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Morphometric Study of the Segmental Branches of the Splenic Artery in Human Cadaver Spleens by Dissection Method

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ABSTRACT

Introduction: The spleen, an essential organ of the lymphatic and immune systems, is highly vascularized and performs vital functions, including filtering blood, recycling iron, and managing immune responses.

Objective: To analyze the morphometric characteristics, branching patterns, and anatomical variations of the segmental branches of the splenic artery in human cadaver spleens through dissection.

Methodology: This descriptive observational study was conducted at the department of Anatomy, Gomal Medical College, Dera Ismail Khan during May 2024 to April 2025. Data were collected from 55 **human cadaver spleens.** Cadaver spleens were collected from a medical anatomy lab, ensuring they were preserved in 10% formalin to maintain structural integrity. Inclusion criteria required cadavers to be free of any apparent pathological conditions, traumatic injuries, or vascular anomalies that could interfere with the dissection process.

Results: Data were collected from 55 **human cadaver spleens.** Splenic artery most commonly divided into three primary segmental branches, observed in 58% (n=32) of the cadavers. Two branches were identified in 30% (n=17) of the cases, while four branches were seen in 12% (n=6). The mean diameter of the branches was 2.6 ± 0.5 mm, and the mean length was 42 ± 8 mm. The superior branches supplied 45 ± 3% of the splenic parenchyma, while the inferior branches accounted for 40 ± 4%. Anatomical variations were present in 18% of the cadavers, including accessory arteries (12%) and unusual origins of branches (6%).

Conclusion: It is concluded that the segmental branches of the splenic artery exhibit considerable variability in their branching patterns, dimensions, and anatomical configurations. The most common pattern observed was three primary segmental branches, supplying distinct vascular territories with minimal overlap.

1. INTRODUCTION

The spleen, an essential organ of the lymphatic and immune systems, is highly vascularized and performs vital functions, including filtering blood, recycling iron, and managing immune responses. Arterial blood supply especially the splenic artery reflects a good deal of anatomical variation. The splenic artery arises as a major branch of the celiac trunk, runs a long and winding course before entering the spleen by passing through its hilum then branches into segmental arteries for various areas of the organ [1]. Therefore, it is essential to decipher the morphometric measures of these segmental branches for purposes of surgical planning, treatment of injuries and diverse clinical practices. In a clinical setting, the identified branching patterns of the splenic artery possess considerable implications for practice [2]. It is not unusual for surgeons to experience

such differences during surgeries such as splenectomy, splenic artery embolization and partial splenic resections [3]. For example, understanding of segmental arteries is mandatory for achieving competent partial splenectomy with minimal risk for the development of postoperative ischemic phenomena. Likewise, in trauma cases such as splenic, knowing the arterial supply will help in sectioned ligation or selective embolization of the specific extra hepatic branches rather than having to compromise on total organ ligation [4]. Demographic characteristics included age, booking status, area of residence, socioeconomic status, and gestational age at presentation were noted. Clinical characteristics including presenting complaints, fetal heart sounds (normal, reduced, and absent), and obstetric factors were

For example, CT angiography and MRA have offered better possibilities for depicting the splenic vasculature without invasiveness [5]. Although technetium-99m-MAA scintigraphy coupled with planning Using CT angiography images is still formidable for definition of the detailed anatomical information based on intraoperative micro dissector, dissection-based methods still provide three-dimensional perception about the spatial topography, branching profile and segmental position of splenic artery [6]. Such studies not only confirm the radiological diagnoses made but also provide a strong model for anatomical education and investigations [7]. By genetic, developmental and environmental factors influence, anatomy branching pattern of splenic artery as well as morphometric characteristics include length, diameters, and angles branching. Several researchers have published their findings of the distribution of certain branching kinds, like the bifurcation, trifurcation or other types. However, much controversy has not been laid to rest on classifications of splenic artery branching and its segmental supply and hence should be further studied [8].

The dissection method is accepted by many as the most accurate approach for anatomical studies because of high definition of arteriole structures as well as detailed perforation of fine structures. Thus, when studying cadaveric spleens, lowered morphometric parameters can be quantified, and differences in branching patterns can be recorded. The typical benefits of this method also include the ability to detect the presence of accessory or aberrant arteries potentially affecting the clinical outcome [9]. For instance, AIO can result in incomplete arterial contraction during embo list or unexpected bleed during surgery when the accessory splenic artery is not known. The splenic artery is one of the Celiac trunk branches that helps in supplying oxygenated blood to the spleen, the pancreas and some part of the stomach. Its highly ramified structure, especially within the spleen, has attracted extensive studies in the clinical as well as the anatomical sciences [10]. The splenic artery is described to be tortuous and displays variability in segmental anatomy, which is the reason why it is of considerable interest of surgeons and radiologists. Appreciation of accurate morphometry of the segmental branches of the splenic artery is important in splenectomy, partial splenectomy, splenic artery embolization, and in the management of splenic injury [11]. The spleen per se is an organ with rich vascularization and immunological and hematological relevance. These are divided into several segments vascularized by different branches of the splenic artery. These segmental branches pervade distinct regions of the spleen, and there is variability in the distribution of the branches among the population [12].

