# ANATOMICAL STRUCTURE OF THE ADRENAL GLAND: A FORENSIC APPROACH

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***Abstract.*** *This article provides a systematic analysis of the anatomical and morphological features of the adrenal glands, which are of significant importance in forensic medical practice. The adrenal glands play a crucial role in maintaining the body's homeostasis, forming responses to stress, and regulating vital metabolic processes. The article examines their location, external and internal anatomical structure, blood supply, venous drainage, lymphatic flow, and neural innervation. Furthermore, the functional connections of the adrenal glands with the central nervous system and other endocrine organs are highlighted. Particular attention is given to the diagnostic relevance of assessing the condition of the adrenal glands in forensic examinations, identifying their anatomical and topographic changes, and differentiating pathological conditions. These findings serve as an essential scientific and practical basis for in-depth forensic analysis, determining the causes of violent death, and understanding pathologies of the endocrine system.*

***Keywords:*** *adrenal gland, glandula suprarenalis, anatomical structure, morphological features, forensic medical practice, blood supply, lymphatic flow, neural innervation, endocrine system, stress response, homeostasis, forensic examination, topographic anatomy.*

1. **Introduction.** The adrenal glands are among the most important endocrine organs in the human body, playing a crucial role in regulating stress responses, maintaining homeostasis, and managing various metabolic processes. These glands secrete hormones in response to signals from the hypothalamus, influencing a wide range of physiological functions such as energy production and storage, blood pressure regulation, and water-electrolyte balance. In particular, hormones like cortisol, adrenaline, and aldosterone enable the adrenal glands to regulate immune responses, stress reactions, and metabolic activity. The scientific study of the adrenal glands has evolved over centuries. These glands were first described in 1564 by the Italian anatomist Bartolomeo Eustachio as *"glandulae quae renibus incumbent"*, meaning "glands resting on the kidneys" [5]. This article provides a systematic analysis of the anatomical and morphological characteristics of the adrenal glands, including their location, blood supply, innervation, lymphatic drainage, and connections with the central nervous system. In addition, it evaluates recent imaging studies that document adrenal gland size variations in patients with depression. These findings enhance our understanding of the diagnostic value of adrenal morphology in forensic medical practice.

2. **Materials and Methods**. In preparing this article, a wide range of scientific literature, textbooks, modern anatomical atlases, and scholarly articles on the anatomical and morphological features of the adrenal glands were analyzed. Source materials included classical anatomical references such as F. Netter's *Atlas of Human Anatomy* (2003), as well as a recent article on the modern anatomy and physiology of the adrenal glands by Al-Khanaty et al. (2025). Historical context was provided by examining the original discovery of the glands by Bartolomeo Eustachio, as documented by Papadopoulos et al. (2015).

The following methodological approaches were employed in the analysis:

- **Structural analysis based on scientific literature and atlases:** The anatomical features of the adrenal glands — including their location, shape, blood supply, innervation, and lymphatic drainage — were systematically studied.
- **Anatomical evaluation:** Special attention was given to the morphological state, topographical position, and diagnostic relevance of the adrenal glands in forensic medical examinations.

• **Use of illustrations:** Anatomical images illustrating the visual structure of the adrenal glands were selected, processed for clarity, and annotated with analytical commentary. These images were sourced from classical anatomical atlases (e.g., Netter, 2003) and modern medical imaging resources.

• **Literature review:** Morphological and clinical research from recent decades (e.g., Stepansky et al., 2025; Kahl et al., 2015; Nemeroff et al., 1992) was reviewed to assess variations in adrenal gland size and morphology.

