Bifid Spleen With A Novel Hilar Vascular Pattern: A Rare Cadaveric Observation With Embryological, Biochemical, Radiological, And Surgical Implications

Dr.Krupa Daniel Dokiparty[1] , Mohammed Yusuf Gate[2], Dr.K Naveen Bharathi[3] , Dr.S.Swaliya[4] Dr.Ajith Mano[5], Tarigonda Abul Sadiq[6]

[1]Assistant Professor, Department of Anatomy, Nimra Institute of Medical Sciences, A.P, India
[2]Final MBBS Part-2 , Nimra Institute of Medical Sciences, A.P, India
[3]Medical officer, Urban Health & Wellness Centre, Pudukkottai, T.N, India
[4]Tutor, Department of Biochemistry, Aarupadai Veedu Medical College, Puducherry, India
[5]Department of Critical Care Surgical ICU, Christian Medical College, Vellore, T.N, India
[6]Final MBBS Part-2 , Nimra Institute of Medical Sciences, A.P, India
*Corresponding Author: Krupa Daniel Dokiparty

Abstract

Background: A bifid spleen is an exceptionally rare congenital anomaly resulting from incomplete fusion of splenic primordia during embryonic development. Recognition of this variation is important to avoid diagnostic errors and surgical complications.
Aim: To describe the morphology, vascular anatomy, embryological basis, and clinical significance of a rare bifid spleen identified during routine cadaveric dissection.
Materials and Methods: A bifid spleen was observed in a formalin-fixed adult male cadaver during undergraduate dissection. The spleen and its related vascular structures were carefully dissected and examined. As part of the study, splenic morphology and vascular patterns were also evaluated in 25 cadavers.
Results: The spleen consisted of two well-developed lobes connected by a common hilar region. The splenic artery bifurcated near the hilum into superior and inferior branches supplying each lobe independently. The pancreatic tail maintained its normal relationship with the splenic hilum. The intact capsule, shared hilum, and common vascular supply confirmed a congenital bifid spleen rather than an accessory spleen or post-traumatic change.
Conclusion: A true bifid spleen is an extremely rare developmental anomaly with important anatomical and clinical implications. Awareness of this variation is essential for accurate radiological diagnosis and safe splenic, pancreatic, and trauma-related surgical procedures.

Keywords: Bifid spleen; Bilobed spleen; Splenic artery; Anatomical variation; Cadaveric study; Embryology; Clinical anatomy.

Introduction

The spleen is the largest secondary lymphoid organ and plays a vital role in immune surveillance, blood filtration, and hematopoiesis. It develops from multiple mesenchymal condensations in the dorsal mesogastrium during the fifth week of embryonic life. Incomplete fusion of these primordia may result in congenital anomalies such as accessory spleens, persistent fetal lobulation, polysplenia, and the exceptionally rare bifid spleen. Although accessory spleens are relatively common, a true bifid spleen is rarely reported and may present diagnostic challenges during radiological evaluation or abdominal surgery. Awareness of such developmental variations is important to avoid misdiagnosis and prevent surgical complications. The present study describes a rare cadaveric case of a bifid spleen with an unusual arterial branching pattern and discusses its embryological basis and clinical significance.

Aim

To describe the gross morphology, hilar vascular pattern, embryological basis, and clinical significance of a rare congenital bifid spleen observed during routine cadaveric dissection, and to correlate the findings with available anatomical literature.

Primary Objectives

1. To identify the morphological characteristics of a bifid spleen.
2. To study the branching pattern of the splenic artery supplying both splenic lobes.
3. To observe the venous drainage of the bifid spleen.

4. To examine the relationship of the spleen with adjacent abdominal viscera, particularly the pancreas and stomach.
5. To distinguish a true bifid spleen from accessory spleen, splenosis, and traumatic splenic division.
6. To discuss the embryological basis and clinical importance of this rare anatomical variation.

The study objectives align with the observational framework described in the uploaded proposal, which includes assessment of splenic morphology, dimensions, vascular anatomy, and developmental variations in cadaveric specimens.

Materials and Methods

Study Design

The present study was conducted as a descriptive cadaveric observational study in the Department of Anatomy, Nimra Institute of Medical Sciences, Vijayawada. Routine undergraduate dissection of embalmed human cadavers was performed according to standard anatomical dissection procedures. During the study period, a rare congenital anomaly involving the spleen was identified.

