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Splenic Notches and Morphometrics of Spleen as Tools for Sexual Dimorphism: an Analysis in Pune Region of Maharashtra

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Abstract

Variations in shapes and morphometry of spleen is seen. Number and location of splenic notches show regional variation. This study is done to determine tools for sexual dimorphism of spleen. 72 spleen of known sex were used from cadavers used for 1st MBBS dissection. Shape, number and location of splenic notches were noted. Length, breadth, thickness and weight of spleen were calculated. Triangular shaped spleen was seen most commonly. Maximum 5 notches were seen on a spleen. Morphometric measurements showed regional variations and sexual dimorphism. We conclude that formation of splenic notches by incomplete fusion of various lobes has been mentioned in earlier embryological studies but new hypothesis suggests that these notches can be considered developmental variations. A wide variation in shapes and morphometrics of spleen is seen. They can be used as tools of sexual dimorphism.

Keywords: Accessory Spleen, Bilobed Spleen, Ectopic Hilum, Splenomegaly, Triangular Spleen.

Introduction

Spleen is the largest secondary lymphoid organ. Graveyard of RBCs is a term used for spleen. It filters the blood, serves to destroy and remove old and damaged RBCs. It has an important role in immunology and hematology. So the spleen is normally conserved during operative procedures (1). It is located in the stomach bed, related posteriorly on the diaphragmatic surface to 9th, 10th and 11th rib. The spleen has a superior border, inferior border, anterior end and posterior end. A splenic notch is seen on the superior border near the anterior end. Splenic cleft, intersplenic fold, splenic fissure are other terms used for the splenic notch. The visceral surface shows a hilum, which lodges splenic artery, splenic vein and tail of pancreas (2). Spleen develops in 4th week of intrauterine life from mesoderm in dorsal mesogastrium, as multiple lobules which fuse incompletely forming splenic notches on the superior border (1). Buijktendink *et al*., (3) state a contradicting hypothesis that splenic notches are developmental variations. Many shape of spleen like oval, wedge triangular, quadrangular, irregular shapes and accessory spleens with ectopic hilum are documented (4). Normal sized spleen is located below the left side of costal cartilage. Spleen can be diseased and damaged in many disorders, thus affecting its size and morphometry. It can be palpated only during inspiration or when enlarged more than double its normal size. An enlarged spleen is called splenomegaly. An enlarged spleen will compress the abdominal viscera leading to various complications. Variations in shapes should be checked to not consider it as a case of splenomegaly. Tail of pancreas may lodge accessory splenic lobules, these may be involved in splenomegaly. While operating for splenectomy which is removal of spleen, extra care must be taken to preserve the tail of pancreas. Removal of tail of pancreas during splenectomy will hamper the insulin production (2). A complete fissure dividing the spleen into lobes can be seen.42% of blunt traumatic abdominal injuries involve the spleen (5). Morphological studies to evaluate the various shapes and morphological measurement of spleen have been done in various countries and states of India (6 - 9). Variations in location and number of splenic notches have been reported (10 - 12). Differences have been seen between male and female spleens during some morphometric studies (13 - 15). Aim of this study is to

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demonstrate regional variations of spleen and find tool for sexual dimorphism by analysis of location of splenic notches and morphometrics of spleen.

Methodology

72 Spleens from formalin embalmed cadavers used for undergraduate teaching were obtained after meticulous dissection. 77.08 % male and 22.92% female cadavers were used in this study. Ethical approval was sought from the Institutional ethical sub-committee by Ref.No.: I.E.S.C./W/72/2024. Spleen was observed for various shapes like oval, wedge, triangular, quadrilateral and irregular shaped. Various parameters like length, breadth, width and weight of spleen were measured. A digital verniar caliper and digital weighing scale were used for the measurements. Splenic notches were observed for their location and number. Accessory spleens were observed for. Measurements of spleen were taken in centimeters while weight was measured in grams. Measurements were taken as follows (1)-

- Length of spleen [l] was measured as maximum length from anterior to posterior pole.
- Breadth of spleen [b] was measured as maximum length from superior border to inferior border.
- Thickness of spleen [t] was measured as maximum width measured between diaphragmatic and visceral surface.
- Weight of spleen [w] was checked on digital weighing scale.

Results

Variations in shape and morphometrics of spleen are seen in study of 72 spleen from formalin embalmed cadavers. Potential limitations in cadaveric formalin embalmed specimen like tissue shrinkage and post martum changes should be considered while correlating clinically. Shapes of spleen like wedge shaped, triangular, oval, and quadrilateral and irregular shaped were found, as seen in Figure 1, 2, 3 and 4. Triangle shape was seen in maximum specimen (29.16%). Results are tabulated and compared with other studies in Table 1.