**3. Discussion.**

3.1. **Embryology.** The adrenal cortex develops from the mesoderm, beginning around the 5th week of gestation, concurrently with the formation of the developing gonads. The cortex is formed through a sequential zonal differentiation, initially giving rise to the fetal (embryonic) zone, which is later replaced by the definitive adult cortex. The fetal zone regresses rapidly after birth. The medulla develops by invagination into the cortical tissue, forming a unified adrenal gland structure [7]. The adrenal gland is enclosed by a fibrous capsule, which sends septa inward, dividing the gland into several lobules. On section, the gland consists of a yellowish outer cortex and a darker central medulla. These two regions differ in structure, development, and function. The cortex is rich in lipid droplets and cholesterol and is subdivided into three histological zones. The medullary portion of the adrenal gland contains chromaffin cells, which stain yellow-brown with chromium salts and are rich in nerve fibers and sympathetic ganglionic neurons. The cortical portion arises from mesoderm on either side of the primitive mesentery during weeks 4–5 of embryogenesis, while the medulla originates from ectodermal-derived sympathetic elements. For this reason, the medulla is also referred to as part of the adrenal (chromaffin) system. By the 6th–7th week of embryonic development, the developing cortex separates from the coelomic epithelium, forming the interrenal body, a mass of cells located lateral to the aorta. By the 8th week, the precursors of the medulla, called chromaffinoblasts, proliferate and migrate into the interrenal body, giving rise to the adrenal medulla. These chromaffinoblasts also contribute to the formation of the aortic paraganglia (paraganglion aorticum) located anterior to the aorta. Due to their origin from different embryonic layers, the two systems (interrenal and chromaffin) remain separate in lower vertebrates, unlike in mammals where they are integrated into a single organ [2].

3.2. **Anatomy of the Adrenal Gland**. The adrenal gland (glandula suprarenalis) is a paired endocrine gland located at the level of the 11th–12th thoracic vertebrae, situated on the superomedial aspect of each kidney within the retroperitoneal tissue. It is enclosed by the renal fascia (fascia renalis) and positioned like a cap atop each kidney, forming a paired organ structure (Figures 1 and 2) [8,11].

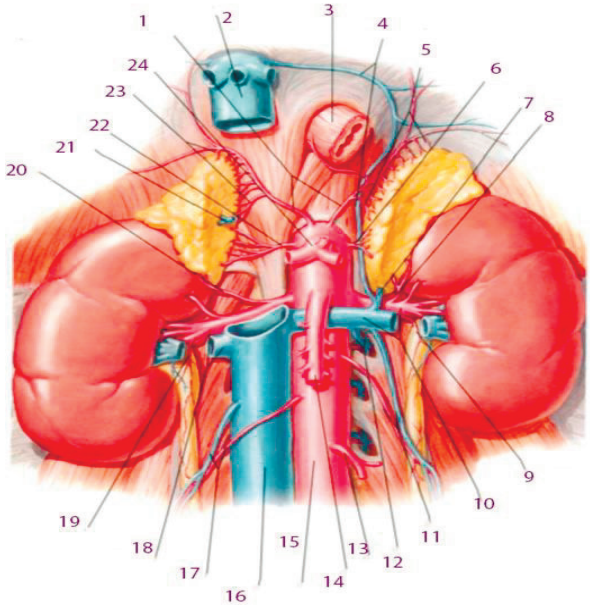


**Fig. 1. Source:** Netter, F. *Atlas of Human Anatomy*. Moscow: GEOTAR-Media, 2003 [4].

1.A.phrenica inferior (dextra et sinistra) 2.V. cava inferior 3. Oesophagus 4. V. phrenica inferior sinistra 5. Aa. suprarenales superiores sinistrae 6. A. suprarenalis media sinistra 7. V. suprarenalis sinistra 8. A. suprarenalis inferior sinistra 9. Ramus uretericus a. renalis sinistra 10. A., v. renalis sinistra 11. A., v. testicularis/ovarica sinistra 12. Chap ikkinchi v. lumbalis, yuqoriga yo‘nalgan c v. lumbalis ascendens (v. hemiazygos) 13. A. mesenterica inferior 14. A. mesenterica superior 15. Aorta abdominalis 16. V. cava inferior 17. A., v. testicularis/ovarica dextra 18. A., v. renalis dextra 19. Ramus uretericus a. renalis dextra 20. A. suprarenalis inferior dextra 21. V. suprarenalis dextra 22. A. suprarenalis media dextra 23. Aa. suprarenales superiores dextra 24. Truncus coeliacus

Each adrenal gland measures approximately 30–60 mm in length and weighs on average 12–13 grams [2]. In newborns, the adrenal glands constitute about one-third the size of the kidneys, whereas in adults, this ratio decreases to approximately 1/30 [3]. Anatomically, the adrenal gland is enclosed by a fibrous capsule, which extends septa into the gland, dividing it into lobules (Figure 3) [2]. In some morphological descriptions, the gland is subdivided into a wing (ala), body, and tail, and in cases of hyperplasia, enlargement is typically observed in the wing and tail regions [7].

