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"A Study Of The 3D Branching Patterns Of The Splenic Artery Using Silicon Cast"

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Abstract:
Background: *The human spleen is a highly vascular lymphatic organ supplied by the splenic artery, a branch of the celiac trunk of the abdominal aorta. It is tortuous and an end artery. The knowledge of the variational anatomy of the splenic artery is important for surgeons and radiologists to prevent iatrogenic complications. This study aimed to accurately identify the 3D view of segmental branches of the splenic artery by the use of silicone gel cast.*
Materials and methods: *The spleens were collected from the cadavers of the Anatomy department and Forensic medicine department, JSS Medical College, and dissected carefully. The splenic artery and all its branches were cleaned and traced. Silicone gel was injected into the coeliac trunk after thoroughly cleaning the spleen with saline water. After injection, the specimen was kept in the open air for 24 hours until the sealant solidified, and the surrounding tissue was destroyed by concentrated Hydrochloric acid. Thus, a luminal cast was prepared, and the pattern was studied based on the obtained cast.*
Results: *A splendid luminal cast of the splenic artery showed its 3D view of segmental branches and polar branches of the spleen. The splenic artery was originated from the coeliac trunk and is divided into polar branches and terminal primary branches.*
Conclusions: *An excellent, three-dimensional, dry, and long-lasting model of the artery's internal structures and branches is produced by silicon cast plastination of the splenic artery, which is perfect for teaching intricate vascular anatomy.*
Keywords: *Splenic artery, Silicon cast, Polar artery, Segmental branches, Plastination.*
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I. Introduction

The spleen is an encapsulated, highly vascular lymphoid organ located in the left hypochondriac region of the abdomen. It lies between the fundus of the stomach and the left dome of the diaphragm. The human spleen is mainly concerned with phagocytosis and immune responses. It plays an important role in the immunological defense mechanism, body metabolism, and maintenance of circulating blood cells. In the newborn, it is a major site of hematopoiesis and can resume this role among adults in certain pathological conditions. A normal adult human spleen is usually not palpable on abdominal examination unless it gets enlarged or splenomegaly. In living healthy adults, it is most frequently located between the tenth and twelfth ribs, with its long axis along the eleventh rib, its posterior border is 4 cm from the midline at the level of the 10^{th} thoracic vertebral spine and it extends 3cm just anterior to the mid-axillary line. The splenic artery arises directly from the coeliac trunk, in common with the left gastric and common hepatic arteries. It may however originate from the common hepatic artery or the left gastric artery, or very rarely directly from the aorta either in isolation or as a spleno-mesenteric trunk. At the point of its origin, the artery runs inferiorly before it turns to the left just behind the stomach to run horizontally just posterior to the upper border of the body and tail of the pancreas [1].The superior, middle, and inferior primary branches of the splenic artery are the three terminal branches that the artery divides into at its termination. The main branches enter through the hilum of the spleen [2]. These branches after entering the hilum get divided into four to five segmental arteries. A specific demarcated area of the splenic tissue is supplied by such arteries. There is less collateral circulation between these segments, therefore, occlusion of such segmental arteries can frequently cause splenic infarction and this can be catastrophic sequelae[3,4]. Plastination is the method of long-term preservation of the biological tissues with completely visible surface and high durability. It was developed by Dr. Gunther von Hagens in 1978 at the Heidelberg University in Germany. This procedure replaces the lipids and water in biological tissues with curable polymers, which are then impregnated into anatomical specimens and hardened to preserve them. The plastinates serve as excellent teaching tools in education and they are devoid of any harmful effects of formalin. Additionally, plastination is an outstanding tool to study cross-sectional anatomy [5]. Luminal cast plastination is the process of using a solidifying material to fill an organ's lumen or cavity, so that it hardens,

and then the surrounding soft tissue is carefully removed to create a luminal cast. During whole organ Plastination, the dehydration process might change the inner structure of the organ. Therefore, fresh organs are usually recommended for this procedure [6]. Different materials have been used to develop the casts like resin and various polymers but in our present study, we will be using silicon material to develop the luminal cast. A detailed anatomical knowledge of the arterial tree of the spleen is required for segmental resection. Our present study aims to to accurately identify the 3D view of segmental branches of the splenic artery using a newer silicon luminal cast plastination technique.