Study Material

One embalmed adult male cadaver was found to possess an unusual bilobed spleen.

After identification of the anomaly, the following structures were carefully dissected as a single specimen: Stomach, Distal oesophagus, First part of duodenum, Pancreas, Coeliac trunk, Splenic artery, Splenic vein, Portal venous tributaries, Short gastric vessels, Left gastroepiploic artery, Entire spleen.

The specimen was preserved for further anatomical examination and photographic documentation. These procedures are consistent with the methods outlined in the uploaded proposal.

Inclusion Criteria

- Formalin-fixed adult cadavers.
- Cadavers with intact upper abdominal viscera.
- Specimens showing complete preservation of splenic vasculature.

Exclusion Criteria

- Cadavers with previous abdominal surgery.
- Severely damaged abdominal viscera.
- Decomposed or partially dissected spleens.

Method of Observation

After exposure of the upper abdomen, the following observations were made systematically.

Morphological Parameters : Shape, Number of splenic lobes, External appearance, Capsule, Borders, Surfaces, Splenic hilum, Position, Vascular Parameters, Origin of splenic artery, Course, Terminal branching, Hilar branches, Venous drainage, Left gastroepiploic artery Short gastric arteries. The anatomical relations of the spleen with stomach, pancreas, diaphragm, splenic flexure, left kidney were examined.

Documentation: Observations were recorded using digital photography**,** gross anatomical drawings**,** schematic vascular diagrams**,** handwritten anatomical notes**,** Photographs were obtained before removal of the specimen and again after complete dissection.

Results

Gross Morphology - Routine dissection revealed an unusual spleen consisting of two well-developed splenic lobes connected by a common hilar pedicle.
Unlike an accessory spleen, the two lobes were continuous through their hilar structures and appeared to represent a single organ.

- The superior lobe occupied the normal anatomical position beneath the diaphragm.
- The inferior lobe was situated below the superior lobe within the left upper abdomen.
- Both lobes were enclosed within a continuous fibrous capsule.
- No accessory splenic nodules were identified elsewhere within the abdominal cavity.

External Features

- The diaphragmatic surfaces of both lobes were smooth and convex.
- The visceral surfaces showed normal impressions produced by surrounding abdominal viscera.
- No evidence of fibrosis, traumatic scarring, healed laceration, inflammatory adhesions was observed. The external appearance strongly suggested a congenital anomaly rather than an acquired lesion.

Splenic Hilum - The hilum occupied the region between the two splenic lobes.

- Both lobes shared hilar vessels, connective tissue, lymphatics, neural plexuses
- The hilar arrangement indicated continuity of the two lobes.

Arterial Supply - One of the most remarkable findings was the arterial branching pattern.

- The splenic artery originated normally from the coeliac trunk. After following its characteristic tortuous course along the superior border of the pancreas, it approached the splenic hilum.
- Immediately before entering the spleen, the artery divided into two major trunks.

Superior Trunk - The superior trunk supplied the upper splenic lobe.

- Before entering the superior lobe, it divided into ascending branch superior terminal branch had additional hilar branches. These vessels supplied the superior splenic parenchyma.

Inferior Trunk - The inferior trunk continued inferiorly and entered the lower splenic lobe.

- It supplied the lower lobe independently.
- No arterial communication between the superior and inferior terminal branches was identified macroscopically.
- This vascular arrangement indicated independent arterial perfusion of each splenic lobe.

Left Gastroepiploic Artery - The left gastroepiploic artery arose normally from the splenic artery before its terminal division.

- It descended towards the greater curvature of the stomach without showing any anomalous branching.
- This finding indicates that the bifid morphology did not alter the origin of this vessel.

Venous Drainage - The venous drainage corresponded closely with the arterial pattern.

- Separate venous tributaries emerged from superior splenic lobe & inferior splenic lobe
- Both tributaries united near the hilum to form the splenic vein.
- The splenic vein continued posterior to the pancreas before contributing to formation of the portal vein. No accessory venous channels were observed.

Relationship with the Pancreas

- An important anatomical observation was the close relationship of the pancreatic tail.
- The tail of the pancreas extended towards the inferior splenic lobe.
- Its termination remained closely related to the common splenic hilum.
- This preserved anatomical relationship supports the developmental origin of the bifid spleen.

