

Morphological Variations of the Spleen and Prevalence of Accessory Spleens: A Retrospective Cadaveric Study

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Abstract:

Background: The spleen exhibits considerable anatomical variation in shape, notches, lobulation, and associated accessory splenic tissue. Recognition of these variations is important for anatomical understanding, surgical procedures, and radiological interpretation.

Aim: To assess morphological variations of the spleen and determine the prevalence, number, location, and morphometric characteristics of accessory spleens in adult cadaveric specimens.

Methodology: A retrospective cadaveric observational study was conducted on 40 adult cadaveric specimens at the Department of Anatomy, Darbhanga Medical College, Laheriasarai, Darbhanga, Bihar, India. Previously documented dissection records were reviewed for splenic morphology, notches, lobulations, and accessory spleens. Data were analyzed using IBM SPSS Statistics version 27.0 and expressed as frequencies, percentages, mean $\pm$ SD, and range.

Results: Wedge-shaped spleens were predominant (60%), followed by oval (20%), triangular (12.5%), and irregular (7.5%) forms. Notches or lobulations were present in 57.5% of specimens. Accessory spleens were identified in 20% of specimens; 75% had one and 25% had two. The splenic hilum was the commonest location (50%). Most accessory spleens were oval (62.5%), with a mean diameter of 1.42 ± 0.38 cm.

Conclusion: The study demonstrates substantial splenic morphological diversity and a notable prevalence of accessory spleens, emphasizing their recognition during dissection, surgery, and imaging.

Keywords: Spleen, Morphological Variation, Accessory Spleen, Cadaveric Study, Splenic Notch, Lobulation.

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Introduction

The spleen is a vital lymphoid and blood-forming organ, which is responsible for the filtration of blood, immune surveillance, elimination of old or damaged blood cells and regulation of haemological functions [1]. It lies in the left hypochondrium near the stomach, left kidney, diaphragm and tail of the pancreas. The external morphology of the spleen is usually typical, but there are significant variations in size and shape, lobulation, notches, borders, surfaces, and associated splenic tissue. These morphological differences are significant both anatomically and clinically as they can impact on imaging interpretation, surgical procedures and pathological diagnosis.

The spleen originates from numerous condensations of the mesenchyme in the dorsal mesogastrium in early intrauterine life. These initially separate

splenic buds normally fuse to form a single definitive spleen. Failure of fusion of these embryonic splenic nodules can lead to the retention of individual masses of normal splenic tissue, known as accessory spleens or splenunculi [2]. Typically, accessory spleens are histologically similar to the primary spleen with a vascular supply of their own. They are most often seen in the region of the splenic hilum, but can be seen also in the gastrosplenic ligament, splenorenal ligament, pancreatic tail and other surrounding anatomical areas. The occurrence is an important developmental variant of the spleen.

Individual variability in the morphology of the spleen itself can be very large [3]. There may be some differences in size, dimensions, external surface, edges, poles, and notches during the dissection of the anatomical structure. Splenic notches are

important as they are traditionally described along the upper border and can help in the identification of the spleen. But not all people have them and their visibility may change. The same applies to variations in splenic shape and lobulation, which can be related to different developmental fusion and growth. This recognition becomes important in anatomical education and to achieve an adequate knowledge of normal human anatomical diversity [4].

The accessory spleen is of great clinical importance, especially in those who have received splenectomy for haematological diseases [5]. If the accessory splenic tissue is not identified and removed, it could lead to splenic activity persisting after surgery and could be a factor in recurrent or persistent disease. Therefore, surgeons who perform splenic surgery must have knowledge of their prevalence, number, size and anatomical location. They are also significant when splenic tissue is being saved, such as in partial splenectomy [6]. Correct identification of an accessory spleen can thus help minimize the risk of inadequate surgical treatment and aid in the planning of the surgery.

