan, M. (2006). Culture and Health: A Critical Perspective Towards Global Health. West Sussex, England: John Wiley & Sons.
- Mejuyev, V. (1987). Kültür ve Tarih. Ankara: Başak Yayınları.

- Nazan, T. (2015). Kültürlerarası hemşirelik ve etik. Turkiye Klinikleri J Public Health Nurs-Special Topics;1(3): 7-13.

- Özdemir, F., Evgin, D., İnci, F. (2022). Pediatri Hemşirelerinin Kültürel Duyarlılıkları ve Mülteci Hastalara Yönelik Aile Merkezli Bakım Uygulamaları: Kesitsel Bir Çalışma. Turkiye Klinikleri Journal of Nursing Sciences, 14(2).

- Özsezer, G., Yıldırım, Y., Türeyen, A. (2022). Demans Tanısı Olan Budist Bir Kadın Hastanın Leininger'ın Gündoğumu Modeli ile Kültürel Değerlendirilmesi. Humanistic Perspective; 4(3): 641-657.

- Öztürk, C., Ayar, D. (2018). Pediatri Hemşireliğinde Transkültürel Yaklaşım. Turkiye Klinikleri Pediatric Nursing-Special Topics, 4(1): 87-96.

- Öztürk, E., Öztaş, D. (2012). Transkültürel hemşirelik. Batman Üniversitesi Yaşam Bilimleri Dergisi; 1(1): 293-300.

- Pekyiğit, A., Yıldız, D., Fidancı, B.E., Bağrıyanık, B.Ç., Dehmen, Ö., Koçak, T., Altıntaş, S. (2020). Annelerin bebek bakımında kullandıkları geleneksel uygulamaların kuşaklararası boyutu. Turkish Journal of Family Medicine and Primary Care;14(3): 443-451.

- Perry, S.E., Hockenberry, M.J., Cashion, M.C., Alden, K.R., Olshansky, E., Lowdermilk, D.L. (2022). Maternal child nursing care-E-Book. Elsevier Health Sciences:15-29

- Price, K., Cortis, J. (2000). The way forward for transcultural nursing. Nurse Education Today; 20(4): 233–243.

- Prosen, M., Karnjuš, I., Ličen, S. (2021). Introduction to Transcultural Nursing. In: Transcultural Nursing: Better & Effective Nursing Education for Improving Transcultural Nursing Skills (Benefits) (Eds. Yava A, Tosun B). Ankara Tıp Nobel Kitabevleri: 9-18
- Serrant-Green, L., Schwass, M., Elander, E., Latham, C. (2001). Transcultural nursing education: a view from within. Nurse Education Today, 21(8), 670–678.

- Tanrıverdi, G. (2017). Hemşirelerde kültürel yeterliliği geliştirmeye yönelik yaklaşım ve öneriler. Florence Nightingale Hemşirelik Dergisi; 25(3): 227-236.

- Tanrıverdi, S., Soylemez, N., Dilekçi, C. (2018). Türkiye'deki Mültecilere Transkültürel Hemşirelik Yaklaşımı. Annals of Health Sciences Research; 7(1): 40-44.

- Tortumluoğlu, G. (2004). Transkültürel Hemşirelik ve Kültürel Bakım Modeli Örnekleri. C.Ü. Hemşirelik Yüksekokulu Dergisi; 8(2): 47–57.

- Tutar, Ş., Karol, T. (2023). Pediatri Hemşireliği Dersi Alan Öğrencilerin Kültüre Özgü Bakım Verme Yeterliliği, Yaşadığı Güçlükler ve Çözüm Önerileri. Med J SDU;30(3): 434-443

- Soyanıt, Ş., Altay, B.. (2023). Madeleıne Leınınger: Kültürel Bakımda Çeşitlilik Ve Evrensellik Teorisi. Tanrıverdi G (Ed.). 6. Ulusal 3. Uluslararası Kültürlerarası Hemşirelik Kongresi Bildiriler Kitabı .

- Sönmez, M. N., Yıkar, S. K., Nazik, E. (2024). Kültürlerarasi Hemşirelik ve Kadın Sağlığına Yansımaları. Dental and Medical Journal-Review, 6(3): 141-152.

- Williams, R. (2016). Anahtar sözcükler : Kültür ve toplumun söz varlığı (6.).İstanbul: Sena Ofset. Retrieved from http://www.iletisim.com.tr/kitap/anahtarsozcukler/ 7924#.WX8MS4jyhPY.

- Yüksel Kaçan, C. (2018). Kültürlerarası hemşirelik eğitiminin, öğrencilerin mesleki değerlerine, empatik becerilerine, kültürel duyarlılıklarına ve zekalarına etkisi: bir müdahale çalışması (Yayımlanmamış Doktora Tezi). Eskişehir Osmangazi Üniversitesi.

Resistance to Parasitic Drugs in Small Ruminants and its Control

Fatma ATLI[1]
Çağrı KANDEMİR[2]
Turgay TAŞKIN[3]

1. Dr. Ege University Faculty of Agriculture, Department of Animal Science, Bornova-İzmir, atli.fatma@ege.edu.tr ORCID: 0000-0001-6536-5594
2. Doç.Dr. Ege University Faculty of Agriculture, Department of Animal Science, Bornova-İzmir, ORCID: 0000-0001-7378-6962
3. Prof.Dr. Ege University Faculty of Agriculture, Department of Animal Science, Bornova-İzmir, ORCID: 0000-0001-8528-9760

INTRODUCTION

In animal husbandry, gastrointestinal parasites significantly reduce the production of meat, milk, and wool, and also adversely affect the draft power of animals used for agricultural purposes. The drugs used in parasite control are important antiparasitic agents (Afework and Edget, 2022). However, the emergence of resistance among parasites against these drugs, which is spreading globally, poses a serious problem for animal health and productivity (Mandonnet et al., 2020). Managing this resistance is possible through the proper use of chemical or non-chemical means (Butako, 2023). Today, there is a considerable increase in the number of drug-resistant parasites worldwide (Kaplan, 2020). Furthermore, the use of parasitic drugs contradicts the legitimate consumer demand for animal products free from chemicals. In rural areas, the use of these drugs becomes even more complex due to inadequate veterinary services and the relatively high cost of drugs (Bambou et al., 2008). In recent years, strategies aimed at eradicating gastrointestinal parasites have evolved into a more agroecological approach, which aims to reestablish balance between the host and the parasite through various actions. The genetic resistance of small ruminants to gastrointestinal infections plays a significant role in this new approach (Adduci et al., 2022).

The purpose of this article is to encourage the conscious use of several classes of parasitic drugs available for parasite control, with a special emphasis on the uncontrolled use in food-producing ruminants such as sheep, goat, and cattle. The study covers definitions related to the topic, the global scope of anthelmintic resistance, and its causes. It also discusses the resistance developed by parasites and its diagnosis, as well as the challenges at the core of resistance, including parasite management in animals and the regulation of drugs used for treatment.

Life Cycle of Gastrointestinal Parasites

In sheep farming during the spring months, the primary parasite affecting lambs is Nematodirus battus, whereas later in the season, other roundworms, such as Teladorsagia and Trichostrongylus species, are also observed (Kebede, 2019). Generally, the life cycle of all these gastrointestinal parasites (except Nematodirus battus) is quite similar. After mating, adult parasites residing in the gastrointestinal tract of sheep lay eggs, which are excreted into the environment through the animals' feces. The

eggs then develop within the feces and hatch into feeding larvae known as the L1 stage. These larvae subsequently develop into the L2 and then the infective L3 stage (Rios-de Alvarez, 2009).

The larvae migrate onto pasture vegetation after reaching the L3 stage, where they await ingestion by a suitable host (Figure 1). Once ingested by grazing sheep, the L3 larvae mature into adult parasites within 15 to 21 days. Nematodirus battus has a slightly altered life cycle since it develops to the L3 stage wholly inside the eggshell, and the cold weather the following spring may cause it to react differently.it is largely recommended not to graze lambs on the same pasture every year to decrease problems on N. battus (Sangster and Gill, 1999).

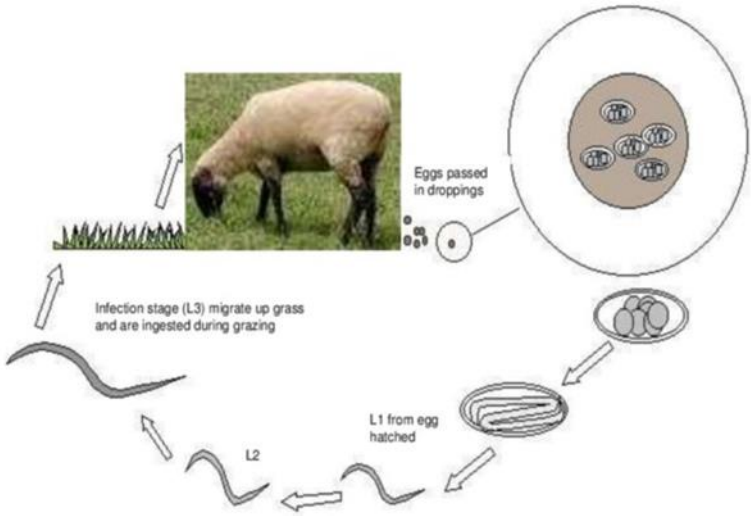


Figure 1. Life cycle of gastrointestinal parasites.
Source: Leyla Ríos de Álvarez, 2009.

Effects of Parasites on Animals

The effect of intestinal parasites have on livestock raised differs significantly between affluent nations in underdeveloped nations. First off, the expense of treatment needed to control nematode dosages that limit output is the primary factor influencing the impact of gastrointestinal parasites in wealthy countries. However, in developing nations, particularly those in tropical areas, animal mortality may also be a cost.This becomes particularly significant in areas where native sheep breeds do not display a

lot of genetic resistance to gastrointestinal parasitic infections (Fleming et al., 2006). Drug treatments used to reduce deaths from parasitic infections can have adverse effects, including residual substances in dairy and meat products. In addition to secondary consequences such environmental contamination, these products may have negative effects on food safety and the environment (Taylor et al., 2002). Studies in the late 1900s found that parasites cost sheep producers in Uruguay, a South American country that produces sheep, over 42 million USD in losses (Nari et al., 1997) and Australia over 222 million USD (McLeod, 1995). According to Nieuwhof and Bishop (2005), a study carried out in the United Kingdom established the cost of three significant endemic diseases: gastrointestinal parasites, foot rot, and scab. These calculations, which took into account output losses, preventative actions, and the care of afflicted animals, came to the conclusion that gastrointestinal parasites alone caused yearly expenses of more than 80 million pounds. Figure 2 illustrates how diseases, especially parasitic infections, can affect herd productivity in different ways, including effects on digestion and metabolism. Even if we start with a simple assessment of the impact on metabolism and digestion, the diseases eventually impact not only individual animals but also the herd as a whole. The size of parasite populations is also related to the percentage of animal deaths brought on by parasitic infections. Therefore, successfully identifying and evaluating parasite populations is becoming increasingly important (Gruner and Cabaret, 1985; Taylor, 2010).

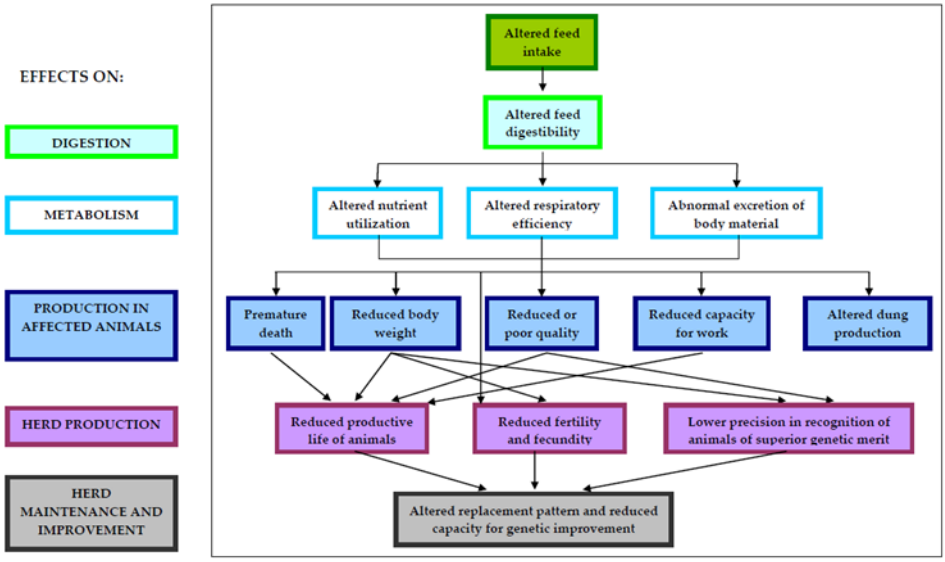


Figure 2. Factors related to diseases and parasitic infections affecting ruminant animals.
Source: Morris and Marsh (1994)

Taylor et al. (2007) have documented the following clinical symptoms that are induced by parasites in small ruminant husbandry:

T. colubriformis, also known as the black scour worm, can sometimes be confused with malnutrition. Initially, there might be less feed consumed, low growth rates, and soft feces. As parasite numbers increase, dark-colored diarrhea, death, and severe weight loss are possible outcomes.

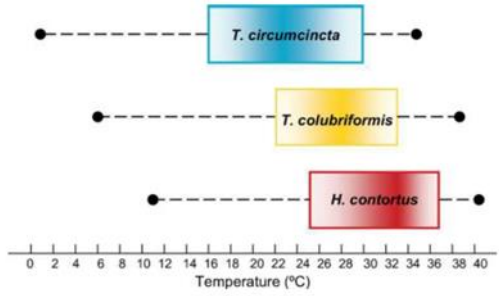


Figure 3. Ideal temperature ranges for major strongyle species.
Source: O'Connor et al., 2006

In infections caused by T. circumcincta, animals may show weight loss, decreased feed intake, and abnormal protein metabolism. Diarrhea is not always observed, but staining around the hindquarters is common. Post-mortem, upon examination, the abomasum may exhibit a distinctive lesion.

Since H. contortus may eat roughly 250 milliliters of blood per day and can exist in levels of up to 5000 in a single sheep, acute anemia usually manifests two weeks after infection. Eventually, the host becomes increasingly anemic, red blood cell counts drop, and hematocrit levels stabilize at low levels over the following days. After days of inappetence and losses of protein and iron, hematocrit may decrease further, leading to death. Examination may reveal between 2000 and 20,000 parasites in the abomasum and many lesions. In hyperacute cases, hemorrhagic gastritis can cause death.

Resistance and Resilience

Sheep that are exposed to parasites may eventually become "resistant" and/or "resilient" to infection (Barnes et al., 1995). Resistant sheep can sustain low fecal egg counts when exposed to infective larvae, thus limiting infection by regulating parasite establishment and survival within the body. The pasture contamination decreases with the animals' level of parasite resistance, and this feature is somewhat heritable. On the other hand, animals are said to be robust since they may continue to produce even when they have parasite infections (Greer et al., 2020). Compared to resistance, resilience tends to have lower heritability, and resilient animals can remain productive even if they carry higher parasite egg counts. Previously, before the widespread usage of commercially sold antiparasitic drugs by producers, animals could naturally develop resistance to parasites, and producers had the opportunity to cull susceptible animals while keeping resistant ones in the flock. These days, producers frequently keep these weaker animals since antiparasitic drugs are so widely used, which increases their dependency on drugs (Bisset et al., 2001). Figure 4 shows the correlation between fecal egg counts and a rise in live weight. Figure 4 makes it evident that animals with high live weight gain and low fecal egg counts are considered resilient and robust, making them appropriate for ongoing flock membership. However, other researchers argue that selecting animals based on their growth and performance could simultaneously increase immunity (Greer, 2008).

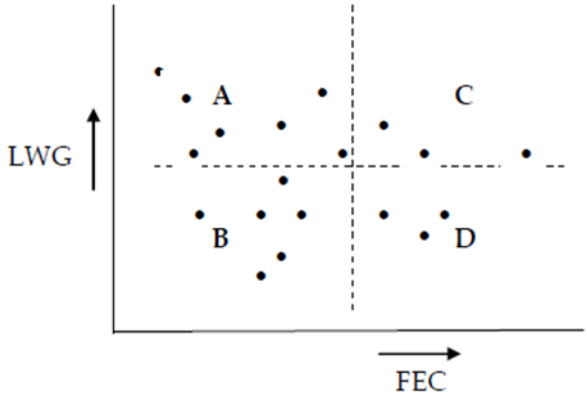


Figure 4. Relationship between live weight gain (LWG) and fecal egg count (FEC) in animals under strongyle challenge. Animals classified as "resistant" had low FEC (areas A and B), whereas animals classified as "susceptible" had above-average FEC (areas C and D). Groups in regions A and C that are sustaining high LWG under pressure are considered “resilient,” and even those in area C with high FEC but above-average LWG are viewed as “tolerant.” The best performing animals are both resistant and resilient (area A).
Source: Bisset et al., 2001.

Definition Of Resistance To Parasitic Drugs

According to the World Health Organization, resistance is the evolution of an organism's strain's capacity to withstand hazardous concentrations of substances that would typically be fatal to the majority of individuals of the same species (Kebede, 2019). decrease in the efficacy of medications that were previously successful in managing a parasite population (Sangster and Gill, 1999).

A rise in the frequency of resistant gene alleles brought on by selection pressure from recurrent drug usage causes this decrease in medicine sensitivity (Fleming et al., 2006). Frequent use of antiparasitic drugs to control gastrointestinal parasites increases the risk of developing resistant populations (Taylor et al., 2002). Resistance is frequently thought to exist in the field when there is a clinically poor response to therapy. A genetic change in the parasite population that makes it able to withstand therapeutic treatments that were previously effective against the same type

of infection at the same dose is known as drug resistance, according to Kelly and Hall (1997).Practically speaking, resistance is present in a parasite population when the medication's effectiveness drops below what was historically expected. Such changes typically develop slowly over many years due to the direct impact of parasite populations ' natural selection responding to drug treatments. Many parasites possess biological and genetic characteristics that promote the development of resistance to treatment. One of the most noteworthy of these is the exceptionally high degree of genetic variation commonly found in sexually reproducing parasites that infect migratory vertebrate hosts.Short life cycles, high reproduction rates, and many parasites possess remarkably high levels of genetic variety as a result of their enormous effective population sizes and quick nucleotide sequence changes (Blouin et al., 1995). The genetic makeup of parasite populations is mostly determined by host migration, as seen by the high degree of gene flow seen in the population structure of most parasite species. Because of this, many parasites possess the genetic capacity to successfully resist chemical treatments as well as spread resistance alleles through host migration.

The fact that resistance in certain parasites and hosts develops more slowly compared to others is due to many complex factors. These factors are related to biology and epidemiology of parasites, the dynamics of host–parasite relationships, and the pharmacokinetics of drugs. Some factors directly related to parasite biology include reproduction time, direct or indirect life cycles, female parasite fecundity, lifespan of adult parasites, number of genes involved, genetic diversity, inheritance patterns of resistance traits, the persistence of free-living phases in the surroundings, the distinction between the label dose and the actual amount needed to kill vulnerable parasites, and parasite pathogenicity (Dobson et al., 2011). Regarding host-related factors: innate and acquired immunity levels, behavioral differences affecting exposure to drugs, and species-specific pharmacokinetic differences come to mind. In animal species, antiparasitic drugs generally show the highest bioavailability in cattle and the lowest in goats (Yarsan and Kaya, 2005). It has frequently been proposed that goats' high anthelmintic resistance prevalence nematodes is linked to this distinct profile of pharmacokinetics. All of these elements influence how quickly resistance develops, as do treatment frequency, drug administration

techniques, dosage levels, drug persistence, drug quality, and the degree of refugia experienced during therapy. It is challenging to determine the precise role that each of these factors plays in the emergence of resistance, and it probably varies depending on the host-parasite interaction. Even though the essential nematodes of sheep, goats, and cattle are very closely related, resistance in cattle nematodes develops much more slowly, indicating that a number of factors other than parasite genetics play a role in resistance development (Sangster and Dobson, 2002).

Causes Of Resistance To Parasitic Drugs

Making the distinction between diminished efficacy and actual anthelmintic resistance is crucial, but it's not always simple in reality. A variety of complex factors should be ruled out before assuming resistance since they could alter the effectiveness of a parasite therapy. Research on these issues has focused primarily on gastrointestinal parasites that infect animals, whereas less emphasis has been paid to species that infect humans (Bartram et al., 2012).

One significant host-related factor is the variance in anthelmintic pharmacokinetics. Recent advances in understanding the pharmacokinetics of anthelmintic drugs like benzimidazoles (BZMs) in livestock have significantly improved parasite control in these animals (Elard et al., 1999). By contrast, there is limited pharmacokinetic and pharmacodynamic data for anthelmintics used in humans. The broad-spectrum activity of BZM compounds relies on maintaining effective drug concentrations in the parasite's niche within the host for extended periods (Sargison, 2011). This suggests that increasing drug concentrations in this region and prolonging the parasite's exposure should result in greater clinical efficacy (Sangste and Rj, 2022). Therefore, manipulating formulation and dosing regimens could lead to improved pharmacokinetic profiles and thus increased drug efficacy. Pharmacogenetic variation in drug use, changes in medication distribution, and interactions with age from concurrent treatments, and coexisting diseases can also affect anthelmintic efficacy. Many drugs also need a strong immune system in order to function at their best. Some medications and foods, like cimetidine, an antacid, and grapefruit, may influence the cytochrome P450-mediated metabolism of albendazole (ALB), altering its pharmacokinetics (Larsen, 2006).

Four main anthelmintic resistance developments have been reported, linked to certain circumstances:

•The initial frequency of resistance alleles,

•Treatment frequency,

•Refugia, and

•Possibly underdosing.

Initial frequency of resistant alleles: Genetic data show that the alleles responsible for resistance were already present in worm populations before the drug's launch. The same gene associated with resistance to benzimidazole is present in many resistant strains, suggesting it emerged distributed as a neutral allele after one instance (Waller et al., 2004). Selection for resistance is not necessary because novel mutations that are not needed can proceed rapidly (Stear et al., 2007). For veterinary parasites, it is mostly unknown what percentage of supposed resistance genes are present in soil-transmitted helminths that infect humans; nevertheless, techniques to quantify this in populations that have recently received treatment are now available.

Treatment frequency: The pace of selection for anthelmintic resistance is largely determined by this factor: the greater the drug pressure, the faster resistant nematode strains are selected. Treating five or more times per year (up to ten treatments) is not uncommon in livestock (Smith and Zarlenga, 2006). Humans are often only treated for A. lumbricoides and hookworms one to three times annually. However, despite these lower treatment rates, anthelmintic resistance selection has been often observed in sheep and goat nematodes, especially when the same drug is used for extended periods of time, as is the situation with benzimidazoles for the treatment of STH in humans. Farmers frequently use a single drug until it ceases effective, as seen in the case of cattle nematodes (Zajac and Garza, 2020).

Underdosing:Anthelmintic resistance may also develop as a result of underdosing. The initial and subsequent frequencies of resistance genes in the worm population determine the effect. Depending on the ability of specific dose regimens to kill all susceptible homozygotes, heterozygotes, and/or resistant homozygotes, and the resistance allele's initial frequency, several dosing approaches might select for resistance in various ways. The most deadly dose is one that kills all susceptible homozygotes while sparing all heterozygotes and resistant homozygotes if resistance is caused by a

single main gene with two alleles at an autosomal locus, and the resistance allele's initial frequency is modest. However, if the starting frequency of the resistance allele is large, the dose that most strongly selects for resistance spares resistant homozygotes while killing susceptible homozygotes and all heterozygotes (Kotze et al., 2020).

Refugia (untreated parasite populations):The percentage of a parasite population that has not been exposed to the drug is known as its refugia; as a result, it is not under selection pressure to develop resistance. Despite occasionally being overlooked, this component is essential to the selection pressure that drives resistance development (Tarekegn et al., 2023). The two main elements that influence the scope of refugia are the proportion of the population undergoing treatment and the proportion of worm populations in the environment that are not subjected to the effects of medications. Climate, the length of free-living stages, and the resistance of transmission phases to environmental stressors all have an impact on this. It has been shown that leaving some sheep untreated or moving them to pastures with low infectious larval populations yields better results. In such cases, the development of resistance can be delayed, and nematode control can be maintained when approximately 1–4% of the parasite population remains untreated (Sutherland et al., 1999). The volume of parasites not affected by the drug is also heavily influenced by treatment timing and climatic conditions before treatment, as both affect the selection pressure on parasites.

Parasitic Drug Resistance Mechanisms

Resistance occurs when there are members of a population who can withstand certain amounts of a substance at a higher frequency than the normally susceptible population of the same species. For each chemical class of parasitic drug, resistance developed in one animal generally confers resistance in other animals. A change in the drug's distribution within the target organism that prevents it from reaching its site of action, a change in metabolism that makes the drug inactive or eliminates it, or a modification of the drug receptor that makes the medication useless at safe, low dosages because it no longer binds with high affinity are the few ways that drug resistance can develop (Sherrill et al. 2006; Sissay et al. 2006).

Parasites employ several strategies to become resistant, including:

a. Molecular changes affecting the drug's late accumulation capacity in the intracellular space. For example, resistance to Benzimidazole (BZM) in Haemonchus contortus has been associated with loss of high-affinity binding receptors and altered β-tubulin isoform patterns based on well-conserved mutations at amino acids 200 or 167 in both β-tubulin isotypes 1 and 2;

b. Altered activity of the parasite's enzymatic system;

c. Changes in the number, structure, and/or similarity of cellular drug receptors; and

d. Amplification of target genes to abolish the effect of the antiparasitic drug.

The mechanism of action determines the time course of the antiparasitic drug's effect and the potential risk of developing resistance to a particular class of drug chemicals.

Methods For Determınıng Resistance To Parasitic Drugs

A few factors must be considered before determining pharmaceutical resistance. It's important to remember that a number of illnesses might present with clinical symptoms that resemble parasite symptoms before beginning medication delivery.Secondly, drugs used against diseases caused by parasites may ultimately fail to control the parasites due to resistance. In these circumstances, failure is often attributed to issues such as malfunctioning equipment or inadequate dosing due to inaccurate body weight estimation. With the increasing prevalence of resistance, the demand for reliable and standardized detection methods is increasing. In vivo or in vitro approaches are used to detect and treat resistance (VanHoy et al. 2025).

In Vivo Methods

Fecal Egg Count Reduction Test (FECRT)

This test is the most popular field technique for identifying gastrointestinal parasite resistance (Zajac and Garza, 2020). It computes the decrease in parasite egg counts in fecal samples mathematically. The efficacy of the treatment can be evaluated by examining the reduction in the average parasite egg count, comparing the group to the control group, comparing the results to the expected effectiveness, or computing the mean's confidence interval.An untreated control group is used to account for natural variations in parasite egg counts between sampling times.Under grower conditions, YSAT is a useful and practical tool that can be used to assess

parasite resistance in some farms. The results provide information about which group of parasite drugs remains effective for a given group of animals (Waller, 2003). YSAT has numerous shortcomings despite being the most popular method for determining a parasite's resistance to medication. These include:

• Fecal parasite egg counts may be less accurate in cattle than in small ruminants. This is because the usual egg count method's detection threshold is close to the small number of eggs in one gram of cattle excrement. By employing more sensitive egg-counting techniques, accuracy can be increased.

• In general, parasite egg counts are not highly correlated with the actual parasite load within the animal.

• Animals in a herd may exhibit varying rates of parasite egg shedding. On pasture, certain animals may produce a disproportionately higher amount of parasite eggs than others. This variability can be achieved by sampling different individuals within the herd.

• Fecal egg counts decrease as animals age or as host immunity develops against parasites.

• The YSAT method does not distinguish between parasite species present. Under a light microscope, the eggs of common nematode parasites in goats, sheep, and cattle—aside from those in the genus Nematodirus—appear to be similar. Because of this, the information gathered from this test can only determine whether resistance is present; it cannot pinpoint the specific parasite species that is causing the resistance. Nonetheless, the majority of parasitic medications are broad-spectrum, therefore YSAT results will be useful when deciding how best to control parasites.

The effectiveness of a drug is determined by comparing parasite egg counts in animals before and after treatment. This test has been extensively standardized, allowing for its widespread use. According to the YSAT, resistance is evident when two requirements are met: the percent decrease in the number of eggs is less than 95%, and the 95% CI's lower bound is equivalent to or less than 90%. For benzimidazoles, posttreatment egg counts should be performed 10–14 days after anthelmintic administration. Because anthelmintic treatment can temporarily suppress egg laying without killing adult nematodes, Using it is a smart idea. Less than ten days between treatments may result in decreased egg production, which could lower the

effectiveness of benzimidazole anthelmintics. Fecal samples should therefore be taken 10–14 days following treatment (Hale, 2015). Fecal samples should be taken less than seven days following therapy if a single resistance is detected. As a result, the anthelmintic group affects how long it takes between treatment and the second egg count.

In vitro Methods

Egg Hatching Assays (EHAs)

Benzimidazoles prevent the embryonation and hatching of parasite eggs. This technique was developed to detect resistance to certain anthelmintic drugs. The test is unfit for use with tetrahydropyrimidines, imidazothiazoles, and macrocyclic lactones because they are not ovicidal. In the test, fresh eggs are inserted into a 24-well plate, and after being incubated for 48 hours at 27°C, benzimidazole is added at several concentrations (0.5, 1, 2, 3, and 5 ppm). The remaining eggs and hatched larvae are counted, and LD50 values are calculated. This is a more applicable method for testing resistance to benzimidazoles (Schoenian and Enrigue, 2019).

Larval Development Test (LGT)

The ability of the larvae to live and grow at different anthelmintic medication concentrations forms the basis of this test. Larval development tests examine the development of larvae under various drug doses. Incubation can be performed in liquid or solid nutrient medium (agar). Using this approach, resistance to major anthelmintic families is detected. Variations in the LD50 (larval 50% mortality) have been reported in this test, particularly when macrocyclic lactones (ML) are used, depending on the timing of infection (Burke et al. 2016).

Larval Motility Test (LMT)

Larvae in different medication doses are cultured for 24 hours at 25°C in the dark. They are then exposed to light for 20 minutes to stimulate non-paralyzed larvae. The number of non-motile larvae is then counted and calculated from the total number of larvae found at each drug concentration (McEvoy et al. 2024).

Polymerase Chain Reaction (PCR)

Adults with sensitive (rS and SS) or resistant (rr) genotypes of parasites or larvae is possible with this PCR-based technology. Parasites can be genotyped for the mutation at β-tubulin residue 200 (lanine to tyrosine),

which is involved in BZ resistance, using the same reaction mixture with four primers (Aktaş et al. 2007; Ayan et al. 2019).

Molecular Diagnostic Methods

Molecular methods are needed to identify and classify resistant alleles or to identify genetic markers associated with drug resistance. In other words, these methods would be useful for diagnosing drug resistance before it manifests clinically in YSAT or reaches treatment failure. A thorough grasp of the mechanisms of action of each anthelmintic class and the genetic basis of drug resistance are necessary for molecular detection of resistance, which is now limited to the medication benzylate (BZ) (Woodgate et al. 2017).

It is commonly recognized that BZ selectively inhibits nematode β-tubulin, which stops microtubule synthesis and causes worms to become hungry, produce fewer eggs, and eventually die. Certain worm species are resistant to benzilate (BZ) due to a mutation from TTC (encoding phenylalanine [phe]) to TAC (encoding tyrosine [tyr]) caused by a single nucleotide polymorphism (SNP) at codon 200 of the nematode P-tubulin isotype 1 gene (Kotze et al. 2014).Resistance to the benzilate (BZ) class of medications has been linked to other SNPs in the same P-tubulin gene at codons 167 and 198 (Whittaker et al. 2017). Pyrosequencing and allele-specific PCR tests for the identification of BZ resistance have been made possible by the SNP at codon 200 (Muchiuta et al. 2018). These techniques have undergone successful testing in the field to confirm the benzilate (BZ)-resistant status of selected nematode strains (Peña-Espinoza et al. 2018).Since no SNP has been linked to resistant phenotypes in parasitic nematodes to date, despite intensive research efforts to identify markers of resistance to macrocyclic lactones (MLs), it is likely that variations at particular target sites are linked to ML resistance (Kotze et al. 2014).

Recent research have examined the multigenic nature of ML resistance in worms by using genome-wide SNP detection and examining the role of P-glycoproteins and other ATP-binding cassette (ABC) transporters in the nematode's active efflux of ML drugs (Godoy et al. 2020). Once molecular diagnostic methods for ML are available, it will be crucial to connect these results with the phenotypic expression of AR in order to advise farmers when to cease drug use and prevent further selection of resistance.

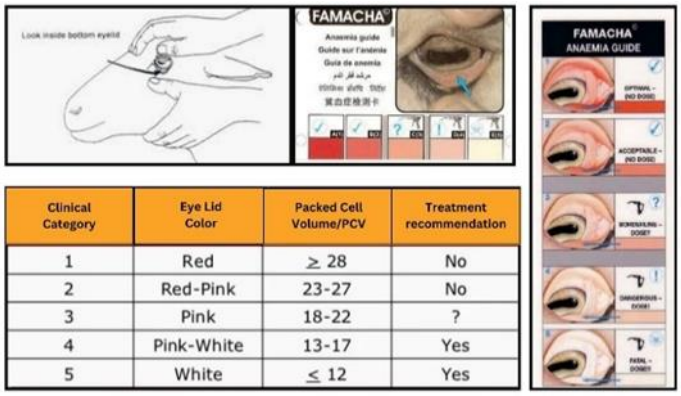
Control and Management of Parasitic Drug Resistance

From a medical standpoint, it is essential to understand that resistance genes are a phenotypically expressed genetic trait when their allele frequencies are quite high. Therefore, preventing drug resistance should aim to reduce the number and rate of resistance alleles. Strategies to slow the rate of resistance development should be incorporated into the early phases of the resistance evaluation process. Treating patients concurrently with two drugs from different parasite control groups is one way to prevent resistance from forming (Barnes et al. 1995).The most important rationale/principle for the successful implementation of rational and sustainable internal parasite control programs in pasture-grazing animals is a solid understanding of the parasite's epidemiology and how it interacts with the host within a specific climate, herd management, and production environment (Barger et al. 1999). The epidemiological knowledge base has been accumulated through extensive studies and field studies conducted in many developed countries, mostly in connection with industrial cattle production. The epidemiological knowledge base has been built through extensive studies and field trials conducted in many developed countries, mostly about the production of industrial livestock. In many developing and transitioning nations, this is not the case, and even when data is accessible, it hardly ever discusses the variety of production systems.Lack of infrastructure, financial, and human resources is usually the cause of this.However, it is also assumed that epidemiological studies carried out in a single climate or industrial system can be generalized to another, or that the availability of modern broad-spectrum antiparasitic drugs obviates the need for epidemiological information. Current tools for controlling gastrointestinal parasites consist of chemical and non-chemical technologies. Chemical technology relies entirely on treatment with different drug formulations, which are used in different control strategies depending on the availability of epidemiological information. Non-chemical technology relies on pasture and breeding management and nutritional interventions, among other practices (Sissay et al. 2006).

a. Biosecurity: Less valuable are management techniques that effectively stop anthelmintic resistance from developing if producers purchase resistant parasites already in their breeding stock. Therefore, strict quarantine must be implemented for all new additions. Spreading resistance

can't be done more quickly than introducing gastrointestinal parasites to a farm. Currently, it is recommended that each new addition be isolated and treated with a triple-class anthelmintic.and then do a test to reduce the number of fecal eggs. Animals ought to be on contaminated pasture. Animals should never be placed on clean pasture after receiving a triple-class antiparasitic treatment, as surviving parasites will not only be triple-resistant, but also sheltered area on the pasture, reducing future transmission of excreted eggs (Sherrill et al. 2006).

b. Famacha-Rethinking Strategy: FAMACHA is a method for determining an animal's level of anemia. This method is useful in identifying whipworm infection. This is because anemia is the primary symptom of whipworm (Figure 5). The FAMACHA system categorizes animals based on their level of anemia, ranging from 1 to 5 (Kaplan et al. 2004). South Africa built the system, and the United States verified it (Kaplan et al. 2004). Sheep and goats' conjunctivae are inspected in order to use the system, which only treats anemic animals. This approach reduces the use of parasite medications, slows the development of resistant parasites, and saves the breeder money. Most importantly, it allows the breeder to select healthier animals (Burke and Miller, 2008).Over time, the herd or flock will be strengthened by breeding the healthiest animals and eliminating the weaker ones. It's crucial to remember that FAMACHA works only on H. contortus (whipworm). Since other parasites do not cause anemia, they cannot be diagnosed with this method. FAMACHA training is required for breeders (Terril et al., 2012). Nonetheless, this approach is quick to adopt and simple to understand. In a survey of breeders who trained in integrated parasite management, including FAMACHA, 94% of participants reported that the method helped control internal parasites, 74% reported fewer parasite issues after training, and 88% reported cost savings from reduced medication use and fewer animal deaths in the first year after training (Kaplan et al. 2004).



Clinical Category	Eye Lid Color	Packed Cell Volume/PCV	Treatment recommendation
1	Red	≥ 28	No
2	Red-Pink	23-27	No
3	Pink	18-22	?
4	Pink-White	13-17	Yes
5	White	≤ 12	Yes

Figure 5. Assessment of anemia with the FAMACHA scorecard
Source: https://nwlivestock.com.au/famacha-score/

Small ruminant breeders often employ one of two strategies to control Haemonchus contortus: either treating the entire group when one or more animals are present and exhibit clinical indications suggestive of parasite infection, or treating all animals at regular intervals during the peak infestation period. A major flaw in this method, which was created in South Africa to detect sheep anemia, is the FAMACHA system, which categorizes the ocular mucous membranes of sheep and goats by comparing them with a restricted color scheme of the sheep's conjunctiva. This method may help to determine animals that need therapy (Bath et al. 1995).

c. Pasture Management: Lowering vulnerable hosts' exposure is crucial in a control program.Providing a safe pasture for grazing is the aim of pasture management. Controlling gastrointestinal parasites through pasture management can be based on a comprehensive study of the epidemiology, including seasonal fluctuations in larval development and pasture availability. These parasites have been successfully managed with a differential grazing method (Barger et al. 1999).

d. Rapid rotation grazing: In an effort to maximize pasture growth and productivity, rotational grazing has recently attracted more attention. This is an excellent tool for productivity because animals will consume a higher proportion of the available forage, which in turn encourages pasture regrowth (Dobson et al. 2011).

e. Alternative grazing: Using alternate grazing for parasite control relies on grazing pastures either by distinct species or by several age groups

within the same species. When using different age groups, calves are typically fed before more experienced livestock, taking advantage of the greater resilience of older animals. If the system is based on species rotation, many parasites have decreased sensitivity to various host species. It should be mentioned that alternate grazing methods are probably less successful in reducing parasites in temperate temperatures (Sutherland et al. 1999).

f. Vaccines: The mechanisms behind sheep and cattle's spontaneously acquired immunity against gastrointestinal helminth infections have been extensively studied in order to help develop vaccines (Waller, 2003). However, the situation is complex, involving a combination of cell-mediated antibody and inflammatory responses, as well as local hypersensitivity, and is further complicated by the inherent unresponsiveness of the young lamb or calf and the mother at birth. There have been unsuccessful attempts to create vaccinations against intestinal parasites in ruminants, including the successful development of a vaccine against the bovine lungworm utilizing Dictyocaulus viviparus irradiation larvae as a model. The most promising vaccines for small ruminants are based on a latent intestinal antigen, specifically targeting Haemanchus contortus. When the animal is given this antigen, which comes from the worm's gut, antibodies are created when the worm consumes blood. The worm's capacity to assimilate nutrients required for healthy growth and maintenance is subsequently hampered by these antibodies' attack on the worm's target intestinal cells (Kabagambe et al. 2004).

g. Five Checkpoints: A technique called Five Checkpoints was created to determine which animals needed internal parasite treatment. The same scientists that developed FAMACHA also developed this system (Bath and Van Wyk, 2009).While FAMACHA is used only to identify animals affected by H. contortus infection, the Five Checkpoints also identify symptoms of other internal parasites.Remember that any parasite-induced symptom might possibly be caused by another parasite, and that the five checkpoints are parts of the animal's body that need treatment (Table 1).

Table 1. Five control points for sheep and goats

Number of checks	Control area	What to check	Possible parasites
1	Eye	Anemia (FAMACHA)	Whipworm
2	Back	Body Condition Score	All
3	Tail and surrounding area	Dag Score	Brown stomach worms
4	Chin	Check for a pouch under the chin	Whipworm
5	Nose	Runny nose	Nose fly
5	Skin/fleece cover	Skin/coat condition	Whipworm

Source:https://attra.ncat.org/wpcontent/uploads/2022/10/managing_internal_parasites.pdf

SUGGESTIONS

Controlling intestinal parasites in goats and sheep is quite challenging. Previously implemented internal parasite control methods are no longer applicable on farms. Stated otherwise, it is advantageous to implement more effective and newer control methods today. These methods include pasture management, smart pesticide use, FAMACHA, Five Control Points, and selecting parasite-resistant animals. Attention to nutrition and pasture management also contributes significantly to controlling infection levels.The methods indicated above reduce the need for parasiticides on animals and contribute to a more sustainable herd management approach. Combining several of these tactics into one program will be far more successful than depending just on one. Intestinal parasites are one of the primary factors reducing animal fertility and productivity. These parasites are still among the most prevalent and dangerous illnesses that tiny ruminants face globally. Both direct and indirect harms are their fault.

Losses and the direct expenses of control stem from deaths and reduced productivity brought on by subclinical parasitism. Anthelmintics are

among the non-chemical and chemical treatments that can be used to manage it. A thorough study of the pharmacokinetics of anthelmintic medications is required to improve their efficacy against parasites that are challenging to manage in veterinary and human medicine while keeping an adequate safety margin, as the host's metabolic rhythms are affected. However, the specific causes of parasite resistance are widespread and negligent antibiotic use, frequent treatment, and inadequate dosage. By improving the production and health of small ruminants, the following recommendations are made to maintain the country's food sufficiency plan and manage parasite resistance: After receiving triple antiparasitic drug therapy, it is advised that parasites be retained on pastures infested with parasites due to the potential for triple drug resistance.