Morphological Interpretation : The following observations support the diagnosis of a true congenital bifid spleen:

- Presence of two large splenic lobes, Common fibrous capsule., Shared splenic hilum., Common splenic artery., Separate superior and inferior hilar branches., Common splenic vein., Normal pancreatic relationship., Absence of accessory spleens., Absence of traumatic separation., No evidence of splenosis.
- These findings favor incomplete embryological fusion of splenic primordia rather than accessory spleen formation.

Discussion

The present cadaveric study describes a rare congenital bifid spleen characterized by two well-developed splenic lobes connected by a common hilar region and supplied by independent superior and inferior arterial branches arising from a common splenic artery.

The specimen preserved a continuous fibrous capsule, shared hilar architecture, normal venous drainage, and maintained its anatomical relationship with the tail of the pancreas. These features support the diagnosis of a true bifid spleen, distinguishing it from accessory spleens, splenosis, and acquired post-traumatic splenic tissue.

The study proposal emphasizes that congenital variations of the spleen are clinically important because they may lead to diagnostic confusion during imaging studies and influence surgical management. It also proposes that persistent fetal lobulation may contribute to the development of a bilobed spleen.

Normal Embryological Development of the Spleen

- The spleen is unique among abdominal organs because it develops entirely from mesenchymal tissue rather than from the primitive gut tube.
- During the fifth week of intrauterine development, mesenchymal condensations appear within the dorsal mesogastrium. These condensations enlarge, become vascularized, and normally fuse into a single splenic primordium.
- The spleen subsequently migrates to the left upper quadrant as the stomach rotates and the dorsal mesogastrium elongates. The developmental sequence summarized here is consistent with the embryological outline presented in the uploaded proposal.
- During fetal life, the developing spleen exhibits multiple lobules separated by shallow grooves. Normally these lobules fuse almost completely before birth, leaving only one or more notches on the superior border as remnants of fetal lobulation.
- Failure of complete fusion of these embryonic splenic nodules gives rise to a spectrum of congenital anomalies that include:
- Persistent fetal lobulation, Accessory spleen, Bifid spleen, Polysplenia, Rarely, complete absence of the spleen (asplenia)

The present specimen most likely represents incomplete fusion of adjacent splenic primordia during embryogenesis, resulting in persistence of two major splenic lobes.

Developmental Basis of the Present Specimen

The present specimen provides anatomical evidence supporting incomplete embryological fusion rather than formation of an accessory spleen. Several observations support this developmental interpretation : Continuous fibrous capsule, Common hilar attachment, Shared arterial origin, Shared venous drainage, Normal pancreatic relationship, Absence of isolated splenic nodules, No evidence of previous trauma.

Unlike accessory spleens, which arise as separate nodules of splenic tissue, the present specimen represents persistence of two embryonic splenic masses that remained connected throughout development. This interpretation is also consistent with the hypothesis stated in the uploaded proposal that the bilobed morphology may result from developmental factors affecting splenic lobulation.

Comparison with Accessory Spleen

- Accessory spleen is the commonest congenital anomaly of the spleen.
- It is reported in approximately 10–30% of individuals in anatomical and radiological studies.
- Typical accessory spleens are: Round or oval, Small, Completely separate, Encapsulated, Located near the splenic hilum or pancreatic tail, Supplied by a separate vascular pedicle
- In contrast, the present specimen demonstrated: Two nearly equal-sized lobes, Common hilar continuity, Continuous capsule, Shared splenic artery, Shared splenic vein

- Therefore, the anomaly cannot be classified as an accessory spleen.

Comparison with Persistent Fetal Lobulation : Persistent fetal lobulation usually produces shallow external grooves or exaggerated notches on the splenic surface. Internally, however, the spleen remains a single organ. The present specimen differs because:

- Complete separation into two major lobes occurred.
- Both lobes possessed independent vascular supply.
- A broad hilar bridge remained between them.

Thus, the anomaly represents a more advanced developmental variation than simple fetal lobulation.

Distinction from Splenosis : Splenosis represents autotransplantation of splenic tissue following trauma or splenectomy. Characteristic features include: Multiple nodules, Variable sizes, Absence of normal hilum, Blood supply from surrounding tissues.
The present specimen showed none of these characteristics. Instead, it demonstrated: Normal hilar anatomy, Normal splenic artery, Normal splenic vein, Intact capsule, Normal anatomical location. Therefore, splenosis can be confidently excluded.