Objective

To analyze the morphometric characteristics, branching patterns, and anatomical variations of the segmental branches of the splenic artery in human cadaver spleens through dissection.

2. METHODOLOGY

This descriptive observational study was conducted at department of Anatomy, Gomal Medical College, Dera Ismail Khan during May 2024 to April 2025. Data were collected from 55 human cadaver spleens. Cadaver spleens were collected from a medical anatomy lab, ensuring they were preserved in 10% formalin to maintain structural integrity. Inclusion criteria required cadavers to be free of any apparent pathological conditions, traumatic injuries, or vascular anomalies that could interfere with the dissection process. Cadavers with visible damage or distortion to the spleen or its arterial supply were excluded. The materials used for the study included standard dissection tools such as scalpels, forceps, scissors, and probes, which were essential for isolating and examining the splenic artery and its branches. Calipers and rulers were utilized for morphometric assessment as the result of which genuine dimensions were obtained. Small branches, from middle aged and younger trees, were further examined using magnifying glasses and all observations recorded on data sheets. Digital high-resolution photos were also captured for the same purpose and for record taking. The abdominal cavity of each cadaver was opened via the standard dissection process in order to firstly analyse the area of the celiac trunk and secondly, to try and find the splenic artery. With respect to the course of the artery that lies tortuous towards the spleen, the connective tissues extending around it were dissected off to best reveal the segmental branches. Every branch was traced further to see how they started, in which direction they ran and where they spread in the spleen. The branching patterns and vascular territories were described along with dimensions such as length and diameter of the branches that were taken using vernier caliper. Some adjustments were made to the kinds of observations being made so that a proper account of the segmental distribution could be achieved regarding the branching patterns. It should be noted that the study was undertaken observing the ethics of using cadaveric trees samples. Before the conduct of the study, informed Institutional ethics committee approval was sought. Data were analyzed using SPSS v26. Descriptive statistics were employed to calculate the frequencies and percentages of branching patterns and anatomical variations. Additionally, mean and standard deviation values were computed for the measured dimensions of the branches.

3. RESULTS

Data were collected from 55 human cadaver spleens. Splenic artery most commonly divided into three primary segmental branches, observed in 58% (n=32) of the cadavers. Two branches were identified in 30% (n=17) of the cases, while four branches were seen in 12% (n=6).

Table 1: Branching Pattern of the Splenic Artery

Number of Segmental Branches	Frequency (n=55)	Percentage (%)
2	17	30%
3	32	58%
4	6	12%

The morphometric analysis of the segmental branches revealed that the diameter ranged from 1.5 mm to 3.8 mm, with a mean diameter of 2.6 ± 0.5 mm. The length of the branches varied between 25 mm and 65 mm, with an average length of 42 ± 8 mm.

Table 2: Dimensions of Segmental Branches

Parameter	Observed Range	Mean ± SD
Diameter (mm)	1.5–3.8	2.6 ± 0.5
Length (mm)	25–65	42 ± 8

The vascular territories of the segmental branches showed a balanced distribution, with the superior branches supplying 40–50% of the splenic parenchyma, averaging 45 ± 3%. The inferior branches accounted for 35–45%, with a mean of 40 ± 4%. Accessory branches, when present, supplied 10–20% of the parenchyma, with an average of 15 ± 3%.

Table 3: Segmental Distribution of Vascular Territories

Branch	Vascular Territory (%)	Mean ± SD
Superior Branches	40–50	45 ± 3
Inferior Branches	35–45	40 ± 4
Accessory Branches	10–20	15 ± 3

Anatomical variations were observed in 18% of the specimens. Accessory segmental arteries were the most common variation, found in 12% (n=7) of the cases. Unusual origins of segmental branches were identified in 6% (n=3) of the specimens. No cases of absent or duplicated branches were observed.

Table 4: Anatomical Variations in Segmental Branching

Variation Type	Frequency (n=55)	Percentage (%)
Accessory Segmental Artery	7	12%
Unusual Origin of Segmental Branches	3	6%
Absent or Duplicated Branches	0	0%

The analysis of vascular segmentation revealed that the superior segment of the spleen was typically supplied by an average of 2.5 ± 0.6 branches, accounting for 45 ± 3% of the total blood supply. The inferior segment received blood from an average of 2.0 ± 0.5 branches, contributing to 40 ± 4% of the total supply.