- Training on when and how to avoid underdosing animals for parasite control should be provided to smallholder farmers and herders.

- FAMACHA should be developed, and treatment should only be given to animals that require it.

- Farmers and veterinary professionals should begin to recognize anthelmintic resistance as a serious problem, and routine diagnosis of helminth infections should be complemented by efficacy assessment techniques.

- Appropriate veterinary extension and services should be implemented, and appropriate parasite control programs should be implemented.

- Pasture management and rotational grazing with other livestock species should be implemented.

REFERENCE

Adduci, I., Sajovitz, F., Hinney, B., Palmieri, N., & Joachim, A. (2022). Haemonchosis in sheep and goats, control strategies and development of vaccines against Haemonchus contortus. Animals, 12(18), 2339. https://doi.org/10.3390/ani12182339

Afework, K., & Edget, A. (2022). Epidemiology of gastrointestinal nematodes in small ruminants in Gamo Zone, Southern Ethiopia, with a special reference to field survey on parasite management and risk factor analysis. The Indian Association For The Advancement Of Veterinary Parasitology, 36(1), 17–38.

Aktas, M., Altay, K., & Dumanli, N. (2007). Determination of prevalence and risk factors for infection with Babesia ovis in small ruminants from Turkey by polymerase chain reaction. Parasitology Research, 100, 797–802.

Ayan, A., Ural, D. A., Erdogan, H., Kilinc, O. O., Gültekin, M., & Ural, K. (2019). Prevalence and molecular characterization of Giardia duodenalis in livestock in Van, Turkey. International Journal of Environment and Ecology Sciences (IJEES), 9(2), 289–296.

Bambou, J. C., Arquet, R., Alexandre, G., Mahieu, M., & Mandonnet, N. (2008). Genetic resistance to gastrointestinal nematodes in small ruminants. Veterinary Parasitology, 158, 311–318.

Barger, I. A., Miller, J. E., & Klei, T. R. (1999). The role of epidemiological knowledge and grazing management for helminth control in small ruminants. International Journal for Parasitology, 29, 41–47.

Barnes, E. H., Dobson, R. J., & Barger, I. A. (1995). Worm control and anthelmintic resistance. International Journal for Parasitology, 25, 1363–1367.

Bartrama, D., Dave, M., Leathwick, M., Kelly, G., Hosking, B., Besier, B., & Cotton, S. (2012). The role of combination anthelmintic formulations in the sustainable control of sheep nematodes. Veterinary Parasitology, 186, 151–158.

Bath, G. F., & van Wyk, J. A. (2009). The Five Point Check© for targeted selective treatment of internal parasites in small ruminants. Small Ruminant Research, 86(1), 6–13.

Bath, E. H., & Malan, F. S. (1995). The FAMACHA ovine anemia guide to assist with the control of Haemonchus. Paper presented at the 7th Annual Congress of the Livestock Health and Production Group of the South African Veterinary Association, Port Elizabeth, South Africa.

Bisset, S. A., van Wyk, J. A., Bath, G. F., Morris, C. A., Senson, M. O., & Malan, F. S. (2001). Phenotypic and genetic relationships amongst FAMACHA score, faecal egg count and performance data in Merino sheep exposed to Haemonchus contortus infection in South Africa. In Proceedings of the 5th International Sheep Veterinary Congress, Cape Town, South Africa.

Blouin, M. S., Yowell, C. A., Courtney, C. H., & Dame, J. B. (1995). Host movement and the genetic structure of populations of parasitic nematodes. Genetics, 141, 1007–1014.

Burke, J. M., Miller, J. E., Terrill, T. H., Smyth, E., & Acharya, M. (2016). Using copper oxide wire particles to increase dewormer efficacy. American Consortium for Small Ruminant Parasite Control. Retrieved from http://www.wormx.info/cowpcombo

Burke, J. M., & Miller, J. E. (2008). Use of the FAMACHA system to evaluate gastrointestinal nematode resistance/resilience in offspring of stud rams. Veterinary Parasitology, 153, 85–92.

Butako, B. (2023). Prevalence of gastrointestinal parasites of small ruminants in Sodo Zuria District, South Ethiopia. International Journal of Advanced Research in Biological Sciences, 10(11), 24–36.

Dobson, J. M., Blackwood, L. B., McNiel, E. A., et al. (2011). The clinical presentation and histopathologic-immunohistochemical classification of histiocytic sarcomas in the Flat Coated Retriever. Veterinary Pathology, 48, 764–771.

Elard, L., Cabaret, J., & Humbert, J. F. (1999). PCR diagnosis of benzimidazole-susceptibility or -resistance in natural populations of the small ruminant parasite, Teladorsagia circumcincta. Veterinary Parasitology, 80(3), 231–237.

Fleming, S. A., Craig, T., Kaplan, R. M., Miller, J. E., Navarre, C., & Rings, M. (2006). Anthelmintic resistance of gastrointestinal parasites in small ruminants. Journal of Veterinary Internal Medicine, 20, 435–444.

Godoy, M. C., Rodríguez, L. A., & Vargas, J. M. (2020). Uso de bloques multinutricionales en sistemas de producción bovina: impacto en salud y desempeño animal. Revista Agropecuaria Tropical, 37(2), 112–120.

Greer, A. W., van Wyk, J. A., Hamie, J. C., Byaruhanga, C., & Kenyon, F. (2020). Refugia-based strategies for parasite control in livestock. Veterinary Clinics of North America: Food Animal Practice, 36(1), 31–43. https://doi.org/10.1016/j.cvfa.2019.11.003

Gruner, L., & Cabaret, J. (1985). Current methods for estimating parasite populations: potential and limits to control gastrointestinal and pulmonary strongyles of sheep on pasture. Livestock Production Science, 13(1), 53–70.

Hale, M. (2015). Managing internal parasites in sheep and goats. ATTRA Sustainable Agriculture. Retrieved from https://attra.ncat.org/wp-content/uploads/2022/10/managing_internal_parasites.pdf

Kabagambe, E. K., Barras, S. R., & Liy, T. (2004). Attempts to control Haemonchus in grazing ewes by the vaccination with gut membranes proteins of the parasites. Veterinary Parasitology, 92, 15–23.

Kaplan, R. M., Denwood, M. J., Nielsen, M. K., Thamsborg, S. M., Torgerson, P. R., Gilleard, J. S., Dobson, R. J., Vercruysse, J., & Levecke, B. (2023). World Association for the Advancement of Veterinary Parasitology (W.A.A.V.P.) guideline for diagnosing anthelmintic resistance using the faecal egg count reduction test in ruminants, horses and swine. Veterinary Parasitology, 318, 109936. https://doi.org/10.1016/j.vetpar.2023.109936

Kaplan, R. M. (2020). Biology, epidemiology, diagnosis, and management of anthelmintic resistance in gastrointestinal nematodes of livestock. Veterinary Clinics of North America: Food Animal Practice, 36(1), 17–30.

Kaplan, R. M. (2004). Drug resistance in nematodes of veterinary importance: a status report. Trends in Parasitology, 20, 477–481.

Kaplan, R. M., Burke, J. M., Terrill, T. H., Miller, J. E., Getz, W. R., Mobini, S., Valencia, E., Williamson, M. J., Larsen, M., & Vatta, A. F. (2004). Validation of the FAMACHA eye color chart for detecting clinical anemia in sheep and goats on farms in the southern United States. Veterinary Parasitology, 123(1–2), 105–120.

Kebede, A. (2019). Review on anthelmintic drug resistance nematodes and its methods of detection in Ethiopia. Journal of Veterinary Medicine and Animal Science, 2(1), 1013.

Kelly, J. D., & Hall, C. A. (1997). Resistance of animal helminthes to anthelmintics. Advances in Pharmacology and Chemotherapy, 16, 89–128.

Kotze, A. C., Gilleard, J. S., Doyle, S. R., & Prichard, R. K. (2020). Challenges and opportunities for the adoption of molecular diagnostics for anthelmintic resistance. International Journal for Parasitology: Drugs and Drug Resistance, 14, 264–273.

Larsen, M. (2006). Biological control of nematodes in sheep. Journal of Animal Science, 84, E133.

Mandonnet, N., Mahieu, M., Gunia, M., Alexandre, G., & Bambou, J. C. (2020). Genetic resistance to parasites in small ruminants: from knowledge to

implementation in the tropics. In Proceedings of the 10th World Congress of Genetics Applied to Livestock Production, Vancouver, Canada.
McEvoy, A., O'Boyle, P., Ellis, S., Dalton, J. P., Parkinson, M., Keane, O. M., & Mach, C. (2024). Comparison of traditional copromicroscopy with image analysis devices for detection of gastrointestinal nematode infection in sheep. Veterinary Parasitology, 329, 110216.
McLeod, R. (1995). Costs of major parasites to the Australian livestock industries. International Journal for Parasitology, 25, 1363–1367.
Muchiuta, S. M., Fernández, A. S., Steffan, P. E., Riva, E., & Fiel, C. A. (2018). Anthelmintic resistance: management of parasite refugia for Haemonchus contortus through the replacement of resistant with susceptible populations. Veterinary Parasitology, 254, 43–48.
Nari, A., Salles, J., Castell, D., & Hansen, J. W. (1997). Control of gastrointestinal nematodes in farming systems of Uruguay. In Hansen, J. W., & Waller, P. J. (Eds.), Proceedings of Biological Control Workshop. FAO Technical Series Report No. 141 (pp. 89–94).
Nieuwhof, G. J., & Bishop, S. C. (2007). Costs of the major endemic diseases of sheep in Great Britain and the potential benefits of reduction in disease impact. Animal Science, 81(1), 23–29.
Pena-Espinoza, M., Valente, A. H., Thamsborg, S. M., Simonsen, H. T., Boas, U., Enemark, H. L., Lopez-Muñoz, R., & Williams, A. R. (2018). Antiparasitic activity of chicory (Cichorium intybus) and its natural bioactive compounds in livestock: a review. Parasites & Vectors, 11, 475.
Ríos-de Álvarez, L., Jackson, F., Greer, A. W., Grant, G., Jackson, E., Morrison, A. A., & Huntley, J. F. (2012). Direct anthelmintic and immunostimulatory effects of oral dosing semi-purified phytohaemagglutinin lectin in sheep infected with Teladorsagia circumcincta and Trichostrongylus colubriformis. Veterinary Parasitology, 187, 267–274.
Sangster, N., & Dobson, R. J. (2002). Anthelmintic resistance. In D. L. Lee (Ed.), The biology of nematodes (pp. 531–567). Harwood Academic Publishers.
Sangster, N. C., & Gill, J. (1999). Pharmacology of anthelmintic resistance. Parasitology, 15, 141–146.
Sargison, N. (2011). Pharmaceutical control of endoparasitic helminth infestations in sheep. Veterinary Clinics of North America: Food Animal Practice, 27(1), 139–156.
Schoenian, S., & Nelson, E. (2019). Best management practices for internal parasite control in small ruminants. Professional Agricultural Workers Journal, 6(2), Article 8.
Sherrill, A., Fleming, S. A., Craig, T., Ray, M., & Kaplan, R. M. (2006). Anthelmintic resistance of gastrointestinal parasites in small ruminants. Journal of Veterinary Internal Medicine, 20, 435–444.
Sissay, M. M., Asefa, A., Uggla, A., & Waller, P. J. (2006). Anthelmintic resistance of nematode parasites of small ruminants in eastern Ethiopia: exploitation of refugia to restore anthelmintic efficacy. Veterinary Parasitology, 135, 337–346.
Smith, W. D., & Zarlenga, D. S. (2006). Developments and hurdles in generating vaccines for controlling helminth parasites of grazing ruminants. Veterinary Parasitology, 139, 347–359.

Stear, M., Doligalska, M., & Donskow-Schmelter, K. (2007). Alternatives to anthelmintics for the control of nematodes in livestock. Parasitology, 134(2), 139–151.

Sutherland, I. A., Leathwick, D. M., Green, R., Brown, A. E., & Miller, C. M. (1999). The effect of continuous drug exposure on the immune response to Trichostrongylus colubriformis in sheep. Veterinary Parasitology, 80, 261–271.

Tarekegn, Y., Wale, Y., & Mequanint, G. (2023). Current approach in the control of helminthes of ruminants. International Journal of Zoological and Entomological Letters, 3(2), 34–39.

Taylor, M. A., Hunt, K. R., & Goodyear, K. I. (2002). Anthelmintic resistance detection methods. Veterinary Parasitology, 103, 183–194.

Taylor, M. A. (2010). Parasitological examinations in sheep health management. Small Ruminant Research, 92(1–3), 120–125.

Terrill, T. H., Miller, J. E., Burke, J. M., Mosjidis, J. A., & Kaplan, R. M. (2012). Experiences with integrated concepts for the control of Haemonchus contortus in sheep and goats in the United States. Veterinary Parasitology, 186, 28–37.

VanHoy, G., Carman, M., Habing, G., Lakritz, J., Lakritz, J., & Hullinger, P. (2018). Safety and serologic response to a Haemonchus contortus vaccine in alpacas. Veterinary Parasitology, 252, 180–186.

VanHoy, G., & Abuelo, A. (2025). Overview of gastrointestinal parasites of ruminants. MSD Veterinary Manual. Retrieved from https://www.msdvetmanual.com/digestive-system/gastrointestinal-parasites-of-ruminants/overview-of-gastrointestinal-parasites-of-ruminants

Waller, P., Schwan, O., Ljungström, B., Rydzik, A., & Yeates, G. (2004). Evaluation of biological control of sheep parasites using Duddingtonia flagrans under commercial farming conditions on the island of Gotland, Sweden. Veterinary Parasitology, 126, 299–315.

Waller, P. J. (2003). The future of anthelmintics in sustainable parasite control programs for livestock. Helminthologia, 40, 97–102.

Whittaker, J. H., Carlson, S. A., Jones, D. E., & Brewer, M. T. (2017). Molecular mechanisms for anthelmintic resistance in strongyle nematode parasites of veterinary importance. Journal of Veterinary Pharmacology and Therapeutics, 40, 105–115.

Woodgate, R. G., Cornell, A. J., & Sangster, N. C. (2017). Occurrence, measurement and clinical perspectives of drug resistance in important parasitic helminths of livestock. In D. L. Mayers, J. D. Sobel, M. Ouellette, K. S. Kaye, & D. Marchaim (Eds.), Antimicrobial Drug Resistance (pp. 1305–1326). Springer, Cham. https://doi.org/10.1007/978-3-319-47266-9_30

Yarsan, E., & Kaya, S. (2005). Protozoon hastalıklarında kullanılan ilaçlar ve farmakolojik özellikleri. In A. Burgu & Z. Karaer (Eds.), Veteriner Hekimliğinde Parazit Hastalıklarında Tedavi (pp. 321–400). Türkiye Parazitoloji Derneği Yayın No:19, İzmir.

Zajac, A. M., & Garza, J. (2020). Biology, epidemiology, and control of gastrointestinal nematodes of small ruminants. Veterinary Clinics of North America: Food Animal Practice, 36(1), 73–87

What is Lacertus Fibrosus? A Comprehensive Evaluation

Gülseren KIRBAŞ DOĞAN[1]

1- Associate Professor.; Kafkas Üniversity Veterinary Faculty, Department of Anatomy. Glsrn36@gmail.com ORCID No: 0000-0003-3770-9956

ABSTRACT

In veterinary anatomy, the lacertus fibrosus, which is particularly well developed in single-hoofed animals, is part of the stay apparatus, a mechanism that keeps the front leg in an upright position. This structure, which allows horses to sleep and rest while standing, helps to stabilize the shoulder joint. It transfers the action of the biceps brachii muscle to the extensor carpi radialis muscle. The presented study brings together research conducted on lacertus fibrosus in animals. Evaluations were made regarding whether lacertus fibrosus is found in certain animals.

As a result, while a developed lacertus fibrosus is present in ungulates and primates, it was also found in rats and elephants. It has been understood that ruminant species (such as sheep, goats, calve, cow, and deer) possess anatomical structures similar to lacertus fibrosus and that these structures vary between species. It was understood that no clear information was available regarding this structure in carnivores, pigs, and rabbits, and that it was either underdeveloped or had not been analyzed in detail in the literature. No information was found regarding the presence of a structure similar to lacertus fibrosus in non-mammalian vertebrates such as birds, reptiles, amphibians, and fish. It is believed that the presented work may be useful for veterinary anatomy, surgical anatomy, and artistic anatomy studies.

Keywords – Anatomy, Horse, Lacertus fibrosus, Veterinary

INTRODUCTION

In Classical Latin, lacertus was a polysemous word meaning “lizard” as well as “muscle,” and thus, particularly in anatomy, “(upper arm) muscle, upper arm, arm.” (Agrawal, 2019: 390). The word “Lacertus” emerged during the classical Latin period and held an important place in Rome's military and athletic culture. In this context, the emphasis on the strength and endurance of the human body symbolizes the warrior spirit and athleticism of the Roman Empire. Today, although the term “lacertus” is rarely used, its root words are often associated with concepts representing sovereign power or resilience in Turkish and other languages. Such words are still used, especially in scientific terminology or biological classifications. This also demonstrates the evolution and influence of Latin. In the Middle Ages, the semantic narrowing of the word lacertus began, and the word started to refer

mostly to lizards. During the same period, a distinction was made between musculus and lacertus. However, there was generally no clear criterion for distinguishing between them. Beginning with Andreas Vesalius, the father of artistic anatomy, the great modern historical anatomists used other terms for muscle in addition to musculus (lacertus and pisciculus) (Cuyer, 2024:50). However, they preferred the word musculus. In the 18th century, the word lacertus was further reduced to fasciculus, meaning "small bundle of muscle fibers". In 1694, William Cowper was the first to describe the aponeurosis of the biceps brachii muscle and named it fascia tendinosa. Later, other terms were also used for this structure. In 1864, Josef Hyrtl added the synonymous term lacertus fibrosus to the German aponeurotisches Fascikel. Finally, this term (lacertus fibrosus) became part of the BNA, the first unified anatomical nomenclature system, in 1895. Its synonym, aponeurosis musculus bicipitis brachii, was added to the 1955 Paris anatomical nomenclature system. These two terms have persisted in the official anatomical nomenclature system to this day (Šimon et al., 2016:320).

Lacertus fibrosus is also known as the bicipital aponeurosis or Pirogoff aponeurosis. The term "lacertus fibrosus" is commonly used in medical literature. In animal anatomy literature, it is sometimes referred to as "aponeurosis bicipitalis," "fibrous extension of the biceps brachii," or "long tendon/central tendon + fibrous band connection". In veterinary anatomy, lacertus fibrosus plays an important role as part of the stay apparatus, which is the mechanism that keeps the front leg upright in single-hoofed animals (Demiraslan and Özcan, 2014:60).

The front leg muscles are supported by fasciae, just like the muscles in other parts of the body. The front leg muscles are supported by fasciae, just like the muscles in other parts of the body. The fascia axillaris on the medial surface of the shoulder continues distally as the fascia brachii on the lateral surface of the arm around the deltoid, brachial, triceps, and biceps muscles. The fascia antebrachii covers the flexor and extensor muscles of the forearm region, from the fingers to the elbow (König and Liebich, 2022:220). The biceps brachii muscle is a powerful biarticular muscle that originates from the elbow joint and also passes through the shoulder joint. Unlike humans, this muscle has only one tendon in domestic mammals. The biceps brachii muscle originates from the tuberculum supraglenoidale of the scapula with its tendon. It passes over the intertubercular sulcus to the extensor side of the

shoulder joint. It progresses along the craniomedial side of the humerus in the distal direction. The tendon of this muscle splits into two parts at the level of the elbow joint. The medial part of the tuberosity of the radius ends at the lateral part of the proximal end of the radius and ulna (McDiarmi, 1999:65). Lacertus fibrosus radiates distally in a radial pattern within the fascia of the forearm and the extensor carpi radialis muscle. In horses, the musculus biceps brachii is a powerful muscle. The lacertus fibrosus formed by the fibers of this muscle extends toward the fascia brachii and the musculus extensor carpii radialis (Nevens et al., 2005:60). The biceps brachii muscle flexes the elbow joint and extends the shoulder joint. This keeps the shoulder joint immobile while the animal is standing. This is very important for horses. The extensor carpi radialis muscle is the largest of the carpal joint extensor muscles (Harrison et al., 2012:2990). It separates from the lateral epicondyle of the humerus and the lateral epicondyle crest. It attaches to the radius. The insertion tendon of this muscle is covered by a synovial sheath extending from the middle of the radius to the insertion point on the proximal end of the metacarpal bones or the distal carpal bones. The tendon attaches to the lacertus fibrosus, which separates from the biceps brachii muscle (König and Liebich, 2022:225). The lateral view of the foreleg in horses and the region where the lacertus fibros is located are shown in Figures 1 and 2. The medial view of the foreleg in horses and the region where the lacertus fibros is located are shown in Figure 3.

Figure 1: Lateral view of the front leg in horses and the region where the lacertus fibros is located (red circle) (Anonymous 1)

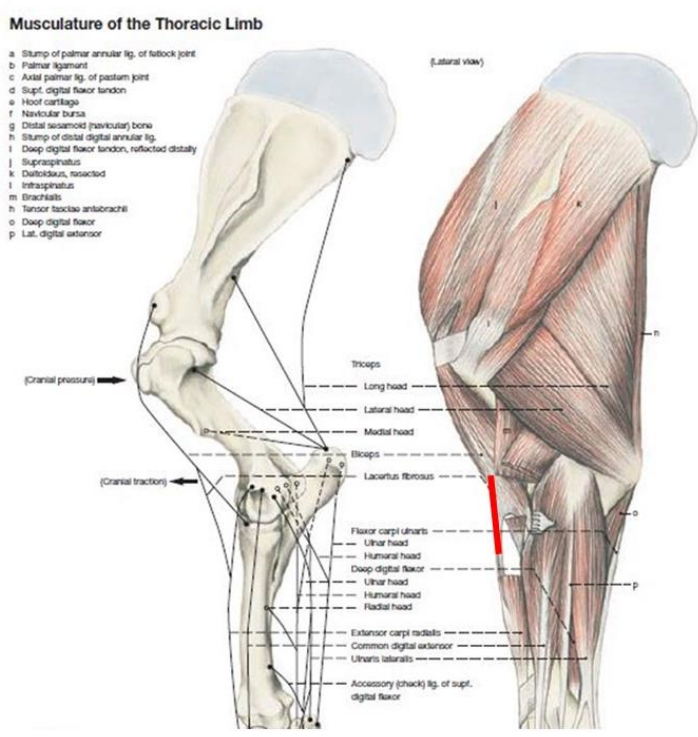


Figure 2: Lateral view of the front leg in horses and the region where the lacertus fibros is located (red line) (Budras et al., 2009)

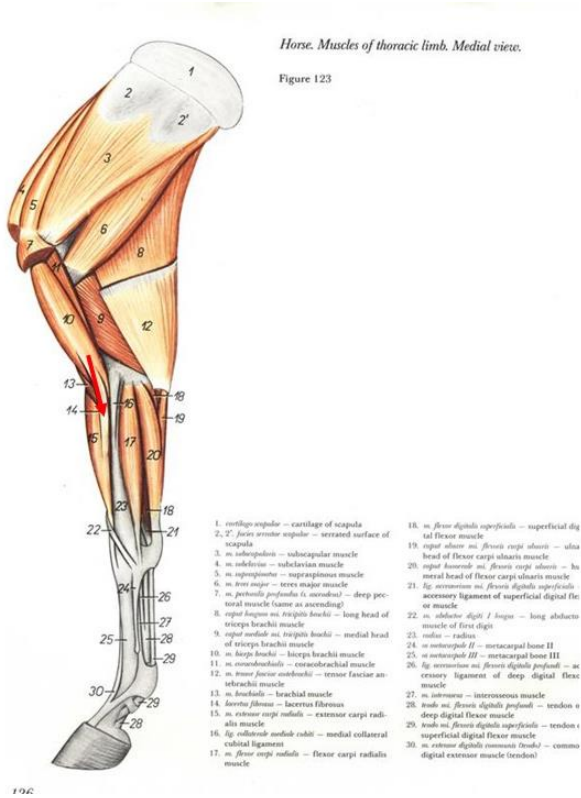


Figure 3: Medial view of the front leg in horses and the region where the lacertus fibros is located (red arrow) (Budras et al. 2009)

Extending from the distal tendon of the biceps brachii muscle, it first forms the roof of the elbow fossa and then the deep fascia of the forearm. This structure particularly protects the brachial artery and median nerve in humans. It separates superficial and deep anatomical structures. This anatomical structure has functions such as strengthening the elbow pit, protecting important vessels and nerves, and supporting muscle-tendon integration by distributing the strength of the biceps muscle to the forearm fascia. The width and angle of this structure have been measured in humans. The average width in both arms was found to be ~15–17 mm, and the angle between it and the tendon was ~21°. It is suggested that in some individuals, this structure may be absent or replaced by a fibromuscular structure due to various anatomical variations (Caetano et al., 2017:80). In horses, the mass of the lacertus fibrosus has been measured at ~4.6–12.4 grams, and its length at ~10–16 cm (Watson and Wilson, 2007:35). In the single-humped camel, the mass is reported to be 75 g and the length 35 cm (Allouch, 2017:60).

While it is not clearly defined in the Sumatran rhinoceros (Susantı, 2012:23), a single-toed mammal, the presence of lacertus fibrosus has been reported in Amiata donkeys (Nocera et al., 2020: 103242) and Thoroughbred horses (Bardin, 2020:34, Bardin et al., 2021: 103666). In Amiata donkeys (Nocera et al., 2020: 103242), this structure is reported to be located in the cranial part of the front leg, while in Miniature donkeys, it is stated to be located in the caudal part of the carpus (Nazem and Sajjadian, 2017:115). In a comparative anatomical study, lacertus fibrosus-like structures were observed in sheep, goats, and fallow deer. In these species, lacertus fibrosus originates from the biceps brachii muscle and fuses with the antebrachial fascia or the tendon of the musculus extensor carpi radialis. An examination of sheep, goats, and fallow deer revealed a fibrous structure resembling lacertus fibrosus in the deep layers of the brachial and antebrachial fascia. This structure was described as bipartite (two-part) in sheep and goats, while it was described as undivided (single-part) in fallow deer. Additionally, this structure is located within the antebrachial fascia, blending with the extensor carpi radialis muscle. In these animals, homologous (equivalent) muscle-tendon connections have also been found between the biceps brachii muscle and the pronator teres muscle (Künzel and Forstenpointner, 1994:550). This structure has also been reported in Baladi goats (Gewaily et al., 2017:115). However, data on the detailed structure and functional role of lacertus fibrosus in large animals appears to be quite limited. A thesis study reported its presence in calves (Mirza, 2018:33). Literature reviews revealed that this structure exists in small ruminants (lambs, goats, etc.), but its dimensions are too small to be compared to those in horses and have not yet been definitively published in studies.

Direct and clear anatomical evidence regarding the lacertus fibrosus structure in dogs and cats is limited in online sources. Therefore, it is not possible to reach a definitive conclusion about its presence or development in these species. However, it is likely that structures containing homologous or similar ligaments exist. Lacertus fibrosus does not appear to have been specifically studied in dogs. There are studies on pathological conditions related to the bicipital tendon/tendon sheath (tenosynovitis, tendinitis, tendon sheath lesions) (Gilley et al., 2002:405, Bruce et al., 2000:50). More scientific studies are needed to determine whether lacertus fibrosus is present in carnivores.

Studies on the muscle anatomy of wild boar and domestic pig generally focus on shoulder muscles and soft tissue structures, without placing particular emphasis on lacertus fibrosus (Rodrigues et al., 2021:243). This suggests that either the lacertus fibrosus is not significantly developed in pigs, or even if it exists, it has not been the subject of detailed examination in the anatomical literature.

Lacertus fibrosus is well developed in primate species such as humans. A study conducted on humans reported that lacertus fibrosus does not exhibit gender-related variability (Snoeck et al., 2014:1320). In single-toed ungulates such as horses, a highly developed lacertus fibrosus structure has been identified as an important component of the "stay apparatus" standing system. Fascial ligaments are important structural elements connecting the musculus biceps brachii muscle to the extensor muscles. The integration of the lacertus fibrosus within the forearm fascial structures (superficial and deep fascia) of horses is thought to contribute to load bearing and joint stabilization (Lusi and Davies, 2018:44). The histological structure of Lacertus fibrosus has been shown to contain not only tendon connections but also sensory receptors in horses and donkeys; it has been emphasized that this may be important in terms of proprioceptive function (Palmieri et al., 1986:80). This structure has been reported in African elephants (Nagel et al., 2018:200).

In laboratory animals, rat, lacertus fibrosus has been mentioned (Bertelli et al., 1992:272). In Laonastes (rock rat), Ctenodactylus, and Chinchilla, a lacertus fibrosus has been reported to be present on the dorsal surface of the distal third of the musculus biceps brachii muscle, passing into the external fascia of the musculus pronator teres (Gambaryan et al., 2013:235). In a study examining the anatomical sections of the rabbit forearm joint and surrounding area using imaging and plastination, no mention is made of a specific aponeurotic band such as the lacertus fibrosus (Akgün et al., 2023:765). Another study examined the neural innervation of the musculus biceps brachii and musculus triceps brachii muscles in rabbits in detail. However, this study also does not provide an anatomical description of the presence of lacertus fibrosus (Kollitz et al., 2020:185).

No direct, definitive scientific evidence has been found for the presence of "lacertus fibrosus" in birds (Aves) or bicipital aponeurosis in human mammals. However, some anatomical studies indicate the presence

of aponeurotic and tendon-like connective structures. These structures may be homologous or similar anatomical structures with similar functions. Lacertus fibrosus may not be a complete homologue, but it appears that tendon-aponeurosis-fascia connections with similar functions are present (Razmadze et al., 2018:514, Yang et al., 2015:6).

In birds, whether the distal biceps tendon joins with the medial or forearm fascia, and whether a broad fibrous band emerges from this junction, has not been studied according to species. The biceps insertion region and tendon-fascia transition regions have not been studied in detail in histological sections, or there is a lack of information on this subject in the literature. If such a structure exists, questions such as what are its effects on flight or wing maneuvers in birds, and does it contribute to load bearing and tendon strength, remain open-ended and unclear.

No information was found regarding the presence of a structure similar to lacertus fibrosus in non-mammalian vertebrates such as birds, reptiles, amphibians, and fish. Although some aponeurotic-like structures have been identified in tetrapods belonging to reptiles and amphibians, this specific structure (bicipital aponeurosis) is generally considered to be unique to mammals (Abdala and Diogo, 2010:545).

SHORTCOMİNGS/AREAS for IMPROVEMENT

The reviews revealed that the microanatomy, collagen connective tissue properties, and histological structure of lacertus fibrosus in animals have been studied very little. Compared to human studies, it was found that detailed data on animal anatomy in this regard is very limited.

Functional experimental studies on animal models related to Lacertus fibrosus (e.g., how joint stability, muscle strength, and tendon load change when Lacertus fibrosus is removed or cut) were also found to be limited.

The developmental/structural differences between species (e.g., horse vs. sheep vs. cow vs. dog) have not yet been systematically compared.

In the context of clinical veterinary medicine, specific pathologies such as lacertus fibrosus injuries and nerve compressions have hardly been described. The microscopic structure of lacertus fibrosus (collagen types, connective tissue cell profile, vascular structure) in large animals (cows, cattle) or small animals has not been sufficiently documented.

In pathology studies, cases of lacertus fibrosus causing lesions, constriction, or clinical symptoms have been very limited or have not been identified.

Identification of lacertus fibrosus-like structures through imaging (ultrasound, MRI); it is thought that establishing normal variations in dogs, cattle, wild animals, birds, etc. could be beneficial.

As a result, while a developed lacertus fibrosus was found in ungulates and primates, it was also observed in rats and elephants. It was understood that ruminant species (such as sheep, goats, and deer) have lacertus fibrosus-like anatomical structures and that these structures differ between species. In carnivores, pigs, and rabbits, no clear information about this structure was found; it was either underdeveloped or not analyzed in detail in the literature.

REFERENCE

Abdala, V., Diogo, R. (2010). Comparative anatomy, homologies and evolution of the pectoral and forelimb musculature of tetrapods with special attention to extant limbed amphibians and reptiles. Journal of Anatomy, 217, pp536–573.

Agrawal, A. (2019). Musculoskeletal etymology: What's in a name? Journal of Clinical Orthopaedics and Trauma, 10, 387–394.

Akgün, R.O., Orhan, I.O., Ekim, O., Bumin, A. (2023). Magnetic resonance imaging, computed tomography, and gross anatomy of forelimb joints in New Zealand rabbit (Oryctolagus cuniculus L.). Anatomia Histologia Embryologia, 52(5), 762-769. doi: 10.1111/ahe.12934. Epub 2023 May 30. PMID: 37254602.

Allouch, G.M. (2017). Geometrical architectural structure, morphometrical and physical characteristics of the biceps brachial muscle in the one-humped camel (Camelus dromedarius). International Journal of Veterinary Science, 6(1), 57-63.

Anonymous 1. (2025). https://www.3dscanstore.com/ecorche-3d-models/horse-ecorche-3d-model. Access date: 10.10.2025

Bardin, A. (2020). Predicting Horse Limb Responses to Surface Variations with a 3D Musculoskeletal Model. At Massey University, Manawatu, New Zealand.

Bardin, A.L., Tang, L., Panizzi, L., Rogers, C.W., Colborne, G.R. (2021). Development of an anybody musculoskeletal model of the thoroughbred forelimb. Journal of Equine Veterinary Science, 103, 103666.

Bertelli, J.A., Mira, J.C., Pecot-Dechavassine, M. (1992). Morphologic aspects of biceps brachii in the rat: application to brachial plexus reconstruction. Surgical Radio1ogical Anatomy, 14, 271-273.

Bruce, W.J., Burbidge, H.M., Bray, J.P. Broome, C.J. (2000). Bicipital tendinitis and tenosynovitis in the dog: a study of 15 cases. New Zealand Veterinary Journal, 48(2), 44-52.

Budras, K.D., Sack, W.O., Röck, S. (2009). Anatomy of the Horse. Fifth, revised Edition.

Caetano, E.B., Vieira, L.A., Almeida, T.A., Gonzales, L.A.M., Bona, J.E., Simonatto, T.M. (2018). Bicipital aponeurosis. Anatomical study and clinical implications. Revista Brasileira de Ortopedia, 5 3(1), 75–81

Cuyer, É. (2024). The Artistic Anatomy of Animals Book. E-kitap yayıncılık.

Demiraslan, Y., Özcan, S. (2014). The balance mechanism of the fore---and hindlimbs in horses. Atatürk Üniversitesi Veteriner Bilimleri Dergisi, 9(1), 55-62.

Gambaryan, P.P., Zherebtsova, O.V., Perepelova, A.A. (2013). Comparative analysis of forelimb musculature inlaonastes aenigmamus (Rodentia: Diatomyidae). Proceedings of the Zoological Institute RAS, 317 (3), pp. 226–245.

Gewaily, M.S., Fayed, M.H., Farrag, F.A. (2017). Architectural and functional specifications of the intrinsic muscles of the forelimb of the Egyptian baladi goats (Capra hircus). Alexandria Journal of Veterinary Sciences, 55 (1), 110-124.

Gilley, R.S., Wallace, L.J., Hayden, D.W. (2002). Clinical and pathologic analyses of bicipital tenosynovitis in dogs. American Journal of Veterinary Research, 63(3), 402-7. doi: 10.2460/ajvr.2002.63.402. PMID: 11911575.

Harrison, S.M., Whitton, R.C., King, M., Haussler, K.K., Kawcak, C.E., Stover, S.M., Pandy, M.G. (2012). Forelimb muscle activity during equine locomotion. The Journal of Experimental Biology, 215 (17), 2980–2991.

Kollitz, K.M., Giusti, G., Friedrich, P.F., Bishop, A.T., Shin, A.Y. (2020). The rabbit brachial plexus as a model for nerve injury and repair Part 1: Anatomic study of the biceps and triceps innervation. Microsurgery, 40(2), 183-188. doi: 10.1002/micr.30482. Epub 2019 Jun 27. PMID: 31246325.

König, H.E., Liebich, H.G., (2022). Veteriner Anatomi (Evcil Memeli Hayvanlar). Medipress matbaacılık Ltd. Şti, 7. Baskı (gözden geçirilmiş ve genişletilmiş), 200-225.

Künzel, W., Forstenpointner, G. (1994). Comparative studies on looking into lacertus fibrosis and aponeurosis of the bicipitis brachii muscle as well as assessment of the biceps brachii and bracialis muscles in sheep, goats and wild deer. Annals Anatomy, 176 (6), 549-54.

Lusi, C.M., Davies, H.M. S. (2018). Fascia of the Equine Antebrachium. 1st Edition, CRC Press, 44.

McDiarmi, A. M. (1999). The equine bicipital apparatus - review of anatomy, function, diagnostic investigative techniques and clinical conditions. Equine Veterinary Education, 11 (2), 63-68.

Mirza, U. (2018). Peripheral Nerve Stimulator and Ultrasound Guided Mid-humeral Radial, Ulnar, Median and Musculocutaneous (RUMM) Nerve Block in Calves. Faculty of Veterinary Sciences Sher-e-Kashmir, Phd Thesis.

Nagel, R.M., Forstenpointner, G., Soley, J.T., Weissengruber, G.E. (2018). Muscles and fascial elements of the antebrachium and manus of the African elephant (Loxodonta africana, Blumenbach 1797): starring comparative and functional

considerations. Anatomia Histologia Embryologia, 47, 195–205. https://doi.org/10.1111/ahe.12340

Nazem, M.N., Sajjadian, S.M. (2017). Anatomical transverse magnetic resonance imaging study of ligaments in palmar surface of metacarpus in Miniature donkey: identification of a new ligament. Folia Morphologica, 76(1), pp. 110–116. DOI: 10.5603/FM.a2016.0032

Nevens, A.L., Stover, S.M., Hawkins, D.A. (2005). Evaluation of the passive function of the biceps brachii muscle-tendon unit in limitation of shoulder and elbow joint ranges of motion in horses. American Journal of Veterinary Research, 66 (3).

Nocera, I., Aliboni, B., Sgorbini, M., Calvo, L.A.G., Conte, G., David, L.B., Citi, S. (2020). Ultrasonographic appearance of elbow joints in a population of Amiata donkeys. Journal of Equine Veterinary Science, 94, 103242.

Palmieri, G., Panu, R., Asole, A., Farina, V., Sanna, L., Gabbi, C. (1986). Macroscopic organization and sensitive innervation of the tendinous intersection and the lacertus fibrosus of the biceps brachii muscle in the ass and horse. Anatomia Histologia Embryologia, 69, 73-82. PMID: 3153560.

Razmadze, D., Panyutina, A.A., Zelenkov, N.V. (2018). Anatomy of the forelimb musculature and ligaments of Psittacus erithacus (Aves: Psittaciformes). Journal of Anatomy, 233(4), 496-530. doi: 10.1111/joa.12861. Epub 2018 Jul 22. PMID: 30033585; PMCID: PMC6131962.

Rodrigues, G.F., Coelho, V.M., Ribeiro, L.A., Santos, L.A., Menezes, L.T., Barros, R.A.C., Silva, Z., Silva, D.C.O. (2021). Anatomy of the thoracic limb muscles of wild boars (Sus scrofa, Artiodactyla: Suidae). Anatomical Science International 96, 239–249 https://doi.org/10.1007/s12565-020-00580-w

Šimon, F., Zborovjan, M., Marečková-Štolcová, E. (2016). Lacertus in der Geschichte der anatomischen Nomenklatur. Graeco-Latina Brunensia, 21 (2), pp. 317-327.

Snoeck, O., Lefèvre, P., Sprio, E., Beslay, R., Feipel, V., Rooze, M., Jan, S.V.S. (2014). The lacertus fibrosus of the biceps brachii muscle: an anatomical study. Surgical Radiological Anatomy, 39, 1317–1322. DOI 10.1007/s00276-013-1254-6

Susantı, H. (2012). Anatomi otot daerah bahu dan lengan atas badak sumatera (Dicerorhinus sumatrensis). Fakultas Kedokteran Hewan Instıtut Pertanian Bogor, Bogor.

Watson, J.C., Wilson, A.M. (2007). Muscle architecture of biceps brachii, triceps brachii and supraspinatus in the horse. Journal Anatomy, 210(1), 32-40. doi: 10.1111/j.1469-7580.2006.00669.x. PMID: 17229281; PMCID: PMC2100266.

Yang, Y., Wang, H. & Zhang, Z. (2015). Muscle architecture of the forelimb of the Golden Pheasant (Chrysolophus pictus) (Aves: Phasianidae) and its implications for functional capacity in flight. Avian Research, 6, 3. https://doi.org/10.1186/s40657-015-0013-2

Transcultural Nursing Approach Based on Henderson's Model: Case Study of a Foreign Hemodialysis Patient

İlknur PALAZ[1]

1- Öğr. Gör.; Gümüşhane Üniversitesi Şiran Dursun Keleş Sağlık Hizmetleri MYO Diyaliz Pr. ilknurpalaz@gumushane.edu.tr ORCID No: 0000-0002-5381-8135

ABSTRACT

This chapter per the authors examines the nursing care of a foreign patient receiving hemodialysis in Turkey through the framework of Virginia Henderson's Need Theory. The aim is to demonstrate how Henderson's 14 fundamental needs can be applied to address both clinical and transcultural dimensions of care. A 49-year-old Syrian male with end-stage renal disease was assessed, focusing on physiological needs such as fluid balance, nutrition, and elimination, as well as psychosocial and cultural aspects including communication barriers, religious practices, and social adaptation. Nursing interventions were structured to improve treatment adherence, ensure patient safety, enhance communication, and support psychosocial well-being. Observed outcomes included better adherence to dietary and fluid restrictions, improved sleep patterns, reduced anxiety, and greater satisfaction with care. This chapter highlights the significance of culturally competent and holistic nursing practices, underscoring the need for interdisciplinary approaches in providing quality care to migrant patients.