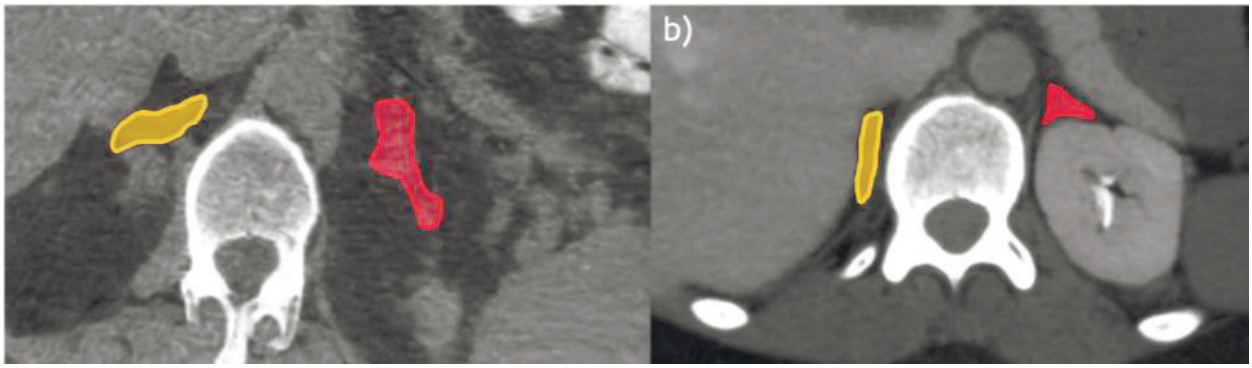


**Fig.e 2.** Segmentation of the adrenal glands. Computed tomography**:** the right adrenal gland is highlighted in yellow**,** and the left adrenal gland in red**.** AGV**:** Adrenal gland volume**.** Source**:** Stepansky et al., 2025 [9].

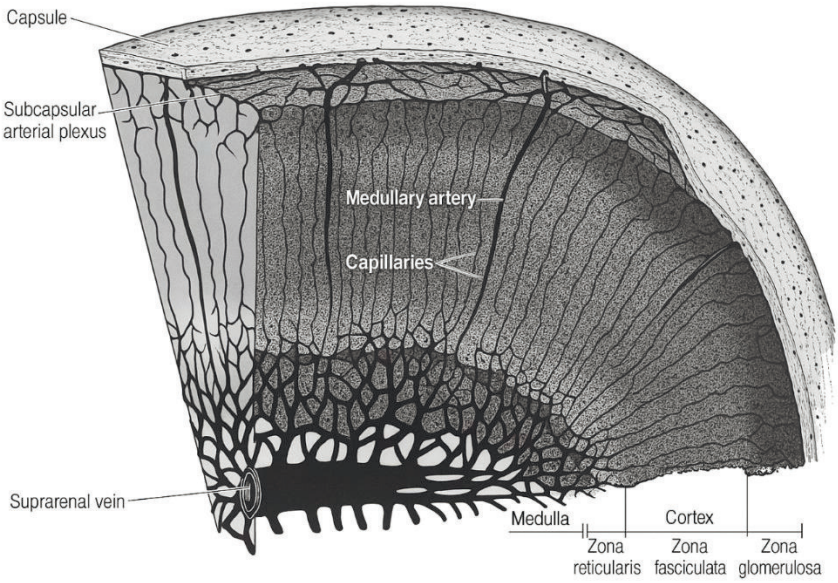


**Figure 3. Blood supply and structure of the adrenal gland.Source:** Carr, J. A., & Norris, D. O. (2005). *The adrenal glands*. In *Endocrine Disruption: Biological Bases for Health Effects in Wildlife and Humans* (p. 111) [1].

Like all endocrine glands, the **adrenal gland** is richly supplied with blood [10]. Each gland receives blood from **three main arteries**:

- **Superior suprarenal artery** (originating from the inferior phrenic artery),
- **Middle suprarenal artery** (originating directly from the abdominal aorta),
- **Inferior suprarenal artery** (originating from the renal artery) [7].