Radiologically, accessory spleens may be visualized as small nodular masses near the spleen or in particular places. They may be confused on imaging with pancreatic lesions, tumours or other soft-tissue masses, and an awareness of their morphology and location is essential for their correct interpretation. This is especially crucial when assessing patients with abdominal masses or when following up after splenectomy [7]. A knowledge of the anatomical basis of these radiological appearances and the potential for variation is valuable, and is best understood from cadaveric knowledge.

Accessory splenic tissues also can become clinically significant after trauma or removal of the spleen. Under these conditions, the accessory tissue may remain in a functional state and grow in size, becoming compensatory. Most accessory spleens do not cause symptoms, but sometimes they become torted, infarcted, or bleed and can cause acute abdominal symptoms [8]. These can be identified during cadaveric dissection and their exact anatomical relationships determined, as well as the documentation of morphological features that may not necessarily be clinically discernible.

Despite the limitations of cadaveric studies, they continue to be a valuable technique for anatomical research due to the ability to observe and document anatomical structures in their natural relationships. Systematically recorded observations at cadaver examination can be used for retrospective analysis to give valuable information about the prevalence and distribution of splenic morphological variants and accessory spleens. These also have importance in anatomical reference data and can assist in defining

patterns in the population. Although anatomic and clinical significance of splenic variations have been established, data on their prevalence and morphological characteristics in particular population of a region are scarce. Anatomical variations can show differences among populations, and therefore region-specific cadaveric studies can be useful in both the academic and clinical settings."

Methodology

Study Design: The present study was designed as a retrospective cadaveric observational study to assess the morphological variations of the spleen and determine the prevalence, number, and anatomical characteristics of accessory spleens among adult cadaveric specimens.

Study Area: The study was conducted in the Department of Anatomy, Darbhanga Medical College, Laheriasarai, Darbhanga, Bihar, India.

Study Duration: The study was conducted over a period of 3 months.

Study Participants: The study participants comprised adult cadaveric specimens whose abdominal dissection records were available in the Department of Anatomy.

Inclusion Criteria

1. Adult human cadavers aged 18 years or above, as documented in the available records.
2. Cadavers that had undergone adequate and complete abdominal dissection.
3. Cadavers in which the spleen, splenic hilum, surrounding peritoneal attachments, and adjacent structures were clearly identifiable.
4. Cadavers with adequate documentation of splenic morphology and associated anatomical findings.
5. Cadavers in which the presence or absence of accessory splenic tissue could be assessed reliably.

Exclusion Criteria

1. Cadavers with a history or evidence of previous splenic surgery or major upper abdominal surgical intervention.
2. Cadavers showing traumatic distortion or gross pathological alteration of the spleen or left upper abdominal region.
3. Cadavers with advanced decomposition that prevented proper identification or assessment of the spleen.
4. Cadavers with incomplete or missing records regarding splenic findings.
5. Specimens in which the splenic hilum or surrounding anatomical structures could not be adequately examined.

Sample Size: A total of 40 adult cadaveric specimens that fulfilled the predefined inclusion criteria

were included in the study. All eligible specimens available within the specified study period and having adequate documentation were considered for analysis.

Procedure: The required data were retrospectively obtained from the departmental cadaveric dissection records. During the original routine anatomical dissection, the spleen and its surrounding structures had been exposed using the standard anatomical dissection approach. The spleen was examined for its external morphology, including shape, surface characteristics, capsular appearance, and other visible morphological variations. The splenic hilum and surrounding structures, including the gastrosplenic ligament, splenorenal ligament, tail of the pancreas, and adjacent peritoneal folds, had been systematically inspected for the presence of accessory splenic tissue. The documented records were reviewed to identify the presence or absence of accessory spleens, their number, anatomical location, shape, surface characteristics, capsular definition, and maximum diameter where measurements had been recorded. The relationship of accessory spleens with the splenic vessels and nearby anatomical structures was also noted whenever documented. Morphological variations of the main spleen, including variations in shape, lobulation, notching, and other externally identifiable features, were recorded. The recorded measurements had been obtained during dissection using a measuring scale or Vernier caliper, wherever available. The extracted information was entered into a structured data sheet for subsequent analysis. To maintain data accuracy, the available dissection registers, photographs, and departmental notes were cross-checked wherever possible, and

original records were consulted in cases of discrepancy.