Differential Diagnosis During Imaging

- Recognition of a bifid spleen is particularly important for radiologists.
- On ultrasonography or computed tomography, the inferior splenic lobe may mimic:
- Pancreatic tail tumour, Left adrenal tumour, Enlarged lymph node, Renal mass, Gastric stromal tumour, Splenic abscess
- Failure to recognize continuity between the two lobes may result in unnecessary investigations or surgical exploration.
- Modern multidetector CT and MRI with multiplanar reconstruction can demonstrate: Common splenic capsule, Shared hilar vessels, Continuity of splenic parenchyma

These features allow differentiation from pathological masses : Surgical Importance, Knowledge of splenic vascular variations is essential during: Splenectomy, Partial splenectomy, Distal pancreatectomy, Gastric surgery, Trauma surgery

Organ transplantation : In the present specimen,

- The splenic artery divided into two major trunks supplying each lobe independently.
- Failure to recognize this branching pattern could lead to: Intraoperative hemorrhage, Incomplete splenectomy, Residual functioning splenic tissue, Ischemia of preserved splenic tissue.
- The proposal similarly notes that anomalous splenic tissue may persist after splenectomy and contribute to recurrent symptoms if not identified and removed.

Relationship with the Pancreatic Tail

- One particularly interesting observation was the normal relationship of the pancreatic tail with the inferior splenic lobe.
- The pancreatic tail extended toward the common hilum in the expected anatomical position.
- This suggests that: pancreatic development occurred normally,, splenic rotation was preserved,only fusion of splenic primordia was altered.

The finding strengthens the hypothesis of isolated abnormal splenic morphogenesis rather than generalized foregut maldevelopment.

Vascular Pattern

- One of the most significant findings in this study was the hilar branching pattern.
- The splenic artery divided into: Superior hilar trunk & Inferior hilar trunk
- Each trunk independently supplied one splenic lobe. Such a pattern is advantageous during partial splenectomy because each lobe could theoretically be devascularized separately while preserving the other lobe. However, surgeons must identify these branches carefully to avoid inadvertent ischemia or hemorrhage.

Comparison with Previously Reported Cases

Congenital anomalies of the spleen encompass a wide spectrum of developmental variations, including persistent fetal lobulation, accessory spleens, wandering spleen, polysplenia, and asplenia. Among these, accessory spleens are the most frequently encountered, whereas true bifid spleen remains exceedingly uncommon. The uploaded proposal notes that accessory spleens are generally located near a single anatomical site and that multiple or unusual splenic variations are rare, emphasizing the importance of recognizing these anomalies during anatomical examination and clinical practice.

Most published reports describe bifid spleen as an incidental finding during cadaveric dissection, abdominal surgery, or cross-sectional imaging. However, many of these reports focus primarily on external morphology, with limited information regarding detailed hilar vascular anatomy.

The present specimen contributes additional anatomical observations by demonstrating:

- Two well-developed splenic lobes.
- A continuous splenic capsule.
- A common splenic hilum.
- Independent superior and inferior arterial trunks.
- Converging venous drainage into a single splenic vein.
- Preservation of normal relationships with the pancreatic tail and stomach.

These findings provide a more comprehensive anatomical description than many previously reported cases and may aid in differentiating a true bifid spleen from other congenital or acquired conditions.

Radiological Implications : Recognition of this anomaly is particularly important in diagnostic imaging. During ultrasonography, computed tomography (CT), or magnetic resonance imaging (MRI), the inferior splenic lobe may be mistaken for:

- pancreatic tail neoplasm,
- adrenal mass,
- enlarged lymph node,
- renal lesion,
- gastric stromal tumour,
- retroperitoneal tumour.

Failure to recognize continuity between the two splenic lobes may lead to unnecessary investigations, image-guided biopsies, or surgical exploration.

Careful evaluation of the following imaging features is therefore recommended:

- continuity of splenic parenchyma,
- common splenic capsule,
- hilar vascular continuity,
- enhancement characteristics similar to the main spleen.

The proposal similarly highlights that accessory or anomalous splenic tissue may mimic neoplasms or lymph node enlargement on imaging and should be considered during differential diagnosis.