**Venous drainage** occurs through the **central vein**, which has a **thick muscular wall** and is located within the **medulla** (Figure 4). This vein drains into the **left renal vein** on the **left side**, and directly into the **inferior vena cava** on the **right side** [7].

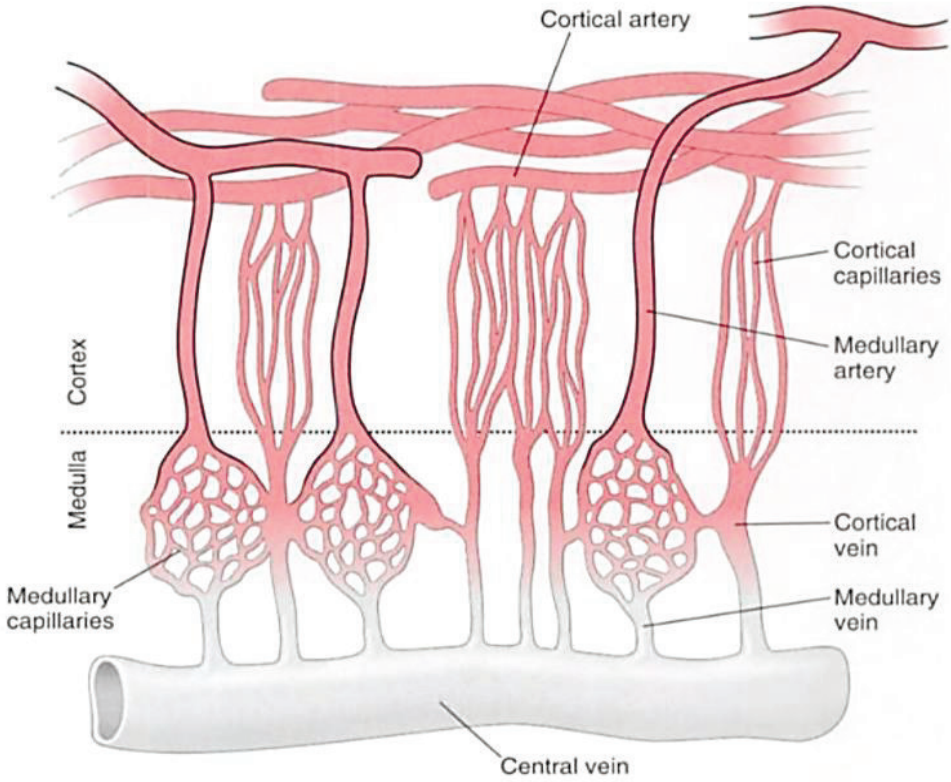


**Fig. 4. Source:** Seifter, J., Ratner, A., & Sloane, D. (2005). *Concepts in Medical Physiology*. Lippincott Williams & Wilkins [6].

The **cortex** and **medulla** of the adrenal gland possess a distinctive **blood supply** and are **functionally interrelated**. Blood enters through the outer **connective tissue capsule**, flows through the **cortical zones**, and then reaches the **medullary cells**, delivering blood rich in **corticosteroids**. This arrangement supports the **complex functional interaction** between the cortex and medulla (Figure 4) [6].

In some cases, **ectopic adrenal tissue** resembling cortical or medullary structures may be found near the adrenal glands [11].

The adrenal glands receive blood from **three paired arteries**:

- **Superior suprarenal artery** (*a. suprarenalis superior*, from the inferior phrenic artery),
- **Middle suprarenal artery** (*a. suprarenalis media*, from the abdominal aorta),
- **Inferior suprarenal artery** (*a. suprarenalis inferior*, from the renal artery) [10] (Figure 5).

The **right adrenal gland** is **triangular in shape**, narrower and located slightly higher than the left gland. It lies near the **upper pole of the right kidney** and is in direct contact with the **inferior vena cava**. The gland is largely **uncovered by peritoneum**, except for a portion of its **anterior surface**.It is related to the **liver**, forming a shallow depression known as the **suprarenal impression** on the liver surface [8,11] (see Figure 3).