Measurements for length [l], breadth [b], thickness [t] and weight [w] were taken by digital vernier caliper and weighing scale. Maximum and minimum length seen was 11.08mm, 6.32 mm and 4.88mm. Minimum length, breadth, thickness seen was 6.85mm, 3.71mm, 1.51mm and maximum and minimum weight seen 340gms and 63gms. Average measurement for all parameters are tabulated in Table 2 and compared with other studies.

Table 1: Shapes of Spleen

Shape of spleen	Covantev S [Russia]	Kaur J [Punjab]	Ashwini NS [Karnataka]	Current Study [Maharashtra]
Wedge	38	53.33	34	26.38
Oval	10	6.67	21	15.27
Triangular	22	6.67	17	29.16
Quadrilateral	11	23.33	17	18.05
Irregular	19.	10	11	11.11

Figure 1: Triangular Shaped Spleen

Figure 2: Wedge Shaped Spleen with Complete Fissure

Figure 3: Quadrilateral Shaped Spleen

Figure 4: Oval Shaped Spleen with Complete Fissure [A] and Ectopic Hilum [B]

Table 2: Regional Comparison of Morphometry of Spleen

Average In cms	Chaudhri M L [Gujarat]	Shivanal U [Karnataka]	More M [Karnataka]	Demissie S [Ethiopia]	Current study [Maharashtra]
Length [l]	9.59	10.29	9.97	10.24	9.21
Breadth [b]	6.58	6.37	7.21	4.79	5.92
Thickness [t]	4.54	3.4	3.65	3.93	4.73
Weight [w]in gms			132.79		188

Number and position of splenic notches was observed and documented. Absence of notch, notch on inferior border and multiple notches were observed. Maximum of 5 notches (Figure 5 and 6) on a spleen were seen in 3% while no notches were seen in 7%. 21% showed notch on inferior border (Figure 5). Absence of notch was seen in 7% spleens while one notch was seen in 59% spleen. Figure 7 shows pie diagram showing number of splenic notches per spleen. All results are tabulated and compared to other studies for regional variations in Table 3. Figure 8 shows pie diagram showing comparison of location of splenic notches of current study.

Figure 5: Spleen with 5 Notches. 1 To 4 on Superior Border and 5th on Inferior Border

Figure 6: Spleen with 5 Notches and 2 Accessory Spleens. Splenic Artery Dividing Into 3 Branches; A – Splenic Artery, B – Branch Going to Accessory Spleen, C and D – Branches Going in Hilum, E – Branch Going to Accessory Spleen, F And G – Accessory Spleens

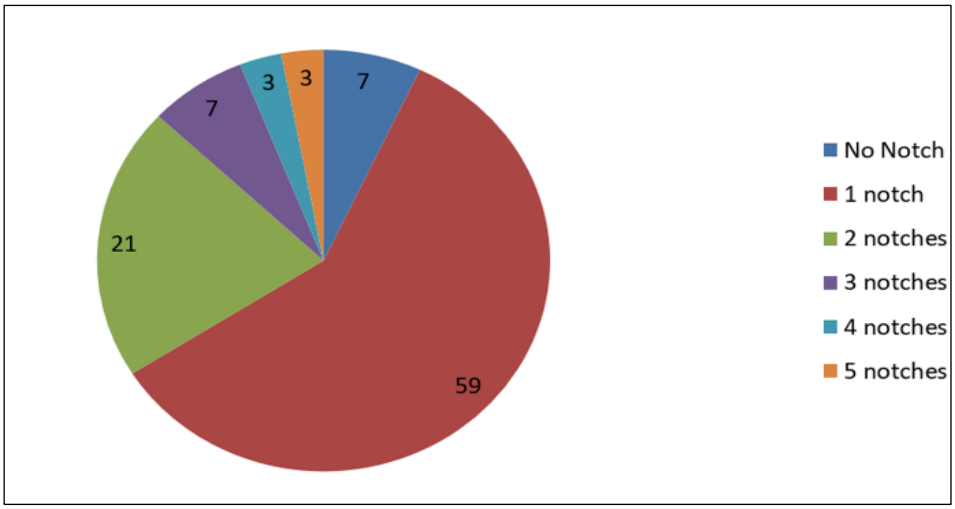

Figure 7: Pie Diagram Showing Number of Splenic Notches

Table 3: Regional Comparison of Number of Splenic Notches

Splenic notches	Chaudhari M L [Gujarat]	Kaur J [Punjab]	Shivakumar A [Tamil Nadu]	Current Study [Maharashtra]
No notch	24.19	6.67	0	7
1 notch	50	23.33	78	59
2 notches	17.74	33.33	16	21
3 notches	3.22	23.33	2	7
4 notches	3.22	13.33		3
5 notches and more	1.61	0	3	3