Keywords – Transcultural nursing; Henderson's Need Theory; Hemodialysis; Migrant health; Nursing care

INTRODUCTION

In order to protect and improve public health, individuals' health conditions must be kept under control (Taş, 2021). Today, increasing migration, wars, and forced displacement complicate access to healthcare on a global scale, and this situation brings multifaceted needs, especially for migrant individuals with chronic diseases. The integration of individuals with different cultural, social, and linguistic backgrounds into the healthcare system requires a care approach that is tailored not only physically but also psychosocially and culturally (WHO, 2018). Particularly in cases requiring long-term treatment, such as chronic kidney failure, these individuals must cope not only with their illness but also with language barriers, unfamiliarity with the healthcare system, social exclusion, and economic hardship (Fernandes et al., 2019).

Globalization and increasing migration have profoundly reshaped healthcare delivery across the world. Millions of individuals are displaced due to war, political instability, or economic hardship, leading to a growing number of migrants and refugees in host countries. These groups often face significant barriers in accessing healthcare services, including language

differences, cultural unfamiliarity, and limited socioeconomic resources (WHO, 2022). Consequently, healthcare systems are challenged to provide care that is not only clinically appropriate but also culturally sensitive, equitable, and responsive to diverse patient populations (Purnell, 2018).

Nursing, as a discipline centered on holistic and patient-centered care, plays a crucial role in addressing these challenges. Culturally competent nursing requires professionals to develop awareness, knowledge, and skills that allow them to deliver safe and respectful care to patients from different cultural backgrounds (Jeffreys, 2016). Studies have demonstrated that when cultural competence is integrated into nursing practice, patient satisfaction increases, adherence to treatment improves, and health disparities are reduced (Douglas et al., 2019). This makes transcultural nursing not only a professional necessity but also an ethical responsibility in today's healthcare environment.

Theoretical models in nursing offer structured frameworks for guiding care in complex and culturally diverse settings. Among these, Virginia Henderson's "Need Theory" is particularly relevant because it focuses on the patient's independence in fulfilling 14 fundamental human needs (Henderson, 1991). The model addresses physical, psychological, social, and spiritual dimensions of health, making it adaptable to various clinical contexts, including the care of migrant patients. By systematically assessing each need, nurses can identify gaps in care related to cultural and linguistic barriers and design individualized interventions (González & Polanco, 2020). In recent years, several case studies have highlighted the effectiveness of Henderson's model in chronic disease management, palliative care, and rehabilitation, demonstrating its flexibility and applicability to transcultural nursing practice (Acun et al., 2022; Bozkurt et al., 2021). Its structured approach allows healthcare providers to integrate both clinical requirements, such as fluid balance and nutritional management in hemodialysis, and culturally specific needs, such as religious practices and family involvement. This dual focus positions Henderson's model as a valuable framework for improving outcomes among migrant and refugee patients who navigate both health challenges and sociocultural adaptation processes (Erol et al., 2016).

One such model, Virginia Henderson's Basic Human Needs Model, defines 14 basic needs that individuals must fulfill in order to maintain or

regain their health. In the model, the nurse is positioned as a helper who steps in when the individual cannot meet these needs, guiding them until they regain their independence (Nicely & Delario, 2011). Henderson's approach provides a highly suitable framework for cross-cultural care, as it considers not only the individual's physiological needs but also their psychological, sociocultural, spiritual, and developmental aspects. Indeed, various applied studies have shown that the Henderson Model can be used effectively, particularly with elderly individuals, palliative care patients, individuals undergoing organ transplantation, and individuals living with chronic diseases such as COPD (Pinheiro et al., 2016; Nicely & Delario, 2011). In this context, the model's applicability in different contexts and its contribution to nursing care are supported by evidence.

Individuals undergoing hemodialysis treatment are a patient group who are forced to spend a large part of their lives in a hospital environment, are dependent on medical devices, and whose quality of life is threatened. For foreign nationals, this process can be made even more difficult by feelings of loneliness, social isolation, incompatibility, fear, and anxiety. Therefore, nursing care provided to this patient group must be sensitive not only to the individual's physical needs but also to their linguistic, cultural, and emotional characteristics (Ciance, 2019).

This study aims to examine the nursing care process of a foreign national living in Turkey and undergoing hemodialysis treatment, based on Virginia Henderson's model. Structured using the case presentation method, this study analyzes nursing care based on the 14 basic needs presented in the model. Individualized care practices have been developed by considering multi-layered factors such as cultural sensitivity, language barriers, communication difficulties, and social context. In this respect, the study aims to contribute to cross-cultural nursing practices and to demonstrate the applicability of the model-based care approach in the field of migrant health.

Case Description

This case presentation involves a 49-year-old male patient (A.M.) of Syrian nationality. The patient has been diagnosed with end-stage renal disease (ESRD) and has been undergoing hemodialysis treatment for approximately two years. The patient's treatment program consists of four-hour dialysis sessions three days a week. In addition to dialysis treatment,

the patient also has hypertension and anemia, which directly affect both his clinical course and quality of life.

The patient was forced to flee his country due to the war in Syria and came to Turkey with his family. He lives in Turkey under temporary protection status. From a socioeconomic perspective, the patient does not have a regular job, which leads to both economic problems and psychosocial stress. The difficulties of adaptation, uncertainties, and lack of social security that come with being a migrant increase the patient's stress levels.

The language barrier stands out as one of the most significant problems in the care process. The patient only speaks Arabic and therefore cannot communicate directly with healthcare professionals. Communication is usually provided through an interpreter or family members, which leads to time loss, misunderstandings, and difficulties in adhering to treatment in both information sharing and care practices. It has been observed that the patient has not received adequate education, particularly regarding fluid restriction, dietary adjustments, medication use, and infection prevention practices, making it difficult for them to comply with treatment.

The patient's cultural characteristics constitute an important dimension that must be considered in the care process. Patients who are bound by religious beliefs and values want to perform their worship, especially during the hemodialysis process, and expect support in this regard. Their unfamiliarity with the healthcare system causes them to experience insecurity, shyness, and anxiety during the treatment process.

From a psychosocial perspective, the traumatic experiences brought about by forced migration, unemployment, social isolation, and cultural alienation negatively affect the patient's mental state. Although family support is partially available, the patient feels lonely, excluded, and alienated due to the lack of a social environment and difficulties in social integration . This situation stands out as a factor that negatively affects treatment compliance and life satisfaction.

In general, when evaluating A.M.'s nursing care, not only their physiological needs but also their cultural, linguistic, psychosocial, and spiritual needs must be taken into account. Therefore, Virginia Henderson's "14 Basic Needs Model" provides an appropriate framework for planning and implementing nursing care for this case.

Virginia Henderson Model

Virginia Henderson is one of the most well-known names among nursing theorists, and her "Needs Model" has become one of the most frequently used approaches in nursing practice. According to Henderson, nursing aims to help individuals gain, maintain, or regain their independence in health or illness (Henderson, 1991). This model defines 14 basic needs necessary for individuals to sustain their lives and structures nursing care around meeting these needs.

The model emphasizes that nurses should pay attention not only to physical needs but also to psychological, sociocultural, and spiritual dimensions (Bozkurt, Yıldırım & Şenuzun Aykar, 2021). This approach enables nurses to provide holistic and individualized care, especially for patients from different cultural backgrounds (Erol, Tanrıkulu & Dikmen, 2016).

It is stated that the use of Henderson's model in clinical practice transforms nursing care from a mechanical process into a more meaningful, planned, and patient-centered process (Acun, Doğan Tekeli & Çalışkan, 2022). Therefore, the model serves as an important guide in cross-cultural nursing practices, particularly for immigrants, refugees, and individuals experiencing language/cultural barriers.

Table 1: Nursing assessment and interventions based on Henderson's 14 fundamental needs.

Basic Need	Assessment	Nursing Interventions
1. Respiratory	The patient's respiration is within normal limits, and there is no additional lung disease. However, due to anemia, the patient occasionally experiences dyspnea.	Assess respiratory parameters before and after hemodialysis, monitor anemia treatment, provide appropriate positioning when dyspnea develops, and provide oxygen support if necessary.
2. Nutrition and fluid intake	Albumin levels are low, and he has difficulty adhering to fluid restrictions. He cannot fully understand dietary recommendations due to a language barrier.	Provide nutrition education with a dietitian and interpreter, prepare Arabic informational materials, and provide visual and written tools to support fluid intake restriction.
3. Urination	Minimal urine output due to chronic renal failure. Body fluid balance is maintained entirely through dialysis.	Recording daily fluid intake and urine output, regularly monitoring dry weight, and educating the patient and family about the importance of fluid restriction.
4. Mobility	Experiences fatigue and weakness after dialysis. Physical	Provide information on light exercise, provide physical therapy

	activity is limited.	support when necessary, and teach energy conservation methods to reduce fatigue.
5. Posture and Position	Discomfort due to remaining in the same position for long periods during dialysis.	Ensuring position changes during the session, using protective pillows and cushions to prevent pressure sores.
6. Sleep and rest	Nighttime sleep is interrupted, and there is a tendency to sleep during the day. Stress and anxiety disrupt sleep patterns.	Provide information on sleep hygiene, teach relaxation techniques, and refer to psychological counseling if necessary.
7. Dressing	Independent in dressing, but clothing may sometimes be inappropriate due to hygiene issues.	Assessing clothing hygiene before dialysis, encouraging personal care.
8. Body temperature	Normothermic, no fever fluctuations observed during hemodialysis.	Monitoring of temperature before and after each session, monitoring for signs of infection.
9. Personal hygiene and bodily integrity	Dry mouth and poor oral hygiene are present. Complaints of mucosal dryness.	Provide an oral care kit, provide Arabic educational materials on dental and oral hygiene, and teach practices to reduce dry mouth.
10. Safety	Due to language barriers, the individual cannot express themselves in emergencies, increasing the risk to safety.	Prepare visual warning cards, provide interpreter support in critical situations, and implement safety protocols with cultural sensitivity.
11. Communication	Unable to communicate directly with the healthcare team due to lack of Turkish language skills.	Use Arabic-Turkish health communication cards, provide regular interpreter support, and disseminate visual materials.
12. Beliefs and values	Wants to fulfill religious obligations, attaches importance to prayer times.	Consideration of prayer times in hemodialysis scheduling, provision of a suitable environment for rituals such as ablution.
13. Work and Productivity	Unable to work due to immigration status, unemployment creates psychological pressure.	Referral to the social services unit, provision of psychosocial support, and encouragement to participate in appropriate social integration projects.
14. Self-actualization	Experiencing a loss of identity due to forced migration, unemployment, and alienation, feeling worthless.	Encouraging participation in cultural integration and social support programs, directing them to activities related to their individual interests, and providing counseling services that boost self-esteem.

Findings

Henderson's Needs Model is a theoretical approach that guides nursing care by focusing on increasing the individual's independence. When

the A.M. case is evaluated within the framework of this model, it is seen that not only the biological but also the cultural, psychosocial, and spiritual needs of the patient are integral parts of the care process. When nursing practices are conducted based on 14 basic need areas, meaningful changes occur in both clinical parameters and the patient's overall quality of life.

Changes Observed in Physiological Needs

Firstly, nutrition and fluid balance emerged as the patient's most critical problem area. Low albumin levels, difficulties in complying with fluid restrictions, and the inability to fully understand dietary recommendations due to language barriers were factors that negatively affected the patient's care process. However, education provided by nurses through interpreters, the adaptation of visual and written materials into Arabic, the explanation of fluid restriction in relation to daily life, and the active participation of family members in the process increased the patient's awareness of this issue. As a result of these initiatives, a decrease in weight gain between sessions, improvement in biochemical parameters, and a marked improvement in overall treatment compliance were observed.

In the excretion area, the patient's urine output is minimal, so fluid balance is entirely dependent on dialysis. This situation increases the importance of dry weight monitoring. Regular monitoring in nursing care and repeated information about the importance of fluid restriction for the patient has raised the patient's level of awareness and ensured that they come to sessions better prepared.

Although respiratory parameters were within normal limits, there were occasional complaints of dyspnea due to anemia. Monitoring respiration before and after dialysis, providing appropriate positioning, and providing oxygen support when needed controlled these problems and reduced the patient's anxiety related to shortness of breath.

In terms of movement and activity, the patient experienced fatigue and exhaustion after dialysis and initially appeared more dependent in daily life. However, teaching simple exercises, encouraging energy conservation methods, and providing physical therapy support led to an increase in the patient's physical endurance. This change contributed to the patient being able to live more independently.

Changes Observed in Psychosocial and Cultural Needs

Henderson's model offers a holistic approach not only in biological terms but also in areas such as communication, security, beliefs-values, and self-actualization. In the digital era, nursing care must encompass not only technological competence but also ergonomic awareness, ensuring that healthcare innovations contribute to both efficiency and human well-being (Taş & Taş, 2023).

In the area of communication, the patient's most prominent problem was not knowing Turkish. Initially, this situation limited nurse-patient interaction, weakened treatment compliance, and increased safety risks. The use of Arabic-Turkish communication cards by nurses, providing critical information with the assistance of an interpreter, and offering written summaries enabled the patient's active participation in the treatment process. This change contributed to the patient feeling more empowered in the care process, understanding their responsibilities, and adhering to treatment.

In terms of safety, the patient often felt at risk due to communication problems. In particular, being unable to express himself in situations requiring urgent intervention caused anxiety. However, the introduction of visual signs, pictograms, and interpreter support strengthened the perception of safety, allowing the patient to express himself more comfortably in emergencies.

The need for faith and values holds an important place for A.M. The desire to continue worship is part of both his identity and life satisfaction. The nurses' efforts to align the dialysis schedule with worship times, provide a suitable environment for rituals such as ablution, and respect his privacy have increased the patient's confidence in the care process. This initiative has strengthened the patient's motivation for treatment and made the care experience more positive.

In terms of psychosocial needs, forced migration, unemployment, and cultural alienation have created high levels of stress in patients. Initially, symptoms of loneliness, sleep disturbance, and alienation were observed. However, as a result of increasing psychosocial support in nursing care, referral to social services, and strengthening family support, a decrease in the patient's anxiety level, improvement in sleep patterns, and an increase in the sense of belonging were observed.

Individual Development and Self-Actualization

The work-productivity and self-actualization needs included in Henderson's model were carefully addressed in A.M.'s care. His inability to find work due to migration and the difficulties he experienced in integrating into society initially led to feelings of worthlessness and loss of identity. As a result of the nurses encouraging his participation in social adaptation programs, directing him to individual areas of interest, and supporting his participation in social activities, an increase in the patient's self-confidence was observed, and his feelings of alienation decreased.

Overall Evaluation

In conclusion, the nursing care planned and implemented within the framework of Henderson's 14 Basic Needs Model created positive changes in both the clinical and psychosocial dimensions of A.M.'s care process. While imbalances in physiological parameters, communication deficiencies, safety risks, unmet religious needs, and psychosocial isolation were noticeable at the beginning, significant improvements were achieved in these areas by the end of the process. Improvements in nutrition and fluid control, balance in sleep patterns, strengthening of communication and safety, preservation of beliefs and values, reduction of psychosocial burden, and progress in individual development are the fundamental changes recorded in the care process.

These findings demonstrate that Henderson's model is an effective guide even for patients experiencing migration and cultural differences; it makes nursing care planned, systematic, and holistic, and improves patients' quality of life.

Discussion

The use of theories and models in nursing practice ensures that the care process is carried out in a systematic, holistic, and scientifically based manner. Theoretical frameworks not only guide nurses in clinical practice but also form the basis of individualized care, thereby increasing patient safety, quality of care, and patient satisfaction. From this perspective, Virginia Henderson's Needs Model is one of the most well-known and widely used theoretical approaches in nursing (Henderson, 1991).

Compatibility with holistic and cross-cultural care.

Henderson's model offers a holistic approach to care by encompassing not only the biological but also the psychosocial, cultural, and spiritual

dimensions of human needs (Henderson, 1991). This structure allows for the simultaneous assessment of the physiological burden created by end-stage renal failure, a chronic disease, and the psychosocial burdens brought about by forced migration and cultural adaptation issues, as seen in the case of A.M. The literature also reports that the model can be applied in a "modular" manner to different patient groups (e.g., oncology, geriatric care, palliative processes), and that the 14 requirements can be adapted to each clinical picture, making nursing care planned and traceable (Fernandes et al., 2019; Demir & Akyüz, 2020).

Patient safety and treatment compliance in chronic hemodialysis.

Treatment success in hemodialysis patients is closely related to parameters such as intradialytic weight gain (IDWG), Kt/V values, session continuity, nutritional indicators, and medication adherence. In the case of A.M., a migrant patient, the language barrier negatively affects treatment adherence, particularly in areas requiring constant reminders and reinforcement, such as diet and fluid restrictions. Henderson's "eating–drinking" and "elimination" requirements are guiding principles in this regard. Evidence-based recommendations include educating the patient through an interpreter, preparing Arabic visual materials, applying the "teach-back" technique, and involving family support in the process (Khalaila, 2010; Kaya & Arslan, 2018).

The relationship between communication and safety.

Communication barriers in emergencies or when providing critical treatment information pose a risk to patient safety. Henderson's headings "communication" and "safety" highlight the importance of this dual relationship. In particular, the lack of access to professional interpreters for immigrant patients can lead to both misunderstandings and compromises to patient safety. The literature reports that visual communication cards, bilingual information forms, and symbolic/piktogram-based tools that can be used in emergencies increase patient safety (Suurmond & Seeleman, 2006). It is recommended that such strategies become standard in hemodialysis units.

Beliefs-values and treatment experience.

Another prominent area of need in A.M.'s care process is religious beliefs and values. The desire to perform religious practices is part of the patient's cultural identity and should not be overlooked in the care plan.

Under Henderson's heading of "beliefs and values," this need can be supported through nursing interventions. Scheduling dialysis sessions according to worship times, providing a suitable environment for religious practices such as ablution, and protecting privacy enhance the patient's care experience. Indeed, it has been reported that continuing religious practices in individuals living with chronic diseases increases life satisfaction and treatment compliance (Koenig, 2012).

Psychosocial burden and self-efficacy.

The social isolation, unemployment, and cultural alienation brought about by forced migration cause A.M. to experience problems such as sleep disorders, anxiety, and loss of identity. Henderson's "sleep-rest," "work-productivity," and "self-actualization" needs form the basis of nursing interventions in this area. Initiatives such as referral to psychosocial support programs, sleep hygiene education, relaxation exercises, and participation in social integration projects for migrants can increase both self-efficacy and life satisfaction (İnci & Karadakovan, 2017).

Family involvement and cultural mediation.

Families often play the role of a "cultural mediator" in the adaptation of immigrant patients to the healthcare system. However, communication that relies solely on family members can lead to privacy and ethical issues. Although Henderson's approach views the family as a care partner, patient safety can be more effectively ensured when combined with professional interpreting services. Therefore, both family support and professional mediation should be used in a balanced manner (Leininger & McFarland, 2006). In modern nursing practice, technological competence has become as integral to holistic care as cultural sensitivity. Taş (2022) emphasizes that artificial intelligence applications in healthcare will be among the key components of the future in terms of patient safety and service efficiency. This perspective demonstrates that human-centered approaches, such as the Henderson Model, remain relevant and applicable even in digitally supported care environments.

Interdisciplinary coordination and outcome-focused care.

The Henderson model not only defines nursing care on its own, but also allows for the creation of common goals with disciplines such as dietitians, nephrologists, psychologists, social workers, and physical therapists. The recommended set of outcomes should include not only

biochemical parameters (albumin, hemoglobin, Kt/V, potassium) but also behavioral compliance indicators (compliance with dietary and fluid restrictions, session continuity) and experience-based criteria (patient satisfaction, anxiety level, rate of provision of worship facilities) (Fernandes et al., 2019). This makes care measurable and evaluable.

Since the approach described in this study was developed based on a single case, the generalizability of the findings is limited. However, Henderson's model is a powerful guide in the field of migrant health because it offers a repeatable, systematic framework across different cultural groups. At the institutional level, the development of multilingual educational materials, the integration of cultural mediators into the healthcare team, and the inclusion of cultural competence content in nursing curricula are recommended practices (Papadopoulos, 2006).

CONCLUSION AND RECOMMENDATIONS

In this case presentation, the nursing care of a patient undergoing hemodialysis treatment due to end-stage renal failure, who had experienced migration and faced language and cultural barriers, was addressed within the framework of Henderson's 14 Basic Needs Model. By applying the model, a holistic nursing approach was developed that considered not only the patient's physiological needs but also their psychosocial, cultural, and spiritual dimensions.

One of the most important findings observed during the study was that each requirement area of the model was directly related to the life experience of the immigrant patient. Regular training and interpreter support in the areas of nutrition, excretion, and fluid balance increased compliance with treatment; weight gain between sessions decreased, and biochemical values improved. Sleep hygiene practices and psychosocial support in the sleep and rest domain contributed to the normalization of sleep patterns. Thanks to visual materials, communication cards, and interpreter support used in the communication and safety domain, patients felt more secure and their active participation in treatment increased. Taking into account the need for beliefs and values positively affected the patient's care experience, demonstrating how important cultural sensitivity is in patient compliance. Support provided

in psychosocial areas reduced the patient's anxiety level and strengthened their sense of belonging.

These findings reveal that Henderson's model is an effective and comprehensive guide not only in the management of biological parameters but also in the care of immigrant and culturally diverse patient groups. The application of the model has made nursing care planned, holistic, and systematic, yielding positive results on the patient's quality of life, treatment compliance, and care satisfaction.

Recommendations:

1. Cultural sensitivity training: Adding content on immigrant health and cultural competence to the nursing curriculum will better equip nurses to care for individuals from different cultures.
2. Language and communication support: Increasing professional interpreter support in hospitals and preparing visual and written educational materials in different languages will reduce the risk of communication errors.
3. Consideration of religious and cultural needs: Prayer times, religious rituals, and privacy requirements should be taken into account in nurses' care planning, and healthcare institutions should provide appropriate physical conditions in this regard.
4. Psychosocial support and social integration: Access to social services and social integration programs for immigrant and refugee patients should be facilitated, and these individuals' feelings of loneliness and alienation should be reduced.
5. Interdisciplinary approach: The care of dialysis patients should involve collaboration not only with nurses, but also with different professionals such as dietitians, psychologists, social workers, and chaplains. This approach allows for a more comprehensive response to patients' needs.
6. Research and model development: More clinical research based on Henderson's model should be conducted on immigrant and culturally diverse patient groups, and care practices should be standardized to create national and international guidelines.

In conclusion, Henderson's model is a powerful tool that allows both physiological and cultural dimensions to be addressed together in nursing

care for immigrant patients, as in the case of A.M. The application of the model guides nurses in managing clinical processes while also contributing to the development of a holistic and humane approach to care that preserves patients' cultural identities and individual values.

REFERENCES

Acun, A., Doğan Tekeli, N., & Çalışkan, N. (2022). Nursing care of hospitalized patients in a Palliative Care Center according to the Henderson Nursing Model: A case presentation. Ordu University Journal of Nursing Studies. https://doi.org/10.38108/ouhcd.1015152

Bozkurt, C., Yıldırım, Y., & Şenuzun Aykar, F. (2021). Evaluation of an individual with chronic obstructive pulmonary disease according to the Henderson nursing model. Journal of the Institute of Health Sciences, Cumhuriyet University, 6(1), 1–9. https://doi.org/10.51754/CUSBED.807105

Ciance, K. L. (2019). Providing a peaceful passage through care, comfort, and compassion. Iris Journal of Nursing & Care. https://doi.org/10.33552/IJNC.2019.01.000522

Demir, S., & Akyüz, A. (2020). Henderson Nursing Model-based care practices in cancer patients: Case presentation. Türkiye Klinikleri Hemşirelik Bilimleri Dergisi, 12(3), 321–329.

Douglas, M. K., Rosenkoetter, M., Pacquiao, D. F., Callister, L. C., Hattar-Pollara, M., Lauderdale, J., Milstead, J., Nardi, D., & Purnell, L. (2019). Standards of practice for culturally competent nursing care: 2018 update. *Journal of Transcultural Nursing*, 30(1), 7–28.

Erol, F., Tanrıkulu, F., & Dikmen, Y. (2016). Evaluation of a patient who had a cerebrovascular accident according to the Henderson nursing model: Case presentation. Contemporary Medicine Journal, 6(2), 94–103. https://doi.org/10.16899/CTD.38880

Fernandes, B. K. C., Clares, J. W. B., Borges, C. L., Nóbrega, M. M. L., & Freitas, M. C. (2019). Nursing diagnoses for institutionalized elderly people based on Henderson's theory. Revista da Escola de Enfermagem da USP, 53, e03472. https://doi.org/10.1590/S1980-220X2018004103472

Gentile, D. L., & Marzinski, S. J. (2020). Theory-driven evaluation of a multisite nursing professional practice model. JONA: The Journal of Nursing Administration. https://doi.org/10.1097/NNA.0000000000000910

González, M. A., & Polanco, R. (2020). Nursing theories in multicultural environments: The application of Henderson’s model. *Revista de Enfermería Global*, 19(59).

Henderson, V. (1991). The nature of nursing: Reflections after 25 years. New York: National League for Nursing.

Henderson, V. (1991). *The nature of nursing: Reflections after 25 years*. New York: National League for Nursing Press.

İnci, F., & Karadakovan, A. (2017). Mental health problems in migrants and nursing approaches. Gümüşhane University Journal of Health Sciences, 6(4), 232–239.

Jeffreys, M. R. (2016). *Teaching cultural competence in nursing and health care: Inquiry, action, and innovation* (3rd ed.). Springer Publishing Company.

Kaya, N., & Arslan, H. (2018). Factors affecting dietary compliance in patients with chronic renal failure. Journal of Nursing Research and Development, 20(1), 35–44.

Khalaila, R. (2010). Difficulties in dialysis patients' adherence to fluid restriction: Comparing Arab and Jewish patients in Israel. Journal of Advanced Nursing, 66(12), 2696–2703. https://doi.org/10.1111/j.1365-2648.2010.05422.x

Koenig, H. G. (2012). Religion, spirituality, and health: The research and clinical implications. ISRN Psychiatry, 2012, 278730. https://doi.org/10.5402/2012/278730

Leininger, M., & McFarland, M. (2006). Culture care diversity and universality: A worldwide nursing theory (2nd ed.). Jones & Bartlett Learning.

Nicely, B., & Delario, G. (2011). Virginia Henderson's principles and practice of nursing applied to organ donation after brain death. Progress in Transplantation, 21(1), 72–77. https://doi.org/10.7182/PRTR.21.1.C7617103JUG3466M

Pinheiro, F. M., Espírito Santo, F. H., Chibante, C. L. P., & Pestana, L. (2016). Profile of hospitalized elderly according to Virginia Henderson: contributions to nursing care. Revista de Pesquisa: Cuidado é Fundamental Online, 8(3), 4789–4795. https://doi.org/10.9789/2175-5361.2016.v8i3.4789-4795

Purnell, L. (2018). *The Purnell model for cultural competence*. Springer Publishing Company.

Suurmond, J., & Seeleman, C. (2006). Shared decision-making in an intercultural context: Barriers in the interaction between physicians and immigrant patients. Patient Education and Counseling, 60(2), 253–259. https://doi.org/10.1016/j.pec.2005.01.012

Taş, A. (2021). Üniversite Öğrencilerinin Akılcı İlaç Kullanımının İstatistiksel Değerlendirmesi. Gümüşhane Üniversitesi Sağlık Bilimleri Dergisi, 10(4), 714-723. https://doi.org/10.37989/gumussagbil.847563

Taş, A. (2022). *Sağlık hizmetleri öğrencilerinin sağlıkta yapay zekaya ilişkin görüşleri*. In U. Karadavut (Ed.), *Sağlık Bilimleri Alanında Uluslararası Araştırmalar VII* (pp. 5–16). Eğitim Yayınevi. ISBN: 978-625-8341-33-1

Taş, M. Ü. ve Taş, A. (2023). *Fizyoterapi programı öğrencilerinin teknolojik cihaz kullanımlarının postürleri üzerindeki etkisi*. *Sosyal, Beşerî ve İdari Bilimler Dergisi*, 6(12), 1577–1586. https://doi.org/10.26677/TR1010.2023.1332

World Health Organization. (2018). Health of refugees and migrants: Regional situation analysis, practices, experiences, lessons learned and ways forward. Geneva: WHO. https://apps.who.int/iris/handle/10665/274441

World Health Organization. (2022). *Refugee and migrant health*. WHO. https://www.who.int/health-topics/refugee-and-migrant-health

High-Intensity Interval Training, Brown Adipose Tissue, and Appetite Regulation: Mechanistic Integration, Human Evidence, and Future Directions

Ahmet Alperen SUBAŞI[1]

Sevil ARABACI TAMER[2]

1- PhD Candidate; Sakarya University/ Institue of Health Sciences/ Faculty of Medicine, Department of Physiology
ahmet.subasi2@ogr.sakarya.edu.tr ORCID: 0009-0005-8984-9426

2- Assoc. Prof.; Sakarya University/School of Medicine, Basic Medical Sciences, Department of Physiology
sarabaci@sakarya.edu.tr ORCID: 0000-0003-2336-1450

ABSTRACT

High-intensity interval training (HIIT) elicits pronounced metabolic and endocrine responses that extend well beyond cardiovascular conditioning, positioning it as a multidimensional intervention in energy balance regulation. An expanding body of evidence indicates that HIIT acutely modulates appetite-regulating hormones while simultaneously influencing adipose tissue metabolism and thermogenic capacity. Acute bouts of HIIT transiently suppress subjective hunger, decrease circulating acylated ghrelin, and elevate anorexigenic peptides such as peptide YY (PYY) and glucagon-like peptide-1 (GLP-1), contributing to a short-term anorexigenic milieu. At the molecular level, skeletal muscle acts as an endocrine organ, releasing bioactive myokines and metabolites—including β-aminoisobutyric acid (BAIBA), irisin (the cleaved product of FNDC5), and N-lactoyl-phenylalanine (Lac-Phe)—that communicate metabolic strain to adipose depots. These factors are hypothesized to promote "browning" of white adipose tissue and enhance brown adipose tissue (BAT) thermogenic programming via upregulation of UCP1 and mitochondrial biogenesis pathways. Nevertheless, large-scale human studies employing standardized ^18F-FDG PET/CT imaging criteria (e.g., BARCIST 1.0) have produced inconsistent findings regarding exercise-induced BAT recruitment, likely due to methodological heterogeneity, small sample sizes, and the confounding influence of thermoneutral living conditions. Integrative models propose that repeated HIIT exposures may sensitize adipose tissue to sympathetic stimulation, thereby amplifying thermogenic responsiveness under cold or pharmacologic activation. This chapter synthesizes current mechanistic and translational evidence, emphasizing the interplay between neural-endocrine appetite circuits, myokine signaling, and adipose plasticity, while underscoring the methodological and behavioral considerations necessary to determine whether HIIT can sustainably modulate energy intake and expenditure.

Keywords – HIIT; brown adipose tissue (BAT); appetite; gut hormones; myokines; thermogenesis; batokines

INTRODUCTION

The worldwide prevalence of obesity and metabolic syndrome underscores the need for efficient interventions that alter both energy intake and expenditure (Zhang et al., 2024:1). Conventional recommendations—caloric restriction combined with moderate-intensity continuous training (MICT)—often suffer from poor adherence and modest physiological yield. HIIT, typically consisting of short bouts at ≥ 80–90 % VO_2max interspersed

with recovery, has emerged as a time-efficient modality capable of eliciting comparable or superior cardiometabolic benefits relative to MICT (Gibala & Little, 2020:5). Beyond aerobic adaptation, HIIT provokes robust sympathoadrenal activation, lactate accumulation, and large fluctuations in metabolic hormones, all of which may acutely influence appetite regulation and long-term adipose tissue remodeling (McCarthy et al., 2024:6; Hu et al., 2023:13).

Simultaneously, the rediscovery of metabolically active BAT in adult humans via ^{18}F-FDG PET/CT imaging revolutionized understanding of energy expenditure regulation (Cypess et al., 2009:1516; Virtanen et al., 2009:1523). BAT dissipates chemical energy through UCP1-mediated proton leak, contributing to adaptive thermogenesis. In rodents, chronic exercise induces "browning" of white adipose depots, forming beige adipocytes with thermogenic potential (Cannon & Nedergaard, 2004:279; Boström et al., 2012:463). Whether similar exercise-induced browning occurs in humans remains uncertain: imaging studies yield inconsistent results, partly due to methodological and environmental differences (Chen et al., 2016:210; Martinez-Tellez et al., 2022:6). This chapter therefore explores how HIIT may acutely suppress appetite and potentially recruit thermogenic adipose tissue, reviewing mechanistic pathways, human evidence, and research gaps (Hu et al., 2023:7; McCarthy et al., 2024:6).

1. High-Intensity Interval Training: Definition, Physiologic Signatures, and Metabolic Consequences

HIIT encompasses repeated high-effort intervals separated by brief recovery, eliciting rapid oscillations in cellular energy status. During intense intervals, phosphocreatine depletion and accelerated glycolysis raise AMP/ATP ratios, activating AMP-activated protein kinase (AMPK) and promoting PGC-1α transcription, a master regulator of mitochondrial biogenesis originally identified as the central driver of adaptive thermogenesis (Puigserver et al., 1998:833; Little et al., 2010:1018). These molecular events foster oxidative-enzyme up-regulation, capillarization, and enhanced fatty-acid oxidation (Gibala et al., 2012:1078). At the systemic level, HIIT provokes pronounced catecholamine release, increased cortisol, elevated lactate, and transient changes in plasma glucose and free-fatty-acid concentrations. The oscillatory stress pattern differs qualitatively from the steady metabolic load

of MICT, creating unique signaling cascades that affect multiple organs, including the gut, liver, and adipose tissue (Zhang et al.,2024:6; McCarthy et al.,2024:6).

These acute physiological perturbations also generate a transient anorexigenic milieu. Sympathetic activation suppresses gastric motility and may directly inhibit ghrelin secretion via β-adrenergic mechanisms (King et al., 2013:86). Simultaneously, splanchnic vasoconstriction redistributes blood flow away from the gastrointestinal tract, reducing mechanical stimuli that trigger hunger. Lactate accumulation acts as both a metabolic fuel and a signaling molecule, and its conjugate derivative Lac-Phe has been shown to suppress feeding in animal models and correlate with reduced intake in humans (Li et al., 2022:785). Collectively, these features position HIIT as a potent physiological stimulus capable of influencing both short-term appetite and long-term metabolic remodeling (Hu et al., 2023:8; McCarthy et al., 2024:7).

2. Appetite Regulation and Acute Effects of HIIT in Humans

Appetite arises from the interplay of central and peripheral mechanisms integrating metabolic, hormonal, and hedonic signals. The arcuate nucleus of the hypothalamus contains orexigenic neurons expressing neuropeptide Y (NPY) and agouti-related peptide (AgRP) as well as anorexigenic neurons expressing pro-opiomelanocortin (POMC) and cocaine- and amphetamine-regulated transcript (CART). These neurons receive inputs from circulating peptides such as acylated ghrelin, leptin, peptide YY (PYY), glucagon-like peptide-1 (GLP-1), and cholecystokinin (CCK), thereby linking peripheral nutrient status with central appetite drive (Morton et al., 2014:4).

Acute exercise alters this regulatory axis. Numerous studies report transient post-exercise appetite suppression, characterized by reduced subjective hunger ratings and decreased acylated ghrelin, accompanied by elevations in anorexigenic peptides. In a systematic review and meta-analysis including twelve controlled trials, Hu et al. (2023) found that both HIIT and moderate-intensity continuous training significantly lowered circulating acylated ghrelin while increasing total PYY and GLP-1 relative to resting conditions. The effect size was larger following interval-type protocols, particularly sprint-interval training. The suppression of acylated ghrelin

typically lasted 30–90 minutes, with a parallel blunting of hunger scores (Hu et al., 2023:7).

Experimental data confirm this pattern. In sedentary overweight men, eight weeks of HIIT combined with vitamin D supplementation significantly elevated PYY and reduced fasting insulin and body-fat percentage (Sheikholeslami-Vatani & Rostamzadeh, 2022:4). In a 12-week aerobic training intervention in obese adults, Martins et al. reported that while acute exercise sessions consistently suppressed hunger and reduced ghrelin, baseline fasting concentrations of ghrelin, PYY, and GLP-1 remained unchanged after training, suggesting that chronic hormonal adaptations may be limited or phenotype-dependent (Martins et al., 2017:810). Mechanistically, the transient anorexigenic milieu following HIIT may reflect sympathetic stimulation of β-adrenergic receptors on gastric endocrine cells, delayed gastric emptying, redistribution of splanchnic blood flow, and accumulation of lactate and catecholamines that inhibit ghrelin secretion (King et al., 2013:87; McCarthy et al., 2024:7). Collectively, evidence indicates that HIIT exerts a reproducible, short-term appetite-suppressive effect, although long-term adaptations remain equivocal (Hu et al., 2023:14; Sheikholeslami-Vatani & Rostamzadeh, 2022:4; McCarthy et al., 2024:7).

3. Brown Adipose Tissue: Physiology, Detection, and Metabolic Relevance

Brown adipose tissue (BAT) is a thermogenic organ rich in mitochondria that express uncoupling protein 1 (UCP1), which uncouples oxidative phosphorylation from ATP synthesis to release heat (Cannon & Nedergaard, 2004:279). In adults, BAT depots reside primarily in supraclavicular, cervical, axillary, and paravertebral regions and can be visualized by ^18F-fluorodeoxyglucose positron-emission tomography combined with computed tomography (FDG-PET/CT). The landmark reports established that BAT is metabolically active in humans and contributes to adaptive thermogenesis (Cypess et al., 2009:1516; Virtanen et al., 2009:1523).

BAT activity is highly responsive to sympathetic stimulation through norepinephrine binding to β3-adrenergic receptors, activating cyclic-AMP pathways that enhance lipolysis and UCP1 transcription (Puigserver et al., 1998:833; Cannon & Nedergaard, 2004:295). Beige or “brite” adipocytes, emerging within white adipose tissue (WAT) under cold exposure or certain hormonal cues, share this thermogenic machinery (Wu et al., 2012:366).

Active BAT oxidizes both glucose and fatty acids, enhancing systemic glucose disposal and lipid clearance (Bartelt et al., 2011:200). Quantifying BAT function presents methodological challenges. FDG-PET measures glucose uptake, which may not correspond precisely to heat production because BAT can preferentially oxidize fatty acids. Variations in ambient temperature, fasting state, cold-exposure duration, and thresholding criteria lead to wide discrepancies in estimated BAT volume. The Brown Adipose Reporting Criteria in Imaging Studies (BARCIST 1.0) consensus sought to standardize FDG-PET/CT methodology by specifying pre-imaging cooling protocols, standardized-uptake-value (SUV) thresholds normalized to lean mass, and reporting conventions (Chen et al., 2016:211). These refinements improve cross-study comparability but do not resolve substrate-specific limitations. Complementary techniques, such as radiolabeled fatty-acid tracers, oxygen-consumption PET, and MRI thermometry, can yield more accurate assessments of BAT thermogenesis (Sampath et al., 2016:9). Despite small absolute mass, active BAT significantly influences systemic energy metabolism, rendering it a plausible target for interventions aiming to enhance energy expenditure (Cypess et al., 2009:1516; Virtanen et al., 2009:1523; Chen et al., 2016:215).

4. Myokines and Metabolites Linking Skeletal Muscle to Adipose Tissue

Skeletal muscle functions as an endocrine organ, secreting "myokines" and metabolites that orchestrate inter-organ communication during and after exercise (Pedersen & Febbraio, 2012:457). Among the best characterized are irisin, β-aminoisobutyric acid (BAIBA), and N-lactoyl-phenylalanine (Lac-Phe), each implicated in adipose browning and energy-balance regulation.

Irisin: Boström et al. demonstrated that peroxisome-proliferator-activated-receptor-γ coactivator-1α (PGC-1α) induces expression of FNDC5 in muscle, whose cleaved, secreted product irisin stimulated UCP1 expression and mitochondrial biogenesis in white-adipose cells in mice (Puigserver et al., 1998:833; Boström et al., 2012:463). Human translation remains controversial: circulating irisin concentrations vary across assays, and multiple studies have questioned antibody specificity (Albrecht et al., 2015:6; Perakakis et al., 2017:3). Some investigations report transient post-exercise

increases in irisin, whereas others find none, suggesting methodological artifacts or population heterogeneity.

BAIBA: In contrast, β-aminoisobutyric acid has shown more consistent exercise responsiveness. Roberts et al. identified BAIBA as a PGC-1α-regulated metabolite that increases fatty-acid oxidation and browning gene expression in murine white adipocytes and correlates inversely with cardiometabolic risk factors in humans. BAIBA concentrations rise following both endurance and interval training, making it a plausible mediator of muscle-to-adipose signaling (Roberts et al., 2014:107).

Lac-Phe: Recently, Li et al. (2022:785) reported that exercise elevates N-lactoyl-phenylalanine, formed by conjugation of lactate and phenylalanine. In mice, exogenous Lac-Phe suppressed food intake and body-weight gain without affecting locomotor activity, and plasma Lac-Phe levels correlated with reduced feeding behavior after intense exercise. Parallel human data show that Lac-Phe concentrations rise in proportion to exercise intensity, linking it mechanistically to lactate flux and appetite suppression.

Together, these factors illustrate that HIIT's systemic influence extends beyond muscular metabolism. The surge in metabolites and cytokines during intense intervals constitutes a molecular dialogue with adipose tissue and central appetite circuits, potentially mediating both acute anorexigenic effects and longer-term thermogenic remodeling (Boström et al., 2012:463; Roberts et al., 2014:107; Li et al., 2022:788; Albrecht et al., 2015:6; Perakakis et al., 2017:8).

