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Morphological Variations of Human Spleen in Different Age Groups

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Abstract: **Spleen is an organ with varied morphology, diverse functions and applied importance, all subject to many controversies in spite of centuries of studies on it. Aim of the study: To study the morphology of human spleen in different age groups, and to verify whether the specimens can be grouped into various types based on their morphology and the length of the hilum. Materials and Methods: Seventy formalin fixed human spleens obtained postmortem, were subject to study. They were classified into different age groups, in both sexes, for a detailed study of the morphological features, namely, weight, shape and type, appearance of hilum, notching of borders and fissuring of surfaces. Accessory spleen, cysts, lobulation and tubercles, if any, were looked for, along with other developmental anomalies. Observations and results: The average weight of spleen increased from the newborn to reach a maximum in the third decade and then decreased; it was invariably heavier in the males in all age groups. Specimens of all three types, distributed, compact and intermediate, and all four shapes, triangular, wedge shaped, ovoid and tetrahedral were observed. Notching was seen most frequently on the superior border. Eight specimens showed anterior lobule, four showed posterior tubercle and one specimen showed an accessory spleen close to the hilum. Conclusion: Classification of spleen into the three morphological types is valid, considering the external features and the length of the hilum. More studies are required correlating the morphology with microscopy and histogenesis.**

Keywords: **Spleen, Morphological types, Development, Congenital anomalies**

I. INTRODUCTION

Spleen, a secondary lymphoid organ, is a large encapsulated mass of vascular and lymphoid tissue. Its size and weight vary with age and sex. The shape varies from a slightly convex wedge to a domed tetrahedron and is determined by its relations to the neighbouring structures during development. The adult spleen may retain its foetal lobulated form, or may show deep notches in inferior and intermediate borders, or fissures on diaphragmatic surface, in addition to the notches usually present on the superior border[1].

Close observation of this organ shows three morphological types[2], distributed, compact and intermediate, as described by Michels (1942). But such an observation is hardly ever mentioned in any of the latest textbooks or recent publications on the organ. Here an attempt has been to see whether such a classification of spleen types, based on its morphology does exist.

Though spleen is not considered absolutely essential for an individual's survival, a study on its morphology is still deemed important in view of its relevant anatomical, functional and developmental aspects, which are also being reviewed in this study.

II. MATERIALS AND METHODS

The study was done on formalin fixed, postmortem spleens procured in the Department of Anatomy in Government Medical College, Kottayam and Pushpagiri Institute of Medical Sciences and Research Centre, Thiruvalla, Kerala, India. Seventy apparently normal spleens belonging to both sexes were selected for the study. The specimens were grouped according to their age groups. The average weight of the spleen in the different age groups in both sexes were studied.

In the morphology, the presence and number of notches on the superior, inferior and intermediate borders, and the presence of fissures on the diaphragmatic or visceral surface were noted. Deep notches on the superior and inferior borders lying in apposition would give a lobulated appearance to the specimen, frequently seen close to the anterior end. A deep notch seen close to the posterior pole of the spleen, along with a significant prominence related to it, described as posterior tubercle was also looked for. The hilum of the spleen was observed for its number [infrequently more than one hilus is present] and length. Entrance of the arterial branches through sites other than the hilum was also noted. Depending on the length of the hilum and the notches on the superior border three general types of spleen were observed, the *compact type* characterized by a narrow hilum and relatively smooth borders, the *distributed type*, with a notched superior border and longer, distributed hilum with vessels entering over a wider area, and an *intermediate type* showing mixed features.

An attempt has been made to review the development of the organ so as to account for the observed variations. Other conditions like splenunculi, splenoptosis, splenosis, polysplenia, and developmental fusion with other organs were also looked for.

III. OBSERVATIONS

The morphology of spleen was studied in seventy formalin fixed specimens. The specimens were grouped based on the age and sex of the bodies as follows:

Table 1: Age-wise grouping of spleen specimens in both sexes

Age groups	Male		Female		Total	
	No.	%	No.	%	No.	%
0-10 yrs	2	4.44	1	4	3	4.29
11-20 yrs	1	2.22	1	4	2	2.86
21-30 yrs	4	8.89	2	8	6	8.57
31-40 yrs	13	28.89	7	28	20	28.57
41-50 yrs	9	20.0	5	20	14	20.0
51-60 yrs	11	24.44	6	24	17	24.29
61-70 yrs	2	4.44	2	8	4	5.71
71-80 yrs	3	6.67	1	4	4	5.71
TOTAL	***45***	***100***	***25***	***100***	***70***	***100***

The average weight of the spleen in the different age groups in the two sexes (Fig. 1) were noted.