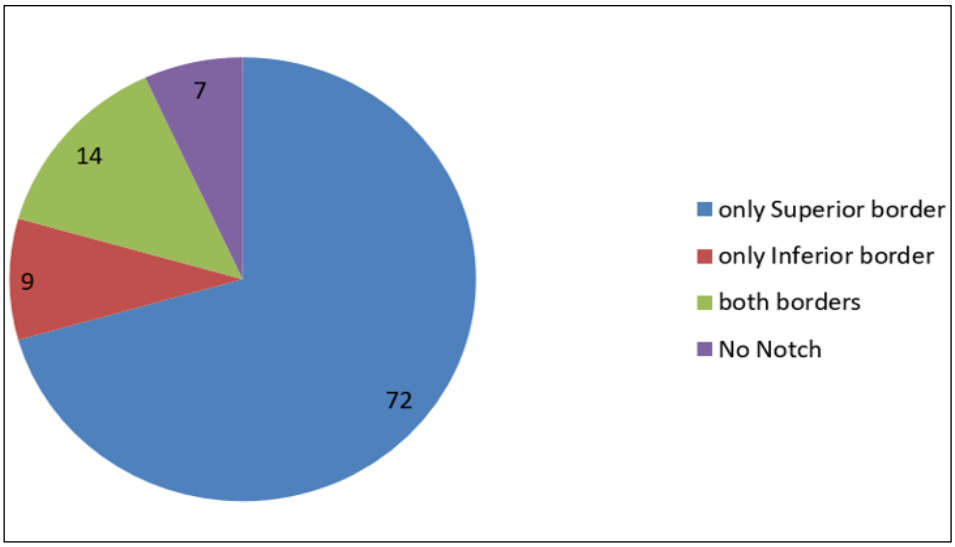

Figure 8: Pie Diagram Showing Location of Splenic Notches

Accessory spleens with ectopic hilum were seen as in Figure 6. Splenic artery dividing into 3 branches before entering hilum was seen in 5 cadavers. Figure 5 shows splenic artery dividing into 4 branches, 2 of which enter ectopic hilum for two accessory spleens. Splenic notch on inferior border was seen in 39% female cadavers. Any differences in measurements of spleen from male and female cadavers were analyzed for sexual dimorphism. Unequal number of male and female due to less availability of female cadavers called for cautious interpretation. Sexual dimorphism was seen in length, breadth, thickness and weight of spleen. Results tabulated and compared with other studies in Table 4.

Table 4: Regional Comparison of Parameters for Sexual Dimorphism of Spleen

Parameters	Mittal *et al.,* [Rajasthan]	Ehimwenma O *et al.,* [Nigeria]	Dang [Haryana]	Asghar [Uttar Pradesh]	Present study [Maharashtra]
Length Male	9.40	11,1	11.45	10.91	10.3
Female	9.34	10.1	9.91	10.34	9.8
Breadth Male	3,45	4.4	6.26	6.74	4.7
Female	3.45	4	6.01	5.61	4.1
Thickness Male			1.92	4.97	3.1
Female			1.92	4.70	2.3
Weight Male			131.6		120.2
Female			87.86		93.7

Discussion

Radiologists and clinicians consider the spleen as "a forgotten organ" (3) but it is very important clinically, hematologically and immunologically. Mesenchymal cells condense in dorsal mesogastrium at end of 4th week of intrauterine life to form spleen. Multiple splenic lobules fuse with formation of splenic notch on the superior border due to incomplete fusion. Anomalies in development can form accessory spleens, lobulated and wandering spleen. Spleno-gonadal fusion, polysplenia and wandering spleen are very rare prenatal developmental defects (16).We found 5 spleens with accessory spleens with ectopic hilum.

Buijktendink M *et al*., proposed a contradicting hypothesis that fusion of splenic lobules is not the only reason for formation of clefts or notches on the border of spleen (3). They studied development of spleen from occurrence of primordium to 2nd trimester, they found number of splenic clefts in foetus was similar to those seen in adults. Pressure by other abdominal organs during development can play a part in formation of the notches on superior and inferior border. So by this hypothesis the splenic notches can be structural variations and not always pointing towards incomplete fusion of developing lobules.

