



# STUDY ON ORIGIN, COURSE, BRANCHING PATTERN AND MORPHOMETRY OF SPLENIC ARTERY AND ITS BRANCHES SUPPLYING THE SPLEEN-A CADAVERIC STUDY

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## ABSTRACT

**Objectives:** 1. To measure the length of splenic artery and its branches supplying the spleen till they enter the hilum. 2. To note the origin and course of the splenic artery. 3. To note type of branching pattern of the splenic artery and occurrence of polar artery.

**Methods:** Splenic artery & its branches supplying spleen were dissected neatly, traced till the hilum and measured with the digital vernier calliper. Other branches of splenic artery were not considered in the study. Results: Mean length of the splenic artery trunk was 7.45cms (Range: 2-11cm), lobar artery 3.24cms (Range: 1.2-8cms), segmental artery 1.21cms (Range: 0.4-3cms), trabecular artery 0.59cm (Range: 0.3-2.5cms). The splenic artery trunk was bifurcated in 80 % (24), trifurcated in 16.66 % (5) and quadrifurcated in 3.3 % (1). Lobar artery was bifurcated in 63.33%, trifurcated in 33.33% and quadrifurcated in 3.33%. Segmental artery was bifurcated in 93.33% and trifurcated in 6.66%. In All the specimens the splenic artery was arising from coeliac trunk. 63.3 % (19) of specimens showed supra-pancreatic course and 36.6 % (11) showed retro-pancreatic course of splenic artery. 26.6 % (8) of specimens showed only superior polar artery, 36.6 % (11) showed only inferior polar artery, 16.6 % (5) showed both polar arteries and 20 % (6) of specimens has no polar artery.

**Conclusions:** knowledge of vascular supply for the spleen is very important for the surgeons during partial resections of spleen and it is also important for radiologist for performing preoperative arteriography and splenic artery embolization..

**Key Words:** Spleen, Splenic artery, Splenic segments, Partial splenectomy, Splenic artery thromboembolism

## INTRODUCTION

The spleen is exclusively supplied by the splenic artery. This is the largest branch of coeliac axis and its course is among the most tortuous in the body. It runs along the superior border of the pancreas in the posterior aspect of the border. It runs as multiple loops or coils. The splenic artery lies anterior to the left kidney and left suprarenal gland. It runs in through splenorenal ligament posterior to the tail of the pancreas and divides in to two or three main branches before entering the hilum of spleen. These branches enter the hilum and they divide further into four or five segmental arteries. These vessels each supply a segment of the splenic tissue. There is little collateral circulation between the segments which means that occlusion of a segmental vessel often leads to infarction of part of the spleen<sup>1</sup>.

Once the thought was spleen had no major role in sustaining life, but now it is known that the two most important activities of spleen in humans. The phagocytic and immune, derive from its peculiar structure, when it comes to its cellular composition & richness of its irrigation. The spleen cells belong to the lymphoid tissue & to the mononuclear phagocyte system<sup>2</sup>.

Now a days spleen preserving surgeries like partial splenectomy, segmental resection are upcoming procedures because the spleen is very important to lead infections free life.

Therefore the Knowledge of extra parenchymal branching pattern of splenic artery, different levels of its division and their measurements, especially of length of terminal branches/ trabecular arteries/ polar arteries which in other way denotes distance of artery from visceral sur-

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face of spleen is very important for surgeons/ radiologists to perform devascularisation of particular part of the spleen to perform partial splenectomy so that, spleen can be preserved<sup>3</sup>.

Intrasplenic avascular demarcation between the segments is yet to be found perfectly, so that the partial splenectomy can be done with minimal blood loss, and methods for normal functioning of retained spleen after partial resection is yet to be found.