Statistical Analysis: The collected data were entered into Microsoft Excel and subsequently analyzed using IBM SPSS Statistics version 27.0. Categorical variables such as the presence of morphological variations, prevalence of accessory spleens, number and anatomical location of accessory spleens, and different morphological patterns were expressed as frequencies and percentages. Continuous variables, such as the recorded size or maximum diameter of accessory spleens, were summarized using mean $\pm$ standard deviation and range, wherever applicable. Descriptive statistical methods were primarily used because the study was observational and retrospective in nature. The findings were presented using appropriate tables and percentages to describe the distribution of splenic morphological variations and accessory spleens."

Result

Table 1 shows the distribution of the 40 cadaveric specimens according to sex. Among the total specimens examined, 25 (62.5%) were male, whereas 15 (37.5%) were female. Thus, male cadaveric specimens constituted the majority of the study sample, accounting for nearly two-thirds of the total specimens. In comparison, female specimens represented slightly more than one-third of the sample. The findings indicate a higher representation of male specimens in the present study, with a male-to-female ratio of approximately 1.67:1. Overall, the sex distribution demonstrates that the study included specimens from both sexes, with male specimens being more frequently observed.

Table 1: Distribution of Cadaveric Specimens According to Sex

Sex	Frequency (n)	Percentage (%)
Male	25	62.5
Female	15	37.5
Total	40	100

Table 2 shows the distribution of the 40 spleens according to their morphological characteristics. The wedge-shaped spleen was the most frequently observed morphology, accounting for 24 specimens (60%). Oval-shaped spleens were identified in 8 specimens (20%), followed by triangular-shaped spleens in 5 specimens (12.5%). Irregular-shaped spleens were the least common, being observed in

only 3 specimens (7.5%). Thus, the findings demonstrate considerable morphological variation among the examined spleens, although the wedge-shaped configuration predominated. Overall, the results indicate that 60% of the spleens exhibited the typical wedge-shaped morphology, while the remaining 40% showed alternative morphological patterns.

Table 2: Distribution of Spleens According to Morphological Characteristics

Morphological characteristic	Frequency (n)	Percentage (%)
Wedge-shaped	24	60
Oval-shaped	8	20
Triangular-shaped	5	12.5
Irregular-shaped	3	7.5
Total	40	100

Table 3 shows the distribution of splenic notches and lobulations among the 40 examined spleens. No prominent notch or lobulation was observed in 17 specimens (42.5%), making this the most common finding. A single notch was present in 8 specimens (20%), while multiple notches were identified in 10 specimens (25%). Accessory lobulation was

observed in 5 specimens (12.5%) and represented the least frequent morphological finding. Overall, 57.5% of the spleens demonstrated some form of notch or lobulation, indicating that these morphological variations were relatively common in the studied specimens. Multiple notches were more frequent than single notches.

Table 3: Distribution of Splenic Notches and Lobulations		
Morphological finding	Frequency (n)	Percentage (%)
No prominent notch/lobulation	17	42.5
Single notch	8	20
Multiple notches	10	25
Accessory lobulation	5	12.5
Total	40	100

Table 4 shows the prevalence and number of accessory spleens among the 40 cadaveric specimens. Accessory spleens were absent in 32 specimens (80%), whereas 8 specimens (20%) demonstrated the presence of accessory spleens. Among the 8 cadavers with accessory spleens, 6 (75%) had a single accessory spleen, while 2 (25%) had two accessory

spleens. Thus, accessory spleens were identified in one-fifth of the examined specimens, with a single accessory spleen being the predominant finding. Overall, the findings demonstrate that accessory spleens were a relatively common anatomical variation in the present study, with a smaller proportion of specimens showing multiple accessory spleens.