II. Material And Methods

This cross-sectional study was carried out on 22 Human spleens. The specimens were obtained from the available cadavers with intact spleen at the dissection hall of Anatomy Department JSS Medical College and Department of Forensic medicine JSS Medical College, Mysuru. The aims of the study were to identify the 3D view of segmental branches of splenic artery, to prepare a luminal cast of splenic artery using silicone gel and to demonstrate the relationship between splenic arterial branches and polar arteries. Chemicals used in the study were 10% formalin, acetone, conc.HCl, silicone gel, hydrogen peroxide, catalyst and hardener. Instruments used are dissection instruments, calipers, measuring tape, disposable syringes and 16 gauge needles.

Study Design: Cross-sectional study

Study Duration: April 2024 to October 2025.

Sampling: Convenient sampling.

Sample size: 22

Subject Eligibility:
Inclusion Criteria:
The intact spleen collected from the cadaver with intact splenic artery is utilized for this study.

Exclusion Criteria:
1. Spleens with lesions due to trauma or injury.
2. The spleen which has undergone surgeries.
3. Abnormal congenital spleens.
4. Spleenomegaly or pathological spleens or ruptured spleen

Procedure methodology

Human spleens were collected from the cadavers in the dissection halls of the Department of Anatomy, JSS Medical College and Department of forensic medicine, JSS Medical College, Mysuru. Dissection was done by the standard method of dissection described by Cunningham's manual 16th edition. The Spleens were preserved in 10% Formalin solution for 2-3 hours. Splenic artery was cleaned thoroughly with saline. Then using running water, all blood were drained out of the splenic artery. Silicone sealant was injected slowly into splenic artery using a silicone gun at the site of its origin till it reaches its segmented branches. Splenic artery was tied with thread after injection. After injection, the specimen will be kept in the open air in a container for 24 hours for the cast to dry. Then the specimen was immersed in concentrated HCl Acid for 3-4 hours. Then, the specimen will be left to corrode in acidic media and then the final cast is removed and studied in detail. Thus a plastinated luminal cast was cleaned carefully and photograph was taken.

III. Results

Splenic artery was originated from the coeliac trunk in all spleens. Splenic artery was divided into terminal primary branches at the hilum. From splenic artery cast, it was clear that in 90% spleens the splenic artery was divided into superior and inferior terminal branches and in 10% spleens divided into superior, middle and inferior terminal branches as shown in table no .1.

Table 1: Numerals of splenic artery with each primary segmental branches

Primary segmental branches	Number of specimens (n=22)	Percentage (%)
One	0	0
Two	20	90
Three	2	10

In 50% of samples, inferior polar artery were present. In 37% of samples superior polar artery were present. In 13% of samples polar arteries were absent. According to this branching pattern the spleen had two lobes, when there were superior and inferior terminal branches and three lobes, when there were superior, middle and inferior terminal branches, additional lobes, when there were polar arteries present. Thus the splenic lobes could be varies from 2-5 in number.

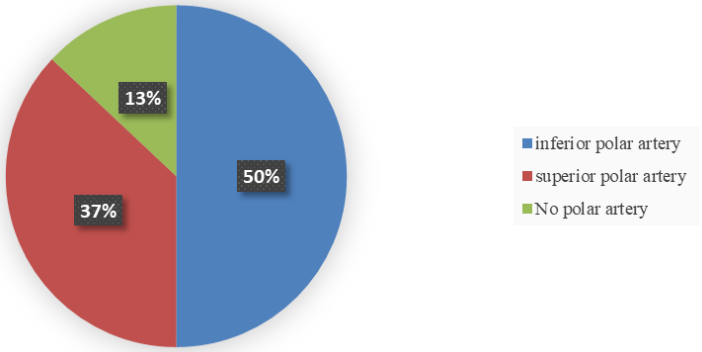

Fig 1: Distribution of polar arteries (N=22)

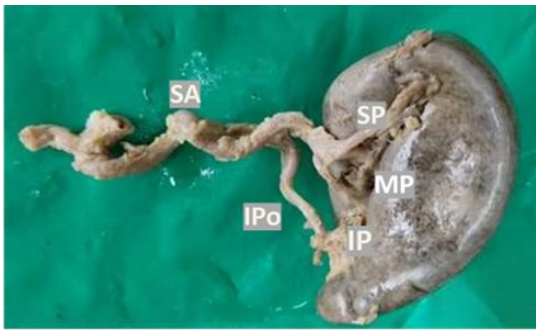

Fig 2: Specimen showig 2 divisions of terminal primary branches. SA: Splenic Artery; IPo: Inferior Polar branch; SP: Superior primary branch ; IP: Inferior primary branch.