5. Human Trials of Exercise and Brown Adipose Tissue

Testing whether exercise, particularly HIIT, activates BAT in humans has produced heterogeneous outcomes. The ACTIBATE randomized controlled trial remains the most comprehensive study to date. After 24 weeks of supervised endurance and strength training in young sedentary adults, ^18F-FDG PET/CT imaging showed no significant increase in cold-stimulated BAT volume or glucose uptake compared with controls (Martinez-Tellez et al., 2022:3). Despite large gains in aerobic capacity and improved insulin sensitivity, exercise failed to augment FDG-derived BAT metrics. The authors emphasized that FDG uptake primarily reflects glucose transport and may underestimate BAT oxidative metabolism if the tissue preferentially oxidizes fatty acids following training.

Smaller interventions have yielded mixed findings. Vosselman et al. observed decreased FDG uptake in endurance-trained athletes relative to sedentary controls, possibly reflecting substrate switching rather than reduced thermogenic function (Vosselman et al., 2015:9). Conversely, biopsy-based studies report training-induced upregulation of thermogenic and mitochondrial genes (e.g., UCP1, PGC-1α) in skeletal muscle and subcutaneous adipose tissue, even when FDG-PET measures remain unchanged (Roberts et al., 2014:100; Boström et al., 2012:464; Cannon & Nedergaard, 2004:279). Cross-sectional PET studies also reveal seasonal and thermal variability: BAT activity peaks in winter and declines during thermoneutral adaptation (Cypess et al., 2009:1514; Chen et al., 2016:211).

Collectively, these data suggest that exercise alone rarely elicits measurable increases in BAT glucose uptake unless paired with chronic cold exposure or adrenergic stimulation. Imaging limitations, small sample sizes, and lack of standardized cooling protocols complicate interpretation. The BARCIST 1.0 consensus highlighted the need for harmonized FDG-PET methods—standardized cooling duration, lean-mass normalization, and SUV thresholds—to ensure cross-study comparability (Chen et al., 2016:214). Without such standardization, interstudy variance obscures subtle adaptations. Thus, current evidence neither confirms nor refutes meaningful BAT recruitment by HIIT; rather, it underscores the methodological barriers to detecting such changes (Martinez-Tellez et al., 2022:3; Chen et al., 2016:214; Cypess et al., 2009:1514).

6. Reconciling Acute Appetite Suppression and Thermogenic Adaptation

Integrating findings across domains yields a temporal model linking acute and chronic responses. Immediately after HIIT, catecholamines surge, splanchnic blood flow decreases, and lactate accumulates, together reducing hunger perception and acylated ghrelin secretion while elevating anorexigenic peptides (Hu et al., 2023:7; McCarthy et al., 2024:5). Simultaneously, skeletal muscle releases myokines and metabolites such as BAIBA, irisin, and Lac-Phe that engage adipose tissue and possibly central circuits (Boström et al., 2012:464; Roberts et al., 2014:100; Li et al., 2022:788). Repeated exposures may, over weeks, reprogram adipose gene expression toward a beige phenotype—upregulating UCP1, PGC-1α, and PRDM16—thus expanding thermogenic potential.

However, realization of this potential requires activation by sympathetic input or cold exposure. In humans living under thermoneutral conditions, recruited beige adipocytes may remain metabolically dormant. Moreover, behavioral compensation—post-exercise hyperphagia or reduced non-exercise activity—can offset acute energy deficits (King et al., 2013:87). Therefore, while HIIT clearly produces transient anorexigenic effects and plausible molecular signals for adipose remodeling, the translation into sustained increases in daily energy expenditure is uncertain. Future protocols combining HIIT with mild cold exposure or nutritional thermogenic stimuli (e.g., capsaicin) could help determine whether repeated sympathetic activation synergizes with exercise-derived signals to realize functional browning (Chen et al., 2016:214; McCarthy et al., 2024:7).

Sex as a moderator of thermogenic and appetite responses. Sexual dimorphism appears to modulate both thermogenic adipose responsiveness and appetite-hormone dynamics relevant to HIIT. In human PET/CT studies under standardized cold exposure, cold-induced thermogenesis (CIT) is significantly higher in women than in men, and circulating estradiol correlates positively with CIT independent of age, adiposity, and other sex hormones, suggesting that estrogenic signaling sensitizes thermogenic adipose to sympathetic activation (Herz et al., 2021:6). Mechanistically, sex steroids influence sympathetic tone, β-adrenergic receptor signaling, and transcriptional programs governing mitochondrial biogenesis and UCP1 expression in brown/beige adipocytes, providing a biologically plausible basis for the observed human differences (Kaikaew et al., 2021:6). From a systems perspective, human BAT is a key effector of both cold- and nutrient-evoked thermogenesis, and diet-induced thermogenesis (DIT) engages gut-hormone–sympathetic pathways that may interact with sex hormones—an additional axis through which men and women could diverge in thermogenic recruitment (Saito et al., 2020:4). On the appetite side, controlled crossover data show sex-dependent post-exercise changes in anorexigenic peptides: total PYY rose more immediately in males, whereas GLP-1 elevations were more evident in females following both moderate-intensity continuous and sprint-interval cycling, with concomitant reductions in perceived hunger across sexes (Hazell et al., 2017:7). Collectively, these findings indicate that sex is not merely a covariate but a substantive moderator of HIIT-related thermogenic and appetite outcomes; future HIIT trials should prespecify sex-stratified analyses

and consider menstrual phase or hormonal status in women during both imaging and appetite-hormone assessments (Herz et al., 2021:6; Kaikaew et al., 2021:6; Saito et al., 2020:4; Hazell et al., 2017:6).

7. Clinical and Translational Implications

From a clinical perspective, HIIT offers several pragmatic advantages. Its time efficiency enhances adherence among individuals citing limited time as a barrier, and the reproducible acute suppression of hunger may aid short-term caloric control (Hu et al., 2023:6). Strategically scheduling HIIT sessions before meals could exploit this transient anorexigenic window. Moreover, if future work confirms even modest exercise-induced browning or BAT activation, the combined effect of increased energy expenditure and reduced intake could produce clinically relevant weight loss over time.

Nevertheless, practical constraints remain. HIIT's intensity requires cardiovascular screening and progressive adaptation, particularly in populations with metabolic or orthopedic limitations. Behavioral compensation remains a major obstacle; individuals may subconsciously increase caloric intake or reduce spontaneous activity following training. Integrating HIIT within multifaceted lifestyle programs—combining nutritional counseling, psychological support, and NEAT monitoring—will likely be necessary to translate physiological benefits into durable outcomes (Zhang et al., 2024:5; McCarthy et al., 2024:7). Finally, expectations regarding BAT's quantitative contribution must remain realistic: even fully activated BAT constitutes a small fraction of body mass, and its thermogenic output may increase resting energy expenditure by only tens of kilocalories per day (Cypess et al., 2009:1516). Consequently, HIIT should be regarded as a valuable but complementary tool in the broader armamentarium against obesity.

8. Methodological Recommendations and Future Research Directions

Clarifying whether HIIT meaningfully recruits BAT or induces beigeing requires experimental precision. Future studies should integrate acute and longitudinal arms, pairing metabolic and behavioral endpoints. Acute trials should capture high-temporal-resolution profiles of appetite-related hormones (acylated ghrelin, PYY, GLP-1), metabolites (lactate, Lac-Phe, BAIBA), and sympathetic markers within the first two hours post-

exercise to characterize kinetics (Hu et al., 2023:13; Li et al., 2022:787). Parallel longitudinal arms can examine adipose-tissue gene expression, mitochondrial function, and thermogenic imaging changes after several weeks of HIIT.

Rigorous imaging standardization is essential. Studies must adopt BARCIST 1.0 recommendations for cooling duration, SUV normalization, and data reporting (Chen et al., 2016:211). Because FDG-PET measures glucose uptake rather than heat output, complementary tracers—such as radiolabeled fatty acids—or oxygen-consumption PET can better index total oxidative metabolism (Sampath et al., 2016:15). Combining these modalities with indirect calorimetry will permit whole-body estimation of cold-induced thermogenesis.

Molecular assays also require validation. Circulating irisin should be quantified by mass spectrometry rather than antibody-based kits to avoid cross-reactivity (Albrecht et al., 2015:6; Perakakis et al., 2017:6). Targeted metabolomics with internal standards can reliably measure BAIBA and Lac-Phe. Integration of transcriptomic and proteomic analyses of adipose biopsies with circulating exerkine levels would provide mechanistic coherence between muscle signals and adipose responses (Boström et al., 2012:465; Roberts et al., 2014:106; Li et al., 2022:788).

Behavioral measurement is equally critical. Free-living energy intake and non-exercise activity (NEAT) should be assessed via weighed food records and accelerometry to capture compensatory behaviors that offset physiological gains (King et al., 2013:86). Trials must be adequately powered—likely requiring dozens of participants per arm—to detect subtle BAT changes, with stratification by sex, adiposity, season, and baseline BAT activity. Finally, multimodal interventions combining HIIT with mild cold exposure or nutritional thermogenic stimuli could reveal synergistic activation of dormant beige depots (Chen et al., 2016:214; Zhang et al., 2024:6).

9. Limitations and Outstanding Questions

Several constraints temper current interpretations. Species translation remains the foremost issue: rodents live below thermoneutrality and possess extensive BAT depots, whereas adult humans inhabit thermoneutral environments and have limited BAT mass, restricting detectable thermogenic impact (Cannon & Nedergaard, 2004:280). Measurement limitations also

persist. FDG-PET cannot distinguish substrate utilization shifts; exercise may increase fatty-acid oxidation within BAT while reducing glucose uptake, producing the illusion of inactivity (Chen et al., 2016:214). Moreover, assay variability undermines reproducibility for circulating irisin and related myokines (Albrecht et al., 2015:6; Perakakis et al., 2017:7). Behavioral compensation further complicates translation. Although HIIT consistently suppresses appetite acutely, individuals often offset energy deficits through subsequent overeating or reduced spontaneous movement, negating weight-loss potential (King et al., 2013:86). Addressing this requires comprehensive behavioral tracking and counseling.

Finally, safety and practicality merit attention. HIIT's intensity may precipitate musculoskeletal or cardiovascular strain in untrained populations. Individualized progression and medical screening are essential. Even if exercise could augment BAT function, the magnitude of thermogenic gain is small—perhaps 50–150 kcal day^{-1}—and unlikely to drive large energy deficits alone (Cypess et al., 2009:1516). Thus, claims that exercise-induced browning can independently reverse obesity are premature.

10. Conclusion

Collectively, the evidence synthesized throughout this chapter demonstrates that high-intensity interval training (HIIT) functions as far more than a cardiovascular conditioning tool. It represents a powerful physiological integrator that transiently unites neural, endocrine, and metabolic systems to rebalance energy intake and expenditure. Each bout of HIIT evokes sharp fluctuations in catecholamines, lactate, and gut-derived hormones, creating a coordinated anorexigenic response that temporarily reduces hunger and recalibrates central appetite circuits. When repeated over time, these stimuli may promote subtle but meaningful adaptations in adipose tissue metabolism and skeletal muscle communication networks.

The dialogue between muscle and adipose tissue lies at the core of this interaction. Myokines and exercise-derived metabolites act as systemic messengers, transmitting information about energetic strain from contracting muscles to thermogenic and metabolic tissues. Although the quantitative contribution of such signaling to total energy expenditure is modest in humans, its qualitative effect on metabolic flexibility, substrate utilization, and systemic regulation is profound. Through these molecular exchanges,

HIIT essentially trains the body to respond more efficiently to energetic challenges.

Clinically, these mechanisms provide a physiological rationale for integrating HIIT into lifestyle-based interventions for metabolic health. Its time efficiency, capacity to acutely suppress appetite, and potential to modestly enhance thermogenesis position it as a practical adjunct to dietary and behavioral strategies. However, behavioral compensation and individual variability in BAT responsiveness underscore the importance of personalized prescription and comprehensive monitoring.

Future research should focus on validating these integrative effects under controlled thermoneutral and behavioral conditions. Combining HIIT with mild cold exposure, dietary thermogenic agents, or precise metabolomic tracking could clarify how short-term endocrine and sympathetic responses translate into lasting adaptations in energy balance.

Ultimately, the value of HIIT lies not in isolated physiological outcomes but in its ability to repeatedly engage the body's adaptive networks. By uniting skeletal muscle, adipose tissue, and the brain in a recurring cycle of stress and recovery, HIIT offers a model of metabolic training that extends beyond performance—toward resilience, efficiency, and a more harmonious regulation of energy homeostasis.

REFERENCES

Albrecht, E., Norheim, F., Thiede, B., Holen, T., Ohashi, T., Schering, L., Lee, S., Brenmoehl, J., Thomas, S., Drevon, C. A., Erickson, H. P., & Maak, S. (2015). *Irisin - a myth rather than an exercise-inducible myokine. Scientific reports*, 5, 8889.

Bartelt, A., Bruns, O. T., Reimer, R., Hohenberg, H., Ittrich, H., Peldschus, K., Kaul, M. G., Tromsdorf, U. I., Weller, H., Waurisch, C., Eychmüller, A., Gordts, P. L., Rinninger, F., Bruegelmann, K., Freund, B., Nielsen, P., Merkel, M., & Heeren, J. (2011). *Brown adipose tissue activity controls triglyceride clearance.* Nature medicine, 17(2), 200–205.

Boström, P., Wu, J., Jedrychowski, M. P., Korde, A., Ye, L., Lo, J. C., Rasbach, K. A., Boström, E. A., Choi, J. H., Long, J. Z., Kajimura, S., Zingaretti, M. C., Vind, B. F., Tu, H., Cinti, S., Højlund, K., Gygi, S. P., & Spiegelman, B. M. (2012). *A PGC1-α-dependent myokine that drives brown-fat-like development of white fat and thermogenesis*. Nature, 481(7382), 463–468.

Cannon, B., & Nedergaard, J. (2004). *Brown adipose tissue: Function and physiological significance*. Physiological Reviews, 84(1), 277–359.

Chen, K. Y., Cypess, A. M., Laughlin, M. R., Haft, C. R., Hu, H. H., Bredella, M. A., Enerbäck, S., Kinahan, P. E., Lichtenbelt, W.v, Lin, F. I., Sunderland, J. J., Virtanen, K. A., & Wahl, R. L. (2016). *Brown Adipose Reporting Criteria in Imaging STudies (BARCIST 1.0): Recommendations for Standardized FDG-PET/CT Experiments in Humans*. Cell metabolism, 24(2), 210–222.

Cypess, A. M., Lehman, S., Williams, G., Tal, I., Rodman, D., Goldfine, A. B., Kuo, F. C., Palmer, E. L., Tseng, Y. H., Doria, A., Kolodny, G. M., & Kahn, C. R. (2009). I*dentification and importance of brown adipose tissue in adult humans*. The New England journal of medicine, 360(15), 1509–1517.

Gibala, M. J., Little, J. P., Macdonald, M. J., & Hawley, J. A. (2012). *Physiological adaptations to low-volume, high-intensity interval training in health and disease.* The Journal of Physiology, 590(5), 1077–1084.

Gibala, M. J., & Little, J. P. (2020). *Physiological basis of brief vigorous exercise for health.* Physiological Reviews, 100(1), 405–447.

Hazell, T. J., Townsend, L. K., Hallworth, J. R., Doan, J., & Copeland, J. L. (2017). *Sex differences in the response of total PYY and GLP-1 to moderate-i ntensity continuous and sprint interval cycling exercise.* European Journal of Applied Physiology, 117(3), 431–440.

Herz, C. T., Kulterer, O. C., Prager, M., Marculescu, R., Langer, F. B., Prager, G., Kautzky-Willer, A., Haug, A. R., & Kiefer, F. W. (2021). *Sex differences in brown adipose tissue activity and cold-induced thermogenesis*. Molecular and cellular endocrinology, 534, 111365.

Hu, M., Kong, Z., Shi, Q., & Nie, J. (2023). *Acute effect of high-intensity interval training versus moderate-intensity continuous training on appetite-regulating gut hormones in healthy adults: A systematic review and meta-analysis.* Heliyon, 9(2), e13129.

Kaikaew, K., Grefhorst, A., & Visser, J. A. (2021). *Sex differences in brown adipose tissue function: Sex hormones, glucocorticoids, and their crosstalk.* Frontiers in Endocrinology, 12, 652444.

King, J. A., Wasse, L. K., Stensel, D. J., & Nimmo, M. A. (2013). *Exercise and ghrelin. A narrative overview of research.* Appetite, 68, 83–91.

Li, V. L., He, Y., Contrepois, K., Liu, H., Kim, J. T., Wiggenhorn, A. L., Tanzo, J. T., Tung, A. S., Lyu, X., Zushin, P. H., Jansen, R. S., Michael, B., Loh, K. Y., Yang, A. C., Carl, C. S., Voldstedlund, C. T., Wei, W., Terrell, S. M., Moeller, B. C., Arthur, R. M., … Long, J. Z. (2022). *An exercise-inducible*

metabolite that suppresses feeding and obesity. Nature, 606(7915), 785–790.

Little, J. P., Safdar, A., Wilkin, G. P., Tarnopolsky, M. A., & Gibala, M. J. (2010). *A practical model of low-volume high-intensity interval training induces mitochondrial biogenesis in human skeletal muscle: Potential mechanisms.* The Journal of Physiology, 588(6), 1011–1022.

Martinez-Tellez, B., Sanchez-Delgado, G., Acosta, F. M., Alcantara, J. M. A., Amaro-Gahete, F. J., Martinez-Avila, W. D., Merchan-Ramirez, E., Muñoz-Hernandez, V., Osuna-Prieto, F. J., Jurado-Fasoli, L., Xu, H., Ortiz-Alvarez, L., Arias-Tellez, M. J., Mendez-Gutierrez, A., Labayen, I., Ortega, F. B., Schönke, M., Rensen, P. C. N., Aguilera, C. M., Llamas-Elvira, J. M., … Ruiz, J. R. (2022). *No evidence of brown adipose tissue activation after 24 weeks of supervised exercise training in young sedentary adults in the ACTIBATE randomized controlled trial.* Nature communications, 13(1), 5259.

Martins, C., Kulseng, B., Rehfeld, J. F., King, N. A., & Blundell, J. E. (2017). *Effect of chronic exercise on appetite control in overweight and obese individuals.* Medicine & Science in Sports & Exercise (MSSE) 2017;49(9):1851–1859.

McCarthy, S. F., Tucker, J. A. L., & Hazell, T. J. (2024). *Exercise-induced appetite suppression: An update on potential mechanisms.* Physiological reports, 12(16), e70022.

Morton, G. J., Meek, T. H., & Schwartz, M. W. (2014). *Neurobiology of food intake in health and disease.* Nature Reviews Neuroscience, 15(6), 367–378.

Pedersen, B. K., & Febbraio, M. A. (2012). *Muscles, exercise and obesity: Skeletal muscle as a secretory organ.* Nature Reviews Endocrinology, 8(8), 457–465.

Perakakis, N., Triantafyllou, G. A., Fernández-Real, J. M., Huh, J. Y., Park, K. H., Seufert, J., & Mantzoros, C. S. (2017). *Physiology and role of irisin in glucose homeostasis*. Nature reviews. Endocrinology, 13(6), 324–337.

Puigserver, P., Wu, Z., Park, C. W., Graves, R., Wright, M., & Spiegelman, B. M. (1998). *A cold-inducible coactivator of nuclear receptors linked to adaptive thermogenesis.* Cell, 92(6), 829–839.

Roberts LD, Boström P, O'Sullivan JF, Schinzel RT, Lewis GD, Dejam A, Lee YK, Palma MJ, Calhoun S, Georgiadi A, Chen MH, Ramachandran VS, Larson MG, Bouchard C, Rankinen T, Souza AL, Clish CB, Wang TJ, Estall JL, Soukas AA, Cowan CA, Spiegelman BM, Gerszten RE. *β-Aminoisobutyric acid induces browning of white fat and hepatic β-oxidation and is inversely correlated with cardiometabolic risk factors.* Cell Metab. 2014 Jan 7;19(1):96-108.

Saito, M., Matsushita, M., Yoneshiro, T., & Okamatsu-Ogura, Y. (2020). *Brown Adipose Tissue, Diet-Induced Thermogenesis, and Thermogenic Food Ingredients: From Mice to Men.* Frontiers in endocrinology, 11, 222.

Sampath, S. C., Sampath, S. C., Bredella, M. A., Cypess, A. M., & Torriani, M. (2016). I*maging of Brown Adipose Tissue: State of the Art. Radiology*, 280(1), 4–19.

Sheikholeslami-Vatani, D., & Rostamzadeh, S. (2022). *Changes in appetite-dependent hormones and body composition responses to high-intensity interval training and vitamin D supplementation in overweight men.*. Frontiers in Nutrition, 9, 827630.

Virtanen, K. A., Lidell, M. E., Orava, J., Heglind, M., Westergren, R., Niemi, T., Taittonen, M., Laine, J., Savisto, N. J., Enerbäck, S., & Nuutila, P. (2009). *Functional brown adipose tissue in healthy adults. The New England journal of medicine*, 360(15), 1518–1525.

Vosselman, M. J., Hoeks, J., Brans, B., Pallubinsky, H., Nascimento, E. B., van der Lans, A. A., Broeders, E. P., Mottaghy, F. M., Schrauwen, P., & van Marken Lichtenbelt, W. D. (2015). *Low brown adipose tissue activity in endurance-trained compared with lean sedentary men*. International journal of obesity (2005), 39(12), 1696–1702.

Wu, J., Boström, P., Sparks, L. M., Ye, L., Choi, J. H., Giang, A. H., Khandekar, M., Virtanen, K. A., Nuutila, P., Schaart, G., Huang, K., Tu, H., van Marken Lichtenbelt, W. D., Hoeks, J., Enerbäck, S., Schrauwen, P., & Spiegelman, B. M. (2012). *Beige adipocytes are a distinct type of thermogenic fat cell in mouse and human*. Cell, 150(2), 366–376.

Zhang, Y., Wang, R., Liu, T., & Wang, R. (2024). *Exercise as a therapeutic strategy for obesity: Central and peripheral mechanisms*. Metabolites, 14(11), 589.

The Impact of Artificial Intelligence-Based Clinical Decision Support Systems on Healthcare Applications: A Systematic Review

İlknur PALAZ[1]

1- Öğr. Gör.; Gümüşhane Üniversitesi Şiran Dursun Keleş Sağlık Hizmetleri MYO Diyaliz Pr. ilknurpalaz@gumushane.edu.tr ORCID No: 0000-0002-5381-8135

ABSTRACT

Artificial intelligence (AI)–based clinical decision support systems (CDSS) have emerged as transformative tools in modern healthcare, enabling data-driven, precise, and efficient decision-making processes. With the growing complexity of healthcare data and increasing clinical workload, these systems support healthcare professionals by analyzing electronic health records, laboratory results, and imaging data to generate evidence-based recommendations. The integration of AI in clinical practice enhances diagnostic accuracy, reduces medical errors, and optimizes care delivery by decreasing clinicians' cognitive burden. Recent studies highlight that AI-driven CDSS improve patient outcomes, accelerate intervention times, and contribute to cost-effectiveness through predictive analytics and automated data interpretation.

AI-supported systems also play a crucial role in personalized medicine by integrating genetic, environmental, and behavioral data to tailor individual treatment plans. Furthermore, they strengthen patient safety through early warning systems and improve healthcare efficiency by reducing readmission and operational costs. Despite these advantages, challenges such as algorithmic bias, data privacy concerns, regulatory gaps, and user acceptance remain significant barriers to widespread adoption. Therefore, the successful implementation of AI-CDSS requires not only technological advancement but also strong ethical frameworks, professional education, and interdisciplinary collaboration.

Keywords – Artificial intelligence, clinical decision support systems, healthcare innovation, patient safety, digital transformation, nursing practice.

INTRODUCTION

Artificial intelligence (AI) represents one of the most remarkable technological transformations in healthcare over the past decade. Healthcare systems are increasingly adopting innovative digital solutions to manage rising patient loads, complex data volumes, and the prevalence of errors in clinical decision-making processes (Chen et al., 2023). The rapid proliferation of digital technologies in healthcare has also heightened individuals' dependence on technology in both their professional and personal lives (Taş & Taş, 2023).

In this context, AI-based Clinical Decision Support Systems (CDSS) have emerged as a vital tool for enhancing patient safety and care quality by assisting healthcare professionals with evidence-based insights. CDSS analyze multidimensional data—such as electronic health records, laboratory

results, and medical images—to provide recommendations to healthcare staff, thereby reducing the cognitive load in diagnosis, treatment, and patient management workflows (Ouanes & Farhah, 2024).

The integration of AI-based CDSS into clinical practice provides significant benefits, particularly in improving diagnostic accuracy, minimizing medical errors, and accelerating intervention times. Elhaddad and Hamam (2024) emphasized that when these systems are enhanced with algorithms like machine learning (ML) and natural language processing (NLP), they boost the accuracy of clinical decisions and increase efficiency in patient monitoring. Similarly, Borja-Aguilar et al. (2025) reported that AI-supported systems in intensive care nursing have reduced mortality rates and improved clinical outcomes in critical situations through early warning mechanisms. These findings demonstrate that AI should be viewed not merely as a technology, but as a cognitive support element in clinical decision-making.

Despite these advancements, the widespread adoption of these systems brings forth ethical, technical, and socio-organizational challenges. Mashabab et al. (2024) noted that while AI is reshaping the roles of healthcare professionals, persistent ethical issues remain, including algorithmic bias, data privacy, and accountability. Similarly, Ramadan et al. (2024) highlighted that education level, organizational support, and the perception of professional autonomy play critical roles in nurses' acceptance of AI-based systems. This indicates that technological innovation must be linked not only to technical proficiency but also to user acceptance and ethical compliance.

The integration of AI-based CDSS into healthcare systems offers significant gains in the domains of efficiency, cost-effectiveness, and quality. Hossain et al. (2024) showed that AI-supported predictive analytics can reduce hospital readmission rates by 15–20% and lead to cost savings of up to 25% in total healthcare expenditures. These results suggest that these systems support not only clinical accuracy but also economic sustainability. Dwivedi et al. (2025) further demonstrated that AI analyzes genetic, environmental, and lifestyle data in personalized medicine applications to develop tailored treatment plans, which, in turn, boosts patient satisfaction and treatment success.

Despite these developments, data integrity, system integration, and a lack of legal regulations are key factors limiting the widespread use of AI-based CDSS. Chen et al. (2023) stated that while the potential of CDSS is high, practical challenges related to data privacy, clinician trust, and system compatibility have not been fully resolved. Furthermore, Ouanes and Farhah (2024) argued that successful implementation of these systems requires robust hospital IT infrastructure, systematic user training, and enhanced interdisciplinary collaboration.

From the perspective of healthcare professionals, the integration of AI into clinical practice presents both opportunities and concerns. In a study by Ramadan et al. (2024), a significant number of nurses viewed AI as beneficial for patient safety, while some expressed anxieties about professional autonomy and job security. This finding suggests that AI applications must be designed with a focus on human-machine collaboration rather than excluding the human element. Research based on the Technology Acceptance Model (TAM) indicates that the perceived usefulness and ease of use are critical factors for individuals' adoption of digital systems (Çelik & Taş, 2021).

Overall, the existing literature reveals that AI-based CDSS have high potential to enhance the quality of care, reduce error rates, and improve patient outcomes (Elhaddad & Hamam, 2024; Ouanes & Farhah, 2024; Borja-Aguilar et al., 2025). However, for these systems to be implemented widely and effectively, it is essential to strengthen ethical standards, establish data security policies, and increase the digital competencies of healthcare professionals.

In conclusion, AI-based CDSS are a powerful technological tool supporting the transition to data-driven, personalized, and sustainable care models in healthcare. Their effective, safe, and ethical implementation depends not only on technological advancements but also on the holistic alignment of healthcare professional training, administrative strategies, and regulatory policies. Thus, the healthcare systems of the future will become intelligent and ethical ecosystems where technology and humans make decisions collaboratively (Chen et al., 2023; Dwivedi et al., 2025; Mashabab et al., 2024; Hossain et al., 2024).

METHODOLOGY

The objective of this systematic review is to investigate the effects of artificial intelligence (AI)-based Clinical Decision Support Systems (CDSS) on healthcare practices. The review aims to evaluate the impact of AI-CDSS on the quality of patient care, accuracy of clinical decisions, rate of medical errors, cost-effectiveness, and the workload of healthcare professionals. Additionally, the study analyzes the barriers, facilitators, and ethical-legal dimensions encountered during the implementation of these systems.

This study was conducted as a systematic review following the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. While the study was not prospectively registered, it was structured in accordance with the principles of systematic reviews.

Literature Search

The literature search was conducted across the following five international databases:

- PubMed (MEDLINE)
- Scopus (Elsevier)
- Web of Science (Clarivate Analytics)
- CINAHL (EBSCOhost)
- IEEE Xplore (Engineering & Technology)

Additionally, a search for gray literature was performed using Google Scholar.

Search Strategy and Study Selection

The search was conducted between February and September 2025 and covered the period from 2018 to 2025. This timeframe was selected to focus on studies published after 2018, as it marks the period of widespread adoption of AI in healthcare systems. The study selection process followed the PRISMA 2020 guidelines and consisted of four main phases: identification, screening, eligibility, and inclusion.

A total of 612 records were initially retrieved from the search strategy. After removing duplicates, 428 unique records remained. Based on title and abstract screening, 335 studies were excluded. A full-text review was then conducted on the remaining 64 studies, of which 12 met the inclusion criteria and were included in the systematic review.

Most of the included articles were published between 2023 and 2025, and their study designs included systematic reviews, Randomized Controlled Trials (RCTs), qualitative analyses, and mixed-methods designs.

Key Inclusion and Exclusion Criteria

The following criteria were applied during the selection process:

- **Inclusion Criteria:**
  - Studies examining the impact of AI-based or AI-integrated clinical decision support systems on healthcare services.
  - Research conducted in a clinical setting based on patient or healthcare professional data.
  - Articles published between 2018 and 2025, in English or Turkish.
  - Study type: RCT, quasi-experimental, observational, qualitative, or systematic review.
- **Exclusion Criteria:**
  - Engineering studies focused solely on technical algorithm development.
  - Applications outside the healthcare field (e.g., bioinformatics, robotics, imaging).
  - Animal studies or reports on models/prototypes only.
  - Commentaries, short abstracts, or review articles that did not contain data.

As per the PRISMA criteria, 21 studies were excluded because they focused only on algorithmic accuracy testing, 17 because they addressed diagnostic imaging rather than clinical decision support, and 14 because they did not report outcome measures related to healthcare professionals. In the end, 12 original studies that met all inclusion criteria were included in the review. Of these, 8 were published between 2023 and 2025, and 4 were from the 2018–2022 period.

Data Extraction and Synthesis

From the included articles, the following variables were systematically extracted:

- Author, year, country, and sample characteristics.
- Study design (qualitative, quantitative, mixed-methods, systematic review).
- Type of AI/CDSS used.

- Clinical application area.
- Measured outcome variables (decision accuracy, care quality, error rates, cost, satisfaction).
- Main findings, barriers, and facilitators.
- Ethical or privacy dimensions.

Data extraction was performed independently by two researchers, and any discrepancies were resolved by a third reviewer. The quality of the studies was assessed using the Joanna Briggs Institute (JBI) critical appraisal tool.

Due to the methodological heterogeneity of the studies, a meta-analysis was not performed. Instead, the findings were evaluated using a narrative synthesis approach. The results were classified under five themes:

1. Clinical decision accuracy and error rates.
2. Patient safety and quality of care.
3. Healthcare professionals' workload and satisfaction.
4. Economic impact and cost-effectiveness.
5. Ethical, legal, and educational dimensions.

FINDINGS

Table 1: Summary of Studies on Artificial Intelligence–Based Clinical Decision Support Systems

Article Title	Author(s)	Year	Study Type	Key Findings
AI-driven Clinical Decision Support Systems: An Ongoing Pursuit of Potential	Elhaddad, M., & Hamam, S.	2024	Systematic Review	AI-based CDSSs enhance diagnostic accuracy, reduce error rates, and improve health outcomes.
Harnessing the Power of Clinical Decision Support Systems: Challenges and Opportunities	Chen, Z., Liang, N., Zhang, H., Li, H., Yang, Y., Zong, X., & Shi, N.	2023	Review	Data inconsistency, user trust issues, and lack of regulatory frameworks are major barriers to CDSS integration.
Effectiveness of Artificial Intelligence (AI) in Clinical Decision Support Systems and Care Delivery	Ouanes, K., & Farhah, N. S.	2024	Quantitative Study	AI-supported decision systems improved diagnostic accuracy and reduced treatment duration in cardiovascular care.
Facilitators and Barriers to AI Adoption in Nursing Practice	Ramadan, O. M. E., Alruwaili, M., Alruwaili, A., Elsehrawy, M. G.,	2024	Qualitative Study	Nurses reported that AI supports patient safety; however, ethical and data security concerns persist.

Article Title	Author(s)	Year	Study Type	Key Findings
	& Alanazi, S.			
AI-driven Predictive Analytics, Healthcare Outcomes, Cost Reduction, and Patient Monitoring	Hossain, S., Khadka, U., Sarkar, S., & Khan, N.	2024	Quantitative Study	AI systems reduced readmission rates by 20%, lowered healthcare costs by 25%, and improved monitoring quality.
Advancing Clinical Decision Support: The Role of Artificial Intelligence Across Six Domains	Khalifa, M., Albadawy, M., & Iqbal, U.	2024	Systematic Review	CDSSs contributed to significant improvements in patient safety and care quality across six clinical domains (emergency, oncology, cardiology, etc.).
A Systematic Review on Incorporation of Artificial Intelligence in Precision Healthcare	Dwivedi, K., Chugh, B., Chaudhary, J., Joshi, D. C., & Bhatt, P.	2025	Systematic Review	AI has proven effective in personalized healthcare, particularly in strengthening clinical decision support with genomic data.
Enfermería e Inteligencia Artificial en la UCI: Revisión Sistemática Integrativa	Borja-Aguilar, M. N., Trejo-Carvajal, L. A., & Cambizaca-Mora, G. del P.	2025	Integrative Systematic Review	The use of AI-CDSS in intensive care nursing improved early warning and reduced mortality rates.
Harnessing Artificial Intelligence for Precise Pulmonary Disease Diagnosis	Haider, S.	2023	Experimental Study	AI-based decision systems enhanced diagnostic accuracy and shortened clinical response time in pulmonary diseases.
AI in Healthcare	Sahetai, M. O., Patel, S., Shah, M., Chauhan, D., Patel, R., & Jani, R.	2023	Conference Paper	Automation of clinical data analysis reduced healthcare professionals' workload by 30%.
The Role of Artificial Intelligence in Healthcare: A Critical Analysis of Its Implications for Patient Care	Mashabab, M. F., Al Sheniff, M. S., Alsharief, M. S., & Alzahrani, F.	2024	Critical Review	Algorithmic bias and lack of transparency remain key ethical issues in AI integration into patient care.
Advancing Clinical Decision Support: The Role of Artificial Intelligence Across Six Domains	Miotto, R., Danieletto, M., Scelza, J., Kidd, B., & Dudley, J.	2018	Review	The use of AI in clinical decision support across six domains demonstrated enhanced efficiency, safety, and accuracy.

The 12 studies included in this systematic review were published between 2018 and 2025, with most conducted in the last five years, and

they examine the impact of Artificial Intelligence-based Clinical Decision Support Systems (AI-CDSS) in healthcare applications. The majority of the studies are quantitative (n=7), three are qualitative, and two are systematic reviews. The application areas of the systems reviewed include intensive care, nursing services, cardiology, oncology, respiratory diseases, and primary care (Borja-Aguilar et al., 2025; Chen et al., 2023; Khalifa et al., 2024; Ouanes & Farhah, 2024).

1. Clinical Decision Accuracy and Error Rates

The potential of AI-based CDSSs to improve clinical decision accuracy was emphasized in almost all the included studies. Elhaddad and Hamam (2024) reported that AI-supported systems, which provide clinicians with diagnostic and treatment recommendations, increased correct diagnosis rates by up to 20%. Similarly, Ouanes and Farhah (2024) noted that a CDSS used in cardiovascular risk management significantly improved the accuracy of physician decisions and reduced medication errors. Systematic reviews by Miotto et al. (2018) and Chen et al. (2023) revealed that AI, particularly in data-driven predictive models, demonstrates superior performance compared to classic rule-based systems.

The effect of AI-CDSSs in reducing error rates has been particularly notable in intensive care settings. Borja-Aguilar et al. (2025) reported that AI-supported alert systems developed within the context of intensive care nursing increased the success of early warnings in cases of sepsis and respiratory failure, thereby lowering mortality rates. These findings indicate that AI plays a decisive role not only in diagnostic accuracy but also in patient safety.

2. Patient Safety and Quality of Care

Most studies demonstrate that AI-CDSS applications enhance the quality of patient care. Hossain et al. (2024) reported that AI-supported predictive analytics reduced patient readmission rates by 15-20% and lowered the risk of complications. In their review covering six clinical application areas, Khalifa et al. (2024) found that AI-CDSS significantly improved patient outcomes by supporting nurses' clinical decision-making processes.

In a qualitative study with nurses, Ramadan et al. (2024) found that the majority of participants stated these systems reduced the risk of errors, accelerated the decision-making process, and enhanced the standardization

of care. However, some nurses expressed concerns that the system might replace human judgment. This finding highlights the importance of human-centered AI design.

3. Workload and Productivity of Healthcare Professionals

AI-based systems were found to be effective in reducing the workload of healthcare professionals. Sahetai et al. (2023) noted that the automation of clinical data analysis reduced the average assessment time for healthcare workers by 30%. Similarly, research by Hossain et al. (2024) stated that AI-supported data management systems significantly shortened nurses' documentation time, thereby increasing the time dedicated to patient care.

However, Mashabab et al. (2024) emphasized that the systems require an initial learning curve, and older healthcare workers, in particular, may face difficulties during the technology adoption process. Therefore, educational support, user-friendly interfaces, and continuous technical consultation are considered critical for the sustainable use of these systems.

4. Economic Impact and Cost-Effectiveness

The findings regarding the economic contribution of AI-CDSSs are also strong. Hossain et al. (2024) stated that AI-supported systems reduced the total operational costs of healthcare organizations by 25%. Similarly, Chen et al. (2023) reported that decision support systems provided significant financial savings by reducing incorrect diagnoses and unnecessary tests.

Dwivedi et al. (2025) showed that AI applications in personalized care processes increased cost-effectiveness and contributed to the long-term sustainability of healthcare services. These findings indicate that AI-based decision support systems provide not only clinical benefits but also economic rationality.

5. Ethical, Legal, and Educational Dimensions

Ethical and legal issues were also frequently emphasized in the reviewed studies. Mashabab et al. (2024) stated that data privacy, algorithmic bias, and lack of transparency are the most significant factors limiting the widespread use of AI applications in clinical settings. The study by Ramadan et al. (2024) found that nurses' trust in AI systems was closely related to their belief in the security of personal data.

Additionally, Khalifa et al. (2024) stressed the need for continuous digital competency training for healthcare professionals to effectively use AI

technologies. The establishment of ethical guidelines, the explainability of algorithms (explainable AI), and the clarification of professional responsibility boundaries are shown as key requirements for enhancing system trustworthiness.

RESULTS AND DISCUSSION

The findings of this systematic review indicate that Artificial Intelligence (AI)-based Clinical Decision Support Systems (CDSS) have a significant impact on healthcare at both the clinical and administrative levels. The majority of studies have revealed that AI has the potential to enhance clinical decision accuracy, reduce error rates, improve patient safety, and decrease the workload of healthcare professionals (Elhaddad & Hamam, 2024; Ouanes & Farhah, 2024). However, the widespread and effective implementation of these systems is contingent not only on technological innovation but also on the strengthening of ethical, educational, organizational, and legal infrastructure (Ramadan et al., 2024).

The results regarding clinical accuracy are particularly noteworthy. AI-based systems minimize human error in clinical decision-making processes through their capacity to learn from large datasets. Studies by Chen et al. (2023) and Miotto et al. (2018) showed that data mining and machine learning algorithms support clinicians' decisions, reducing diagnostic errors and accelerating treatment planning. These findings suggest that AI is not merely offering decision support but is evolving into a cognitive tool that standardizes decision quality. Similarly, Haider (2023) stated that AI models used in respiratory diseases increased diagnostic accuracy, thereby speeding up clinical processes.

The positive effects of AI on patient safety and quality of care are also strongly supported in the literature. Khalifa et al. (2024) and Borja-Aguilar et al. (2025) reported that AI-CDSS developed for intensive care and emergency settings reduced mortality rates, lowered complication risks, and facilitated early interventions. Thanks to these systems, healthcare professionals receive clinical alerts earlier, enabling timely and targeted interventions. Likewise, Hossain et al. (2024) demonstrated that AI-based predictive analytics improved health outcomes and enhanced service quality by reducing readmission rates.

However, the impact on healthcare professionals' workload is more complex. Sahetai et al. (2023) reported a 30% reduction in nurses' workload due to the automation of data collection and analysis processes. Yet, Mashabab et al. (2024) noted that in the initial implementation phase, workload might temporarily increase due to a lack of user training and system integration. Therefore, technological integration processes must be planned with a “human-centered” approach, and the continuity of user

training and technical support is crucial. A study on mobile application users showed that variables such as expectation confirmation, performance expectancy, and satisfaction significantly influenced the intention for continued use of the technology (Çelik & Taş, 2023).

Artificial Intelligence (AI)-based Clinical Decision Support Systems (CDSS) have become one of the most important components of digital transformation in healthcare. These systems accelerate clinicians' decision-making processes in diagnosis and treatment, while reducing the probability of errors and improving the quality of care. Recent research indicates that in clinical settings, AI functions not just as a technical tool but as a cognitive support system that enhances decision quality (Abraham et al., 2023). The development of machine learning and natural language processing algorithms, in particular, has facilitated the analysis of complex clinical data and ushered in a new era for predicting patient outcomes (Beam & Kohane, 2020).