Table 4: Prevalence and Number of Accessory Spleens		
Accessory spleen status	Frequency (n)	Percentage (%)
Absent	32	80
Present	8	20
Total	40	100
Among the 8 cadavers with accessory spleens:		
Number of accessory spleens	Frequency (n)	Percentage (%)
One	6	75
Two	2	25
Total	8	100

Table 5 describes the anatomical location and morphometric characteristics of the 8 accessory spleens identified in the study. The splenic hilum was the most common location, accounting for 4 accessory spleens (50%), followed by the gastrosplenic ligament with 2 (25%). One accessory spleen each (12.5%) was located in the splenorenal ligament and

near the pancreatic tail. Regarding shape, oval accessory spleens were predominant, observed in 5 cases (62.5%), followed by round-shaped spleens in 2 cases (25%) and irregular-shaped spleens in 1 case (12.5%). The maximum diameter ranged from 0.8 to 2.1 cm, with a mean of 1.42 ± 0.38 cm.

Table 5: Anatomical Location and Morphometric Characteristics of Accessory Spleens		
Parameter	Category/Measurement	Frequency (n) / Value
Anatomical location	Splenic hilum	4 (50.0%)
	Gastrosplenic ligament	2 (25.0%)
	Splenorenal ligament	1 (12.5%)
	Near pancreatic tail	1 (12.5%)
Shape	Oval	5 (62.5%)
	Round	2 (25.0%)
	Irregular	1 (12.5%)
Maximum diameter (cm)	Mean $\pm$ SD	1.42 ± 0.38
	Range	0.8–2.1

Discussion

In the present retrospective cadaveric study, a large amount of spleen morphologic variation was found,

and many accessory spleens were encountered. Of the 40 specimens, 62.5% were males and 37.5% were females. This sex distribution is mostly representative of the cadaveric sample that was available,

and should not be interpreted to indicate a difference in splenic morphology by sex. The predominant form was wedge-shaped (60%), and the other forms—oval, triangular, and irregular—comprised 40% in total. This finding is similar to the report from Chaware et al, in which they conducted a study on 111 cadaveric spleens, having found that 61.26% of the cases had wedge-shaped morphology while 21.61% had tetrahedral morphology, 12.61% had triangular morphology, 3.60% had oval and 0.9% had irregular [9]. The close similarity of the present finding with Chaware et al. (61.26%) corroborates the predominance of the wedge-shaped configuration, but the presence of other configurations indicates there was a significant amount of variation among the individuals.”

Border irregularity of the spleen was also common in the present study. In total, 57.5% of the specimens had a single notch, multiple notches, or accessory lobulation, while 42.5% of the specimens had no prominent notch or lobulation. Twenty-five percent showed multiple notching, 20 percent single notching, and 12.5 percent accessory lobulation. Similar differences have been reported in cadaveric splenic morphology. Notches and lobulations are thought to be a result of the development and coalescence of splenic tissue. Gandhi 2013 [10] highlighted the significance of splenic notches and variations in their number and distribution. Likewise, notching and surface irregularities were found to be variable among cadaveric spleens (Chidambaram RS, 2015) [11], which further supported the notion that these abnormalities are not necessarily pathological.

An important finding of the present study was the prevalence of accessory spleen. In 40 specimens, accessory splenic tissue was seen in 8 (20%). This is greater than the pooled prevalence reported by Vikse et al. (2017) [12] in a systematic review and meta-analysis of 22,487 individuals, which was 14.5%. The difference might be due to the small sample size of the present study, the differences in study populations and the direct visualization that could be achieved in cadaveric examination. However, the current prevalence suggests that accessory spleen is a common finding and should be routinely detected during anatomical dissection and splenic surgery.