Fig 3: Specimen showing 3 divisions of terminal primary branches. SA: Splenic Artery; IPo: Inferior Polar branch; SP: Superior primary branch; MP: Middle primary branch ; IP: Inferior primary branch.

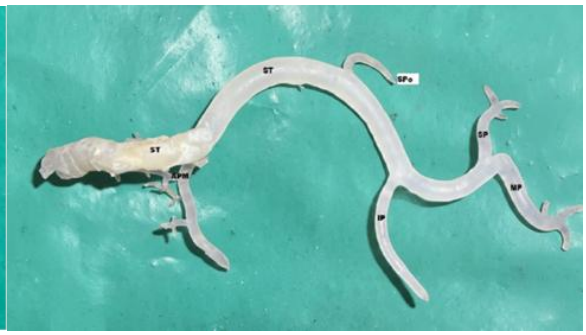

Fig.4: Splenic artery cast showing two divisions of terminal primary branches. SA: Splenic Artery; SPo: Superior Polar branch; IPo: Inferior Polar branch; SP: Superior primary branch; IP: Inferior primary branch.

Fig.5: Splenic artery cast showing three divisions of terminal primary branches. SA: Splenic Artery; APM: arteria pancreatica magna; SPo: Superior Polar branch; SP: Superior primary branch; MP: Middle primary branch, IP: Inferior primary branch.

IV. Discussion

In the present study, the primary and the polar branches of the splenic artery were observed, which divided the spleen into definite segments. Two primary branches were found in 90% of spleen samples and three primary branches were found in 10% of spleen specimens. Dequeurce et al have stated that Honore‟ Fragonard the eminent French anatomist had prepared several dry anatomical specimens between 1766 and 1771 that have miraculously survived till today. In the eighteenth century most of the French anatomists

injected the vascular system with a coloured mixture of wax, animal fat and plant resins and the body was dehydrated by immersion in a bath of alcohol[7]. According to Prashant NC et al the splenic artery terminated near the hilum by dividing into two or three primary branches. Of the 111 spleens, 95 [85.58%] had two primary branches and 16 [14.42 %] showed three primary branches. Polar branches were seen in 92 specimens. The superior polar branch was present in 32 [28.82 %] specimens, the inferior polar branch was present in 47 [42.34 %] specimens, both the superior and inferior branches were present in 13 [11.71%] specimens and no polar branch was observed in 19 [17.11%] of the total spleens[8.] Shashikala R. Londhe et al in their study of splenic artery cast noticed that in 90% spleens the splenic artery was divided into superior and inferior terminal branches and in 10% spleens divided into superior, middle and inferior terminal branches. In 26 spleens primary terminal branches were present without polar arteries and in 24 spleens primary terminal branches were present with polar arteries. In 33% spleens there was superior polar branches, In 54% spleens inferior polar branches and in 24.4% spleens both superior and inferior polar branches as in. Polar arteries were originated from splenic trunk. In our study, In 37% spleens there was superior polar branches, In 50% spleens inferior polar branches and in 13% spleens both superior and inferior polar branches[9]. Mikhail Y. et al reported two primary terminal branches of splenic artery in 77% of cases and three primary terminal branches in 23% of cases. They also reported polar branches, in 12% upper polar, in 50% lower polar and in 12% both upper and lower polar branches[10.] Guitierrez reported the presence of two segments in 90% of his series and three or four segments in the rest[11]. In a study conducted by N Sujata et al, 119 human cadaver spleen were examined for the number of primary segmental branches of splenic artery, and it was found that 70.6% of spleens had 2 primary segmental branches for the splenic artery and four primary segmental branches were observed among 5.0% of human cadaver spleen[12]. The polar and segmental branches of the splenic artery showed considerable variations, as described by Michel et al[13], Gupta et al [14], and Garcia et al[15]. Eighty percent had two and twenty percent had three primary branches, according to Michel et al. According to Gupta et al., 84% of primary branches had two branches, and 16% had three. Garcia et al found that 77% of primary branches had two branches and 23% had three.

V. Conclusion

The plastinated spleen specimens are dry odorless and facilitate the demonstration of macroscopic morphological details and internal structures. It is a great substitute for specimens that have been fixed in formalin. It is simple and ideal for teaching complex splenic vascular anatomy. Plastination has a bright future in all academic and scientific domains. Understanding the splenic artery's circulatory patterns aids in the identification of the spleen's lobes or segmentation, which is crucial for partial splenectomy and surgical repair of spleen damage.

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