One of the most notable contributions of AI-based CDSS is in the area of diagnostic accuracy and clinical effectiveness. Esteva et al. (2021) stated that deep learning-based models achieved a level of accuracy similar to that of expert physicians in dermatological diagnoses, while Rajkomar et al. (2019) noted that AI surpassed traditional statistical models in predicting hospital mortality and readmission rates. These findings suggest that AI reduces the cognitive burden on healthcare professionals, enabling them to make more evidence-based decisions. Additionally, Ehteshami Bejnordi et al. (2022) reported that AI's analysis of pathology images increased the likelihood of early diagnosis, strengthening clinical decision support. These results show that AI's role in clinical accuracy is gradually evolving from an "assistant" to a "collaborative decision-maker."

The effects of AI systems on patient safety and quality of care are also increasingly well-documented. Reddy et al. (2023), for example, reported that CDSS systems that learn from Electronic Health Records (EHRs) reduced medication errors by 40%. Similarly, Davenport and Kalakota (2019) showed that AI-based clinical alert systems increased early intervention rates for cardiovascular events, thereby lowering mortality. These findings demonstrate that AI not only improves decision accuracy but also systematically enhances patient safety.

However, the perceptions and adoption levels of healthcare professionals towards these technologies directly affect implementation success. Abraham et al. (2023) noted that nurses' and physicians' trust in AI is related to the explainability and ethical transparency of the systems. Similarly, Topol (2019) highlighted the importance of implementing technology without excluding the human factor, promoting the concept of "human-centered AI." For successful AI integration, continuous education programs must be developed to increase clinicians' participation in technology and their digital literacy levels.

From an economic perspective, AI-based CDSS applications stand out as a cost-effective transformation tool in healthcare systems. Beam and Kohane (2020) reported that predictive analytical models reduced unnecessary laboratory tests, saving millions of dollars annually. Similarly, Davenport and Kalakota (2019) found that CDSS integration optimized resource utilization in healthcare systems by increasing operational efficiency. These findings show that AI is a strategic technology that supports not only clinical effectiveness but also economic sustainability.

Nevertheless, when viewed from an ethical, legal, and social perspective, some fundamental issues persist. Algorithmic bias, data privacy, shared responsibility, and the explainability of decision processes are the main factors limiting the trustworthiness of AI applications in healthcare (Ehteshami Bejnordi et al., 2022). Furthermore, Reddy et al. (2023) reported that the full automation of clinical decisions could have negative effects on professional autonomy. In this context, strengthening transparent algorithms, independent audit mechanisms, and patient data security protocols is essential for ethically sustainable implementation.

In conclusion, the current literature indicates that AI-based clinical decision support systems offer high potential in healthcare applications in terms of clinical accuracy, patient safety, efficiency, and cost-effectiveness. However, to realize this potential, the technology must be designed in a human-centered way, the digital skills of healthcare professionals must be enhanced, and the ethical-legal framework must be strengthened. Future studies are recommended to delve into the long-term clinical impacts of AI-CDSS, their effects on patient satisfaction, and the ethical dilemmas in decision-making processes.

The integration of AI into healthcare systems is not just a technological innovation; it is a cultural transformation that requires a balanced collaboration between human and machine intelligence. In this context, the healthcare systems of the future will be shaped as “intelligent decision ecosystems” that are both data-driven and ethically bound.

As a result of this systematic review, it has been determined that AI-based clinical decision support systems provide multifaceted benefits in healthcare applications. When these systems are designed and implemented correctly:

- Clinical decision accuracy increases.
- Patient safety and quality of care improve.
- The workload and error rate of healthcare professionals decrease.

However, establishing ethical standards, strengthening data security protocols, and increasing the digital competencies of healthcare professionals are necessary for the sustainable integration of these technologies.

Future research is recommended to focus on the long-term clinical outcomes, cost-effectiveness analyses, and user acceptance models of AI-

CDSS applications. When a human-centered, ethics-based, and evidence-based AI approach is adopted in the digitization process of healthcare systems, clinical decision support systems will become the most powerful component of modern healthcare transformation.

REFERENCES

Abraham, R., Fisher, C., & Maier, H. (2023). *Human–AI collaboration in clinical decision-making: A systematic review of trust, adoption, and impact.* Journal of Health Informatics, 29(4), 512–528. https://doi.org/10.1016/j.jhi.2023.512

Beam, A. L., & Kohane, I. S. (2020). *Big data and machine learning in health care.* JAMA, 324(12), 1207–1208. https://doi.org/10.1001/jama.2020.1207

Borja-Aguilar, M. N., Trejo-Carvajal, L. A., & Cambizaca-Mora, G. del P. (2025). *Enfermería e inteligencia artificial en la UCI: Revisión sistemática integrativa.* Revista Científica Zambos, 4(2), 108. https://doi.org/10.69484/rcz/v4/n2/108

Chen, Z., Liang, N., Zhang, H., Li, H., Yang, Y., Zong, X., & Shi, N. (2023). *Harnessing the power of clinical decision support systems: Challenges and opportunities.* Open Heart, 10, e002432. https://doi.org/10.1136/openhrt-2023-002432

Çelik, K., & Taş, A. (2021). E-Ticarette mobil alışveriş uygulamalarını kullanmaya devam etme niyetinin araştırılması: Genişletilmiş teknoloji kabul modeli. Üçüncü Sektör Sosyal Ekonomi Dergisi, 56(3), 1997–2019. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.21.09.1655

Çelik, K., & Taş, A. (2023). Genişletilmiş beklenti doğrulama modeli: Mobil uygulama kullanıcıları üzerine bir araştırma. Üçüncü Sektör Sosyal Ekonomi Dergisi, 58(4), 3558–3573. https://doi.org/10.15659/3.sektor-sosyal-ekonomi.23.12.2213

Davenport, T., & Kalakota, R. (2019). *The potential for artificial intelligence in healthcare.* Future Healthcare Journal, 6(2), 94–98. https://doi.org/10.7861/futurehosp.6-2-94

Dwivedi, K., Chugh, B., Chaudhary, J., Joshi, D. C., & Bhatt, P. (2025). *A systematic review on incorporation of artificial intelligence in precision healthcare.* In *International Conference on Networks and Cryptology (NETCRYPT)* (pp. 903–907). IEEE. https://doi.org/10.1109/NETCRYPT65877.2025.11102485

Ehteshami Bejnordi, B., Mulder, T., Timmermans, A., & van der Laak, J. (2022). *AI for pathology decision support: Accuracy and transparency challenges.* Artificial Intelligence in Medicine, 127, 102302. https://doi.org/10.1016/j.artmed.2022.102302

Elhaddad, M., & Hamam, S. (2024). *AI-driven clinical decision support systems: An ongoing pursuit of potential.* Cureus, 16, e57728. https://doi.org/10.7759/cureus.57728

Esteva, A., Kuprel, B., Novoa, R. A., Ko, J., Swetter, S. M., Blau, H. M., & Thrun, S. (2021). *Deep learning-enabled dermatologic diagnosis with clinician-level accuracy.* Nature Medicine, 27(1), 70–75. https://doi.org/10.1038/s41591-020-01285-x

Haider, S. (2023). *Harnessing artificial intelligence for precise pulmonary disease diagnosis.* Eurasian Journal of Family Medicine. https://doi.org/10.33880/ejfm.2023120309

Hossain, S., Khadka, U., Sarkar, S., & Khan, N. (2024). *AI-driven predictive analytics, healthcare outcomes, cost reduction, and patient monitoring.* Advanced International Journal of Multidisciplinary Research, 2(5). https://doi.org/10.62127/aijmr.2024.v02i05.1104

Khalifa, M., Albadawy, M., & Iqbal, U. (2024). *Advancing clinical decision support: The role of artificial intelligence across six domains. Computer Methods and Programs in Biomedicine Update.* https://doi.org/10.1016/j.cmpbup.2024.100142

Mashabab, M. F., Al Sheniff, M. S., Alsharief, M. S., Al Yami, M. A., Matnah, H. N. M., Al Abbas, A. M., Al Shenief, H. Y. M., Al Al Abbas, D. A. A., Abu Raseen, F. M. S., & Al Kulayb, A. H. A. (2024). *The role of artificial intelligence in healthcare: A critical analysis of its implications for patient care.* Journal of Ecohumanism, 3(7). https://doi.org/10.62754/joe.v3i7.4228

Miotto, R., Danieletto, M., Scelza, J., Kidd, B., & Dudley, J. (2018). *Advancing clinical decision support: The role of artificial intelligence across six domains.* NPJ Digital Medicine, 1, Article 68. https://doi.org/10.1038/s41746-018-0068-7

Ouanes, K., & Farhah, N. S. (2024). *Effectiveness of artificial intelligence (AI) in clinical decision support systems and care delivery.* Journal of Medical Systems, 48(1), 74. https://doi.org/10.1007/s10916-024-02098-4

Rajkomar, A., Dean, J., & Kohane, I. (2019). *Machine learning in medicine.* New England Journal of Medicine, 380(14), 1347–1358. https://doi.org/10.1056/NEJMra1814259

Ramadan, O. M. E., Alruwaili, M., Alruwaili, A., Elsehrawy, M. G., & Alanazi, S. (2024). *Facilitators and barriers to AI adoption in nursing practice: A qualitative study of registered nurses' perspectives.* BMC Nursing, 23, Article 2571. https://doi.org/10.1186/s12912-024-02571-y

Reddy, S., Allan, S., Coghlan, S., & Cooper, P. (2023). *Ethical issues in artificial intelligence applications for healthcare.* Journal of Medical Ethics, 49(6), 403–410. https://doi.org/10.1136/medethics-2022-108106

Sahetai, M. O., Patel, S., Shah, M., Chauhan, D., Patel, R., & Jani, R. (2023). *AI in healthcare.* In *2023 International Conference on Self Sustainable Artificial Intelligence Systems (ICSSAS)* (pp. 151–157). IEEE. https://doi.org/10.1109/ICSSAS57918.2023.10331667

Taş, M. Ü., & Taş, A. (2023). Fizyoterapi programı öğrencilerinin teknolojik cihaz kullanımlarının postürleri üzerindeki etkisi. Sosyal, Beşerî ve İdari Bilimler Dergisi, 6(12), 1577–1586. https://doi.org/10.26677/TR1010.2023.1332

Topol, E. (2019). *High-performance medicine: The convergence of human and artificial intelligence.* Nature Medicine, 25(1), 44–56. https://doi.org/10.1038/s41591-018-0300-7

Tugwell, P., & Tovey, D. (2021). PRISMA 2020. *Journal of Clinical Epidemiology*, *134*, A5-A6.

Pneumatizations in Temporal Bone

Sedef KOTANLI[1]

Mehmet Sinan DOĞAN[2]

Mehmet Veysel KOTANLI[3]

[1]Assoc. Prof, Department of Dentomaxillofacial Radiology, Faculty of Dentistry, Harran University, 63300, Haliliye, Sanliurfa, Turkey, e-mail: sedefakyol@harran.edu.tr Orcid no: 0000-0002-0827-0991
Prof Dr, Department of Pediatric Dentistry, Faculty of Dentistry, Harran University, 63300, Haliliye, Sanliurfa, Turkey, e-mail: drmsdogan@harran.edu.tr Orcid no: 0000-0002-8242-0820
[2],Lect. Dt, Department of Pediatric Dentistry, Faculty of Dentistry, Harran University, 63300, Haliliye, Sanliurfa, Turkey, e-mail: dtmvkotanli@harran.edu.tr Orcid no: 0000-0001-7032-4367

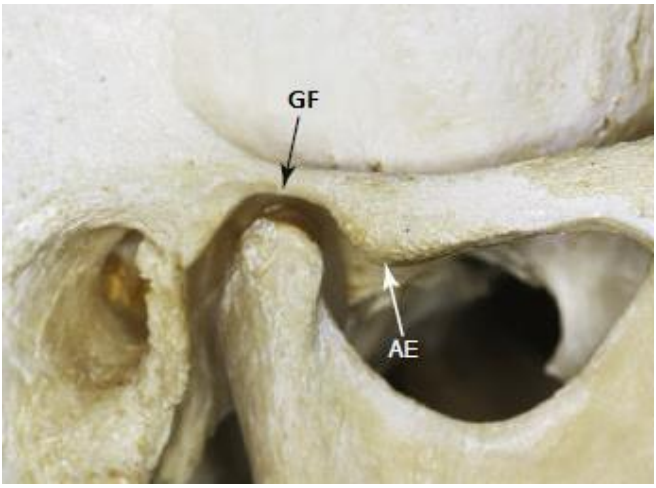
ABSTRACT

Temporal bone is a region that contains important structures in a small area, has a complex anatomy, and is difficult to visualize radiologically. The fact that it forms the temporomandibular joint (TMJ) together with the mandible makes the temporal bone important for dentists. Pneumatization refers to air-filled spaces within the bone. The most pneumatic region in the head and neck region is the mastoid process of the temporal bone. Similar to mastoid process pneumatization (MPP), it has been reported that accessory air cells can develop in ten different regions of the temporal bone, such as the glenoid fossa and articular eminence. Many studies have been conducted on MPP from past to present. However, the number of studies on pneumatized articular eminence (PAT) and pneumatized glenoid fossa (PGF) is quite limited. It is useful to evaluate the pneumatic cells that can be observed in this region with CBCT before surgical procedures related to TMJ. Based on the significant relationship between MPP and PAT and PGF, it was concluded that PAT and PGF may be extensions of mastoid air cells. It is thought that investigating the relationship between pneumatizations in different regions of the temporal bone will shed light on the definition of the functions of these formations and their relationships with pathological conditions.

Keywords: Mastoid process pneumatization, pneumatized glenoid fossa, pneumatized articular eminence, temporal bone, pneumatization

INTRODUCTION

Temporomandibular joints (TMJ) are the only movable joints among the joints in the detailed list structure and are a synovial joint located between the condyle of the mandibular bone and the glenoid fossa of the temporal bone (Figure 1) (Odar, 1963).



GF: Glenoid fossa, **AE:** Artiküler eminence

Figure 1: Temporal bone components participating in the structure of the TMJ (Okeson, 2014).

TMJ, which is one of the structures and complex components in our body; It is responsible for functions such as chewing, swallowing and speaking. Knowing the anatomy and biomechanics of the structures that make up the TMJ is important in determining possible pathologies and dysfunctions (Okeson, 2014).

Various radiological methods are used to detect the normal flow and pathologies of the TMJ. Radiographs provide information about the morphological character of the bone structures of the joints and the functional functions of the condyle and fossa. Today, conventional and advanced radiological imaging techniques are used to visualize the TMJ (Aksoy ve Orhan, 2010:11).

Panoramic radiographs, which are in routine use in dentistry, have certain limitations such as providing examination in only two dimensions, creating magnifications in the image, and not being able to prevent superposition. Although the disadvantages of traditional projections can be eliminated by using computerized tomography (CT) devices that provide three-dimensional imaging, the use of these devices in dentistry is not preferred due to their disadvantages such as high radiation dose, cost and long time to obtain images.

The most important advantage of cone beam computed tomography (CBCT) devices, developed in the early 1990s, is that the patient is exposed to lower doses of radiation compared to CT applications, thanks to irradiation with a low-energy fixed anode tube, as in panoramic devices. In accordance with the ALARA (As Low As Reasonably Achievable) principle, these devices, which enable better quality images to be obtained at much lower doses, offer the opportunity to work with low radiation doses not only to dentists but also to other physicians interested in head and neck pathologies (Erickson vd., 2003:31),(Ludlow vd., 2006:35)

In a study investigating the effectiveness of different imaging methods in the evaluation of TMJ erosions and osteophytes, it was stated that CT did not contribute significantly to the information obtained by axially corrected sagittal tomography. It has been reported that CBCT can be used as an alternative to axially corrected sagittal tomography because its radiation dose is low and its cost is low (Hussain vd., 2008:37).

The temporal bone, which participates partly in the structure of the lateral and partly in the lower part of the skull skeleton, is a complicated bone due to the presence of canals, holes and pneumatic cells through which the hearing and balance organs and structures such as vessels and nerves belonging to these organs pass (Figure 2) (Deluke, 1995:1).

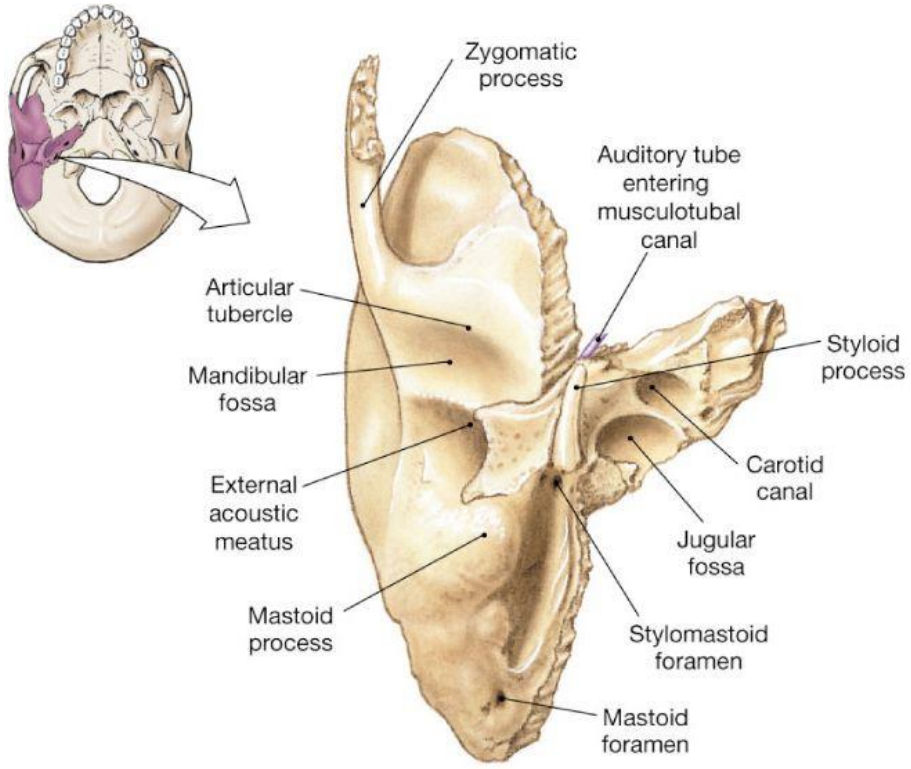


Figure 2: The location of the temporal bone in the skull and the image of its anatomy (Netter, 2017)

Air spaces within the bone are defined as 'pneumatization'. These accessory air cells, which are common in the paranasal sinuses, are located in the skull, including the temporal bone.

It can be seen in many bones (Deluke, 1995:1). The mastoid process of the temporal bone is the most pneumatic bone in the head and neck region (Figure 3/Figure 4). It has been reported that, together with the mastoid process, accessory air cells may develop in ten different regions of the temporal bone, such as the glenoid fossa and articular (Bronoosh vd., 2014:69).

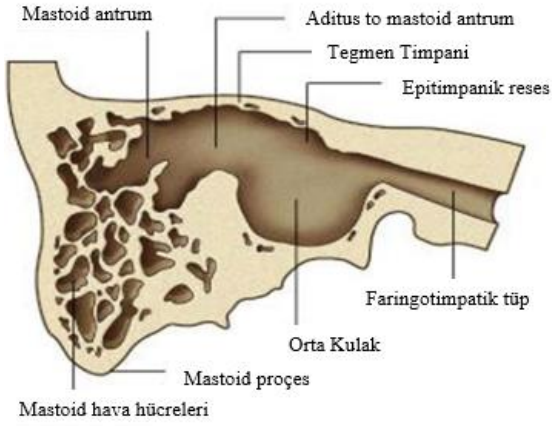


Figure 3: Anatomic image of mastoid air cells (Netter, 2017)

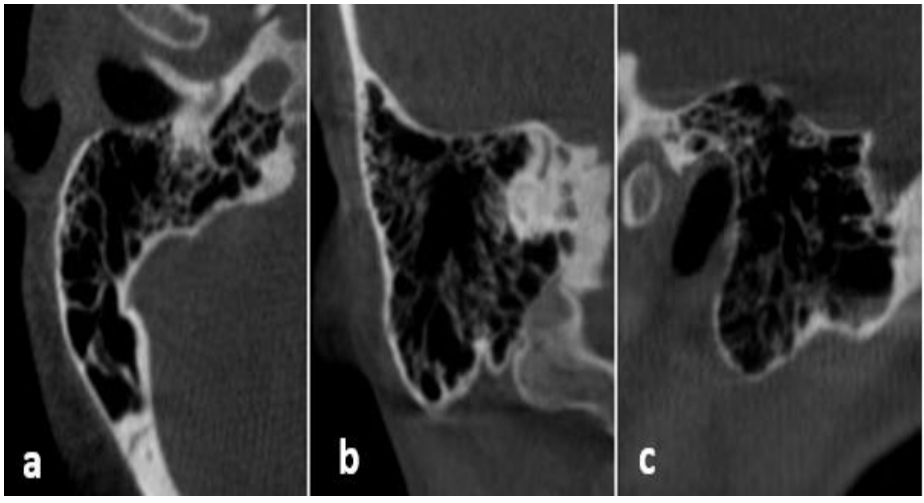


Figure 4: CBCT images of mastoid air cells (axial (a), coronal (b) and sagittal (c) sections)

Many studies have been conducted on the mastoid process from past to present. Although it is not yet definitive, it is accepted by many authors that there may be a correlation between some ear diseases such as chronic otitis and secretory otitis and mastoid process pneumatization (MPP) (Aoki vd., 1990:110), (Ikarashi ve Nakato, 1987:104), (Sade ve Hadas, 1989:225). It is known that these air cells facilitate the spread of inflammation, fractures,

tumors and various pathologies, and reduce the likelihood of fractures with their buffering effect at the time of trauma (Aoki vd., 1990:110), (Laderia vd., 2013:42). Despite these studies in the field of mastoid bone, the number of studies on pneumatization of other bones in the head and neck region is quite limited.

TMJ; Since it is the junction point of the mandible, maxilla and temporal bone, any pathological condition in these regions is likely to affect the TMJ. Since existing pneumatizations will facilitate the spread of pathologies, pneumatic formations in this region must be detected and kept under observation. The articular eminence and glenoid fossa of the temporal bone are important bone components of the TMJ. Pneumatized articular eminence or tubercle (PAT) and pneumatized glenoid fossa were defined by Tyndall and Matteson (1985:43) in 1985 as intrabony air spaces formed in the articular eminence of the temporal bone, resembling the air cells in the ethmoid bone and mastoid process (Figure 5/Figure 6). PATs are thought to be extensions of mastoid air cells, similar to extensions of paranasal sinuses. In previous studies, it was reported that pneumatization could occur in the alveolar bone and tuber region of the maxillary sinus and in the dorsum sella of the sphenoid sinus (Tyndall ve Matteson, 1985:43), (Ohan vd., 2006:35).

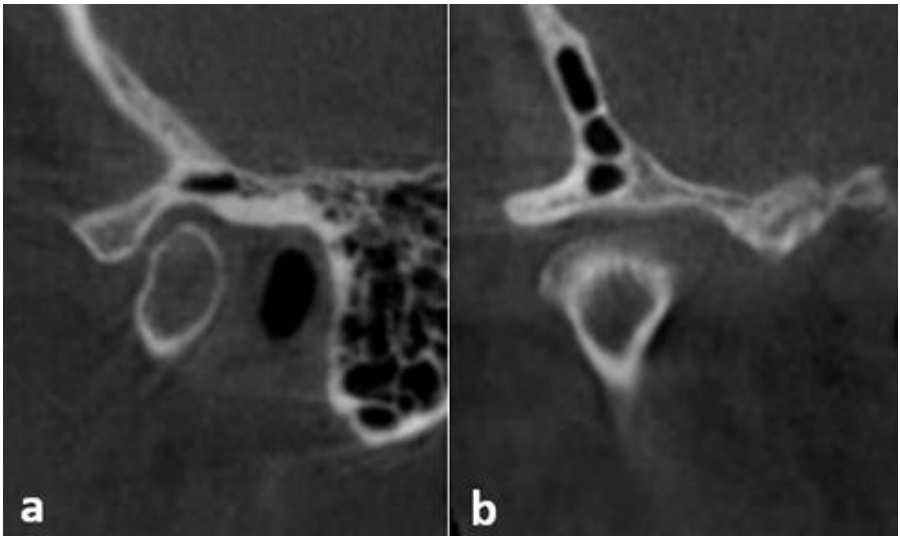


Figure 5: CBCT images of PGF (sagittal (a) and coranal (b) sections)

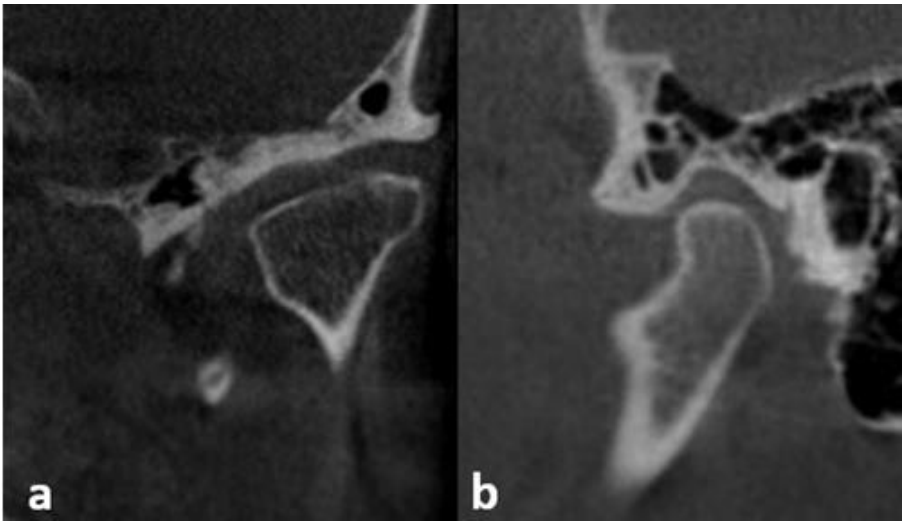


Figure 6: CBCT images of PAT (coranal (a) and sagittal (b) sections)

The differential diagnosis of PAT and PGF is one of the most discussed topics in the literature. Differential diagnosis of PAT should be made with hemagioma, aneurysmal bone cyst, giant cell tumor, eosinophilic granuloma, metastatic tumor and fibrous dysplasia. Almost all of these formations are characterized by pain, expansion and facial asymmetry. These formations are radiographically destructive and expansive type lesions. PAT is an asymptomatic formation that is noticed incidentally on radiography without causing any expansion or destruction (Shokri vd., 2013:43)

Zygoma involvement of aneurysmal bone cyst is very rare. It is distinguished from pneumatizations because it is observed as painful and expansive lesions on the body of the zygoma and may be accompanied by swelling in the cheek (Carter vd., 1999:28).

Bone hemangioma is a rare lesion with an incidence of 0.5-1.0% among all bone neoplasms (Savastano vd., 1999:28). It is known that these hemangiomas tend to be seen in the skull, vertebral column and long bones, and are also seen in the maxilla and mandible.

However, it has been stated in the literature that it is extremely rare in zygoma (Carter vd., 1999:28). Clinically, hemangiomas seen in the zygoma are seen as soft, spherical-shaped masses that expand upwards, characterized by slow-growing swelling. On radiography, it is observed as a uni- or multilocular, expansive radiolucent image that often has a honeycomb appearance and contains many lines similar to sunlight (Carter vd., 1999:28),

(Har-El vd., 1987:18). Differential diagnosis of bone hemangioma should be made by pneumatization before the operation (Carter vd., 1999:28).
Fibrous dysplasia primarily affects the frontal and sphenoid bones, followed by the ethmoid and parietal bones. It has been reported that the occipital and temporal bones are also rarely involved. Although a few cases have been reported in which the zygomatic arch is affected, it should be taken into consideration that all parts of the bone are affected when temporal bone is involved (Nager ve Holiday, 1984:93), (Wood ve Nortje, 1988:43).
The most common symptoms of fibrous dysplasia affecting the temporal bone are; It is stated as progressive hearing loss, slowly developing swelling, change in temporal bone borders and bone obliteration affecting the external auditory canal (Nager ve Holiday, 1984:93), (Ricciardelli vd., 1992:101). Radiographic features vary with the stage of the disease. While lesions in the early stages exhibit a radiolucent appearance, in advanced stages the matrix mineralization produced by the lesion increases bone density and is often observed as a ground glass, orange peel appearance or fingerprint pattern. A differential diagnosis of early fibrous dysplasia lesions and pneumatizations needs to be made (Carter vd., 1999:28).
Eosinophilic granuloma with temporal bone involvement is extremely rare, and zygomatic arch involvement has not been reported in any of the cases in the literature (Carter vd., 1999:28), (Hadjigeorgi vd., 1990:20). Eosinophilic granuloma involving the temporal bone erodes the mastoid cortex, tegmen tympani, cochlea and semicircular canals. Unlike pneumatations, eosinophilic granulomas are observed as expansive and destructive radiolucencies on radiography (Carter vd., 1999:28).

CONCLUSION

As a result, it can be said that pneumatic cells in this region are useful before surgical procedures involving the articular eminence and glenoid fossa region. Investigating the relationship between pneumatizations in different regions of the temporal bone, examining the prevalence and characteristic features of pneumatizations will shed light on the definition of the functions of these formations and their relationships with pathological conditions.

REFERENCES

1. Odar, İ.V. (1963). Anatomi ders kitabı ve atlası 1. cilt Hareket sistemi. 4. baskı. Ankara Üniversitesi Tıp Fakültesi Yayını.
2. Okeson, J.P. (2014). Management of temporomandibular disorders and occlusion-E-book: Elsevier Health Sciences.
3. Aksoy, S., Orhan, K. (2010). Temporomandibular eklem görüntüleme yöntemleri. Ondokuz Mayıs Üniversitesi Diş Hekimliği Fakültesi Dergisi, 11(2),69-78.
4. Erickson, M., Caruso, J., Leggitt, L. (2003). Newtom QR-DVT 9000 imaging used to confirm a clinical diagnosis of iatrogenic mandibular nerve paresthesia. Journal of the California Dental Association, 31(11), 843-845.
5. Ludlow, J.B., Davies-Ludlow, L., Brooks, S., Howerton, W.(2006). Dosimetry of 3 CBCT devices for oral and maxillofacial radiology: CB Mercuray, NewTom 3G and i-CAT. Dentomaxillofacial Radiology, 35(4), 219-226.
6. Hussain, A., Packota, G., Major, P., Flores-Mir, C. (2008). Role of different imaging modalities in assessment of temporomandibular joint erosions and osteophytes: a systematic review. Dentomaxillofacial Radiology, 37(2), 63-71.
7. Deluke, D.M. (1995). Pneumatization of the articular eminence of the temporal bone. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology, 1(79), 3-4.
8. Bronoosh, P., Shakibafard, A., Mokhtare, M., Rad, T.M. (2014). Temporal bone pneumatisation: a computed tomography study of pneumatized articular tubercle. Clinical radiology, 69(2), 151-6.
9. Aoki, K., Esaki, S., Honda, Y., Tosz, M. (1990). Effect of middle ear infection on pneumatization and growth of the mastoid process: an experimental study in pigs. Acta oto-laryngologica, 110(5-6), 399-409.
10. Ikarashi, H., Nakano, Y. (1987) The Effect of Chronic Middle Ear Inflammation on the Pneumatization of the Tympanic Bulls in Pigs. Acta oto-laryngologica, 104(1-2),130-137.
11. Sade, J., Hadas, E. (1979). Prognostic evaluation of secretory otitis media as a function of mastoidal pneumatisation. Archives of oto-rhino-laryngology, 225(1), 39-44.
12. Ladeira, D., Barbosa, G., Nascimento, M., Cruz, A., Freitas, D., Almeida, S. (2013). Prevalence and characteristics of pneumatization of the temporal bone evaluated by cone beam computed tomography. International journal of oral and maxillofacial surgery, 42(6),771-775.
13. Tyndall, D., Matteson, S. (1985). Radiographic appearance and population distribution of the pneumatized articular eminence of the temporal bone. Journal of Oral and Maxillofacial Surgery, 43(7),493-497.
14. Orhan, K., Delilbasi, C., Orhan, A. (2006). Radiographic evaluation of pneumatized articular eminence in a group of Turkish children. Dentomaxillofacial Radiology, 35(5), 365-370.
15. Shokri, A., Noruzi-Gangachin, M., Baharvand, M., Mortazavi, H. (2013). Prevalence and characteristics of pneumatized articular tubercle: First large series in Iranian people. Imaging science in dentistry, 43(4), 283-287.

16. Carter, L., Haller, A., Calamel, A., Pfaffenbach, A. (1999). Zygomatic air cell defect (ZACD). Prevalence and characteristics in a dental clinic outpatient population. Dentomaxillofacial Radiology, 28(2),116-122.
17. Savastano, G., Russo, A., Dell'Aquila, A. (1997). Osseous hemangioma of the zygoma: a case report. Journal of oral and maxillofacial surgery, 55(11), 1352-1356.
18. Har-El, G., Hadar, T., Zirkin, H.Y., Sidi, J. (1987). Hemangioma of the zygoma. Annals of plastic surgery, 18(6), 533-540.
19. Nager, G.T., Holliday, M.J. (1984). Fibrous dysplasia of the temporal bone: update with case reports. Annals of Otology, Rhinology & Laryngology, 93(6), 630-633.
20. Wood, R., Nortjé, C. (1988). General practitioner's radiology casebook X. Fibrous dysplasia of the maxilla and zygoma. The Journal of the Dental Association of South Africa= Die Tydskrif van die Tandheelkundige Vereniging van Suid-Afrika, 43(5), 251.
21. Ricciardelli, E.J., Borrow, J.A., Makielski, K.H. (1992). Three-dimensional computed tomography in a case of craniofacial fibrous dysplasia. Annals of Otology, Rhinology & Laryngology, 101(3),275-279.
22. Hadjigeorgi, C., Parpounas, C., Zarmakoupis, P., Lafoyianni, S. (1990). Eosinophilic granuloma of the temporal bone: radiological approach in the pediatric patient. Pediatric radiology, 20(7),546-549.

Excretory Disorders in Children

Özge PINARCIK SAKARYALI[1]

1-Prof. Dr.; Alanya Alaaddin Keykubat University, Department of Child Development, o_pinarcik@hotmail.com ORCID NO:0000-0001-9652-2089

1. ENURESIS

1.1. Definition

Enuresis is the involuntary or voluntary wetting of bedding or clothing during the night and/or day for at least three consecutive months in children over the age of five. The American Academy of Pediatrics defines enuresis as involuntary wetting of the bed or clothing during the day or night. Enuresis is derived from the Greek term "enourein," meaning to urinate. Although there are differences in methods and timing between societies regarding bladder control and toilet training, bedwetting is generally defined as enuresis in children over the age of 5 (Neyzi and Ertuğrul, 2002; Gündüz, 2020).

Enuresis is a significant and common health problem in childhood both worldwide and in our country. While the prevalence of enuresis worldwide ranges from 5% to 22%, in Turkey this rate is between 12.4% and 25.5% (Aras et al., 2007). Enuresis is more common in boys, and academic studies show that enuresis is influenced by environmental, ethnic, and socio-cultural factors. Factors such as being male, being the first child, having enuresis in the family, low socioeconomic status, and difficulty waking up are said to be important in the development of enuresis (Dolgun et al., 2012). If enuresis is not treated, it can continue into adolescence and even adulthood. Enuresis is one of the most common disorders encountered in pediatric health and disease, child mental health and disease, urology, and pediatric surgery clinics. Today, it ranks among the five most common disorders seen in child mental health clinics.

Enuresis is both a social and medical problem that can negatively affect families as well as children. Some studies have found that families tend to seek solutions to the problem by punishing children with enuresis, viewing behaviors that can negatively affect the child's self-esteem as a solution. However, some studies have also shown that despite these attitudes, families may neglect medical treatment for their children's problem. A study by Varol (2009) found that only 26.4% of families took their children to a doctor for treatment (Varol, 2009; cited in Gündüz, 2020).

1.2. Classification

Nocturnal enuresis is divided into two main groups: primary and secondary (Gündüz, 2020).

1.2.1. Primary Enuresis

Enuresis accounts for 80-85% of cases. Children in this situation have not yet gained bladder control. Enuresis is a problem that has persisted continuously since infancy. Primary enuresis may be caused by slow nervous and muscular development in the child, or it may be due to inappropriate toilet training. The

problem of primary enuresis disappears over time, and children who develop slowly in this regard compared to their peers eventually reach the level of their peers after a certain period of time (Gökduman, 2006).

1.2.2. Secondary Enuresis

It accounts for 20% of enuresis cases and refers to the recurrence of bedwetting after the child has remained dry for at least 6 months to 1 year. It is more common between the ages of 5 and 8. These cases are generally seen in situations that may cause psychological stress in the child, such as having a sibling or moving to a new home. In these situations, children may revert to immature behavior patterns, at least temporarily (Dönmez, 2004).

1.3. DSM-5 Diagnostic Criteria

A. Involuntary or voluntary, repeated urination in bed or on clothing.

B. This behavior is clinically significant because it occurs at least twice a week for at least three consecutive months or because it causes clinically significant distress or impairment in social, academic (occupational), or other important areas of functioning.

C. The individual is at least five years of age (or has a developmental level equivalent to five years of age).

D. This behavior cannot be attributed to the physiological effects of a substance (e.g., a diuretic, an antipsychotic medication) or another medical condition (e.g., diabetes, spina bifida, a developmental disorder).

1.4.Symptoms

Daytime symptoms accompanying nighttime symptoms (Toros et al., 2003):

• Daytime urinary incontinence

• Feeling an urgent need to go to the toilet

• Using various maneuvers such as crossing the legs, pressing the genital area with the hand, or dancing to delay urination

• Intermittent urination

• Difficulty initiating urination (resistant urination)

• Straining to initiate urination by contracting the abdominal muscles

• Dribbling after urination

• Feeling of incomplete bladder emptying after urination

• Weak urine stream

• Pain in the genital area during or after urination (pelvic pain)

1.5. Causes

1.5.1. Biological Causes

Family predisposition: Genetic factors are extremely important, as 70-75% of enuretic children have first-degree relatives who have also been diagnosed with enuresis. It is stated that if one parent has a history of nocturnal enuresis, the risk is 50%; if both parents have a history, the risk is 77%; and if neither parent is enuretic, the risk is 15%. The incidence of enuresis is also higher in identical twins (Dönmez, 2004).

Sleep disorders: Some researchers argue that enuresis is a sleep disorder. Studies investigating the relationship between sleep stages and enuresis suggest that deep sleep plays a role in the etiology of enuresis. While it is believed that enuretic children experience deep sleep at an advanced level, studies of sleep electroencephalography show no abnormality in the basic structure of sleep in these children. There are also studies that conclude that enuretic children respond later to calls made to wake them up than normal children, and that these children can only wake up after wetting the bed (Gündüz, 2020).

Factors related to the urinary system: Structural and neurological abnormalities in the urinary system, as well as urinary tract and bladder infections, are other prominent factors contributing to enuresis. Bladder and urinary tract infections are among the most common causes of enuresis, particularly in girls. Urinary tract infections are known to be responsible for 30% of secondary enuresis cases. Studies show that there is no difference in bladder capacity between children with nocturnal enuresis and children without enuresis. However, in children with nocturnal enuresis, the functional bladder capacity, which refers to the volume of the bladder at the time of emptying, is more limited. Therefore, limited functional bladder capacity can result in frequent urination during the day and bedwetting at night. In addition, while the internal sphincter functions fully in normal children by the age of six, this period may be longer in enuretic children (Bak et al., 2007).

Developmental issues: Some studies suggest that enuresis may be related to motor development. Some children with enuresis may also experience delays in speech and walking. Children diagnosed with enuresis may be shorter than other children and may be more common in babies with low birth weight (Gür et al., 2004).

Hormonal factors: In healthy individuals, the amount of urine produced at night is two to three times less than during the day. This normal rhythm is not yet established in children and is completed around the age of three. However,

this change is not completed in enuretic children, and therefore there is no decrease in the amount of urine produced at night (Yurtçu et al., 2006).

Other causes: Incomplete bladder emptying, intestinal parasites such as Enterobius vermicularis, chronic kidney failure, meningomyelocele, spinal cord tumors, convulsions, neurological disorders such as neurogenic bladder, upper airway obstruction, and secondary nocturnal enuresis may cause enuresis. Additionally, diabetes mellitus, diabetes insipidus, sickle cell anemia, and polyuria due to nighttime alcohol or caffeine intake may be seen in children (Unalacak et al., 2004).

1.5.2. Psychosocial Factors

Psychosocial factors also play an important role in the etiology of enuresis. Psychosocial factors include parents' attitudes during toilet training, stressful events, and accompanying psychiatric conditions (Neyzi and Ertuğrul, 2002: cited in Gündüz, 2020).

a. Problems related to toilet training: Toilet training that is started too early and involves pressure is a common cause of enuresis. Enuresis may occur as a reaction to toilet training that is imposed by overly strict mothers. On the other hand, not providing any toilet training at all can also cause enuresis. Toilet training is extremely important not only for the child but also for the parents. While some parents see toilet training as a way to get rid of dirty diapers, others want to experience another aspect of child development and the pride of being able to do this at an early age. For these reasons, no other developmental process is supported by parents as much as toilet training (Düşünsel, 2008).

b. Difficult life events: Enuresis is closely related to the child's emotional state. Academic studies also report that enuresis is more common in children who lack sufficient emotional interaction within the family. On the other hand, factors such as an extended family structure, inadequate educational conditions, and low parental education levels also increase the incidence of enuresis. Furthermore, anxieties caused by life events such as death, separation, discord, illness, and school failure within the family also increase the likelihood of enuresis. Furthermore, family discord, negative mother-child relationships, child neglect and abuse, and psychiatric problems in parents are also considered psychosocial factors that can play an important role in the etiology (Gündüz, 2020).

c. Accompanying psychiatric conditions: Studies show that children diagnosed with enuresis exhibit more behavioral problems than normal children. Research findings on the reasons for this also show that it stems from lower self-esteem and self-confidence in children with enuresis. The relationship between enuresis and mental disorders appears to increase with age. While these mental problems may be secondary to enuresis, enuresis is often secondary to these behavioral problems. Mental problems play a greater

role in the development of secondary enuresis, while mental retardation plays a greater role in the development of primary enuresis. Additionally, research findings indicate that children who wet the bed both at night and during the day exhibit more psychological symptoms (Gündüz, 2020).