Of all the specimens with accessory spleens, 75% had only one accessory spleen and 25% had two accessory spleens. This is similar to the general literature in which the number of solitary accessory spleens predominates. Vikse et al. found that most of the people with accessory spleen had a single accessory spleen, but multiple accessory spleens were also noted. In the present series, the presence of two or more accessory spleens suggests that the persistence of splenic tissue nodules can take place during embryological development. In a cadaveric study of accessory spleens, Mohammadi et al. concluded that

it is important to carefully examine the splenic area for the presence of accessory spleens [13].

In the present study, the most common site was the splenic hilum, with 50% of the accessory spleens found there. The gastrosplenic ligament was the largest, accounting for 25%, followed by the splenorenal (12.5%) and pancreatic-tail region (12.5%). This agrees very well with Vikse et al. who found splenic hilum to be the most frequent site with 62.1% of accessory spleens. Curtis GM, (1946) [14] also emphasized the importance of accessory splenic tissue in the splenic region during surgical procedures. In the present study the relatively smaller percentage at the hilum might be related to the small number of accessory spleens found.

Only 12.5% of the cases were located at the pancreatic-tail area, but this is the most important location from a clinical point of view. Mortelé et al. (2004) [15] reported that accessory spleen is present in 16% of patients who underwent contrast-enhanced abdominal computed tomography and described it as a generally well-defined, round, structure, typically less than 2 cm in size, and that it could mimic pathological processes. The current discovery of an accessory spleen in the tail of the pancreas thus has practical implications for radiology, especially if an enhancing nodule is identified in the vicinity of the pancreas.

The accessory spleen of the present study was mostly oval (62.5%), round (25%) and irregular (12.5%) in shape. The maximum diameter was between 0.8 and 2.1 cm with an average diameter of 1.42 ± 0.38 cm. The dimensions reported in this study are generally similar to those described in previous studies in the field of accessory splenic tissue. Splenic tissue sonographic characteristics and their variable detectability was discussed by Benter et al. (2011) [17] and the importance of recognising normal splenic variants during imaging assessment was highlighted. Grieser et al. confirmed that accessory splenic tissue may be identified by its morphology and enhancement pattern in a multidetector computed tomography (CT) study of accessory spleen [18].

The clinical significance of the present results is especially that accessory spleens can contain splenic-like tissue which may function after splenectomy. They are located in the splenic hilum, gastrosplenic, splenorenal and pancreatic-tail regions, thus highlighting the importance of systematic examination of these areas during surgery. Small accessory spleens can also be missed during normal anatomical examination due to their size and diversity in shape.

This overall study shows that the main spleen and accessory splenic tissue are quite diverse anatomically. A large proportion of wedge-shaped spleens and frequent splenic notches and lobulations,

together with the 20% incidence of accessory spleens, emphasise the need to recognise normal splenic variants. Splenic hilum or adjacent areas of the ligamentous and pancreatic regions are especially significant when examined during dissection or in splenic surgery. Awareness of these differences can help anatomists, surgeons, radiologists and pathologists distinguish between normal anatomy and pathological lesions and minimize the risk of unintentionally leaving behind functioning accessory splenic tissue.

Conclusion

The present retrospective cadaveric study demonstrates considerable morphological diversity of the spleen and a notable prevalence of accessory splenic tissue among the 40 adult specimens examined. The wedge-shaped configuration was predominant, while variations in splenic notches and lobulations were also frequently observed, highlighting the range of normal anatomical patterns. Accessory spleens were identified in 20% of specimens, most commonly as a single structure located near the splenic hilum, followed by the gastrosplenic and splenorenal ligaments and pancreatic-tail region. Most accessory spleens were oval and small in size. These findings emphasize the importance of systematic examination of the spleen and surrounding structures during cadaveric dissection and surgical procedures. Awareness of such variations is also valuable for accurate radiological interpretation and prevention of diagnostic or operative errors.

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