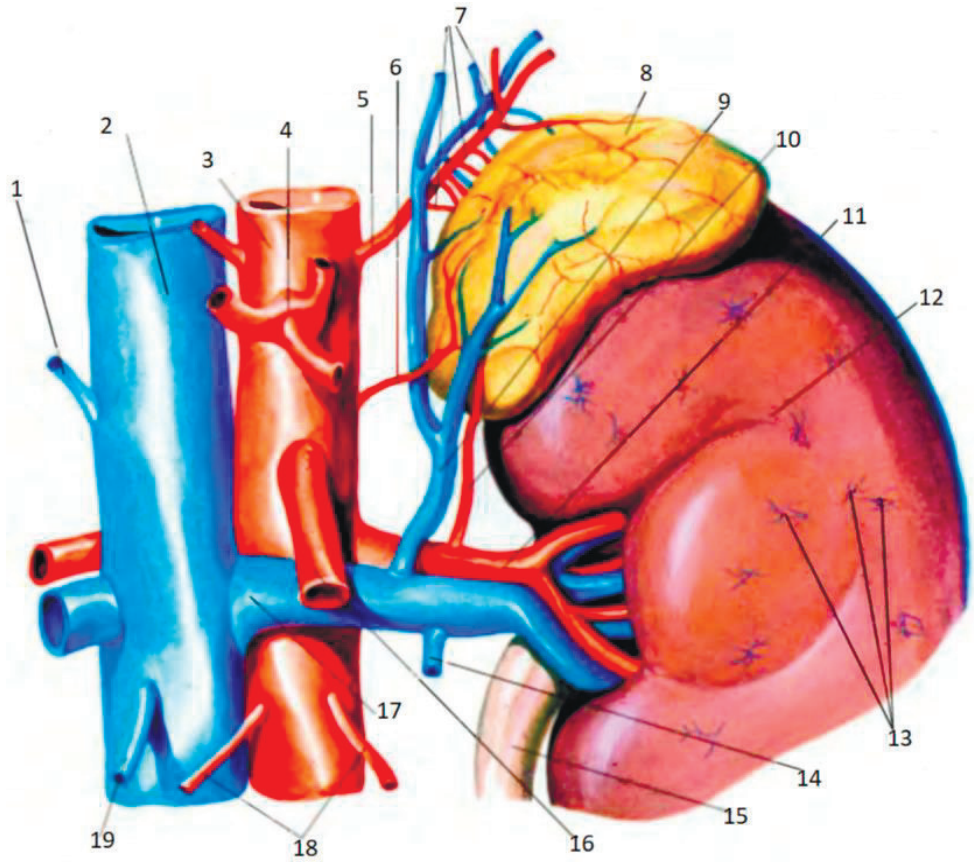


**Fig. 5.** Blood supply and anatomical position of the adrenal gland.Source: Sinelnikov, R. D., Sinelnikov, Ya. R., & Sinelnikov, A. Ya. (2009). *Atlas of Human Anatomy* (Vol. 2, 7th ed., revised). Moscow: RIA "Novaya volna" / Publisher Umerenkov [8].
1. V. suprarenalis dextra 2. V. cava inferior 3. Aorta 4. Truncus coeliacus 5. A. phrenica inferior 6. A. suprarenalis media 7. Aa. suprarenales superiores 8. Gl. suprarenalis 9. V. suprarenalis sinistra 10. A. suprarenalis inferior 11. A. renalis sinistra 12. Ren 13. Vv. stellatae renis 14. V. testicularis sinistra 15. Ureter 16. A. mesenterica superior 17. V. renalis
18. Aa. testiculares 19. V. testicularis dextra.

Lymphatic vessels from the adrenal gland drain into the lumbar lymphatic pathways [11].

The left adrenal gland is semilunar in shape, with one portion in contact with the upper pole of the kidney and another adjacent to its medial border. The superior part of the left gland is covered anteriorly by peritoneum.It lies in close proximity to the cardiac region of the stomach, the spleen, and the pancreas. Both adrenal glands are posteriorly related to the diaphragm [8,11].

On the left side, various anatomical variations can occur in venous drainage. For example, the left suprarenal vein may drain into the left renal vein, the gonadal vein, or the inferior phrenic vein. In some cases, a double suprarenal vein on the left side has been observed [3].

The portal vein is formed in the region of the superior mesenteric artery and collects venous blood from many abdominal organs.The abdominal aorta lies posterior to the portal vein and gives rise to multiple arterial branches supplying the abdominal organs and tissues [11].