1.6.Treatment

If enuresis persists into elementary school, the source of the problem should be investigated and these factors treated. The child's age, the frequency and consequences of the problem, and the urgency of treatment should be considered when choosing a treatment method. The combined use of different techniques is recommended in the treatment of nocturnal enuresis (Neyzi and Ertuğrul, 2002).

1.6.1. Non-Pharmacological Treatment Methods

a. Record-keeping and reward systems: This method requires maintaining a positive and constructive attitude toward the child and motivating them to stay dry. Keeping records and implementing reward systems during treatment is considered an effective method for increasing the child's motivation to stay dry and for fostering a sense of responsibility. Wet and dry nights are noted by the child on a calendar. It has been observed that this method of behavioral motivation results in improvement in 70% of patients. If the child does not respond to this treatment method within three to six months, other treatment methods should be considered (Dönmez, 2004).

b. Fluid restriction and nighttime waking: Regulating fluid intake and output is one of the simplest methods. Restricting fluid intake after dinner can reduce the amount of urine produced during sleep. The child should be taken to the bathroom immediately before bedtime and 1.5-2 hours after falling asleep. Regular bathroom breaks should also be ensured during the day. Efforts should be made to establish a toilet routine before leaving home in the morning and upon returning from school. The child should be taught not to hold their urine until the last moment, to relax during urination, to continue urinating until the bladder is completely empty, and to adopt an optimal posture (Gür et al., 2004).

c) Bladder and sphincter training: In the treatment process for functional and psychological enuresis, bladder training is initiated and parents should help the child develop the habit of urinating at specific times under their supervision. This method is known to be successful in approximately 30-35% of cases. This method can also be used in conjunction with sphincter training, which is defined as requests for the child to suddenly stop and continue urinating many times while urinating. The sphincter technique allows the child to increase muscle tone and also provides control over urination. It is stated that this method is generally beneficial for children over the age of nine (Gökduman, 2006).

d. Alarm sistemleri: Alarm sistemi yöntemini içeren özel yapılmış yataklar kullanılabilmektedir. Bu yataklar uykuda idrar kaçırma durumunda alarm vererek çocuğu uyandırmaktadır. Bir süre sonra çocuk koşullanmakta ve uyanıp tuvaletini yapma gereksinimi duymaktadır. Araştırmalar bu yöntemin başarı oranının %75 olduğunu, tekrar alt ıslatma oranının büyük ölçüde azaldığını göstermektedir (1,9). Ancak bu yöntemin kullanımı gece korkusu olan çocukların alarm gürültüsünden olumsuz etkilenmesi veya birçok ülkede sağlık sistemlerinin bu gideri karşılamaması gibi nedenlerden dolayı kısıtlıdır (Gündüz, 2020).

1.6.2. Pharmacological Treatment Methods

In the treatment of nocturnal enuresis, tricyclic antidepressants (imipramine, desipramine, and clomipramine), prostaglandin inhibitors (ibuprofen, diclofenac sodium), anticholinergics (oxybutynin chloride), diuretics (furosemide), amantadine, carbamazepine, and stimulants have been tried, with desmopressin and imipramine being the primary drugs used in treatment. The use of these drugs is recommended when other methods have failed. However, due to socio-economic difficulties, they are often the first choice for some patients (Gündüz, 2020).

2. ENCOPRESIS

2.1. Definition

Encopresis is fecal soiling associated with functional constipation in a child. Constipation and encopresis are common problems in children. According to the most recently published psychiatric diagnostic manual, DSM-V (Diagnostic and Statistical Manual of Mental Disorders), a diagnosis of encopresis requires that stool be passed in inappropriate places regularly (at least once a month) for three months. A child with normal development can consciously control their bowel movements from the age of 2-3 years. If a child still experiences fecal incontinence after the age of 3-4 years and there is no physical disorder, this is called “encopresis.” Encopresis is the passing of stool into clothing or any inappropriate place in children aged four and older. It is accepted that 95% of four-year-olds and 99% of five-year-olds gain bowel control (Collis et al., 2007).

2.2. Classification

Primary Encopresis: If the child has never developed control, it is primary encopresis.

Secondary Encopresis: If the child starts to have accidents after having developed control for at least one year, it is called secondary encopresis. It usually occurs more frequently during the day while awake. Secondary encopresis begins between the ages of 4 and 8. It is common in 1% of five-

year-old children. It is three times more common in boys than in girls. The child must be over four years of age and this condition must not be due to a general medical condition or substance use (American Psychiatric Association, 1994). Unlike the DSM, the ICD-10 specifies that the disorder must last at least six months (WHO, 1992).

2.3. DSM-5 Diagnostic Criteria

A. Repeated, involuntary or intentional soiling of inappropriate places (e.g., clothing, furniture).

B. At least one such incident occurs at least once a month for at least three months.

C. Chronological age is at least four years (or developmental level is equivalent).

D. This behavior cannot be attributed to the physiological effects of another medical condition, excluding those caused by a substance (e.g., laxatives) or a mechanism involving constipation.

With constipation and fecal incontinence: There is evidence of constipation in the physical examination or information provided in the medical history.

Without constipation and fecal incontinence: There is no evidence of constipation in the physical examination or information provided in the medical history (Köroğlu, 2013).

2.4.Symptoms

It manifests as diarrhea or constipation due to the inability to control the muscles at the anal opening. There is also a problem with defecating in inappropriate places.

2.5. Causes

Physiological causes: In some children with encopresis, anal manometry and electromyography (EMG) studies reveal an inability to relax the anal sphincter during defecation, inability to achieve adequate sphincter pressure during non-defecation times and with voluntary contraction of the anal sphincter, and paradoxical contraction of the anal sphincter and pelvic floor muscles during defecation (Butler and Heron, 2008).

Psychosocial factors: Psychosocial factors are also thought to play a role in the development and maintenance of encopresis. An adult study showed that rectal blood flow changed depending on emotional state in adults with constipation. In addition, decreased bowel motility and constipation have been reported in those exposed to chronic stress due to sympathetic system activation (Emmanuel et al., 2001).

Stresses during toilet training: The age range of 4-6 years old, when children start preschool and kindergarten, is the most effective age for toilet training. The period from birth to the start of primary education, aged 0-6 years, is referred to as preschool education or early childhood education. The quality of education provided during this period remains important throughout the child's subsequent years into adulthood. The gains acquired during this critical period, when learning and development are most intense, accompany the individual throughout their entire life. Thanks to preschool education, children who participate in social life will interact with their peers, learn to express themselves effectively, and discover their creative sides. Engaging in activities with a specific duration and sequence within a certain time frame will help the child develop their perception of time and space. As children of this age begin to take responsibility for their actions, an increase in their problem-solving skills and, consequently, their self-confidence can be observed. Children who have the opportunity to interact with their peers will both recognize their uniqueness and increase their sense of worth, as well as learn to exist within social life (Muti, 2020).

Attention Deficit Hyperactivity Disorder: It has been suggested that children with Attention Deficit Hyperactivity Disorder may fail to notice rectal tension and delay going to the toilet due to their short attention span and poor selective attention. Furthermore, when sitting on the toilet, impulsivity prevents them from sitting long enough to fully empty their bowels. leading to constipation and, consequently, encopresis. Considering these mechanisms, it has been suggested that ADHD should be considered among the etiological factors, as opposed to comorbidity. Furthermore, it has been reported that encopresis is more common in children who have been sexually abused and in children with developmental delays compared to the general population (Cox et al., 2002).

Family-related reasons: It is believed that the attitudes and personality traits of the mother and father also play a role in the development and persistence of encopresis. The child's inability to control their bowel movements causes anger and fear of this socially unacceptable event in a mother with such traits. In addition, the mother begins to exert more pressure out of fear that she will lose her parental authority and control over the child. The child, in turn, continues to express his anger towards his mother by defecating in inappropriate places and tries to show through his behavior that he wants to control his own bowels. This struggle for control between mother and child continues in a vicious cycle. In some families with dysfunctional family roles, this situation serves to maintain the family, and the family's other functions are left out of the agenda (Muti, 2020).

2.6.Treatment

Establishing a good therapeutic relationship with the family and child is very important in the treatment of encopresis. First, the stubbornness and power

struggle seen between the family and the child should be addressed, and it should be explained to the family and child that this is not the child's fault, but rather that this situation occurs because the child has lost the sensation of defecation. This aims to reduce the child's sense of guilt and eliminate the family's perception that the child is “doing it on purpose, to spite us.” It is emphasized that the responsibility lies with the child, and the child is shielded from the family's potentially angry reactions. The family and child are informed about the chronic course of the disease and their expectations are adjusted accordingly. Motivational interviews are planned. Behavioral tasks are assigned to the child and family. If constipation is present, medication treatment may be initiated (Muti, 2020).

2.6.1.Behavioral therapy

In behavioral therapy, it is recommended that the child go to the toilet 3-4 times a day, especially after meals, and sit for 5 minutes. This aims to help the child regain the sensation of defecation that they have lost over time by utilizing the gastrocolic reflex, prevent constipation by keeping the bowels empty, and restore the tone and reduce the volume of the rectum, which has lost its tone and become enlarged. The family can reward the child when they defecate in the toilet, but should ignore them when they soil themselves. Additionally, an agreement should be made with the child to go to the toilet without delay when they feel the urge to defecate (Lorenzo and Benninga, 2004).

The toilet should be made into an appealing place rather than a place that children fear and dislike. Once toilet habits are established (when the child defecates 1-2 times a day), toilet visits can be spaced out. However, the child should keep a separate daily record of accidents, toilet use, and sitting on the toilet. The child should fill out the log themselves. This ensures both treatment follow-up and the child's motivation. Furthermore, as a sign of giving responsibility to the child, it is recommended that the child wash their own underwear when they have an accident, or ask their mother for help if they cannot do it themselves (Muti, 2020).

2.6.2. Laxative therapy

Laxative therapy is recommended as a two-step process: The evacuation (disimpaction) phase aims to remove accumulated feces from the patient's intestines. For this purpose, polyethylene glycol, liquid paraffin, lactulose/lactitol, bisacodyl, phosphate enemas for severe cases, and other enemas can be used. Maintenance therapy aims to prevent stool accumulation in the rectosigmoid region (Kuhn, Marcus, and Pitner, 1999).

2.6.3. Other medications

Limited research has reported that imipramine, amitriptyline, and cisapride are beneficial in the treatment of encopresis. However, cisapride is not recommended due to its serious side effects. In a study comparing behavioral therapy and imipramine, no difference was found between the two groups in terms of treatment response (Mikkelsen, 2001).

2.6.4. Psychotherapy

It has been reported that psychotherapy can be used in treatment in cases where there are other psychopathologies in addition to encopresis, where the child experiences feelings of guilt and shame, and where family dynamics contribute to the persistence of symptoms. For this purpose, family therapy, play therapy, and individual psychotherapy can be used. However, the superiority of these methods over other methods has not been demonstrated. In addition, it has been reported that behavioral family therapy, as part of a multidisciplinary treatment approach combined with medical treatments, achieves success rates of 43-75%. In cases with comorbid psychiatric disorders, it is thought that the response to treatment is negatively affected by the comorbid disorder, and that the treatment of the accompanying psychiatric disorder will have a positive effect on the outcome (Carr, 2009).

2.6.5. Biofeedback

Based on the hypothesis that the anal sphincters and pelvic floor muscles of some encopretic children do not function properly, some researchers have developed the pressure biofeedback method. This method uses manometry or EMG to provide auditory, visual, or verbal feedback, attempting to teach the child normal defecation patterns (Muti, 2020).

2.6.6. Other treatment methods

Other treatment methods include massage therapy, probiotics, electrical nerve stimulation, reflexology, and acupuncture, but these methods have not yet been sufficiently researched (Culbert and Bonez, 2007).

REFERENCE

Amerikan Psikiyatri Birliği (1994). DSM-IV Mental bozuklukların tanımsal ve sayımsal el kitabı. Dördüncü baskı, (çeviri editörü Köroğlu E,) pp:65-66 Hekimler yayın birliği, Ankara.

Aras, Ş., Ünlü, G., Taş, F. V. (2007). Çocuk ve ergen psikiyatrisi polikliniğine başvuran hastalarda belirtiler, tanılar ve tanıya yönelik incelemeler, Klinik Psikiyatri Dergisi, 10: 28-37.

Bak, M., Bıcılıoğlu, Y., Serdaroğlu, E. (2007). Monosemptomatik nokturnal enürezis ve tedavisi, Türkiye Klinikleri J Pediatri, 16: 104-117.

Butler, R. J., Heron, J. (2008). The Prevalence of Infrequent Bedwtting and Nocturnal Enuresis in Childhood., Scandinavian Journal of Urology and Nephrology, 42(3), 257-264.

Carr, A. (2009). The effectiveness of family therapy and systemic interventions for child focused problems. Journal of Family Therapy, 31:3–45.

Collis, D., R., Norton, L., N., Wallis, M., C. (2007). Childhood constipation in children: an innovative community-based parent education group program. Australian occupational therapy journal, 54:307-309.

Cox, D. J., Morris, J. B., Borowitz, S., Sutphen, J. L. (2002). Psychological Differences Between Children With and Without Chronic Encopresis, Journal of Pediatric Psychology, 27(7): 585-591.

Culbert, T. P., Banez, G. A. (2007). Integrative Approaches to Childhood Constipation and Encopresis. Pediatr Clin N Am, 54:927-947.

Dolgun, G, Savaşer, S, Balcı, S, Yazıcı S. (2012). Prevalance of nocturnal enuresis and related factors in children aged 5-13 in İstanbul, Iran J Pediatr, 22: 205-212.

Dönmez O. (2004). Çocuklarda Nokturnal Enürezis, Güncel Pediatri Dergisi, 134-136.

Düşünsel, R. (2008). Enürezis Nokturnalı Çocuğa Yaklaşım. J Curr Pediatr; 6(1)

Emmanuel, A. V., Mason, H. J., Kamm, M. A. (2001). Relationship between psychological state and level of activity of extrinsic gut innervation in patients with a functional gut disorder. Gut, 49:209–211.

Gökduman, M. K. (2006). Enürezis Nokturna Tedavisinde Davranış Tedavisinin Etkinliği; Davranış Tedavisine Yanıtsız Vakalarda İmipramin ve Oksibutinin Tedavisi, Uzmanlık Tezi, İstanbul: Kartal Eğitim ve Araştırma Hastanesi Çocuk Sağlığı ve Hastalığı 2. Çocuk Kliniği.

Gündüz, Buse. Okul Çocuklarında (5-12 Yaş) Enürezis Sıklığının Endişe Düzeyi ile İlişkisi. Yüksek Lisans Tezi, İstanbul Okan Üniversitesi Lisansüstü Eğitim Enstitüsü, 2020.

Gür, E., Turhan, P., Can, G., Akkuş, S., Sever, L., Güzelöz, S., Cifçili, S., Arvas, A. (2004). Enuresis: prevalence, risk factors and urinary pathology among school children in Istanbul, Turkey. Pediatr Int, 46(1):58-63.

Köroğlu, E. (2013). DSM-5 Tanı Ölçütleri Başvuru Kitabı, Hekimler Yayın Birliği, Ankara

Kuhn, B. R., Marcus, B. A., Pitner, S. L. (1999). Treatment guidelines for primary nonretentive encopresis and stool toileting refusal. Am Fam Physician. 15; 59(8): 2171-2178, 2184-6. PMID: 10221303.

Lorenzo, C. D., and Benninga, M. A. (2004). Pathopysiology of Pediatric Fecal Incontinence. Gastroenterology, 126(1): 33-40. doi: 10.1053/j.gastro.2003.10.012. PMID: 14978636.

Mikkelsen, E. J. (2001). Enuresis and encopresis: ten years of progress. J Am Acad Child Adolesc Psychiatry, 40:1146-1158.

Muti, A. S. (2020). Rize İlinde Yaşayan 4-11 Yaş Arası Çocuklarda Enkoprezis Sıklığının Araştırılması ve Etiyolojide Rol Alan Etkenlerin Araştırılması. Doktora Tezi, Recep Tayyip Erdoğan Üniversitesi Tıp Fakültesi.

Neyzi O., Ertuğrul T. (2002). Pediatri 1-2, Nobel Tıp Kitabevi, İstanbul.

Toros, F., Tot, Ş., Bozlu, M., Okyay, Y., & Çamdeviren, H. (2003). Dikkat Eksikliği Hiperaktivite Bozukluğu ve Primer Enürezis Nokturnalı Çocukların Annelerindeki Psikiyatrik Belirtiler ve Yeti Yitimi. Klinik Psikiyatri, 6:135-140

Unalacak, M., Sogut A, Aktunç E, Demircan N, Altın. R. Enuresis nocturnal prevalence and risk factors among school age children in Northwest Turkey, Eur J Gen Med, 2004, 1(3): 21-25.

World Health Organisation (1992). The ICD-10 Classification of Mental and Behavioural Disorders: B. Clinical Descriptions and Diagnostic Guidelines. WHO, Genova.

Yurtçu, M., Bilban, S., Dinçer, Ş., Bakıcı, H., Şahin, T. K, Günel, E. (2006). Sağlıklı ve enüretik çocuklarda idrar tutabilme yaşlarının araştırılması, TAF Preventive Medicine Bulletin, 5(1): 41-49.

Anatomical Foundations of Neurocardiac Communication

Albaraa RIYADH MOHAMMED AL-SAMANEE [1]
Rukiye Sümeyye BAKICI [2]
Zülal EKİNCİOĞLU ÖNER [3]

[1] Dr. Albaraa RIYADH MOHAMMED AL-SAMANEE, Karabuk University, Faculty of Medicine, Department of Anatomy, dr.mousl.love@gmail.com, 0000-0002-6707-4085

[2] Dr. Öğr. Üyesi Rukiye Sumeyye BAKICI, Karabük University, Faculty of Medicine, Department of Anatomy, sumeyyebakici@karabuk.edu.tr, 0000-0001-8008-7174

[3] Prof. Dr. Zulal EKINCIOGLU ONER, İzmir Bakırçay University, Faculty of Medicine, Department of Anatomy, zulal.oner@bakircay.edu.tr, 0000-0003-0459-1015

ABSTRACT

The bidirectional communication between the heart and the brain, known as the heart-brain axis, represents a fundamental concept in integrative physiology. This discourse transcends the traditional perception of the heart as a mere mechanical pump and the brain as its simple regulator, revealing instead a highly complex network of continuous neurocardiac interaction. This article provides an extensive and integrative examination of the neuroanatomical foundations underlying this axis. We describe in detail the extrinsic innervation of the heart through the autonomic nervous system, emphasizing both the sympathetic and parasympathetic pathways, along with their essential afferent and efferent components that sustain dynamic feedback loops. Furthermore, we explore the intricate organization of the intrinsic cardiac nervous system (ICNS), often referred to as the "heart brain," highlighting its anatomical distribution, neuronal composition, and its crucial role in local information processing and modulation of cardiac function. Central processing of cardiac afferent signals within the brainstem, hypothalamus, limbic system, and cerebral cortex is also analyzed, demonstrating how emotional, cognitive, and autonomic centers are interconnected. Finally, we correlate these structural and functional mechanisms with clinical implications, emphasizing how dysfunctions in the heart-brain axis contribute to diverse neurological and cardiovascular pathologies. This comprehensive review underscores the heart and brain as an integrated, reciprocally communicating system rather than separate entities.

Keywords: Neurocardiac Communication, Neuroanatomy, Autonomic Nervous System, Vagus Nerve, Intrinsic Cardiac Nervous System, Nucleus Tractus Solitarius, Heart-Brain Axis.

INTRODUCTION

The heart has traditionally been considered the locus of emotions and intellect, whereas the brain has been attributed with the functions of logic and reasoning (Hestad et al., 2022). Nonetheless, progress in

neuroanatomy and neurophysiology in recent centuries has unveiled a significantly more intricate and captivating narrative. The connection between the heart and the brain is recognized as a profound, reciprocal alliance, supported by a complex network of neuronal, hormonal, and hemodynamic pathways (Silvani et al., 2016). The heart is now regarded as an active sensory organ with its own nervous system, rather than a passive entity that merely obeys the brain's commands. It continuously transmits intricate information to the brain, which subsequently affects perceptual, emotional, and cognitive processes (Giannino et al., 2024). Neurocardiology is a research subject focused on elucidating this complex interaction (Goh et al., 2025). A comprehensive understanding of the neuroanatomical foundations that establish the communication channel between these two organs is vital to grasping the functional mechanisms of this integration, including autonomic regulation, emotional processing, and cognitive influence (Hanna & Ardell, 2024). This chapter aims to elucidate their anatomical basis comprehensively. We shall examine the neural connections between the heart and the brain, starting with the nerves on the heart's surface, advancing via the spinal cord and brainstem circuits, and concluding with the higher processing regions in the cerebral cortex. This exposition seeks to establish that heart and cerebral health are fundamentally interconnected at the anatomical level.

1. Historical Perspective on the Heart-Brain Connection

Understanding anatomical concepts necessitates consideration of their historical context. In ancient civilizations like Egypt, the heart was the sole organ preserved during mummification, as it was regarded as the center of the soul and intellect (Ziskind & Halioua, 2004). Likewise, the Greek philosopher Aristotle stated that the heart serves as the center of sensation, movement, and cognition, but he considered the brain's function to be only the cooling of the blood. The Renaissance, marked by anatomical discoveries led by individuals such as Andreas Vesalius in the 16th century, initiated a change in focus toward the brain, although the conviction of the heart's primary importance remained (Mesquita et al., 2015). The 19th century, marked by the

elucidation of the autonomic nervous system by researchers like Langley and Gaskell, established the foundation for comprehending the heart's extrinsic innervation (Lemery, 2024). The crucial turning point occurred in the late 20th century due to the groundbreaking contributions of Dr. J. Andrew Armour. He presented the notion of the intrinsic cardiac nervous system (ICNS), offering comprehensive descriptions of a sophisticated network of ganglionated neurons on the heart's surface, which resulted in the coining of the term "the little brain in the heart" (Armour, 2008). This revelation changed our understanding of the heart, portraying it not merely as a passive entity but as an active participant in an ongoing neurological dialogue with the brain.

2. Extrinsic Cardiac Innervation: The Autonomic Nervous System

The autonomic nervous system (ANS) serves as the principal communication pathway between the central nervous system and the heart. It is partitioned into two equilibrated yet functionally opposing divisions: the sympathetic and parasympathetic nerve systems (Shen, 2021). The sympathetic circuit facilitates the "fight or flight" response by augmenting heart rate (chronotropy), enhancing contractile force (inotropy), and accelerating conduction velocity (dromotropy) (Goldberger et al., 2019). The preganglionic neuronal cell bodies of this system arise in the intermediolateral gray column of the spinal cord, particularly within the thoracic segments T1 to T5 (Yau et al., 1991). The efferent fibers leave the spinal cord through the ventral roots and create the white rami communicantes, which proceed to the paravertebral ganglia of the sympathetic chain. The majority of these fibers synapse in the cervical and thoracic ganglia, especially within the stellate ganglion (a fusion of the inferior cervical and first thoracic ganglia) and the upper thoracic ganglia (Seki et al., 2014). The unmyelinated postganglionic fibers, termed gray rami communicantes, originate from these ganglia and converge to create the cardiac plexus. The sympathetic nerves subsequently penetrate the heart and extensively innervate the sinoatrial (SA) node to elevate heart rate, the atrioventricular (AV) node to improve conduction velocity, the atrial and ventricular myocardium to enhance contractile

strength, and the coronary arteries to promote vasodilation for increased blood flow (Durães Campos et al., 2018). The parasympathetic system, conversely, facilitates the "rest and digest" response by decreasing heart rate, diminishing contractile force, and narrowing the coronary arteries (Takahashi et al., 2007). The preganglionic neuronal cell bodies for this system largely arise from the nucleus ambiguus and partially from the dorsal motor nucleus of the vagus (DVM) in the medulla oblongata (Massari et al., 1995). The axons of these neurons traverse the vagus nerve (cranial nerve X), the principal nerve of the parasympathetic system. These fibers traverse the vagus nerve until they arrive at the heart. They synapse within tiny ganglia situated on the epicardial surface of the heart, which are components of the intrinsic cardiac neural system, predominantly concentrated around the atria and pulmonary veins (Wink et al., 2020). From these intrinsic cardiac ganglia, brief postganglionic fibers arise to innervate the SA node, thereby reducing the heart rate, and the AV node, which prolongs conduction and enhances its refractory time; their innervation of the ventricular myocardium is minimal (Fedele & Brand, 2020). The crucial element in comprehending the bidirectional nature of this discussion is the function of afferent (sensory) fibers. Approximately 80-85% of the fibers of the vagus nerve are afferent, conveying information from the heart and internal organs to the brain (van Weperen et al., 2023). The cardiac walls, coronary arteries, and aorta house diverse sensory receptors, such as baroreceptors that detect stretch due to pressure fluctuations, chemoreceptors that monitor variations in oxygen, carbon dioxide, and pH levels, and mechanoreceptors that perceive alterations in volume and muscular contraction (Fahim, 2003). Signals from these receptors are sent through afferent fibers in the vagus nerve and some sympathetic pathways. All convergent information culminates in the nucleus of the solitary tract (NTS) within the medulla oblongata, functioning as the principal central receiving station for visceral information from the heart and other regions (Ishii et al., 2010).

3. The Intrinsic Cardiac Nervous System (ICNS): The Heart's Little Brain

The ICNS is a sophisticated and interconnected network of neurons, ganglia, and pathways situated within the heart. It is not solely a relay point for extrinsic pathways but operates as an integrated processor. The ganglia of the ICNS are predominantly situated in the adipose tissue on the epicardial surface of the heart, with substantial aggregations located in the dorsal region between the atria, surrounding the origins of the pulmonary veins and vena cava, as well as on the anterior and posterior surfaces of the atria; innervation of the ventricles is comparatively sparse (Aksu et al., 2021). The cellular structure of the ICNS comprises various neuron types: motor (efferent) neurons that synapse with preganglionic fibers from the vagus and sympathetic nerves, subsequently transmitting their axons to cardiomyocytes; sensory (afferent) neurons that sense local alterations in the heart and relay information to other ICNS ganglia and the brain; and local interneurons that interconnect neurons within and across different ganglia, facilitating local information processing and integration without direct reliance on the brain (Birand, 2008). The ICNS functions as a local coordinator. It amalgamates signals from the brain (through the ANS) and the heart, precisely modulating cardiac output (heart rate, contractility) in a coordinated fashion, mediates local reflexes (such as the Bezold-Jarisch reflex, which reacts to ventricular ischemia by inducing bradycardia and hypotension through vagal stimulation), and functions as a filter for sensory information prior to transmission to the brain, thereby averting informational overload (Ghali, 2017).

4. Central Processing: From Brainstem to Cortex

Afferent information from the heart is not merely processed at the NTS; it is integrated and disseminated to higher brain areas. The nucleus of the NTS in the brainstem serves as the primary hub. Information is transmitted to the DMV and the nucleus ambiguus to regulate the efferent activity of the vagus nerve (e.g., the baroreflex), to the rostral ventrolateral medulla for the modulation of sympathetic outflow, and to the locus coeruleus and ventral tegmental area to affect arousal and the dopaminergic system (Mastitskaya et al., 2020). The hypothalamus serves as the principal coordinator between the

autonomic nervous system and the endocrine system. It obtains information from the NTS and coordinates suitable responses to stress, exercise, temperature, and emotion (Ulrich-Lai & Herman, 2009). The limbic system establishes the emotional connection. The amygdala processes information on cardiac status and activates in response to anxiety and stress, transmitting signals to the hypothalamus and brainstem to effectuate alterations in heart rate (Vancheri et al., 2022). The hippocampus has a role in the establishment of memories for emotional events associated with alterations in heart activity. The anterior cingulate cortex is involved in emotion regulation and the synthesis of sensory-emotional impulses (Aldhafeeri, 2025). The insular cortex serves as the principal visceral sensory cortex at the cortical level. It obtains direct input from the NTS through the thalamus and is accountable for the conscious sense of heart activity, including palpitations. Right insula activity correlates with sympathetic activation (e.g., elevated heart rate), whereas left insula activity is associated with parasympathetic activity (Makovac et al., 2018). The prefrontal cortex, especially the orbitofrontal and ventromedial areas, exerts top-down inhibitory regulation on the amygdala and brainstem nuclei. It is crucial for emotional adaptation and autonomic flexibility. Prefrontal brain dysfunction results in diminished control, leading to the predominance of emotional and sympathetic reactions, which is evidenced by a decrease in heart rate variability (HRV) (Wei et al., 2018).

5. Functional Mechanisms and Clinical Implications

The outlined neuroanatomical structure facilitates various functional communication modalities: neural communication through sympathetic and parasympathetic pathways and afferent fibers; endocrine communication via the hypothalamic-pituitary-adrenal axis, wherein stress-induced cortisol secretion impacts both cardiac and cerebral functions; and mechanical/hemodynamic communication, whereby alterations in blood pressure and cardiac output detected by baroreceptors affect cerebral perfusion and functionality (Marina et al., 2020). Comprehending this neuroanatomy elucidates several clinical disorders. The correlation between

depression and heart disease can be elucidated by diminished prefrontal brain activity and elevated amygdala activity in depression, resulting in autonomic imbalance (lower HRV), which heightens the risk of cardiac arrhythmia and accelerates atherosclerosis (Philippi et al., 2024). Takotsubo cardiomyopathy, also known as stress-induced cardiomyopathy, arises from a significant release of catecholamines due to severe sympathetic activation caused by acute emotional distress, which can "stun" the ventricular myocardium (Lyon et al., 2008). Autonomic dysfunction in neurodegenerative illnesses, including Parkinson's disease, arises when Lewy body pathology disseminates to the sympathetic ganglia and vagal nuclei, resulting in orthostatic hypotension, persistent tachycardia, and further manifestations of dysautonomia. Sudden unexpected death in epilepsy may result from the propagation of seizure activity to the central cardiac control centers in the brainstem, culminating in cardiac arrest (Benarroch, 2014).

CONCLUSION

The comprehensive neuroanatomical analysis demonstrates that neurocardiac communication is a concrete physiological phenomenon, rather than a mere philosophical concept. It is a sophisticated, multi-tiered system that extends from the neurons within the heart to the highest cognitive centers in the cerebral cortex. This anatomical axis underpins integrated health: a healthy heart necessitates a healthy brain for regulation, while a healthy brain requires a healthy heart for sustenance and regulation. This comprehension paves the way for a novel paradigm in medicine, wherein the management of cardiac ailments necessitates a neurological approach, and the management of neurological disorders requires a cardiac perspective. Future research should concentrate on the meticulous mapping of these circuits and the advancement of treatment approaches, such as vagus nerve stimulation, that directly target this axis.

REFERENCES

Hestad, K. A., Engedal, K., Hollan, I., & Girouard, H. (2022). Editorial: The heart-brain connection in emotions, cognition, and dementia. *Frontiers in aging neuroscience*, *14*, 1074280.

Silvani, A., Calandra-Buonaura, G., Dampney, R. A., & Cortelli, P. (2016). Brain-heart interactions: physiology and clinical implications. *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, *374*(2067), 20150181.

Giannino, G., Braia, V., Griffith Brookles, C., Giacobbe, F., D'Ascenzo, F., Angelini, F., Saglietto, A., De Ferrari, G. M., & Dusi, V. (2024). The Intrinsic Cardiac Nervous System: From Pathophysiology to Therapeutic Implications. *Biology*, *13*(2), 105.

Goh, F. Q., Tan, B. Y. Q., Yeo, L. L. L., & Sia, C. H. (2025). The Heart-Brain Axis: Key Concepts in Neurocardiology. *Cardiology discovery*, *5*(2), 162–177.

Hanna, P., & Ardell, J. L. (2024). Cardiac Neuroanatomy and Fundamentals of Neurocardiology. *Cardiac electrophysiology clinics*, *16*(3), 229–237.

Ziskind, B., & Halioua, B. (2004). La conception du coeur dans l'Egypte ancienne [Concepts of the heart in Ancient Egypt]. *Medecine sciences: M/S*, *20*(3), 367–373.

Mesquita, E. T., Souza Júnior, C. V., & Ferreira, T. R. (2015). Andreas Vesalius 500 years--A Renaissance that revolutionized cardiovascular knowledge. *Revista brasileira de cirurgia cardiovascular: orgao oficial da Sociedade Brasileira de Cirurgia Cardiovascular*, *30*(2), 260–265.

Lemery R. (2024). Historical Perspective of the Cardiac Autonomic Nervous System. *Cardiac electrophysiology clinics*, *16*(3), 219–227.

Armour J. A. (2008). Potential clinical relevance of the 'little brain' on the mammalian heart. *Experimental physiology*, *93*(2), 165–176.

Shen M. J. (2021). The cardiac autonomic nervous system: an introduction. Das kardiale autonome Nervensystem: eine Einführung. *Herzschrittmachertherapie & Elektrophysiologie*, *32*(3), 295–301.

Goldberger, J. J., Arora, R., Buckley, U., & Shivkumar, K. (2019). Autonomic Nervous System Dysfunction: JACC Focus Seminar. *Journal of the American College of Cardiology*, *73*(10), 1189–1206.

Yau, J. I., Wu, J. J., & Liu, J. C. (1991). Origins of the afferent fibers to the cat superior cervical ganglion. *Proceedings of the National Science Council, Republic of China. Part B, Life sciences*, *15*(1), 1–7.

Seki, A., Green, H. R., Lee, T. D., Hong, L., Tan, J., Vinters, H. V., Chen, P. S., & Fishbein, M. C. (2014). Sympathetic nerve fibers in human cervical and thoracic vagus nerves. *Heart rhythm*, *11*(8), 1411–1417.

Durães Campos, I., Pinto, V., Sousa, N., & Pereira, V. H. (2018). A brain within the heart: A review on the intracardiac nervous system. *Journal of molecular and cellular cardiology*, *119*, 1–9.

Takahashi, M., Matsukawa, K., Nakamoto, T., Tsuchimochi, H., Sakaguchi, A., Kawaguchi, K., & Onari, K. (2007). Control of heart rate variability by cardiac parasympathetic nerve activity during voluntary static exercise in humans with tetraplegia. *Journal of applied physiology (Bethesda, Md.: 1985)*, *103*(5), 1669–1677.

Massari, V. J., Johnson, T. A., & Gatti, P. J. (1995). Cardiotopic organization of the nucleus ambiguus? An anatomical and physiological analysis of neurons regulating atrioventricular conduction. *Brain research*, *679*(2), 227–240.

Wink, J., van Delft, R., Notenboom, R. G. E., Wouters, P. F., DeRuiter, M. C., Plevier, J. W. M., & Jongbloed, M. R. M. (2020). Human adult cardiac autonomic innervation: Controversies in anatomical knowledge and relevance for cardiac neuromodulation. *Autonomic neuroscience: basic & clinical*, *227*, 102674.

Fedele, L., & Brand, T. (2020). The Intrinsic Cardiac Nervous System and Its Role in Cardiac Pacemaking and Conduction. *Journal of Cardiovascular Development and Disease*, *7*(4), 54.

van Weperen, V. Y. H., & Vaseghi, M. (2023). Cardiac vagal afferent neurotransmission in health and disease: review and knowledge gaps. *Frontiers in neuroscience*, *17*, 1192188.

Fahim M. (2003). Cardiovascular sensory receptors and their regulatory mechanisms. *Indian journal of physiology and pharmacology*, *47*(2), 124–146.

Ishii, H., Niioka, T., & Izumi, H. (2010). Vagal visceral inputs to the nucleus of the solitary tract: involvement in a parasympathetic reflex vasodilator pathway in the rat masseter muscle. *Brain research*, *1312*, 41–53.

Aksu, T., Gupta, D., & Pauza, D. H. (2021). Anatomy and Physiology of Intrinsic Cardiac Autonomic Nervous System: Da Vinci Anatomy Card #2. *JACC. Case reports*, *3*(4), 625–629.

Birand A. (2008). Kalbin içrek gangliyonlanmiş nöral pleksusu [Intrinsic cardiac ganglia]. *Anadolu kardiyoloji dergisi: AKD = the Anatolian journal of cardiology*, *8*(6), 451–454.

Ghali M. G. Z. (2017). Role of the medullary lateral tegmental field in sympathetic control. *Journal of integrative neuroscience*, *16*(2), 189–208.

Mastitskaya, S., Turovsky, E., Marina, N., Theparambil, S. M., Hadjihambi, A., Kasparov, S., Teschemacher, A. G., Ramage, A. G., Gourine, A. V., & Hosford, P. S. (2020). Astrocytes Modulate Baroreflex Sensitivity at the Level of the Nucleus of the Solitary Tract. *The Journal of neuroscience: the official journal of the Society for Neuroscience*, *40*(15), 3052–3062.

Ulrich-Lai, Y. M., & Herman, J. P. (2009). Neural regulation of endocrine and autonomic stress responses. *Nature reviews. Neuroscience*, *10*(6), 397–409.

Vancheri, F., Longo, G., Vancheri, E., & Henein, M. Y. (2022). Mental Stress and Cardiovascular Health-Part I. *Journal of clinical medicine*, *11*(12), 3353.

Aldhafeeri F. M. (2025). Distinct neural circuits processing pleasant and unpleasant sounds: an fMRI-based approach. *BMC neuroscience*, *26*(1), 52.

Makovac, E., Garfinkel, S., Bassi, A., Basile, B., Macaluso, E., Cercignani, M., Calcagnini, G., Mattei, E., Mancini, M., Agalliu, D., Cortelli, P., Caltagirone, C., Critchley, H., & Bozzali, M. (2018). Fear processing is differentially affected by lateralized stimulation of carotid baroreceptors. *Cortex; a journal devoted to the study of the nervous system and behavior*, *99*, 200–212.

Wei, L., Chen, H., & Wu, G. R. (2018). Structural Covariance of the Prefrontal-Amygdala Pathways Associated with Heart Rate Variability. *Frontiers in human neuroscience*, *12*, 2.

Marina, N., Christie, I. N., Korsak, A., Doronin, M., Brazhe, A., Hosford, P. S., Wells, J. A., Sheikhbahaei, S., Humoud, I., Paton, J. F. R., Lythgoe, M. F., Semyanov, A., Kasparov, S., & Gourine, A. V. (2020). Astrocytes monitor cerebral perfusion and control systemic circulation to maintain brain blood flow. *Nature communications*, *11*(1), 131.

Philippi, C. L., Weible, E., Ehlers, A., Walsh, E. C., Hoks, R. M., Birn, R. M., & Abercrombie, H. C. (2024). Effects of cortisol administration on heart rate variability and functional connectivity across women with different depression histories. *Behavioural brain research*, *463*, 114923.

Lyon, A. R., Rees, P. S., Prasad, S., Poole-Wilson, P. A., & Harding, S. E. (2008). Stress (Takotsubo) cardiomyopathy-a novel pathophysiological hypothesis to explain catecholamine-induced acute myocardial stunning. *Nature clinical practice. Cardiovascular medicine*, *5*(1), 22–29.

Benarroch E. E. (2014). The clinical approach to autonomic failure in neurological disorders. *Nature reviews. Neurology*, *10*(7), 396–407.

Anxiety Disorders in Children

Özge PINARCIK SAKARYALI[1]

1-Prof. Dr.; Alanya Alaaddin Keykubat University, Department of Child Development, o_pinarcik@hotmail.com ORCID NO:0000-0001-9652-2089

INTRODUCTION

Feelings of distress, tension, and unease resulting from fear and anxiety are part of children's development (Albano et al., 2003.) Fear and anxiety are necessary for individuals to continue their lives (Kring et al., 2014).

Anxiety (worry, concern, distress) is a strange feeling, distinct from fear, that is not based on reality. Fear stems from the presence of a real danger. Anxiety, on the other hand, arises when there is no apparent danger, in the form of a suffocating feeling of distress, a sense that "something bad and dangerous is going to happen," and a paralyzing fear. For example, people who constantly clean their homes, wash their hands incessantly, cannot shake hands with others, cannot board planes or elevators, cannot dance on the dance floor, who are submissive, domineering, oppressive, or oppressed, are in a state of anxiety at that moment or constantly (Bakırcıoğlu, 2013).

The concept of anxiety includes three elements: (1) Cognitive element (I am afraid/terrified, etc.) (2) Physiological element (rapid heartbeat, blushing, etc.) (3) Behavioral element (strong desire to escape, get away, etc.). In the emotion of fear, only the cognitive element is considered to be present (Butcher, Mineka, and Hooley, 2013).

An anxious individual perceives the world as a dangerous and unsafe place, and therefore dangerous situations attract their attention more. Furthermore, anxious individuals tend to interpret uncertain situations negatively. To such an extent that children of parents with anxiety disorders are more likely to experience problems such as anxiety and shyness than those without such disorders (Şıngır et al., 2021).

When examining whether there is a difference between genders in terms of anxiety disorders, different research results are seen; Yılmaz (2017) found no significant relationship between gender and social anxiety levels in their study. They state that this finding can be explained by the fact that students, both girls and boys, constantly perform the same tasks in the same social environments. In another study, Memik, Yıldız, Tural, Ağaoğlu (2011) found a difference between genders, stating that the prevalence rate of anxiety was 17% in women and 10% in men. The researchers suggest that this situation may be due to society's different expectations of women and men and the acceptance of women being more shy and timid than men (Şıngır et al., 2021).