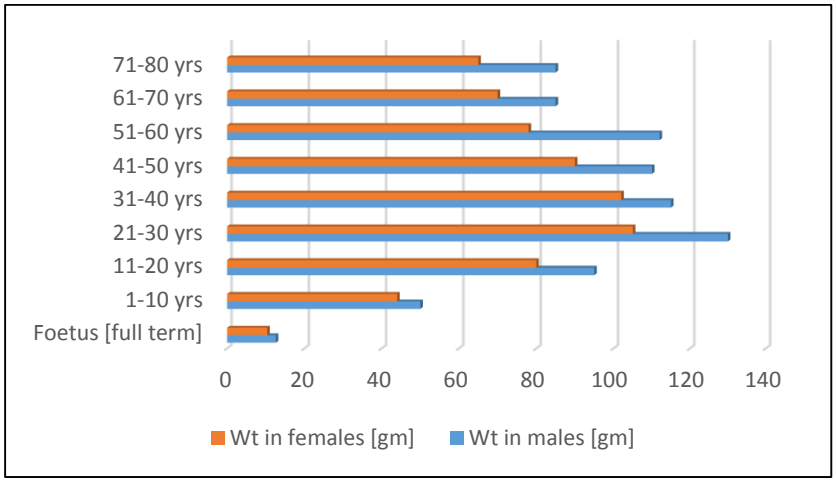

Fig. 1: Age-wise spleen weight

Out of the 70 spleens, 45 belonged to the males and 25 to females. As only a smaller number of spleens of females were available, it was difficult to do a comparative study between the males and females; hence spleens from both sexes were added together for the study.

The weight of spleen in the males was found to increase gradually from an average of 12 grams in a newborn to a maximum of 130 grams by the third decade of life. Then it gradually decreased to an average of 84 grams in the eighth decade. In the females also the weight consistently increased to an average of 105 grams in the third decade of life, and then gradually decreased to an average of 65 grams in the eighth decade. On plotting the weight changes in a graph [Fig. 1], it can be observed that the weight in the males [88.29 ± 36.65] exceeded that in the females [71.60 ± 29.67] in all age groups.

The specimens showed a wide range of variations in their shapes [Fig. 2], i.e., 37 were oval [52.9%], 13 had wedge shape [18.6%], 10 were triangular [14.3%] and nine were tetrahedral [12.9%], as depicted below. A clear dome like appearance was seen in one specimen [1.43%].

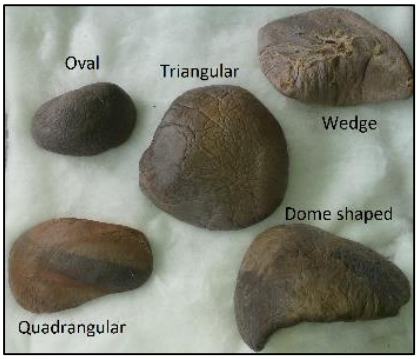

Fig. 2: Variations observed in shape of spleen

Irrespective of the age and the shape the specimens the size of the organ showed considerable variation as represented in Fig. 9, though there was no known factor like profuse blood loss or infections like malaria that could account for this.

The variations in the number and depth of the splenic notches on the different borders were observed (Table 2). In general, the notches were more in number and greater in depth in the superior border, as compared to the inferior and intermediate borders. Nineteen specimens showed notches on superior and inferior borders, and eleven had notches on all three borders. Notches were totally absent on all three borders in six specimens.