Table 5: Frequency of Superior and Inferior Branches in Vascular Territories

Vascular Segment	Number of Branches (Mean ± SD)	Percentage of Total Supply (%)
Superior Segment	2.5 ± 0.6	45 ± 3
Inferior Segment	2.0 ± 0.5	40 ± 4

The analysis of anatomical variations based on gender revealed that accessory segmental arteries were more commonly observed in male cadavers (n=5) compared to female cadavers (n=2), contributing to a total frequency of 12%. Unusual origins of branches were noted in 2 male cadavers and 1 female cadaver, with an overall frequency of 6%. No cases of absent or duplicated branches were identified in either gender.

Table 6: Comparison of Anatomical Variations Based on Gender

Anatomical Variation Type	Male Cadavers (n=30)	Female Cadavers (n=25)	Total Frequency (%)
Accessory Segmental Artery	5	2	12%
Unusual Origin of Branches	2	1	6%
Absent or Duplicated Branches	0	0	0%

4. DISCUSSION

This study provides a detailed morphometric analysis of the segmental branches of the splenic artery, highlighting its branching patterns, dimensions, and anatomical variations. The findings contribute valuable insights into the vascular anatomy of the spleen, with significant implications for clinical and surgical practices. The most frequent branching pattern that was detected in this study was three major segmental arteries in 58 of the cases. This finding supports other literature that has estimated three branches as the normal distribution to the superior and inferior poles of the spleen [13]. The number of branches also differed from two to four, therefore preoperative imaging and intraoperative observation should be made to avoid possible discrepancies. It is important to understand these patterns during partial splenectomy because the care taken to achieve adequate vascular control reduces ischemic-related risks to the retained segments [14]. The diameter and length of the segmental branches were in variable, their mean values being 2.6 mm and 42 mm. These dimensions are useful to advance to embolization planning, where information like catheter diameter and branch selectability is critical. Superior and inferior vascular territories were nearly equivalent, providing blood supply to 45% and 40% of splenic tissue respectively. This relative distribution in the spleen can be of benefit in procedures that permit at least partial retention of splenic function. Variations were detected in 18 percent of the cadavers, with accessory segmental arteries being the most common variation at 12 percent [15]. These cases underscore that splenic vasculature is highly variant and therefore underscore importance of detailed imaging during preoperative evaluations. The segmental branch arose from an unusual location in 6% of the cases; such an artery anatomy might be crucial in determining the outcomes of surgeries. As expected, this study has several clinical implications [16]. This is vital in trauma since it can pinpoint the segmental branches to embolise the bleeding point and at the same time spare healthy splenic tissue. Likewise, as a laparoscopic or robotic splenectomy, knowledge about vascular segmentation can help improve surgical accuracy, decrease the operation time and decrease postoperative accidents [17]. Moreover, the identification of accessory arteries and other anatomical variations help in the diagnosis and treatment of splenic artery aneurysms which are commonly seen at bifurcation sites [18]. The findings of this study correspond to multiple other works identifying the irregularity of splenic arterial branching. However, the involvement of a new scale of morphometric parameters of the branches, for instance branch width and length, gives an additional depth into the existing literature [19]. As opposed to more conventional approaches using imaging methods as the key tools, this study is based on dissections, which allows for more accurate measurements; hence, the presented data can be considered a reference for future research on the topic [20]. Therefore, there are some limitations in the study, regardless of the above-stated strengths. The present cadaveric sample is 55, which is decent but may not be sufficient to account for variation in the population. Moreover, all specimens examined in the present study were embedded in paraffin and fixed with formalin; this might cause changes in vessel sizes as compared with in vivo circumstances. Subsequent research involving greater subjects and enhanced use of imaging technologies ought to afford increased understanding.

5. CONCLUSION

It is concluded that the segmental branches of the splenic artery exhibit considerable variability in their branching patterns, dimensions, and anatomical configurations. The most common pattern observed was three primary segmental branches, supplying distinct vascular territories with minimal overlap. The mean diameter and length of the branches, measuring 2.6 mm and 42 mm respectively, provide important reference points for surgical and interventional procedures. Anatomical variations, such as accessory segmental arteries and unusual branch origins, were identified in 18% of the specimens, emphasizing the need for thorough preoperative imaging and planning to avoid complications. The balanced distribution of vascular territories between the superior and inferior branches further highlights the spleen's functional segmentation, which is critical during partial splenectomy or vascular embolization.

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