Each adrenal gland has three distinct surfaces: the anterior surface (facies anterior), the posterior surface (facies posterior), and the renal surface (facies renalis), which is concave and faces the kidney.Additionally, two borders are distinguished: the superior margin (margo superior) and the medial margin (margo medialis) (Figures 6 and 7).

Both the anterior and posterior surfaces of the adrenal gland contain grooves (fissures), the deepest of which is located on the anteromedial surface and is referred to as the hilum [8,11].

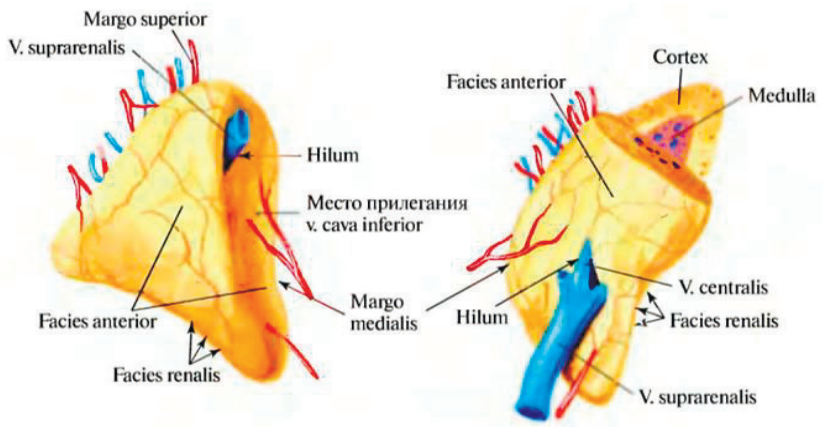


**Fig. 6. Blood supply and anatomical position of the adrenal gland.Source:** Sinelnikov, R. D., Sinelnikov, Ya. R., & Sinelnikov, A. Ya. (2009). *Atlas of Human Anatomy* (Vol. 2, 7th ed., revised). Moscow: RIA "Novaya volna" / Publisher Umerenkov [8].

In the right adrenal gland, the hilum is located closer to the superior pole, whereas in the left gland, it is positioned near the inferior part.Through the hilum, the central vein (v. centralis) exits the gland and continues as the suprarenal vein.The vein from the right adrenal gland drains directly into the inferior vena cava, while the vein from the left gland drains into the left renal vein.

Lymphatic vessels are located within the hilum, whereas arteries and nerve fibers enter the adrenal tissue via the anterior and posterior surfaces.

Externally, the adrenal gland is surrounded by a thin fibrous capsule, which also contains smooth muscle fibers.Extensions of this capsule penetrate the gland and divide it into lobules [8,11].

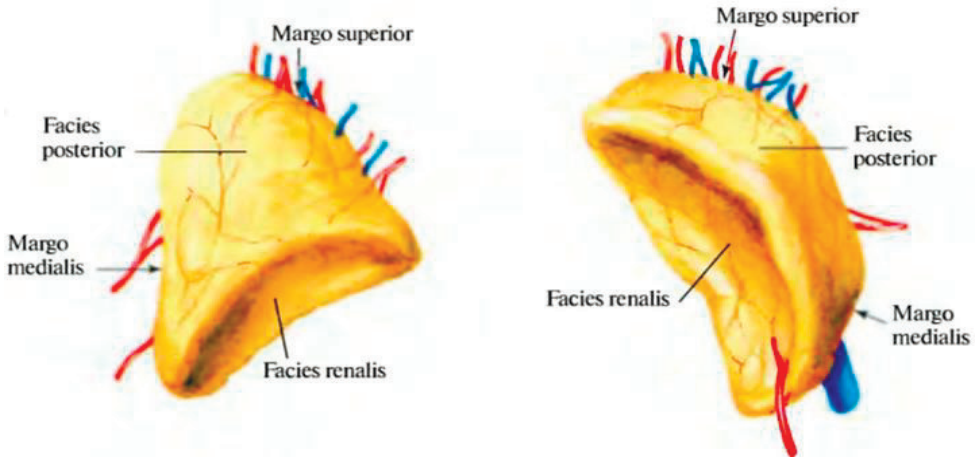


**Fig. 7. Blood supply and anatomical position of the adrenal gland.Source:** Sinelnikov, R. D., Sinelnikov, Ya. R., & Sinelnikov, A. Ya. (2009). *Atlas of Human Anatomy* (Vol. 2, 7th ed., revised). Moscow: RIA "Novaya volna" / Publisher Umerenkov [8].