Table 2: Variations in the notches on the borders of spleen

Borders	**No. of notches**	**No. of spleens**	**%**
Superior border	0	7	10
	1	20	28
	2	23	33
	3	12	17
	4	6	9
	> 4	2	3
	Total	***70***	***100***
Inferior border	0	54	77
	1	11	16
	2	5	7
	Total	***70***	***100***
Intermediate border	0	41	59
	1	7	10
	2	21	30
	3	1	1
	Total	***70***	***100***
Present on sup. & inf. borders		*19*	*27 %*
Present on all three borders		*11*	*16 %*
Absent on all three borders		*6*	*9 %*

In one specimen the deep notches on the superior and inferior borders extended towards the diaphragmatic surface in the form of two fissures (Fig. 4). In eight spleens (11 % of total), the deep notches of the superior and inferior borders, located close to the anterior pole lie in apposition, thus giving a 'lobulated' appearance to the spleen (Fig. 5). A 'posterior tubercle' formed by a deep notch close to the posterior pole was seen in six spleens (9 %). The anterior lobule together with the posterior tubercle (Fig. 6) could be seen in four specimens (6%). The anterior lobule, when present, was seen to be pierced by a small polar branch from the splenic artery. A prominent tubercle in relation to the intermediate border was observed in one specimen (Fig. 6).

Fig. 3: Deep notches on superior and inferior borders

Fig. 4: Anterior lobule demarcated by deep fissures

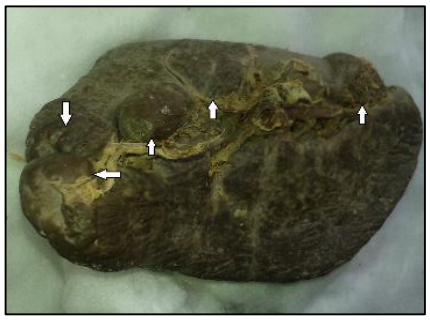

Fig. 5: Tubercles on intermediate border

The visceral surface of the spleen was seen to be pierced by several irregularly spaced apertures for the entrance and exit of vessels and nerves. The line of penetration is almost always marked by a furrow, the hilum of spleen. The position and curvature of the hilum were markedly variable; some were more or less straight, and some greatly curved. More than one hilum could be seen in three spleens. The ends of the hilum seemed to bifurcate in two specimens [Fig. 7].

Fig. 6: Bifurcated end of hilum

A significant furrow seemed absent in one specimen [Fig. 8], in which the splenic artery branches were seen to enter the splenic substance through separate perforations on the visceral surface.

Fig. 7: Hilar furrow absent; arterial branches enter through separate foramina

In a good number of specimens the splenic artery branches were seen to enter the gastric or renal area on the visceral surface, in addition to the hilum [Fig. 9].

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Fig. 8: Splenic artery branches piercing visceral surface, in addition to hilum

The length of the splenic hilum was measured and plotted in a pie diagram (Fig. 9). Majority of spleens (84%) had their hilar lengths varying from four to seven centimetres.