Anxiety symptoms in children are the same as in adults. These include palpitations, increased heart rate, blushing or paleness, muscle tension and cramps, shortness of breath, trembling, sweating, cold hands and feet, stomach

aches, nausea, vomiting, headaches, dizziness, frequent urination, fainting, irritability, restlessness, hypervigilance, insomnia, shyness, dependence on the mother, introversion, discomfort in social settings, excessive risk-taking, or complete avoidance of risk are symptoms of anxiety in children. In early infancy, general distress, constant crying, restlessness, colic pain, and gas pains may be signs of anxiety. In the 6-9 month period, situations such as the approach of a stranger, heights, bright lights, unique fears of physical harm in the preschool period, fears of animals, and specific childhood fears are special cases, and it is not always easy to draw the line between normal behavior and psychopathology in psychiatry. Childhood fears appropriate to the child's age-related development should always be kept in mind. (Uluhan, 2020).

In the diagnosis of anxiety disorders, the initial history, the development of anxiety symptoms, the presence of stressors such as parental separation and school change, medical history, the family's psychiatric-psychological status, and mental status assessment are important in children and adolescents as well as in adults.

Cognitive behavioral therapies, psychodynamic psychotherapy, and family therapy play an important role in the treatment of anxiety disorders in children. When necessary, tricyclic antidepressants, selective serotonin reuptake inhibitors, benzodiazepines, and some antihistamines can be used under the supervision of a psychiatrist to reduce anxiety symptoms. Due to their side effects, neuroleptic drugs are generally not preferred in the treatment of anxiety disorders in children (Uluhan, 2020).

According to the DSM-5, anxiety disorders include the following:

Separation anxiety disorder, selective mutism, specific phobia, social anxiety disorder (social phobia), panic disorder, agoraphobia, generalized anxiety disorder, substance-induced anxiety disorder. This section covers separation anxiety disorder, selective mutism, specific phobia, and panic disorder.

1. SEPARATION ANXIETY DISORDER

Anxiety disorders are common among children. They are more common in girls than in boys. The most common disorder, “separation anxiety,” is found in 2% of children (DSM-4, 2000).

1.1. Definition

Separation anxiety disorder (SAD) is characterized by symptoms of excessive fear and anxiety related to being separated from home or attached objects, and intense worry that something bad will happen to parents during the period of

separation. Most children experience separation anxiety. Therefore, it is very important to distinguish between normal separation anxiety and separation anxiety disorder. The differential diagnosis is based on the type, severity, duration of symptoms, and their impact on the child's functioning (Özekes, 2012).

Separation anxiety in children can also be defined as an inability to separate from the person they are attached to, an inability to distance themselves from the objects they are attached to, and excessive fear and anxiety that is not appropriate for their developmental stage (Gümüş, 2017).

1.2. Reasons

Every parent and every child is unique, and the relationship between them is as deep as it is complex. A child first interacts with their physical environment; then, with an increasingly expanding social environment, they come into contact with different mental, emotional, and social structures. During this period, they expect the greatest support from their parent or caregiver. While every step away from their parent is frightening for a baby, as they grow and move towards childhood and adulthood, their parent's ability to lead their children reveals their true authority. Even conscious parents may, in moments of fatigue, sadness, emotional turmoil, or unawareness of the power of words, say or do things that cause their child to feel fear and anxiety. Parents who are insensitive to their children's behavioral signals for any reason and reject them with their behavior are likely to have anxious children. When a child experiences prolonged stress and becomes unable to cope with the problem, they may exhibit behaviors such as fear, anxiety, rigidity, and avoidance of exploratory activities in order to adapt to the situation (Bowlby, 2012; Cozolino, 2014).

Additionally, these children may be overly emotional, shy, and timid. They may have sleep problems and school phobias. They may be overly dependent on their mothers (Butcher, Mineka and Hooley, 2013).

The theorist of attachment theory, John Bowlby, defines any behavior exhibited by the infant to establish and maintain closeness with the caregiver as attachment behavior, and states that attachment behaviors aim to fulfill the infant's need to feel secure and to protect them from danger. When the caregiver is sensitive to these behaviors and responds to them, the infant perceives the caregiver/mother as a reliable refuge, thereby learning to trust others and transferring this trust to their environment (Morsünbül and Çok, 2011).

Separation anxiety is a normal developmental feature experienced by babies between the ages of 0-1, and it is a state of intense focus on separation from the mother/caregiver. Separation anxiety begins to emerge around the age of one and ends around the age of two and a half. Separation anxiety that exceeds this period is a situation that needs to be investigated. Although fears and anxieties do not continue at excessive levels around the age of three, when this intensity persists, the child's maladjustments increase (Altınbaş, 2009).

The theorist of attachment theory, John Bowlby, defines any behavior exhibited by the infant to establish and maintain closeness with the caregiver as attachment behavior, and states that attachment behaviors aim to fulfill the infant's need to feel secure and to protect them from danger. When the caregiver is sensitive to these behaviors and responds to them, the infant perceives the caregiver/mother as a reliable refuge, thereby learning to trust others and transferring this trust to their environment (Morsünbül and Çok, 2011). However, when this process is disrupted, the infant cannot develop a secure bond with their mother. This situation is considered to cause negativity in meeting the child's basic needs such as feeling safe, understood, and calm (Kaya, 2013).

In a large proportion of children complaining of AKB, symptoms appear between the ages of 8-12. Adolescents with AKB tend to complain of physical symptoms on school days; older children (ages 9-12) report excessive sadness related to separation, while younger children (ages 5-8) report having nightmares related to separation (Özekes, 2012).

Refusal to attend school is often a symptom of GAD, but there may be many other causes. Therefore, it should not automatically be considered an indicator of this disorder (Heyne, King, and Tonge, 2004).

In another study of sixty-one children who refused to attend school, the following diagnoses were made: Adjustment disorder with anxiety, unspecified anxiety disorder, ASD, social phobia, generalized anxiety disorder, specific phobia, obsessive-compulsive disorder, panic disorder with agoraphobia, and agoraphobia without panic disorder (Özekes 2012).

Furthermore, when compared to other anxiety disorders in children, AKB has been found to be the most treatable disorder with the lowest rate of persistence. With appropriate interventions, the recovery process for children with AKB is quite favorable. Some suspicions have been raised that AKB may be associated with the development of panic disorder or agoraphobia in childhood (Manicavasagar, Silove, Curtis, and Wagner, 2000). Although the presence of AKB has been reported in the children of some adults with panic

and agoraphobia disorders, this is not true for all cases. Although the prevalence of SAD in childhood is very low, it is likely to persist into adulthood. It is highly probable that this persistence is due to biological factors and the result of experiencing constant insecurity due to a lack of secure attachment (Manicavasagar et al., 2000).

It is believed that separation anxiety disorder leads to impaired functioning in interpersonal relationships, academic and social life, and that treating this disorder in children is important for developing healthier relationships in their later life and development. The importance of family education in separation anxiety disorder, individual therapy, and medication support in long-term separation anxiety disorders is considered to be positive for the treatment process (Kaya, 2021).

It has been determined that parents of children diagnosed with separation anxiety disorder also exhibit the adult form of separation anxiety disorder. Separation anxiety disorder has a genetic basis (Morrison et al., 2019).

1.3. Separation Anxiety Disorder Diagnosis and Clinical Symptoms

Separation anxiety disorder is diagnosed when separation anxiety persists, impairs functioning, and involves prolonged fear or anxiety that is inappropriate for the child's developmental level. Separation anxiety was first defined as a disorder in DSM 3 and was considered a childhood anxiety disorder that began before the age of 18. The two-week period required for diagnosis was extended to four weeks in DSM 4. According to DSM 4, three of the eight criteria must be met to diagnose separation anxiety disorder. It is defined under anxiety disorders in DSM-5. Again, in DSM-5, changes were made to the diagnostic criteria, removing the requirement that it must occur before the age of 18 and adding the condition that it must last at least 6 months for adults and at least 4 weeks for children (Öztürk, Kutlu, and Atlı, 2011).

Children experiencing separation anxiety may complain of illness and have trouble sleeping. They want their parents to stay with them until they fall asleep. They worry that harm will come to the person they are attached to. They feel excessive anxiety that they or their loved ones may have an accident and think that they will never see them again, that they will lose them.

Children experiencing separation anxiety have nightmares about their own death or that of their parents. The outward expression of separation anxiety is less common in adolescents. However, the anxiety they experience can be observed in situations such as not wanting to participate in activities they could do alone and feeling restless (Küçükdönük, 2015).

1.4. Separation Anxiety Criteria According to DSM 5

Defined by the presence of at least three of the following, involving developmentally inappropriate and excessive anxiety or fear related to separation from attached individuals:

1. Recurrent and excessive distress when separated from home or primary attachment figures, or when such separation is anticipated.

2. Persistent and excessive anxiety about losing primary attachment figures or something bad happening to them.

3. Persistent and excessive anxiety that a bad event will cause separation from the primary attachment figure

4. Persistent refusal to go to school or other places, or reluctance to go, due to fear of separation

5. Reluctance to be alone, to be at home without attached persons, or to be in other settings without important adults, or persistent and excessive fear in these situations

6. Persistent reluctance to sleep away from home or without the presence of attached individuals, or refusal to sleep

7. Having recurring nightmares about separation

8. Repeatedly complaining of physical symptoms (such as headaches, stomachaches, nausea, or vomiting) when separated from primary attachment figures or when such a separation is anticipated

B. This fear, anxiety, or avoidance is persistent, lasting at least four weeks in children and adolescents, and six months or longer in adults.

C. This disorder causes clinically significant distress or impairment in social, academic, occupational, or other areas of functioning.

D. This disorder is not better explained by another mental disorder, such as: refusal to go outside without a trusted person in agoraphobia, anxiety in generalized anxiety disorder about something bad happening to significant others, and anxiety about having a disease in illness anxiety disorder. (American Psychiatric Association, Diagnostic and Statistical Manual of Mental Disorders, DSM-5, 2014).

1.5. Treatment for Separation Anxiety Disorder

Although the treatment process for children and adults with separation anxiety disorder has similarities and differences across all theories, it has been observed that family therapy is important in the treatment process and that family psychoeducation is effective in the separation anxiety process. Cognitive-behavioral methods are effective in the treatment process, and the individual must be supported through play therapy and individual psychotherapy. Separation anxiety disorder has been observed to flare up. Studies have shown that 2/3 of those experiencing separation anxiety disorder can be treated with behavioral approaches. Treatment methods can be evaluated as schema therapy, cognitive-behavioral therapy, group psychotherapy, psychodynamic treatment, marriage and family therapy, and drug treatment (Faith, 2009).

In addition, drug treatment may also be recommended if the duration of separation anxiety disorder is prolonged. It is considered that combining family education, therapy support, and medication in separation anxiety disorder may be important for the effectiveness of treatment (Kaya, 2021).

1.6. Content of Child-Centered Play Therapy Sessions

The initial sessions involved a period of time during which the child appeared quite anxious, spent time quietly in the room without engaging in exploratory behavior, and avoided playing. The child, who cried silently during the first session, spent time clinging to his mother in the next session, relying on the therapist's initiative. In the sessions leading up to the first parent meeting, the child tried to interact by positioning himself where he could see his mother and, at the end of the first 4-week period, began to exhibit new exploratory and play behaviors. The main theme of these sessions was anxiety and the need for security.

In subsequent sessions, the theme of separation was brought up, but the need for exploration and connection was observed more intensely.

Compared to previous sessions, the subject's anxiety began to decrease, strengthened the relationship with the therapist, and began to play more comfortably without his mother in sight. In this process, where the themes of separation, trust, and relationship were experienced, the therapist invited the subject to play, and the monologues he constructed while playing began to turn into dialogues. Their verbalization skills improved, and they began to express their feelings more comfortably.

In the last two sessions, the theme of gaining control and power in the face of separation dominated the games. The subject, who was able to express themselves comfortably through dialogues with the therapist, focused on their behavior and emotional state in the room.

A study conducted with elementary school students showed that play therapy reduced social anxiety levels in a short period of time (Teke, Yılmaz and Sürücü, 2020).

Furthermore, considering the findings of studies conducted with children with high anxiety in younger age groups, it can be said that child-centered play therapy is a method that can be preferred in cases of separation anxiety and other anxiety disorders, in addition to other behavioral problems (Köroğlu, 2023).

2. SELECTIVE MUTISM

2.1. Definition

Selective mutism is a diagnostic category that may be encountered when working with children in the field of mental health. Children in this diagnostic category have different characteristics, but generally speak to some people in their immediate environment and not to others. This situation prevents the child from communicating with their social environment and negatively affects their social and emotional development. At the same time, the situation can be quite challenging for the people in the child's immediate environment (parents, teachers). Different treatment approaches can be applied in Selective Mutism, which is listed under Anxiety Disorders in the DSM-5 (Yanıt, 2019).

The combined use of medication and psychotherapeutic interventions is recommended for treatment. Because SM has been considered an anxiety-based disorder from the past to the present and is classified as an anxiety disorder in the recently published DSM-5, behavioral and cognitive-behavioral therapies have been frequently used therapy options in recent years. Due to their anxiolytic effects, selective serotonin reuptake inhibitors (SSRIs) are the most commonly used psychopharmacological methods in the treatment of SM (Perçinel and Yazıcı, 2014).

2.2. Causes

The exact cause is unknown, but it is suggested that shyness and timidity, traumatic experiences, negative parental attitudes, and language development problems may lead to SM. Although prevalence rates vary across studies, it is reported to be approximately 2% and is more common in girls. There are four

subtypes of SM, and diagnosis usually occurs at the start of school. Treatment of SM is quite difficult. It has been reported that multimodal approaches based on cognitive-behavioral therapy yield successful results (Karaman, 2018).

2.3. Symptoms of Selective Mutism According to DSM-5

•Despite being able to speak in other situations, the individual is consistently unable to speak in specific social situations where speech is expected (e.g., at school).

•This disorder impairs educational or occupational functioning or disrupts social communication.

•The duration of this disorder is at least one month (not limited to the first month of school).

•The inability to speak is not related to not knowing the language spoken in the social situation in question or not being able to speak comfortably in that language.

•This disorder cannot be better explained by a communication disorder (e.g., childhood-onset fluency disorder) and has not emerged during the course of autism spectrum disorder, schizophrenia, or another psychotic disorder.

If left untreated, it causes serious impairment in emotional, social, and academic functioning. The family and school should be involved in the treatment process. CBT is the first choice in treatment. The child is not forced to talk. Communication is attempted through the child's areas of interest. The average duration of the disorder is 9 years. In the long term, it poses a high risk for communication problems, social anxiety, and other psychiatric disorders (Özçelik, 2019).

In addition, a study was conducted on an 11-year-old girl with SM. Within this framework, a cognitive-behavioral approach-based strategy was applied in line with school-family cooperation. The SM case was resolved within a 2-month period, and the problem did not recur during the subsequent 2-month follow-up (Karaman, 2018).

2.4. Treatment of Selective Mutism

SM is a rare and difficult-to-treat childhood disorder. Treatment requires a multidisciplinary approach and collaboration with child mental health specialists, as well as family, teachers, and speech therapists when necessary. In cases where only simple behavioral recommendations are made due to the young age of the child-especially if there is severe impairment in the child's

functioning-the effectiveness of these methods is limited. Regarding pharmacological treatment, the child's age and duration of mutism are considered. It has been reported that the younger the child and the shorter the duration of mutism, the greater the effect of pharmacological treatment (Göktürk and Coşkun 2008).

The average age of onset for selective mutism is between 2 and 5 years old, but symptoms may not be noticed until children start school. The cause is not fully understood; its prevalence ranges from 0.03% to 1%. Psychopharmacology and psychotherapeutic approaches are recommended for treatment. Although treatment is difficult, early diagnosis is important (Güleşen et al., 2022).

While psychodynamic psychotherapies and family therapies were mostly used in the treatment of SM in the past, cognitive behavioral therapies (CBT) and psychopharmacological agents are frequently used today (Perçinel and Yazıcı, 2014).

3. SPECIFIC PHOBIA

3.1. Definition

Specific phobia is defined as an irrational, exaggerated fear of a specific object or situation that causes anxiety symptoms upon exposure and impairs the person's functioning. Common specific phobias include dogs, spiders, thunder, heights, tunnels, darkness, water, flying, and blood (Lindner et al., 2019).

Although specific phobia dates back as far as human history, it was defined in its current form in the early 20th century. Specific phobia has been reported as the most common anxiety disorder and the most prevalent psychiatric disorder in society, with a lifetime prevalence rate of approximately 12.5%. Animal and height fears are the most common subtypes of specific phobia (Öztekin et al., 2016).

In specific phobias, individuals experience a high level of inappropriate anxiety and fear specific to the situation when confronted with the phobic object or situation (Demirci et al., 2016).

In DSM-5, specific phobia is divided into five subtypes: animal, natural environment, situational, blood-injection-injury, and others (Wardenaar et al., 2017).

These types of phobias are limited to specific objects or situations. They are also called simple phobias. Fears of animals, heights, darkness, lightning,

elevators, enclosed spaces, dentists, blood, illness, injections, and urinating or defecating in public restrooms fall within this group. Encountering the specific situation or object mentioned can cause panic attacks, as in cases of agoraphobia and social phobia. Therefore, as with other phobias, there is a marked tendency to avoid phobic stimuli. The possibility of encountering the phobic object or situation causes anticipatory anxiety. For this reason, there is a need to obtain detailed information before entering environments where the phobic stimulus may be encountered (Sungur, 1997).

3.2. Symptoms in Children

In children, anxiety may manifest as crying, irritability, freezing, or clinging. In individuals under 18 years of age, the duration is at least 6 months (DSM-5).

The onset of most specific phobias typically occurs during childhood. Specific phobias may be associated with a high level of psychosocial impairment in some cases. Animal phobia has been reported to have the highest prevalence among the subtypes of specific phobia. Snake phobia is one of the most common fears among people. Fear is considered a phobia when it is debilitating, persistent, and impairs the person's functioning. Specific phobias may be predictors of other mental disorders. Therefore, treating specific phobias may reduce the incidence of other mental disorders (Koç and Hocaoğlu, 2023).

3.3.DSM-5 Specific Phobia Symptom Criteria (APA, 2013)

•There should be a distinct fear of a specific object or situation, such as flying, heights, seeing blood, or seeing any animal.

•The source of the phobia should almost always cause fear and anxiety.

•There should be an effective avoidance of the phobic stimulus or intense fear and anxiety when exposed to it.

•The fear experienced should be disproportionately excessive relative to the actual danger posed by the object or situation.

•The fear, anxiety, or avoidance should have been present for at least 6 months.

•The fear must cause clinically significant distress or lead to a significant loss of functioning in social or occupational areas.

•The symptoms cannot be explained by another mental disorder such as panic disorder, obsessive-compulsive disorder, or post-traumatic stress disorder.

Specific phobia involves an excessive fear and avoidance of certain objects and situations. Examples include animals (dogs, insects), airplanes, elevators, enclosed spaces, public transportation, heights, water, and blood. A diagnosis of specific phobia is made when the fears cause significant distress or markedly impair the person's functioning. Few people seek treatment for specific phobias alone; one reason may be that people become accustomed to avoiding the objects they fear. Individuals with blood-injection-wound phobia may avoid having blood drawn or going to the hospital, which can ultimately negatively affect their health (DSM-IV).

3.4.Specific Phobia Treatment

Specific phobias are both treatable and have high success rates. Medications play a minor role in treating these fears. In fact, medications can even be harmful in some cases. For example, taking sedatives before a flight to overcome a fear of flying may make the trip more comfortable, but it can lead to problems such as addiction and medication side effects. If the individual also has depression in addition to the phobia, antidepressant medication treatments will be beneficial (Turkish Psychiatric Association).

The preferred intervention for specific phobia is exposure combined with cognitive behavioral therapy (Moriana et al., 2017).

The most commonly used method in the assessment of specific phobia is the clinical interview; however, there are also several self-report scales used in phobia assessment in the literature, such as the Fear Survey Schedule (FSS) and the Phobic Stimuli Response Scale (PSRS)7. There is no scale adapted into Turkish that measures the symptoms and severity of the disorder (Öztekin et al., 2016).

Exposure-based treatments, in which patients are systematically confronted with feared objects or situations, are highly effective in treating specific phobias and provide consistent improvement in both reported fear and behavioral avoidance. In fact, exposure is more effective than sensory exposure in most cases. Furthermore, exposure is clearly superior to pharmacotherapy.

•The goal should be to correct erroneous cognitions related to the phobic stimulus, to desensitize the individual to the stimulus by repeatedly exposing them to it, rather than avoiding the stimulus.

•Relaxation exercises may be applied.

•If panic attacks occur when encountering the stimulus, medication for these attacks and treatment for the comorbid disorder (depression) should be provided (Hamm, 2009).

4. PANIC DISORDER

4.1. Definition

Although panic attacks, a subtype of anxiety disorder, are a term that almost everyone is familiar with or has heard of somewhere, they are actually an emotional state about which we know very little (Köroğlu, 2010).

Panic disorder is an anxiety disorder characterized by sudden and spontaneous recurring panic attacks. Panic attacks are intense bouts of anxiety that typically occur unexpectedly, accompanied by a feeling that something terrible is about to happen, intense fear and worry, physical symptoms, reaching their peak within a very short time, and lasting between 10-15 minutes and an hour. The duration of panic attacks varies from person to person. It is generally known that the intensity of the attack subsides and disappears within 10-15 minutes (Erdoğan, 2007).

4.2. Symptoms

The physiological and cognitive symptoms of PB include dizziness, fainting sensation, nausea, abdominal discomfort, chills, shivering, hot flashes, numbness, fear of losing control, and fear of death. Although patients cannot explain the cause of spontaneous panic attacks, the symptoms experienced are interpreted as “dying, something bad happening, or losing one's mind,” and this leads to much more intense fear (Alkın, 2002).

Panic disorder occurs when the moment of anxiety enters a vicious cycle physiologically. According to Köroğlu (2010), people experience anxiety symptoms when they need to, or they cannot cope with the moment of anxiety and enter a vicious cycle. For example, even when a person does not feel in danger, the body's secretion of the adrenaline hormone and the constant experience of excitement symptoms are signs of panic disorder. The emergence of all these symptoms indicates that a vicious cycle has been entered, that panic has been disrupted, and that an attack is present; this process is called a panic attack.

During a panic attack, a person may perceive themselves or their surroundings as altered and unreal. People experiencing a panic attack feel as if they are facing a catastrophe. Panic attacks usually subside within ten to fifteen minutes, but they can also last longer. After a panic attack subsides,

anticipatory anxiety, often described as the fear of having another attack, frequently develops. Patients experience intense anxiety not only about the possibility of a new attack, but also about the consequences that may arise after the attack. Anticipatory anxiety can lower the threshold for panic attacks and increase the risk of new attacks, depending on its intensity (Tükel, 2002).

4.3.Panic Attack Symptoms According to DSM V

Panic attacks, which occur as a result of panic disorder, a type of anxiety disorder, and the symptoms experienced by the individual in this state are detailed in DSM V. The following table summarizes these symptoms:

•Palpitations, pounding heart, or increased heart rate,

•Sweating,

•Trembling or shaking,

•Feeling of tightness in the chest or feeling of suffocation,

•Feeling of choking,

• Chest pain or tightness in the chest,

• Nausea or stomach pain,

• Dizziness, feeling unable to stand, lightheadedness, or feeling faint,

• Trembling, chills, shivering, or feeling hot,

• Numbness (feeling of numbness or tingling),

•Feeling of unreality (‘derealization’) or feeling detached from oneself (‘depersonalization’)

•Fear of losing control or going crazy,

•Fear of death (American Psychiatric Association, 2014; İskifoğlu, 2016).

Panic disorder is characterized by panic attacks, which are sudden and spontaneous episodes of intense anxiety accompanied by physical and cognitive symptoms (Angst 1998; APA 2000). These sudden attacks are quite distressing for individuals and cause functional impairments (Mendlowicz et al., 2000).

According to Başaran and Sütçü (2016), certain health conditions, depression, and substance use may cause panic attacks to occur in individuals. For this

reason, it is appropriate to make a diagnosis after individuals undergo a complete health screening.

4.4.Symptoms

During panic attacks and generally afterwards, there is an increase in heart rate, a feeling of suffocation, shortness of breath, intense restlessness, chest pain, palpitations, numbness, sweating, dizziness, difficulty breathing, anxiety, and palpitations. Cognitive symptoms such as fear of losing control, fear of dying, fear of losing one's mind, and fear of having a heart attack may also accompany these physical symptoms. This intense inner turmoil and thoughts of death, which occur with unexpected attacks, result in an increase in the person's behavior to seek help, a decrease in quality of life, and functional impairment (Altıntaş and Taşkıntuna, 2015).

Affecting 2-4% of the population, PD begins in adolescence and young adulthood, typically in the 30s, with its prevalence decreasing with age (Öztürk, 2015). The average age of onset is 25, and those seeking treatment are typically between 25 and 45 years old. The prevalence of panic disorder decreases with age and is rarely seen in people over 65 years of age. It has been found that the age of onset shows a bimodal age distribution, particularly in women, with early onset (15-34 years) and late onset (45-54 years) (Altıntaş, 2006). Data obtained from the Epidemiological Catchment Area (ECA) study show that the onset age of PD peaks between the ages of 15 and 19, and in some cases begins before adolescence.

Studies on families and twins show that anxiety disorders play a significant role in genetic transmission, although this situation has not yet been fully clarified. The likelihood of panic disorder occurring in first-degree biological relatives of individuals with panic disorder is 4–7 times higher. It is more common among women than men in the families of patients. These data support the contribution of genetic factors in the development of panic disorder (Williams and Wilkins, 1995).

4.5. Panic Attack Symptoms in Young Children

The most common symptoms in young children with panic disorder are as follows:

•Palpitations

•Shortness of breath

•Sweating

•Weakness

•Fatigue

As children get older, chest pain, trembling, headache, dizziness, and hot flashes become more common. The earliest cognitive symptom is fear of death. Fear of losing control or going crazy, derealization, and depersonalization are dissociative symptoms that appear later in children and adolescents (Masi et al., 2006).

If treatment is delayed after the onset of panic disorder, avoidance behaviors related to panic disorder will become more difficult, and it is noted that greater impairment in life skills is observed in individuals diagnosed with panic disorder at a younger age. If panic disorder persists into adulthood, there may be an increased risk of problems in areas such as physical and emotional issues, alcohol dependence, emotional relationships and occupational functioning, increased medication use, and increased visits to the emergency room (Çakmakçı, 2004).

Panic disorder symptoms during late adolescence and early adulthood can increase the risk of both suicidal thoughts and attempts. Taken together, these findings indicate that adolescents with panic disorder are at significant risk for both mental and general health problems. A study reported that adolescents did not seek help during the initial period when panic attacks began, even though they were distressed, and that the first referral occurred several years later when functioning had deteriorated. Furthermore, even when they did seek help, panic disorder was not diagnosed; it is suggested that the high prevalence of panic disorder alongside other anxiety disorders, depression, and behavioral disorders may mask the symptoms of panic disorder (Doerfler et al., 2007).

Panic disorder in children and adolescents is a condition that is accompanied by psychosocial and academic problems and constitutes a risk factor for the emergence of other psychiatric disorders (other anxiety disorders, depression, substance use, etc.) in adulthood (Diler et al. 2004).

4.6. Panic Disorder Treatment

The Cognitive Behavioral Model is a structured, therapist-active, time-limited, and client-collaborative form of therapy that posits that our thoughts influence how we feel and behave (Özcan and Çelik, 2017). Rich in technical applications and possessing a relationship-based structure open to development and innovation, CBT also advocates for greater interaction with

the client in clinical practice, moving beyond psychoanalytic application (Vatan, 2016).

Cognitive behavioral therapy (CBT) is an evidence-based therapy method frequently used in the treatment and prevention of psychopathologies in children and adolescents. CBT attempts to explain human behavior and psychopathologies primarily within the framework of cognitive and behavioral theory. It emphasizes the relationship between our thoughts, emotions, and behaviors. Although it is a structured, goal-oriented therapy method, it also values the therapeutic relationship. When applied using appropriate techniques in the treatment of psychopathologies in children and adolescents, it is quite effective (Özcan and Çelik, 2017).

The effort and time patients spend outside the therapy room to resolve their cognitive, behavioral, and emotional issues is referred to as homework and is an important part of CBT. It ensures that the patient adapts the skills learned during the session to their daily life. Care should be taken to ensure that patients have sufficient time to complete the homework assignments given between sessions (Homework helps patients educate themselves further, test their thoughts and beliefs, and replace them with new behavior patterns (Özcan and Çelik, 2017).

EMDR has been found to desensitize schemas that support panic in panic disorders in response to fear or situations. Assuming that the anxiety and fears felt by the individual are emotions and physical sensations stored in implicit memory, processing these events that cause dysfunction is an important part of EMDR treatment (Fernandez and Faretta, 2007). EMDR consists of basic elements and 8 phases: image, negative cognition, positive cognition, emotions-distress level, body sensations, and eye movements. These are the past history and treatment planning, preparation phase, assessment phase, desensitization phase, installation of targeted positive cognition, body scan, closure, and re-evaluation phases. As mentioned, the first two stages involve taking the client's history and the preparation process. These can be completed in two sessions. The other stages can be completed in varying lengths of time depending on the severity and depth of the problem presented by the client (Shapiro, 2016).

REFERENCE

Albano, A. M., Chorpita, B. F. & Barlow, D. H. (2003). Childhood anxiety disorders. E. J. Mash & R. A. Barkley (ed.), in Child psychopathology. New York: Guilford.

Alkın T. (2002). Birinci Basamakta Panik Bozukluğu Tedavisi. Klinik Psikiyatri, Ek 3, 22-31.

Altınbaş, İ. (2009). Ayrılma Anksiyetesi Tanısı Alan Çocukların Ebeveynlerinin Mizaç ve Karakter Özellikleri. Yüksek Lisans Tezi. Ege Üniversitesi, Sosyal Bilimler Enstitüsü Klinik (Uygulamalı) Psikoloji Anabilim Dalı.

Altıntaş, E. (2006). Panik bozuklukta yaşam kalitesi: 3 aylık izlem çalışması (Tez No. 6069). [Uzmanlık tezi, Çukurova Üniversitesi]. YÖK Tez Merkezi.

Altıntaş, E., & Taşkıntuna, N. (2015). Factors Associated with Depression in Obsessive-Compulsive Disorder: A Cross-Sectional Study. Noro Psikiyatr Ars. Dec;52(4):346-353. doi: 10.5152/npa.2015.7657. Epub 2015 Dec 1. PMID: 28360738; PMCID: PMC5353106.

Angst, J. (1998). Panic disorder: history and epidemiology. Eur Psychiatry, 13:2, 51-55. doi: 10.1016/S0924-9338(98)80014-X.

Amerikan Psikiyatri Birliği (2014). Ruhsal bozuklukların tanısal ve sayımsal elkitabı (DSM 5). E. Köroğlu. (Çev.). (5. Baskı). Ankara: HYB yayıncılık.

American Psychiatric Association (APA). (2014). DSM-5: Manual de Diagnóstico e Estatístico de Transtornos Mentais (5th ed.). Porto Alegre: Artmed.

American Psychiatric Association (APA). (2000). Diagnostic and Statistical Manual of Mental Disorders Fourth Edition Text Revision (DSM-IV-TR). Washington DC: American Psychiatric Association. https://doi.org/10.1176/appi.books.9780890423349

American Psychiatric Association (APA). (2013). Diagnostic and Statistical Manual of Mental Disorders (DSM-V). 5th Edition, American Psychiatric Publishing, Washington DC. https://doi.org/10.1176/appi.books.9780890425596

Öztürk, N., Kutlu, M. & Atlı, A. (2011). İnönü Üniversitesi Eğitim Fakültesi Dergisi, cilt.12, sa.2, ss.45-64,

Bakırcıoğlu, R. (2013). Çocuk ve ergende ruh sağlığı. 5. Baskı. Anı Yayıncılık.

Başaran Kaçar, S., & Sütçü Tekinsav, G. S. (2016). Panik Bozukluğun Tedavisinde Bilişsel Davranışçı Grup Terapisinin Etkililiği: Sistematik Bir Gözden Geçirme. Psikiyatride Güncel Yaklaşımlar, 8 (1), 79-94.

Bowlby J. (2012). Bağlanma (Çev: Tuğrul Veli Soylu) İstanbul: Pinhan Yayıncılık

Butcher, J. N., Mineka, S., & Hooley, J. M. (2013) Anormal psikoloji. Kaknüs Yayınları

Cozolino, L. (2014). İnsan İlişkilerinin Nörobilimi (Çeviren: M. Benveniste) İstanbul: Psikoterapi Enstitüsü Eğitim Yayınları.

Çakmakçı F. K. (2004). Çocuklarda Anksiyete Bozukluklarını Tarama Ölçeği Geçerlik ve Güvenirlik Çalışması. Uzmanlık Tezi. Kocaeli Üniversitesi Tıp Fakültesi, Kocaeli.

Demirci, F., Akan, P., Kume, T., Sisman, A. R., Erbayraktar, Z., Sevinc, S. (2016). American Journal of Clinical Pathology. 146(2), 227-237. https://doi.org/10.1093/ajcp/aqw104

Diler R. S., Birm, A., Rent D. A. (2004). Phenom enology of panic disorder in youth. Depress Anxiety 20: 39-43.

Doerfler L. A., Connor D. F., Volungis A. M., Toscano P.F. Jr. (2007). Panic Disorder in clinically referred children and adolescents. Child Psychiatry Hum Dev, 38(1), 57-71.

DSM-4 (2000). Amerikan Psikiyatri Derneği. DSM-4 Tanı Ölçütleri. Ankara: HYB ve Boylam Psikiyatri Enstitüsü.

Erdoğan, S. (2007). Panik bozukluğunun nörobiyolojisi. Klinik Psikiyatri, 10(4), 3-13.

Faith, C. (2009). Dependent Personality Disorder: A Review of Etiology and Treatment. Graduate Journal of Counseling Psychology, 1(2), 66-75.

Fernandez, I. ve Faretta, E. (2007). Eye Movement Desensitization and Reprocessing in the Treatment of Panic Disorder With Agoraphobia. Clinical Case Studies, 6(1), 44-63.

Göktürk, Ü. & Coşkun, M. (2008). Selektif Mutizm. Çocuk ve Ergen Psikiyatrisi Temel Kitabı içinde, F. Çuhadaroğlu ve Ark. (ed.) Hekimler Yayın Birliği, 366-372, Ankara.

Güleşen, O., Sönmez S. A., Bodur Ş., Cöngöloğlu M. A. (2022). 17-year-old Selective mutism case without treatment for a long time. Düzce Tıp Fak Dergisi, 24(2), 212-214.

Gümüş, C. (2017). Ebeveynleri Boşanmış 21 yaş ve Üzeri yetişkin bireylerin kişilerarası ilişkilerindeki bağlanma modelleri ve ayrılma kaygılarının çeşitli değişkenler açısından incelenmesi. Yüksek Lisans Tezi. Haliç Üniversitesi Sosyal Bilimler Enstitüsü Psikoloji Anabilim Dalı Klinik Psikoloji.

Hamm A.O. (2009). Specific phobias. Psychiatr Clin North Am.; 32(3):577-91.

Heyne, D., King, N. J., & Tonge, B. (2004). School refusal. In T.H. Ollendick & J. S.March (Eds.), Phobic and anxiety disorders in children and adolescents: A clinician's guie to effective psychosocial and pharmacological interventions (pp. 236-271). Oxford University Press.

İskifoğlu, G. (2016). Conducting Norm-Referenced Evaluation In Various Measurement Contexts. Kıbrıs Türk Psikiyatri ve Psikoloji Dergisi 2(3): 4858-4865

Karaman, Ö. (2018). Selektif mutizm olgusu. Klinik Tıp Aile Hekimliği Dergisi 10(2):38-41.

Kaya Y, Şahin N. (2013). Kadınlarda Madde Kullanımı ve Hemşirenin Rolü. Hemşirelikte Eğitim ve Araştırma Dergisi, 10(1). Ss.3–7.

Kaya. M. M. (2021). Ayrılma kaygısı bozukluğu üzerine bir inceleme. Sosyal Bilimler Akademi Dergisi / The Journal of Social Sciences Academy 4(2). Ss.209-220

Koç, E. A., Hocaoğlu, Ç. (2023). Az bilinen bir özgül fobi 'ofidiyofobi': bir olgu sunumu. Sağlık Bilimleri Dergisi (Journal of Health Sciences), 32(1): 145-147.

Köroğlu E. (2010). Panik Bozukluğu Nedir? Nasıl Başa Çıkılır? Hekimler Yayın Birliği, 4. Baskı.

Köroğlu, E. (2023). Zor Kişiliklerle Nasıl Baş Ederiz? Destek Yayınları.

Küçükdönük, C. (2015). 3-5 Yaş Arasında ve Anaokuluna Giden Çocuk Annelerinin Ayrılma Kaygısı ve Bağlanma Biçimleri İle Çocuğun Davranışları ve Ayrılma Kaygısı Arasındaki İlişki: Bilişsel Esnekliğin Aracı Rolü Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü Psikoloji Anabilim Dalı Klinik Psikoloji Bilim Dalı.

Lindner, P., Miloff, A., Reuterskiöld, L., Andersson, G., Carlbring, P. (2019). What is so frightening about spiders? Self-rated and self-disclosed impact of different characteristics and associations with phobia symptoms. Scand J Psychol.; 60(1):1-6.

Manicavasagar, V., Silove, D., Curtis, J., & Wagner, R. (2000). Continuities of separation anxiety from early life into adulthood. Journal of Anxiety Disorders, 14(1), 1-18.

Masi G., Pari C., &Millepiedi S. (2006). Pharmacological treatment options for panic disorder in children and adolescents. Expert Opin Pharmacother, 7(5), 545-54.

Çakın Memik, N., Yıldız, O., Tural, Ü., & Ağaoğlu, B. (2011). Prevalence of Social Phobia: A Review. Archives of Neuropschiyatry, 48(1): 4-10.

Mendlowicz M.V., & Stein M.B. (2000). Quality of life in individuals with anxiety disorders. Am JPsychiatry, 157:669-682.

Moriana, J. A., Gálvez-Lara, M., & Corpas, J. (2017). Psychological treatments for mental disorders in adults: A review of the evidence of leading international organizations. Clinical Psychology Review 54(6251): 29-43

Morrison, K. L., Smith, B. M., Ong, C. W., Lee, E. B., Friedel, J. E., Odum, A., Madden, G. J., Ledermann, T., Rung, J., & Twohig, M. P. (2019). Effects of Acceptance and Commitment Therapy on Impulsive Decision-Making. Behavior Modification, 44(4), 600-623.

Morsünbül, Ü., & Çok, F. (2011). Bağlanma ve İlişkili Değişkenler. Psikiyatride Güncel Yaklaşımlar, 3(3), 553-570.

Özekes, M. (Ed.) (2012). Çocuk ve ergenlerde duygusal ve davranışsal bozukluklar. Nobel Akademik Yayıncılık.

Öztekin S., Aydın O., & Aydemir Ö. (2016). DSM-5 özgül fobi şiddet ölçeği Türkçe formunun geçerliliği ve güvenilirliği. Anadolu Psikiyatri Dergisi 18(2). 31-37

Uluşahin A. Ruh sağlığı ve bozuklukları. Ankara: Tuna Matbaacılık.

Perçinel İ., & Yazıcı K.U. (2014). Okul öncesi dönem selektif mutizm vakalarında fluoksetin tedavisi: iki olgu eşliğinde tartışma. Çocuk ve Gençlik Ruh Sağlığı Dergisi, 21 (2): 123-130.

Shapiro, F. (2016). EMDR: Göz Hareketleri ile Duyarsızlaştırma ve Yeniden İşleme. Temel Prensipler, Protokoller ve Prosedürler. İstanbul, Okuyanus Yayınları.

Sungur, N. (1997). Yaratıcı Düşünce. (İkinci Baskı). İstanbul: Evrim Yayınevi.

Şıngır, H., Ayvaz, A., & Tonga B. (2021). Uluslararası Güncel Eğitim Araştırmaları Dergisi (UGEAD), 7(1): 99-110

Teke, E., Yılmaz, E., & Sürücü, A. (2020). İlkokul Öğrencilerinin Algıladıkları Anne Baba Tutumları ile Sosyal Kaygı Düzeyleri Arasındaki İlişkinin İncelenmesi. The Journal of International Lingual Social and Educational Sciences, 6(1): 24-38.

Tükel, R. (2002). Panik bozukluğu. Klinik Psikiyatri Dergisi, 5(3), 5-13.

Uluhan F. E. (2020). Madde kullanımına bağlı anksiyete bozukluğu. Antalya Psikiyatri

Vatan, S. (2016). Bilişsel davranışçı terapilerde üçüncü kuşak yaklaşımlar. Psikiyatride Güncel Yaklaşımlar-Current Approaches in Psychiatry, 8(3):190-203 doi:10.18863/pgy.238183

Wardenaar K.J., Lim C.C.W., & Al-Hamzawi A.O. (2017). The cross-national epidemiology of specific phobia in the World Mental Health Surveys. Psychol Med,47(10):1744-760.

Yanıt, E. (2019). Selektif Mutizm vakasının yönlendirilmemiş oyun terapi teknikleri ile sağaltımı (olgu sunumu). Türkiye Bütüncül Psikoterapi Dergisi 2(3) 68-76.

Yılmaz, B. (2017). Madde kullanan bireylerde sosyal anksiyete bozukluğu görülme yaygınlığının araştırılması (Tez no.10161157). [Yüksek lisans tezi, Üsküdar Üniversitesi]. YÖK Tez Merkezi.

From Anxiety to Comfort: Review of Deep Sedation Practices in Dental Patient Management

Elif Buse KAPLAN[1]
Aysun AVŞAR [2]

[1] Elif Buse KAPLAN, Ondokuz Mayıs University Faculty of Dentistry Department of Pediatric Dentistry, ORCID : 0009-0003-0493-3166 ,email: buseelifkaplan@gmail.com .
[2] Aysun AVŞAR , Ondokuz Mayıs University Faculty of Dentistry Department of Pediatric Dentistry, ORCID : 0000-0003-3911-452 , email: aysuna@omu.edu.tr .