Inter observer reliability helps maintain consistency of assessment. This helps reduce observer bias. We compared shape and morphometry of spleen in current study with studies from various countries like Russia, Nigeria, Ethiopia and various states of India like Punjab, Uttar Pradesh, Gujarat, Maharashtra, Karnataka, and Tamil Nadu for regional variations. We found most common shape to be triangular (29.16%). A study from Russia (6) found wedge shaped spleen as most common (38%) like a study in Punjab (8). They also found triangular shape in 22% like our findings. A study from Nagpur (17) found most common shape to be wedge shaped (61.26%). Average length, breadth and thickness of spleen observed in our study were 9.21 cm, 5.92 cm and4.73 cm. Average weight of spleen found was 188 grams. Average weight for study in Punjab (8) and Nagpur (17) was 139 and 145.76 grams as compared to 188 grams in current study. Ashwini *et al*., (18) reported spleen with maximum weight of 461.1 gms and minimum of 47.8 gms, while we found maximum and minimum weight as 297 gms and 63 gms. They found wedge shaped spleen as most common [34%] while we reported triangular shape [29.16%] in maximum spleens. Studies from Karnataka (4) and Ethiopia (9) gave lesser measurement for breadth at 3.3 and 3.93 cm as compared to 4.2 and 4.75 cm findings from Punjab (8) and current study from Maharashtra. Average length mentioned by More in a study in Karnataka (1) was 9.97 cm similar to 10.24 cm seen in Ethiopia by Demissie (9), 9.52 cm by Chaudhari (7) in Gujarat and 9.21cm in Maharashtra in current study.

A study in Andhra Pradesh (11) found 3% bilobed spleen with a fissure from superior to inferior border. This is similar to our finding of 2.89% spleen with a complete fissure, thus making it bilobed. They report 50% spleen with no notches, 40% with notch on superior border and 10% with notch on inferior border. Srijit Das et al (12) found 98% splenic notches on superior border and 2% on inferior border. A cadaveric study in Karnataka (10) also found notch on superior border in 70%, inferior border in 7.5%. 5% showed notch on both borders and no notches in 12.5%. In our study we found notch on superior border in 72%, 9% on inferior border and 12% on both borders. 7% showed no notches. Our findings are more similar

to results of others findings (10). A study of autopsy specimen in Germany (19) mentioned that accessory spleen are found in 10-15%, of these 1 to 2% are seen in the tail of pancreas. Our study gives a 6.9% of accessory spleens. We found maximum 5 splenic notches on spleen. Absence of notches was seen in 24.19% in a study in Gujarat (7) as compared to 7% in our study. Only one splenic notch was reported in 78% by a study in Tamil Nadu (20), we found single notch in 59% in current study. Some researchers found maximum 7 notches in one specimen with 3 on anterior and 4 notches on inferior border (20). They report 3 % incidence of 5 notches or more which is similar to our study.

Morphometry of spleen from current study was compared for sexual dimorphism with studies in Nigeria (21), Uttar Pradesh (13), Rajasthan (14) and Haryana (15). Results are tabulated in Table 4. Sexual dimorphism was seen in all the studies along with regional variations. Length, thickness and weight of spleen can be considered as a tool for sexual dimorphism. While interpreting clinically, splenic fissures on inferior border can be misdiagnosed as lacerations in patients with abdominal trauma (6). In cancer patients, unexpected locations of accessory spleens can be misinterpreted as metastatic lymph nodes (9). Knowledge of normal and variant spleen morphology can prevent nonessential diagnostic procedures.

Conclusion

In current study, morphometry of spleen showed regional variation and sexual dimorphism. We found triangular shaped spleen as the most common shape. Regional variation was seen in number of notches and morphometry of spleen. Morphometry and location of splenic notches can be a tool for sexual dimorphism. A new hypothesis that splenic notches appear during development contradicts the known old hypothesis that splenic notches form due to fusion of splenic lobules during development. Splenic notches or clefts should be considered morphometric variations formed during development. Planned conservatory splenectomy operations will be guided by knowledge of morphometric variations of spleen.

Limitations of the Study – 72 cadavers used for 1st MBBS dissection classes across three years were used, of these 22.92% were female. Lack of age and cause of death of the cadavers limits the study. Less number of female cadavers were available for the study owing to body donation trends and availability of unclaimed cadavers. Unequal distribution may limit the conclusion on sexual dimorphism. A more vast number of the sample size will give the hypothesis more authority.

Abbreviation

Nil.

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Author Contributions

Shinde Amol A: Introduction and discussion, Agrawal Sakshi: Methodology and Results, Patel Dinesh K: References.

Conflict of Interest

Authors declare that there is no conflict of interest.

Ethics Approval

Ethical clearance for study was given by letter Ref,No.: I.E.S.C. /W/72 /2024.

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