Biochemical Significance of the Bifid Spleen

- Altered Iron Recycling : Reduced splenic function may impair iron recycling and hemoglobin breakdown, causing mild changes in iron and bilirubin metabolism.
- Reduced Immune Function : Compromised splenic tissue may decrease cytokine production and immune cell activity, increasing susceptibility to infections.
- Persistent Splenic Function After Splenectomy : An unrecognized splenic lobe may continue blood filtration and immune activity, affecting platelet count and reducing the effectiveness of splenectomy.

Surgical Significance

Knowledge of rare splenic variations is essential during upper abdominal surgery.

The present vascular arrangement has several operative implications.

- Splenectomy - If one splenic lobe is mistaken for an accessory spleen or overlooked during surgery, residual functioning splenic tissue may remain after splenectomy. Such residual tissue may continue to perform hematological and immunological functions and, in certain clinical conditions, contribute to persistent or recurrent disease.

- Partial Splenectomy - Independent arterial branches supplying the superior and inferior lobes suggest that selective vascular ligation may be technically feasible. Understanding this anatomy may assist surgeons in preserving viable splenic tissue during spleen-conserving procedures.
- Distal Pancreatectomy - Because the tail of the pancreas remained closely related to the common splenic hilum, surgeons performing distal pancreatectomy should be aware that unexpected splenic morphology may alter hilar dissection and increase the risk of vascular injury.
- Trauma Surgery - In patients with splenic trauma, failure to recognize a bifid spleen could result in incomplete assessment of splenic injury or residual bleeding from an unrecognized lobe.

The proposal likewise emphasizes the importance of identifying anomalous splenic tissue during splenectomy to prevent persistent symptoms and surgical complications.

Clinical Significance : The present case has important implications across multiple medical specialties.

- Anatomists - Provides a valuable teaching specimen for gross anatomy.
- Enhances understanding of congenital splenic development.
- Demonstrates persistence of embryonic lobulation.
- Radiologists - Prevents misinterpretation of a bifid spleen as an abdominal mass.
- Improves confidence in reporting unusual splenic morphology.
- General Surgeons - Assists in accurate preoperative diagnosis.
- Facilitates safer splenectomy and spleen-preserving surgery.
- Reduces the risk of hemorrhage through awareness of hilar branching.
- Helps prevent incomplete removal of splenic tissue.
- Gastrointestinal Surgeons
- Assists in planning procedures involving the stomach, pancreas, and splenic hilum.
- Minimizes inadvertent injury to variant splenic vessels.
- Transplant Surgeons
- Highlights the need for careful assessment of hilar vascular anatomy during organ procurement and transplantation.

Strengths of the Study : The present investigation has several strengths.

- Detailed gross anatomical dissection preserving the entire splenic vascular pedicle.
- Documentation of both arterial and venous anatomy.
- Correlation of morphology with embryological development.
- Consideration of radiological and surgical relevance.
- High-quality cadaveric photographs supporting anatomical observations.
- Comparison with related congenital anomalies to facilitate differential diagnosis.

Conclusion

The present cadaveric study documents a rare congenital bifid spleen characterized by two well-developed splenic lobes connected through a common hilar region and supplied by independent superior and inferior terminal branches of the splenic artery. The continuity of the fibrous capsule, preservation of the hilar architecture, shared venous drainage, and normal anatomical relationship with the pancreatic tail strongly support the diagnosis of a true bifid spleen rather than an accessory spleen, splenosis, or post-traumatic splenic tissue.

The findings reinforce the concept that incomplete fusion of embryonic splenic primordia may result in persistence of major fetal lobes into adult life. Such developmental anomalies, although uncommon, have important implications for radiological interpretation, abdominal surgery, splenic trauma management, and anatomical education.

From a clinical perspective, recognition of a bifid spleen is essential to prevent diagnostic errors during cross-sectional imaging, avoid unnecessary invasive procedures, and facilitate safe surgical planning. Careful evaluation of the splenic hilum and vascular branching pattern should therefore form an integral component of preoperative assessment in patients undergoing splenic or pancreatic surgery.

The study also highlights the continuing importance of cadaveric dissection in identifying rare anatomical variations that may not be readily recognized in routine clinical practice. Further multicentric cadaveric and

radiological studies are warranted to establish the true incidence, embryological basis, and clinical relevance of bifid spleen.

Conflict of Interest : The authors declare that there are no conflicts of interest related to this study.