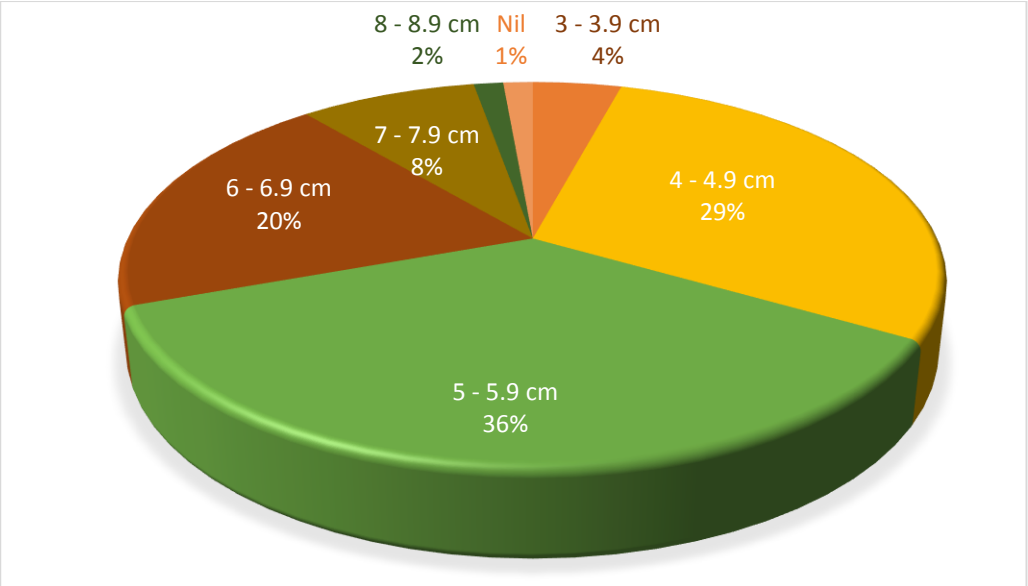

Fig. 9: Splenic hilar length observed in the specimens

Depending upon the length of the hilum and the presence of notches on the superior border, the spleens were classified into distributed [hilar length > 6 cm, seen in 19 specimens, i.e., 28%], compact [hilar length < 5 cm, seen in 24 specimens, i.e., 34%] and intermediate [hilar length 5 - 6 cm, seen in 26 specimens, i.e., 37%] types [Fig. 10]. This grouping has been done, irrespective of the size and shape of the spleen considered.

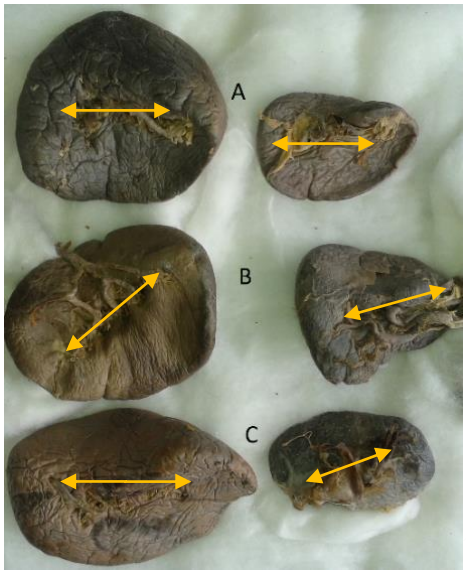

Fig. 10: Compact [A], distributed [B] and intermediate [C] types in different spleen sizes

An accessory spleen was observed as a roughly spherical structure with maximum diameter 1.2 cm, close to the hilum of an intermediate type of spleen. Other congenital anomalies like asplenia, splenoptosis [wandering spleen], polysplenia, and developmental fusion defects [hepatoleinal, splenorenal or splenogonadal fusion] were not observed.

IV. DISCUSSION

In spite of centuries of studies on morphological, microscopic, physiological and developmental aspects of spleen, scientists do not seem to be very successful in unravelling the mysteries concerning this organ. In the present attempt to see the morphology of the organ, like in many of the previous studies, and in the textbook descriptions, plenty of variations could be observed on most of the aspects.

The common shapes observed were oval and wedge shape, with less frequent occurrence of triangular and tetrahedral shapes. The shape variations observed were considerably different from those of previous studies[2,3,4], but not much emphasis was laid on this observation. A more interesting observation was that the spleens of the same shape varied extensively in their sizes and weights. There was definitely a reduction in these parameters with age, but a physiological basis for this observation is yet to be substantiated.

Das *et al.*,[5] mentioned the presence of 0 - 4 splenic notches in their study on 100 spleens. They found a single splenic notch on the superior border of spleen in 98% and in two cases the notch was present on the inferior border, and in one specimen they also observed a notch on the intermediate border. Nayak *et al.*, [6] encountered only 50% of the splenic notches on the superior margin. Contrary to these observations, the present study showed notches on the superior border in 90%, inferior border in 23% and on the intermediate border in 41% specimens. Notches on both superior and inferior borders were observed in 27% samples, and on all three borders in 16% specimens. In nine percent spleens notches were totally absent on all borders.

The variability in the notches and fissures have been explained on the developmental basis of the organ. Spleen has its origin from the mesenchyme of dorsal mesogastrium, which lies over the dorsal pancreatic endoderm, as a long strip of cells adjacent to the developing stomach. Cells required for the haemopoietic function arise from the yolk sac wall, near the dorsal aorta. Splenic vascularization arises initially by branches from dorsal aorta. The proliferating cells invade the underlying angiogenic mesenchyme, which becomes condensed and vascularized. The process occurs simultaneously in several adjoining areas which soon fuse to form a lobulated spleen. The haematopoietic function is lost with embryo development. Lymphoid precursor cells migrate into it late in the foetal life from the central lymph organs. The earlier lobulated structure of the spleen disappears, but is indicated by the presence of notches on the upper border in the adult[1,7,8].