Occasionally, **accessory adrenal glands (glandulae suprarenales accessoriae)** may be present.These structures are composed of **either cortical or medullary tissue** and are typically located in **retroperitoneal regions**, that is, within the tissues posterior to the peritoneum [8].

4. **Conclusion**. The adrenal glands are vital endocrine structures in the human body, and their anatomical position, morphological organization, vascular architecture, blood supply, innervation, and lymphatic drainage are of great importance for understanding both physiological and pathological conditions. Based on the sources analyzed in this article, it is evident that these glands play a key role in shaping stress responses, maintaining homeostasis, and regulating metabolic processes.

Evaluation of the adrenal glands is considered a crucial diagnostic criterion in the fields of forensic medicine, surgery, endocrinology, and pathological anatomy. It is essential for determining the cause of death, understanding endocrine alterations associated with mental disorders, and detecting internal organ damage resulting from invasive trauma. Particularly, the ability to detect volumetric and morphological changes in the adrenal glands using modern imaging techniques allows for the investigation of their associations with psychopathological conditions.

From this perspective, a thorough understanding of the anatomical and morphological structure of the adrenal glands has not only scientific but also practical diagnostic value in forensic practice. It serves as a key tool in identifying and differentiating pathological conditions.In the future, it is advisable to conduct broader, multicenter studies using modern technologies to further investigate the morphology, functional activity, and clinical correlations of the adrenal glands.

**REFERENCES**

1. Carr, J. A., & Norris, D. O. (2005). *The adrenal glands*. In *Endocrine disruption: Biological bases for health effects in wildlife and humans* (p. 111).
2. Gadayev, A., & Mirsharipov, U. (2021). *Human anatomy (Textbook)*. Tashkent: Muharrir Publishing.
3. Megha, R., Wehrle, C. J., Kashyap, S., & Leslie, S. W. (2022). Anatomy, abdomen and pelvis: Adrenal glands (Suprarenal Glands). In *StatPearls [Internet]*. Treasure Island (FL): StatPearls Publishing.
4. Netter, F. (2003). *Atlas of human anatomy* (A. P. Kisov, Trans., 2nd ed.). Moscow: GEOTAR-Media. (Original work published 1989)
5. Papadopoulos, I., Vassiliadi, D. A., Tsagarakis, S., & Makris, K. C. (2015). Landmarks in the history of adrenal surgery. *Hormones*, 14(2), 299–308. https://doi.org/10.14310/horm.2002.1596
6. Seifter, J., Ratner, A., & Sloane, D. (2005). *Concepts in medical physiology*. Philadelphia: Lippincott Williams & Wilkins.
7. Silverman, M. L., & Lee, A. K. (1989). Anatomy and pathology of the adrenal glands. *Urologic Clinics of North America*, 16(3), 417–432.
8. Sinelnikov, R. D., Sinelnikov, Ya. R., & Sinelnikov, A. Ya. (2009). *Atlas of human anatomy: A textbook* (Vol. 2, 7th ed., revised). Moscow: RIA “Novaya volna” / Umerenkov Publishing.
9. Stepansky, L., Ruppel, R., Sommerfeld, L., Kleib, J., Türkan, K., Arndt, S., Bickelhaupt, S., Knoll, F., Uder, M., & May, M. S. (2025). Adrenal gland volume measurement in depressed patients. *Journal of Psychiatric Research*, 187, 74–79. https://doi.org/10.1016/j.jpsychires.2024.11.008
10. Khudoyberdiyev, R. E., Akhmedov, N. K., Zokhidov, H. Z., et al. (1993). *Human anatomy: Textbook for students of medical higher education institutions* (Ed. by S. A. Dolimov, 3rd revised and expanded edition). Tashkent: Ibn Sina Publishing and Printing Association.
11. Sapin, M. R. (2015). *Atlas of human anatomy: A textbook for students of higher medical educational institutions* (8th ed., revised and expanded). Moscow: Mir i Obrazovanie.