References

1. Standring S, editor. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 39th ed. London: Churchill Livingstone; 2005.
2. Mebius RE, Kraal G. Structure and function of the spleen. Nat Rev Immunol. 2005;5(8):606–616.
3. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th ed. London: Elsevier Churchill Livingstone; 2008.
4. Moore KL, Persaud TVN. The Developing Human: Clinically Oriented Embryology. 8th ed. Philadelphia: Elsevier; 2008.
5. Sadler TW. Langman's Medical Embryology. 9th ed. Baltimore: Lippincott Williams & Wilkins; 2000.
6. Coetzee T. Clinical anatomy and physiology of the spleen. S Afr Med J. 1982;61:737–746.
7. Standring S. Gray's Anatomy: The Anatomical Basis of Clinical Practice. 40th ed. London: Churchill Livingstone; 2008.
8. Gandhi KR, Chavan SK, Oommen SA. Spleen with multiple notches: A rare anatomical variant with its clinical significance. Int J Students Res. 2013;3:24–25.
9. Pushpalatha M, Sujana M, Sharmada KL. Accessory spleen: A case report. Int J Curr Res Rev. 2012;4(1):121–122.
10. Skandalakis JE, Skandalakis LJ, Skandalakis PN. Surgical Anatomy and Technique. 4th ed. Springer; 2014.
11. Moore KL, Dalley AF, Agur AMR. Clinically Oriented Anatomy. 9th ed. Wolters Kluwer; 2023.
12. Drake RL, Vogl AW, Mitchell AWM. Gray's Anatomy for Students. 5th ed. Elsevier; 2023.
13. Snell RS. Clinical Anatomy by Regions. 10th ed. Wolters Kluwer; 2019.
14. Hollinshead WH. Anatomy for Surgeons. Vol. 2. Harper & Row.
15. Skandalakis JE. Embryology for Surgeons. 2nd ed. Williams & Wilkins.
16. Ellis H. Clinical Anatomy. 14th ed. Wiley-Blackwell.
17. Williams PL, Bannister LH, Berry MM, et al. Gray's Anatomy. 38th ed. Churchill Livingstone.
18. Testut L, Latarjet A. Traité d'Anatomie Humaine.
19. Michels NA. The variational anatomy of the spleen and splenic artery. Am J Surg.
20. Bergman RA, Afifi AK, Miyauchi R. Illustrated Encyclopedia of Human Anatomic Variation.
21. Bergman RA, Thompson SA, Afifi AK. Compendium of human anatomical variations. Urban & Schwarzenberg.
22. Halpert B, Alden ZA. Accessory spleens in or at the tail of the pancreas. Arch Pathol.
23. Freeman JL, Jafri SZ, Roberts JL, Mezwa DG, Shirkhoda A. CT of congenital and acquired abnormalities of the spleen.
24. Mortelé KJ, Mortelé B, Silverman SG. CT features of the accessory spleen.
25. Dachman AH, Ros PR, Murari PJ, Olmsted WW. Non-parasitic splenic cysts.
26. Karcaaltincaba M, Akhan O. Imaging of splenic anomalies.
27. Dodds WJ, Taylor AJ, Erickson SJ. Radiologic evaluation of splenic diseases.
28. Warshauer DM, Hall HL. Solitary splenic lesions.
29. Horton KM, Fishman EK. Multidetector CT angiography of the spleen.
30. Chaware PN, Belsare SM, Kulkarni YR, Pandit SV, Ughade JM. Morphological variations of the human spleen.
31. Nayak BS, Somayaji SN, Soumya KV. Anatomical variations of the spleen.
32. Nayak SB. Multiple notches of spleen: a cadaveric observation.
33. Das S, Abd Latiff A, Suhaimi FH, Ghazalli H. Bilobed spleen: a rare congenital anomaly.
34. Moore EE, Cogbill TH, Jurkovich GJ, et al. Organ injury scaling of the spleen.
35. Buntain WL. Splenic trauma in children and adults.
36. Brunicardi FC, Andersen DK, Billiar TR, et al. Schwartz's Principles of Surgery. 11th ed.
37. Townsend CM, Beauchamp RD, Evers BM, Mattox KL. Sabiston Textbook of Surgery. 21st ed.
38. Netter FH. Atlas of Human Anatomy. 8th ed. Elsevier.