Varga I *et al.*,[9] studied congenital anomalies of spleen like lobular spleen, accessory spleen, ectopic or wandering spleen, polysplenia, asplenia and spleno-gonadal fusion in ultrasound images. They noticed many lobular spleens with no peculiar clinical features. Accessory spleens are found in approximately ten percent of the population[10]. Splenunculi have been reported in about 10 to 30% of patients at autopsy[9]; they were found near the splenic hilum, in gastro-splenic or leino-renal ligaments, within the pancreas and liver, in the stomach wall or even in the pelvis. They may also be found anywhere along the splenic vessels, in the pancreatic tail, the greater omentum, the mesentery or the gonads and their path of descent[11]. The typical size is approximately one centimeter, but sizes ranging from a few millimeters up to 2–3 centimeters are not uncommon. The major complication was acute, chronic or intermittent torsion caused by increased mobility as it has long mesentery[12].

Splenosis is an acquired condition where foci of splenic tissue undergo auto-transplantation, most often following physical trauma or splenectomy[13]. Displaced tissue fragments can implant on well vascularized surfaces in the abdominal cavity, or, if the diaphragmatic barrier is broken, in the thorax. Histologically splenunculi had histological features of normal spleen, whereas splenosis nodules did not have central arterioles in the follicles[14].

Spleno-gonadal fusion (SGF) is a rare congenital non-malignant anomaly characterized by fusion of splenic tissue to the gonad, and can be continuous or discontinuous[15]. Very few cases have been diagnosed preoperatively, and many such patients who present with testicular swelling undergo unnecessary orchiectomy under the suspicion of testicular neoplasm. Spleno-renal fusion is a rare benign entity; only a handful of cases of developmental spleno-renal fusion have been described in the literature. It refers to the presence of heterotopic splenic tissue in the renal capsule. It may arise as a developmental anomaly secondary to the fusion of nephrogenic mesoderm and splenic anlage in the second month of gestation[16]. It may also be secondarily acquired as a result of splenosis after trauma or splenectomy, and the presence of a renal mass in such patients should raise the suspicion of splenosis.

Hakk Maummer Karakas *et al.*,[17] studied splenic abnormalities on CT scan and MRI. They reported congenital variations like asplenia and polysplenia syndrome. Both anomalies were associated with multiple system and organ anomalies including the liver and heart.

The position of spleen is in part maintained by several suspensory ligaments including gastro-splenic, spleno-phrenic, spleno-colic and leino-renal ligaments[18]. If the surgeon is not well versed with these peritoneal attachments of spleen during surgery, an injury to splenic capsule would cause subsequent serious bleeding. This can occur with traction on phrenico-colic ligament while mobilizing the splenic flexure, and while applying traction on the greater omentum [since the omentum could be adherent to the anterior diaphragmatic surface of spleen. Wandering spleen[19] is most commonly diagnosed in young children as well as women between the ages of 20 and 40. Characteristics of the disorder include the loss, weakening, or malformation of the ligaments that help to keep the spleen located in the upper left part of the abdomen. Though not a genetic disease, wandering spleen is often found at birth. It can occur in adults as the result of injuries and other similar conditions that cause the ligaments to weaken, such as connective tissue disease or pregnancy[20].

The most common site for bleeding after splenectomy is a short gastric vessel[18]. Apart from torrential bleeding, left lower lobe atelectasis is another complication of splenectomy. Loss of spleen in early childhood can lead to a loss of antibody response to systemic infections with encapsulated bacteria, referred to as 'overwhelming post-splenectomy sepsis syndrome'. All patients subjected to splenectomy should hence be treated with *Pneumovax*, and young patients should receive antibiotic prophylaxis against *H. influenzae* sepsis till adulthood[18].

V. CONCLUSIONS

The seventy cadaveric spleens could be classified into three morphological types i.e., distributed, compact and intermediate types, and this grouping seems valid, considering its external features and the length of the hilum. It is interesting to note that the three types are present in spleens of all sizes and shapes. Spleens attained maximum weight by the third decade, and then the weight steadily decreased. More studies correlating the morphological variations with its organogenesis, and the circulation through spleen are required, in view of the multiple aspects of applied importance of this organ. It is unfortunate that a pain of splenic origin is not considered even in the differential diagnosis of abdominal pain. More light has to be thrown into the anatomical and physiological aspects of this organ.

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