1. Definition of Sedation

Sedation is defined as the suppression of the central nervous system and reflexes through pharmacological or non-pharmacological methods, aiming to alleviate discomfort, fear, anxiety, and pain in patients. Sedation is categorized into four distinct levels: *minimal sedation*, *moderate (conscious) sedation*, *deep sedation*, and *general anesthesia*.

Minimal sedation (anxiolysis) refers to a drug-induced state in which patients can easily and normally respond to verbal commands, maintain their airway independently, preserve protective reflexes, and exhibit no impairment of ventilatory or cardiovascular functions.

Moderate sedation (conscious sedation) is defined as a state in which patients are able to maintain a patent airway independently and continuously, respond appropriately to verbal or tactile stimulation, and experience only minimal depression of consciousness.

Deep sedation is characterized by a state in which protective reflexes may be partially lost, the patient cannot maintain airway patency independently or respond to verbal and physical stimuli, and consciousness is more profoundly depressed.

General anesthesia, on the other hand, is defined as a drug-induced loss of consciousness during which the patient is not arousable, even by painful stimulation. In this state, the ability to maintain independent ventilatory function is usually impaired, and positive pressure ventilation is often required to maintain adequate oxygenation and carbon dioxide elimination[1], [2].

2.History of Sedation

The term *sedation* was first formally defined in 1992, emphasizing that patients may transition between different levels of sedation and that healthcare professionals must continuously monitor the patient and be prepared to increase the level of alertness if necessary. Over time, sedation has become widely adopted in medical and surgical practices, evolving significantly in terms of safety, efficacy, and patient comfort[3], [4].

Since ancient times, various civilizations have sought to control pain by inducing altered states of consciousness. In Ancient Egypt and Mesopotamia, herbal substances were employed to achieve these effects. During the Middle Ages, substances such as alcohol and herbal preparations continued to be used for sedative purposes; however, these practices lacked a scientific foundation and were primarily based on empirical and trial-and-error approaches[5], [6].

In the 19th century, advancements in chemistry led to the discovery of effective sedative and analgesic compounds. Substances such as chloroform and ether began to be used in surgical procedures, marking a significant milestone in the development of modern anesthesia[7].

During the 20th century, extensive research on sedative and anesthetic drugs contributed to the evolution of safer and more controllable sedation techniques. The introduction of intravenous (IV) and inhalation anesthesia methods played a crucial role in this progress[8].

Today, sedation techniques have been substantially refined. Modern pharmacological agents are widely utilized in minimally invasive procedures and diagnostic tests to enhance patient comfort and procedural efficiency. The training and clinical experience of anesthesiologists and other healthcare professionals remain critical to ensuring the safe and effective administration of sedation[9].

3.Pre-Sedation Patient Evaluation

Conscious sedation techniques must possess a wide safety margin to minimize the risk of unintended loss of consciousness. In pediatric patients, safe sedation requires a comprehensive pre-sedation assessment. This evaluation should include careful examination of the airway for enlarged tonsils or any anatomical abnormalities, adherence to appropriate fasting (nil per os, NPO) guidelines for elective procedures, understanding of the pharmacodynamic and pharmacokinetic properties of the sedative agents to be used, availability of properly sized airway equipment, and establishment of venous access when necessary[10], [11].

In addition, appropriate intraoperative monitoring, the presence of trained personnel and adequately equipped recovery facilities, as well as well-defined discharge criteria, are essential components of safe sedation practice. Sedative medications may be administered through various routes, including oral, nasal, intramuscular (IM), intravenous (IV), subcutaneous, and inhalation routes[12].

Although pediatric conscious sedation remains widely utilized in dental procedures today, it carries significant risks for both patients and anesthesia providers. Sedation techniques may serve as a viable alternative to general anesthesia (GA) in selected clinical cases when general anesthesia is deemed unnecessary or undesirable. However, both oversedation and inadequate sedation are considered inappropriate and potentially hazardous clinical outcomes[13].

To minimize a patient's dependence on pharmacologic sedation, psychological and behavioral management techniques—such as cognitive restructuring, hypnosis, relaxation, distraction, systematic desensitization, and conditioning—may be employed to complement pharmacological methods[14].

Food and liquids must be restricted for several hours before the sedation appointment to reduce the risk of vomiting and aspiration of stomach contents into the lungs, which can be life-threatening. Therefore, if fasting instructions are not properly followed, the sedation procedure will be postponed or canceled for the child's safety. (figure 1.)

Figure 1. Food and liquids must be restricted.

TYPE OF FOOD / LIQUID	MINIMUM FASTING PERIOD
Clear liquids: water, fruit juices without pulp, carbonated beverages, clear tea, black coffee.	2 hours before sedation
Human milk	4 hours before sedation
Infant formula, nonhuman milk, and light meal (toast and clear liquid)	6 hours before sedation

3.1. Indications for Sedation

The indications for sedation in the pediatric population are established based on behavioral, psychological, and medical considerations that may interfere with safe and effective dental treatment. Sedation is indicated in the following cases:

- Children with limited coping ability or poor tolerance to dental procedures,
- Patients exhibiting behavior management problems,
- Children with dental phobia or severe anxiety,
- Mentally retarded or developmentally delayed patients,
- Patients with medical conditions that may be exacerbated by stress, such as angina, asthma, or epilepsy,
- Children with psychiatric disorders that impair cooperation,
- Cases requiring emergency dental treatment,
- Patients with severe athetosis or spasticity due to cerebral palsy,
- Children with a strong or abnormal gag reflex,

- Patients requiring traumatic, invasive, or prolonged dental procedures.

In these situations, sedation serves to reduce anxiety, movement, and discomfort, thereby facilitating safer and more controlled dental interventions for both the patient and the clinician[15].

3.2. Contraindications for Sedation

The contraindications for sedation in pediatric patients are outlined to prevent adverse events and ensure procedural safety. Sedation is contraindicated in the following circumstances:

- Infants under one year of age,
- Failure to meet pre-sedation fasting requirements,
- Known allergy or hypersensitivity to the pharmacologic agents intended for use,
- Procedures associated with severe or uncontrolled pain,
- Children with obstructive sleep apnea, due to the heightened risk of airway compromise,
- Absence of appropriate resuscitation equipment or trained personnel in the clinical environment.

In all cases, a thorough risk-benefit assessment should be conducted prior to administering sedation, and alternative behavior management or anesthetic techniques should be considered if contraindications are present[15].

4. Drugs Used in Deep Sedation

The selection of appropriate pharmacologic agents is a critical determinant for the effective and safe administration of deep sedation. Ideally, the drugs used should possess short duration of action, exhibit anxiolytic and amnestic properties, and have minimal adverse effects on the cardiovascular and respiratory systems.

The principal sedative agents employed for deep sedation include propofol, midazolam, ketamine, methohexital, and etomidate, while the commonly used analgesic agents comprise fentanyl, morphine sulfate, hydromorphone, and meperidine[16].

4.1. Propofol

Propofol is a short-acting intravenous anesthetic agent that exerts sedative, hypnotic, and anxiolytic effects primarily through the activation of gamma-aminobutyric acid type A (GABA-A) receptors in the central nervous system[17].

During intravenous administration, propofol may cause pain or discomfort at the injection site. To mitigate this, it is recommended that the drug be injected slowly into a large vein, preferably following the administration of intravenous lidocaine, which can significantly reduce injection-related pain[18].

When used for sedation, propofol should be administered in low doses and delivered as a slow infusion rather than a rapid bolus. The dose should be titrated according to the patient's clinical response to prevent adverse effects and to ensure controlled, safe sedation[19].

Propofol formulations contain egg lecithin as an emulsifying component; therefore, the drug should not be administered to children with known egg allergies, in order to reduce the risk of hypersensitivity reactions[20].

Due to limited evidence regarding the safety and efficacy of propofol in pediatric patients, its use in children is not routinely recommended. However, if deemed necessary, propofol should only be administered by an experienced anesthesiologist in a hospital setting, where advanced airway management and resuscitation equipment are readily available. This approach minimizes potential risks and ensures optimal patient safety during deep sedation[18], [19].

4.2. Midazolam

Midazolam is an *imidazobenzodiazepine* derivative that possesses potent sedative properties, along with amnestic and anxiolytic effects. Compared to other benzodiazepines, midazolam exhibits a faster onset of action and a shorter duration of effect. It can be administered via multiple routes, including oral, intranasal, intravenous (IV), intramuscular (IM), and rectal administration routes. Due to its anxiolytic activity, anterograde amnesia, and short duration of action, midazolam is particularly preferred in pediatric patients[21].

When administered orally, midazolam is rapidly absorbed, with sedative effects typically appearing within 5–10 minutes and reaching their peak intensity within 20–30 minutes. Because of the first-pass hepatic metabolism, only 40–50% of the orally administered dose reaches the systemic circulation.

Intranasal administration provides a higher bioavailability and faster onset of action; however, these desirable pharmacokinetic properties are most effectively achieved via parenteral administration[22].

The pharmacologic effects of midazolam usually last between 1 and 4 hours. The drug's rapid penetration into the central nervous system (CNS) and its swift redistribution to other tissues, combined with a short elimination half-life, account for its quick onset and brief duration of action. Objective neurological assessments have demonstrated that the return to baseline values occurs approximately 1.5 hours after intravenous administration and 2 hours after oral administration. Furthermore, midazolam's lack of propylene glycol and its ability to dissolve in water at low pH contribute to reduced tissue irritation during parenteral use[23].

Severe adverse reactions associated with midazolam in pediatric patients include hypoventilation, oxygen desaturation, apnea, laryngospasm, hypotension, cardiac arrest, and anaphylaxis. Therefore, emergency airway and resuscitation equipment must always be readily available when administering the drug. Because midazolam may depress respiratory function, caution is advised in patients with preexisting respiratory disorders or when used in combination with opioids. Milder adverse effects—such as nausea, vomiting, dizziness, headache, diplopia, and paradoxical reactions—are more common but typically transient.

To enhance the therapeutic efficacy of sedation, midazolam may be co-administered with opioid analgesics or barbiturates. When combined with opioids, the dose of midazolam should generally be reduced by 30–50% to minimize the risk of respiratory depression and hemodynamic instability. The doses of other co-administered sedatives should likewise be appropriately adjusted[24].

For intravenous administration, midazolam should be titrated slowly according to the patient's clinical response. The injection should be performed over at least 2 minutes, followed by a minimum 2-minute observation period before additional dosing, allowing adequate time to evaluate the sedative effect and prevent oversedation[25].

4.3. Fentanyl

Fentanyl is a potent opioid agonist characterized by a rapid onset and short duration of action. In dentistry, it is commonly utilized in moderate and deep intravenous (IV) sedation procedures. When administered intravenously, the analgesic and sedative effects typically begin within less than one minute, lasting approximately 30 to 60 minutes. When administered intramuscularly (IM), the onset of action occurs within 5 to 15 minutes, the peak effect is

observed at around 30 minutes, and the duration of action extends to 1–2 hours on average. Fentanyl is therefore considered a valuable adjunct for controlling pain and anxiety during short-term dental and minor surgical procedures, whether administered IV or IM[26].

Like other opioid analgesics, fentanyl can induce dose-dependent respiratory depression. Importantly, the duration of respiratory depression may exceed that of its analgesic effects, necessitating careful patient monitoring. Additional pharmacologic effects common to opioid agonists include miosis, bradycardia, bronchoconstriction, and euphoria. Nausea and vomiting may also occur but are relatively infrequent[27].

A particularly serious but uncommon reaction associated with fentanyl administration is chest wall rigidity (often involving the thoracic and respiratory muscles), which may occur following rapid intravenous injection. This complication is primarily rate-dependent, emphasizing the importance of slow administration and vigilant monitoring of respiratory function throughout the sedation period[28].

5. American Society of Anesthesiologists (ASA) Physical Status Classification

Prior to sedation, a comprehensive preoperative assessment—including a detailed medical history, physical examination, and evaluation of potential risk factors—is essential for determining the appropriateness and safety of sedation. The most widely used risk stratification tool is the American Society of Anesthesiologists (ASA) Physical Status Classification System.

According to established guidelines, non-anesthesiologist clinicians should perform sedation procedures only in ASA I patients, and such procedures should be limited to minimal or moderate sedation levels. As the ASA classification increases, the likelihood of intraoperative or postoperative complications rises correspondingly.

The ASA Physical Status Classification is defined as follows:

- **ASA I:** A normal, healthy patient with no systemic disease.
- **ASA II:** A patient with mild systemic disease that does not limit daily activity.
- **ASA III:** A patient with severe systemic disease that limits activity but is not incapacitating.

- **ASA IV:** A patient with severe systemic disease that is a constant threat to life.
- **ASA V:** A moribund patient who is not expected to survive without the operation.
- **ASA VI:** A declared brain-dead patient whose organs are being removed for donor purposes.

An accurate ASA assessment not only guides the selection of appropriate sedation techniques but also serves as a predictive tool for perioperative risk, thereby contributing to improved patient safety and clinical outcomes[29], [30].

6. Assessment of Sedation Depth

6.1. Clinical Scales

Inadequate levels of sedation or analgesia can lead to patient discomfort, resulting in both physical and psychological distress. Conversely, excessive sedation may precipitate serious cardiovascular or respiratory complications. Certain patient-specific factors—such as age, comorbidities, or airway anatomy—can further increase the risk of sedation-related adverse events. Therefore, since the introduction of sedative agents, clinicians have sought reliable clinical indicators to determine appropriate sedation depth and have continuously developed methods for objective monitoring of sedation levels. Today, sedation assessment and monitoring rely on both subjective clinical observation and objective measurement techniques.

An ideal sedation assessment scale should be simple, reproducible, and easily applicable across various clinical disciplines. It should allow clinicians to titrate sedative dosages accurately, evaluate agitation levels, and provide consistent results when used by different healthcare professionals. Moreover, it must be validated for reliability and applicability within specific patient populations, ensuring that its outcomes are both clinically meaningful and evidence-based.

The effectiveness and appropriateness of sedative therapy depend on the regular evaluation of multiple parameters throughout the procedure. To achieve this, several standardized scales have been developed and validated. Among the most commonly employed tools are the Richmond Agitation–Sedation Scale (RASS), the Ramsay Sedation Scale (RSS), the Wilson Five-Stage Sedation Score, and the Observer’s Assessment of Alertness/Sedation (OAA/S) Scale[31].

During sedation, the attending clinician should regularly assess sedation depth using one of these standardized scales or by observing the patient's verbal and tactile responses to stimuli. This systematic monitoring enables the accurate adjustment of sedative doses, the early detection of adverse effects, and the maintenance of patient safety throughout the procedure[32].

6.1.1. Richmond Agitation–Sedation Scale (RASS)

The Richmond Agitation–Sedation Scale (RASS) is a simple and comprehensive clinical tool that simultaneously evaluates both agitation and sedation levels. It is widely utilized due to its clarity, ease of application, and reproducibility across various clinical settings. The scale consists of 10 distinct levels, ranging from +4 (combative) to –5 (unarousable), with 0 representing a calm and alert state(table 1.). Positive scores indicate agitation, negative scores reflect sedation, and zero denotes baseline calmness[33].

Table 1. Richmond Agitation–Sedation Scale (RASS)

Score	Description
+4	Combative — Overtly violent, dangerous to staff
+3	Very agitated — Pulls or removes tubes/catheters; aggressive behavior
+2	Agitated — Frequent, non-purposeful movements; fights ventilator
+1	Restless — Anxious but movements not aggressive or vigorous
0	Alert and calm
–1	Drowsy — Not fully alert, but sustained awakening (eye contact >10 seconds) to voice
–2	Light sedation — Briefly awakens to voice (eye contact <10 seconds)
–3	Moderate sedation — Movement or eye opening to voice, but no eye contact
–4	Deep sedation — No response to voice, but movement or eye opening to physical stimulation
–5	Unarousable — No response to voice or physical stimulation

This scale allows clinicians to objectively quantify a patient's level of consciousness, monitor sedation depth over time, and adjust drug dosages accordingly to ensure optimal sedation while minimizing adverse effects[32].

6.2. Bispectral Index (BIS) Monitoring

The Bispectral Index (BIS) is an objective neurophysiological monitoring system that evaluates the depth of sedation or anesthesia using electroencephalographic (EEG) data collected from non-invasive electrodes placed on the forehead. The BIS value is expressed as a numerical index between 0 and 100, where lower scores correspond to deeper levels of sedation. Initially developed for use in anesthesia, BIS monitoring has recently gained attention in dental sedation research as a potential adjunct for assessing consciousness levels[34].

Table 2. BIS Values and Corresponding Sedation Levels

BIS Range	Sedation Level
86–100	Awake and responsive
66–85	Responds to loud verbal commands
41–65	Minimal response; low likelihood of recall
20–40	No response to painful stimuli
<20	Deep sedation or near isoelectric EEG
0	EEG suppression; absence of cerebral activity

Although BIS algorithms have been validated primarily in adult populations, their accuracy in pediatric patients remains limited due to differences in brain maturation and EEG patterns. BIS correlates reliably with sedation depth during propofol-based anesthesia; however, with agents such as sevoflurane and ketamine, paradoxically higher BIS scores may occur even under deep sedation or general anesthesia due to cortical excitation[35].

Furthermore, the influence of opioids and benzodiazepines on BIS values is inconsistent and generally modest. Current literature suggests that BIS monitoring provides reliable sedation assessment only during propofol

administration, and thus routine BIS use is not recommended for all sedation protocols in pediatric dentistry[36].

7. Assessment of the Respiratory System

During both sedation and general anesthesia (GA), continuous monitoring of respiratory function is of paramount importance, alongside cardiovascular assessment. The pharmacologic agents used for sedation and anesthesia predominantly act as central nervous system and respiratory depressants, rather than cardiovascular depressants. Consequently, respiratory alterations typically occur before cardiovascular changes become apparent. Because nearly all sedative agents have the potential to depress respiratory function, airway obstruction, aspiration, and respiratory depression are considered the primary causes of sedation-related morbidity[37].

Close and continuous monitoring of respiration during moderate sedation, deep sedation, and general anesthesia significantly reduces both morbidity and mortality risks.

Respiratory function can be assessed by measuring respiratory rate, observing chest wall movements, inspecting mucosal coloration, and monitoring the reservoir bag when inhalation sedation or supplemental oxygen is administered. Although chest wall motion indicates respiratory effort, it does not conclusively confirm effective gas exchange between the lungs and the external environment. Furthermore, cyanosis may not be observed until hypoxia develops, making mucosal color an unreliable indicator of adequate ventilation. In dental practice, the frequent use of rubber dams can further limit the ability to visually inspect the lips and oral mucosa[38].

By contrast, observation of the reservoir bag remains a reliable and practical method for confirming ventilation during both inhalation sedation and general anesthesia. It provides a visual cue of air movement and assists clinicians in detecting early signs of hypoventilation or apnea.

7.1. Precordial and Pretracheal Stethoscopes

Precordial and pretracheal stethoscopes serve as valuable monitoring tools during both sedation and general anesthesia. The stethoscope head is secured to the precordial or pretracheal region of the patient with adhesive tape and connected to the clinician’s earpiece via tubing. When positioned on the precordial area, heart sounds are more prominent, which may sometimes obscure respiratory sounds. However, since the primary goal during sedation is to assess airway patency and ventilation, placement over the pretracheal area is generally preferred[39].

The pretracheal stethoscope allows continuous auscultation of airflow through the trachea and is a simple yet reliable device that enhances the safety of sedation practices. Abnormal breath sounds—such as those associated with airway obstruction or apnea—can be promptly detected, alerting the clinician to intervene immediately. Despite its low cost and high reliability, studies such as the comprehensive report by Langhan et al. (2012) have indicated that pretracheal stethoscopes are used in fewer than 1% of pediatric sedation cases, highlighting their underutilization in clinical settings.

Although the use of stethoscopes in sedation remains limited, clinical guidelines strongly recommend continuous ventilation monitoring through stethoscopy or capnography. The American Society of Anesthesiologists (ASA) advises continuous observation and auscultation of respiratory function during deep sedation. Similarly, the American Academy of Pediatrics (AAP) recommends the use of stethoscope or capnographic monitoring during deep sedation—especially in cases where direct visual observation of the patient's breathing is restricted[40].

7.2. Pulse Oximetry

During sedation, continuous monitoring and documentation of the patient's vital signs—including oxygen saturation levels—are essential. Inadequate oxygen delivery to organs and tissues can result in irreversible damage and severe complications. Hypoxia remains one of the most common and critical complications encountered during both sedation and general anesthesia (GA). For this reason, the pulse oximeter has become an indispensable tool in modern anesthetic and sedation monitoring practices.

Pulse oximeters provide a non-invasive measurement of arterial oxygen saturation (SpO_2), reflecting the proportion of oxygenated hemoglobin (HbO_2) relative to total hemoglobin (Hb) in the blood. Oxygen saturation, expressed as a percentage, indicates the efficiency of oxygen transport within the circulatory system. Under normal physiological conditions, SpO_2 levels approach 100%, while readings below 90% indicate hypoxia and necessitate immediate intervention[41].

The device operates by emitting light at wavelengths of 660 nm, 910 nm, or 940 nm through perfused tissues such as the finger, toe, or earlobe. Because oxyhemoglobin and deoxyhemoglobin absorb light differently at these wavelengths, the pulse oximeter calculates the proportion of each and displays the resulting oxygen saturation (SpO_2) on its monitor. In addition, most pulse oximeters provide auditory and visual alarms that signal significant changes in measured parameters, enabling early detection of oxygen desaturation or hemodynamic instability.

Although the use of pulse oximetry is not mandatory during minimal sedation, it is strongly recommended—and often required—during moderate and deep sedation. According to established guidelines, oxygen saturation should be recorded at least every 10 minutes during moderate sedation and every 5 minutes during deep sedation. Continuous pulse oximetry thus represents one of the most effective and non-invasive methods for ensuring patient safety during dental sedation and anesthesia procedures[42].

8.Assessment of the Cardiovascular System

8.1.Blood Pressure

Monitoring blood pressure (BP), alongside heart rate and rhythm, is a fundamental component in evaluating a patient's cardiovascular status during sedation and anesthesia. In dental practice, blood pressure measurement should be performed routinely as part of the preoperative physical assessment.

In pediatric patients, blood pressure values are typically lower than those observed in adults and may vary according to age, body size, and emotional state. Several techniques are available for blood pressure measurement, the most common being the auscultatory method, which utilizes a sphygmomanometer and a stethoscope. This technique is based on the principle of applying external pressure to a superficial artery using a cuff and gradually releasing it while listening to Korotkoff sounds generated by blood flow through the artery.

Modern practice has seen a shift toward the use of automated blood pressure monitors, which offer improved reliability due to advances in digital sensor technology. These devices provide the advantages of digital readouts, data recording, and programmable intervals for automatic BP measurement, making them particularly useful for continuous intraoperative monitoring in sedation and anesthesia settings[43].

8.2.Pulse

Pulse assessment is a routine component of preoperative evaluation in all patients. In children aged 3 to 6 years, a normal resting pulse rate typically ranges from 80 to 140 beats per minute. During sedation, regular monitoring and documentation of pulse rate and rhythm are essential to ensure patient safety.

If central nervous system depression deepens or the patient becomes less responsive to verbal commands, the frequency of vital sign monitoring should be increased. Continuous assessment of heart rate trends provides critical

information on the depth of sedation, hemodynamic stability, and early signs of distress[44].

8.3.Electrocardiography (ECG)

Electrocardiography (ECG) is the recording and interpretation of the electrical activity of the heart obtained from electrodes placed on the body surface. It serves as a crucial diagnostic and monitoring tool to evaluate cardiac rhythm, conduction abnormalities, and myocardial function during sedation and anesthesia.

In procedures involving deep sedation, continuous ECG monitoring is mandatory to promptly detect arrhythmias or cardiac conduction disturbances. The presence of a defibrillator and other emergency resuscitation equipment in the clinical setting is essential to allow immediate intervention in case of a cardiac emergency[45].

9. Recovery and Discharge Criteria

The recovery period refers to the time required after anesthesia or sedation for a patient to regain normal levels of consciousness, respiratory function, and protective reflexes, allowing them to safely perform routine daily activities. This phase is critical for ensuring complete awakening, stabilization of vital signs, and early detection of potential adverse effects that may arise during recovery.

In the postoperative phase, patient discharge decisions should be based on the Modified Aldrete Scoring System, which provides an objective framework for assessing readiness for discharge. Within the recovery unit, patients are evaluated according to several parameters, including blood pressure, heart rate, respiratory rate, body temperature, level of consciousness, motor activity, pain intensity, presence of nausea or vomiting, and fluid intake and output.

Once these criteria have been satisfactorily met and vital functions are stable, the patient may be considered for discharge. A Modified Aldrete Score of 9 to 10 generally indicates that the patient has achieved an adequate level of recovery and is fit for discharge(table3.).

Table 3. Modified Aldrete Scoring System for Patient Recovery Assessment

Criteria	Description	Score
Activity	The patient is able to move all four extremities voluntarily or on command	2
	The patient can move two extremities voluntarily or on command	1
	The patient is unable to move extremities	0
Respiration	The patient is able to breathe deeply and cough freely	2
	Dyspnea or limited breathing	1
	Apnea	0
Circulation (Blood Pressure)	Blood pressure is within ±20% of the pre-anesthetic level	2
	Blood pressure is within ±20–49% of the pre-anesthetic level	1
	Blood pressure deviates more than ±50% from the pre-anesthetic level	0
Consciousness	Fully awake	2
	Arousable on calling	1
	Not responding	0
Oxygen Saturation (SpO_2)	Maintains $SpO_2 > 92\%$ on room air	2
	Requires supplemental oxygen to maintain $SpO_2 > 90\%$	1
	$SpO_2 < 90\%$ even with supplemental oxygen	0

Total Possible Score: 10
Interpretation: A score of **9–10** indicates the patient is ready for discharge from the recovery unit.

10. Emergence Delirium in Pediatric Patients

Emergence delirium (ED) is a transient neurobehavioral disturbance that may occur in the early postoperative period following anesthesia, particularly in children. It is characterized by disorientation, impaired awareness of the environment, excessive psychomotor activity, and perceptual disturbances. The exact etiology of this phenomenon remains unclear, but it is thought to be associated with rapid recovery from anesthesia, pain, anxiety, or individual susceptibility.

Emergence delirium typically manifests within the first 15 minutes after cessation of anesthesia. Children experiencing ED often appear restless, uncooperative, avoid eye contact, and are inconsolable, even by their parents. Some may exhibit crying, whining, kicking, or other forms of agitated behavior, and may even have difficulty recognizing familiar caregivers or family members.

10.1. Pediatric Anesthesia Emergence Delirium (PAED) Scale

The Pediatric Anesthesia Emergence Delirium (PAED) Scale is a validated clinical tool designed to assess and quantify emergence delirium in children aged two years and older following anesthesia. The scale evaluates behavioral and cognitive responses to the postoperative environment, assigning scores based on five key parameters. A total PAED score of 10 or higher is indicative of clinically significant emergence delirium.

Table 4. Pediatric Anesthesia Emergence Delirium (PAED) Scale

Item	Score Description
The child makes eye contact with the caregiver	4 = Not at all; 3 = Just a little; 2 = Quite a bit; 1 = Very much; 0 = Extremely
The child's actions are purposeful	4 = Not at all; 3 = Just a little; 2 = Quite a bit; 1 = Very much; 0 = Extremely
The child is aware of their surroundings	4 = Not at all; 3 = Just a little; 2 = Quite a bit; 1 = Very much; 0 = Extremely
The child is restless	0 = Not at all; 1 = Just a little; 2 = Quite a bit; 3 = Very much; 4 = Extremely
The child is inconsolable	0 = Not at all; 1 = Just a little; 2 = Quite a bit; 3 = Very much; 4 = Extremely

11. Conclusions

The recovery and discharge phases represent crucial stages in the overall management of pediatric patients undergoing dental procedures under sedation or general anesthesia. During this period, the clinician's primary objective is to ensure the complete restoration of consciousness, airway patency, and stable cardiopulmonary function, while simultaneously monitoring for potential adverse events that may arise as the pharmacologic effects of sedative agents subside.

A structured and evidence-based approach to recovery assessment enhances patient safety and clinical efficiency. The Modified Aldrete Scoring System remains the most widely used and validated tool for determining discharge readiness, providing an objective evaluation of vital signs, activity level, and consciousness. Similarly, the Pediatric Anesthesia Emergence Delirium (PAED) Scale offers a standardized method for identifying emergence delirium, a common and often distressing phenomenon in children recovering from anesthesia. Early recognition and management of this condition, through calm environmental control and parental reassurance, can significantly improve postoperative comfort and cooperation.

Ensuring safe discharge requires not only the normalization of vital parameters but also the resolution of pain, nausea, and psychomotor agitation. Clear communication with caregivers regarding postoperative care, potential delayed reactions, and emergency instructions is indispensable.

In conclusion, recovery and discharge after sedation should be viewed as an integral continuum of perioperative care, demanding vigilant monitoring, interdisciplinary coordination, and adherence to international safety guidelines. Establishing well-trained personnel, appropriate monitoring equipment, and standardized discharge criteria are essential for minimizing complications and promoting optimal recovery outcomes in pediatric dental sedation practice.

References

[1] A. Lele and M. Souter, "Sedation practices in the Neurocritical Care Unit," *J Neuroanaesth Crit Care*, vol. 03, no. 04, pp. S81–S87, Dec. 2016, doi: 10.4103/2348-0548.174743.

[2] S. M. Green *et al.*, "An international multidisciplinary consensus statement on fasting before procedural sedation in adults and children," *Anaesthesia*, vol. 75, no. 3, pp. 374–385, Mar. 2020, doi: 10.1111/ANAE.14892.

[3] J. L. Apfelbaum *et al.*, "Practice Guidelines for Moderate Procedural Sedation and Analgesia 2018: A Report by the American Society of Anesthesiologists Task Force on Moderate Procedural Sedation and Analgesia, the American Association of Oral and Maxillofacial Surgeons, American College of Radiology, American Dental Association, American Society of Dentist Anesthesiologists, and Society of Interventional Radiology," *Anesthesiology*, vol. 128, no. 3, pp. 437–479, Mar. 2018, doi: 10.1097/ALN.0000000000002043.

[4] R. K. Stoelting and R. D. Miller, "Basics of anesthesia," p. xii,697-xii,697, 2007.

[5] A. M. Metwaly *et al.*, "Traditional ancient Egyptian medicine: A review," *Saudi J Biol Sci*, vol. 28, no. 10, p. 5823, Oct. 2021, doi: 10.1016/J.SJBS.2021.06.044.

[6] E. J. Chidiac, R. N. Kaddoum, and S. F. Fuleihan, "Special article: mandragora: anesthetic of the ancients," *Anesth Analg*, vol. 115, no. 6, pp. 1437–1441, Dec. 2012, doi: 10.1213/ANE.0B013E318259EE4D.

[7] A. T. Costarino and J. J. Downes, "Pediatric anesthesia historical perspective," *Anesthesiol Clin North Am*, vol. 23, no. 4, pp. 573–595, Dec. 2005, doi: 10.1016/j.atc.2005.08.005.

[8] C. L. Mai, P. G. Firth, and M. Yaster, "History of pediatric anesthesia timeline," *Paediatr Anaesth*, vol. 23, no. 1, pp. 1–2, Jan. 2013, doi: 10.1111/pan.12094.

[9] C. J. Coté and S. Wilson, "Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures: an update," *Paediatr Anaesth*, vol. 18, no. 1, pp. 9–10, 2008, doi: 10.1111/J.1460-9592.2007.02404.X.

[10] F. Gao and Y. Wu, "Procedural sedation in pediatric dentistry: a narrative review," *Front Med (Lausanne)*, vol. 10, p. 1186823, 2023, doi: 10.3389/FMED.2023.1186823.

[11] C. J. Coté and S. Wilson, "Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures: Update 2016," *Pediatrics*, vol. 138, no. 1, Jul. 2016, doi: 10.1542/PEDS.2016-1212.

[12] “GUIDELINES for Teaching Pediatric Pain Control and Sedation to Dentists and Dental Students”.

[13] S. S. Montarroyos, A. Payson, C. De La Vega, and A. Pulido, “Outpatient Sedation and Risks (Including Dental),” *Pediatr Rev*, vol. 44, no. 4, pp. 203–212, Apr. 2023, doi: 10.1542/PIR.2022-005642.

[14] C. J. Coté *et al.*, “Guidelines for Monitoring and Management of Pediatric Patients During and After Sedation for Diagnostic and Therapeutic Procedures: An Update,” *Pediatrics*, vol. 118, no. 6, pp. 2587–2602, Dec. 2006, doi: 10.1542/PEDS.2006-2780.

[15] “THE REFERENCE MANUAL OF PEDIATRIC DENTISTRY RESOURCES: PREPARING FOR SEDATION VISIT Patient: Sedation appointment: at am/pm”.

[16] N. C. G. C. (UK), “Drugs for sedation in infants, children and young people,” 2010, Accessed: Oct. 20, 2025. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK82229/

[17] V. Chidambaran, A. Costandi, and A. D’Mello, “PROPOFOL: A REVIEW OF ITS ROLE IN PEDIATRIC ANESTHESIA AND SEDATION,” *CNS Drugs*, vol. 29, no. 7, p. 543, Aug. 2015, doi: 10.1007/S40263-015-0259-6.

[18] B. Singla and A. D. Malde, “A prospective observational study of injection pain in children with medium plus long chain triglyceride and long chain triglyceride propofol premixed with lignocaine,” *Indian J Anaesth*, vol. 62, no. 3, p. 214, Mar. 2018, doi: 10.4103/IJA.IJA_506_17.

[19] E. Barbi *et al.*, “Deep Sedation With Propofol by Nonanesthesiologists: A Prospective Pediatric Experience,” *Arch Pediatr Adolesc Med*, vol. 157, no. 11, pp. 1097–1103, Nov. 2003, doi: 10.1001/ARCHPEDI.157.11.1097.

[20] P. Mehta, S. S. Sundaram, G. T. Furuta, Z. Pan, D. Atkins, and S. Markowitz, “Propofol use in pediatric patients with food allergy and eosinophilic esophagitis,” *J Pediatr Gastroenterol Nutr*, vol. 64, no. 4, p. 546, Apr. 2017, doi: 10.1097/MPG.0000000000001291.

[21] S. A. Jain, N. Rathi, N. Thosar, and S. Baliga, “Midazolam use in pediatric dentistry: a review,” *J Dent Anesth Pain Med*, vol. 20, no. 1, p. 1, 2020, doi: 10.17245/JDAPM.2020.20.1.1.

[22] C. Flores-Pérez *et al.*, “Pharmacokinetic–Pharmacodynamic Modeling of Midazolam in Pediatric Surgery,” *Pharmaceutics*, vol. 15, no. 11, p. 2565, Nov. 2023, doi: 10.3390/PHARMACEUTICS15112565.

[23] G. M. Pacifici, “Clinical Pharmacology of Midazolam in Neonates and Children: Effect of Disease—A Review,” *Int J Pediatr*, vol. 2014, p. 309342, 2014, doi: 10.1155/2014/309342.

[24] M. A. Manso, C. Guittet, F. Vandenhende, and L. A. Granier, “Efficacy of oral midazolam for minimal and moderate sedation in pediatric patients: A systematic review,” *Paediatr Anaesth*, vol. 29, no. 11, p. 1094, Nov. 2019, doi: 10.1111/PAN.13747.

[25] T. N. Lingamchetty, S. A. Hosseini, P. Patel, and A. Saadabadi, “Midazolam,” *xPharm: The Comprehensive Pharmacology Reference*, pp. 1–5, Jul. 2025, doi: 10.1016/B978-008055232-3.62185-3.

[26] K. E. Dunn, H. E. Bird, and C. J. Durgin, “Fentanyl,” *The Oxford Handbook of Opioids and Opioid Use Disorder*, pp. 317–353, May 2023, doi: 10.1093/oxfordhb/9780197618431.013.13.

[27] H. E. Bird, A. S. Huhn, and K. E. Dunn, “Fentanyl Absorption, Distribution, Metabolism, and Excretion (ADME): Narrative Review and Clinical Significance Related to Illicitly-Manufactured Fentanyl,” *J Addict Med*, vol. 17, no. 5, p. 503, Sep. 2023, doi: 10.1097/ADM.0000000000001185.

[28] T. H. Stanley, “The fentanyl story,” *Journal of Pain*, vol. 15, no. 12, pp. 1215–1226, Dec. 2014, doi: 10.1016/j.jpain.2014.08.010.

[29] T. Benzoni, A. Agarwal, and M. Cascella, “Procedural Sedation,” *Pediatric Surgery: Diagnosis and Treatment*, pp. 47–63, Mar. 2025, doi: 10.1007/978-3-030-96542-6_6.

[30] L. Ferrari, I. Leahy, S. J. Staffa, and J. G. Berry, “The Pediatric-Specific American Society of Anesthesiologists Physical Status Score: A Multicenter Study,” *Anesth Analg*, vol. 132, no. 3, pp. 807–817, Mar. 2021, doi: 10.1213/ANE.0000000000005025.

[31] C. N. Sessler, M. J. Grap, and M. A. Ramsay, “Evaluating and monitoring analgesia and sedation in the intensive care unit,” *Crit Care*, vol. 12, no. Suppl 3, p. S2, 2008, doi: 10.1186/CC6148.

[32] E. W. Ely *et al.*, “Monitoring Sedation Status over Time in ICU Patients: Reliability and Validity of the Richmond Agitation-Sedation Scale (RASS),” *JAMA*, vol. 289, no. 22, pp. 2983–2991, Jun. 2003, doi: 10.1001/jama.289.22.2983.

[33] R. Tapia, J. López-Herce, Á. Arias, J. del Castillo, and S. Mencía, “Validity and Reliability of the Richmond Agitation-Sedation Scale in Pediatric Intensive Care Patients: A Multicenter Study,” *Front Pediatr*, vol. 9, Jan. 2022, doi: 10.3389/FPED.2021.795487.

[34] Y. Gu *et al.*, “Effectiveness Assessment of Bispectral Index Monitoring Compared with Conventional Monitoring in General Anesthesia: A Systematic Review and Meta-Analysis,” *Anesthesiol Res Pract*, vol. 2024, 2024, doi: 10.1155/2024/5555481.

[35] S. C. Chen *et al.*, “Application of Bispectral Index System (BIS) Monitor to Ambulatory Pediatric Dental Patients under Intravenous Deep Sedation,” *Diagnostics 2023, Vol. 13, Page 1789*, vol. 13, no. 10, p. 1789, May 2023, doi: 10.3390/DIAGNOSTICS13101789.

[36] T. Liang, F. Wu, B. Wang, and F. Mu, “PRISMA: Accuracy of response entropy and bispectral index to predict the transition of consciousness during sevoflurane anesthesia: A systematic review and meta-analysis,” *Medicine (United States)*, vol. 100, no. 17, p. E25718, Apr. 2021, doi: 10.1097/MD.0000000000025718.

[37] J. A. Anderson, “Respiratory Monitoring for Anesthesia and Sedation,” *Anesth Prog*, vol. 70, no. 4, p. 198, 2024, doi: 10.2344/862700.

[38] R. L. Applegate *et al.*, “Advanced monitoring is associated with fewer alarm events during planned moderate procedure-related sedation: A 2-part pilot trial,” *Anesth Analg*, vol. 122, no. 4, pp. 1070–1078, Apr. 2016, doi: 10.1213/ANE.0000000000001160.

[39] K. J. Kramer, “Curious Case of the Pretracheal Stethoscope,” *Anesth Prog*, vol. 68, no. 4, p. 191, Dec. 2021, doi: 10.2344/ANPR-68-04-07.

[40] M. J. Martinez and L. Siegelman, “The new era of pretracheal/precordial stethoscopes”.

[41] T. Lam, M. Nagappa, J. Wong, M. Singh, D. Wong, and F. Chung, “Continuous pulse oximetry and capnography monitoring for postoperative respiratory depression and adverse events: A systematic review and meta-analysis,”

Anesth Analg, vol. 125, no. 6, pp. 2019–2029, 2017, doi: 10.1213/ANE.0000000000002557.

[42] C. J. Coté, S. Wilson, J. Riefe, and R. J. Koteras, "Guidelines for Monitoring and Management of Pediatric Patients Before, During, and After Sedation for Diagnostic and Therapeutic Procedures," *Pediatrics*, vol. 143, no. 6, Jun. 2019, doi: 10.1542/PEDS.2019-1000.

[43] "PEDIATRIC DENTISTRY", Accessed: Oct. 20, 2025. [Online]. Available: http://www.pedsanesthesia.org/.

[44] S. Fleming *et al.*, "Normal ranges of heart rate and respiratory rate in children from birth to 18 years of age: A systematic review of observational studies," *The Lancet*, vol. 377, no. 9770, pp. 1011–1018, 2011, doi: 10.1016/S0140-6736(10)62226-X.

[45] N. S. Gerstein, A. Young, P. M. Schulman, E. C. Stecker, and P. M. Jessel, "Sedation in the Electrophysiology Laboratory: A Multidisciplinary Review," *Journal of the American Heart Association: Cardiovascular and Cerebrovascular Disease*, vol. 5, no. 6, p. e003629, Jun. 2016, doi: 10.1161/JAHA.116.003629.

[46] D. Ding and S. Ishag, "Aldrete Scoring System," *StatPearls*, Jul. 2023, Accessed: Oct. 20, 2025. [Online]. Available: https://www.ncbi.nlm.nih.gov/books/NBK594237/

[47] A. D. Moore and D. L. Anghelescu, "Emergence Delirium in Pediatric Anesthesia," *Paediatr Drugs*, vol. 19, no. 1, pp. 11–20, Feb. 2017, doi: 10.1007/S40272-016-0201-5.

[48] P. S. Sudhakar Russell *et al.*, "Pediatric Anesthesia Emergence Delirium Scale: A diagnostic meta-analysis," *World J Clin Pediatr*, vol. 11, no. 2, p. 196, Mar. 2022, doi: 10.5409/WJCP.V11.I2.196.