## MATERIALS AND METHODS

30 cadavers which were embalmed properly using 10% formalin solution, following standard technique were used for the study. The splenic artery was exposed during routine dissection for the 1<sup>st</sup> MBBS students in the dissection hall, department of anatomy PESIMSR, Kupam over a period of 3 years. The artery was exposed after cutting the greater omentum and lifting the stomach as a whole. Meticulous dissection was done to separate the celiac trunk from its surrounding dense nerve plexus. The splenic artery was identified which was arising from celiac trunk in all the cases. The artery was traced down from its origin till its branches enter in to the hilum of spleen. The artery was separated from the pancreas, adjacent structures and ligaments for the clear view. All other branches of splenic artery were identified which were cut and separated. The artery and its branches concerned with supplying only spleen were painted with red enamel paint from its origin, till its branches enters into the hilum of the spleen, dried and later photographed immediately.

The following parameters were studied:

1. The length of the trunk of splenic artery from its origin from celiac trunk till its branching into primary branches/ lobar arteries
2. Length of the primary branch/lobar artery from its origin till it divides into secondary/segmental arteries
3. Length of the secondary/segmental artery from its origin till it divides into tertiary/sub segmental/ trabecular artery at the hilum of spleen
4. Length of the tertiary/sub segmental/trabecular artery from its origin till it enters into the splenic substance
5. Branching pattern of splenic artery trunk, lobar artery, segmental artery and trabecular artery
6. Percentage of occurrence of lobar artery, segmental artery and trabecular artery
7. Origin of splenic artery
8. Type of Course of the splenic artery
9. Percentage of occurrence of polar artery

Measurements were done by using the digital vernier calipers and immediately noted in the preformed proforma.

The rough outline of the branching pattern in each specimen was drawn separately on the paper immediately and preserved for further reference and noted the length of splenic artery, lobar artery, segmental artery and trabecular artery on the sketch of the specimen drawn.

## Statistical analysis

Simple statistical analysis was done by using Microsoft excel sheet. Mean, range and percentage of each parameter were calculated.

## RESULTS

We have done the study over three years, which includes sample size 30 cadavers (10 cadavers per year).

### 1. Length of splenic artery trunk, lobar artery, segmental artery and trabecular artery (Table: 1)

Mean length of splenic artery was 7.45 cms and range 2-11 cms. Mean length of the lobar artery was 3.24 cms and range 1.2 – 8 cms. Mean length of segmental artery was 1.21 cms and range 0.4-3 cms. Mean length of trabecular artery was 0.59cms and range 0.3-2.5cms.

### 2. Branching pattern of splenic artery trunk, lobar artery, segmental artery and trabecular artery (Tables: 2 & 3)

Splenic artery trunk was bifurcated in 24 (80%) specimens (i.e. shows 2 lobar arteries), trifurcated in 5 (16.66%) specimens (i.e. shows 3 lobar arteries), and quadrifurcated in 1 (3.3%) specimen (i.e. shows 4 lobar arteries). Lobar artery was bifurcated in 19 (63.33%) specimens, trifurcated in 10 (33.33%) and quadrifurcated in 1 (3.3%) of specimens. The segmental artery was bifurcated in 28 (93.33%) and trifurcated in 2 (6.66%) of specimens. These values are shown in table no.

### 3. Percentage occurrence of segmental arteries (Table: 4)

In only 1(3.3%) specimen we found that only 2 segmental arteries were present. in 18 (60%) specimens we found 4 segmental arteries supplying the spleen. 6 (20%) specimens were showing 5 segmental arteries in total. In 4 (13.3%) specimens we found 6 segmental arteries and in only 1 (3.3%) specimen we found 7 segmental arteries.

### 4. Percentage occurrence of origin, course of splenic artery and polar branches of splenic artery (Table: 5)

In All the specimens the splenic artery was arising from coeliac trunk. 19 (63.3 %) specimens shows supra-pan-

creatic course and 11 (36.6 %) specimens shows retro-pancreatic course of splenic artery. 8 (26.6 %) specimens shows only superior polar artery, 11 (36.6 %) specimens shows only inferior polar artery, 5 (16.6 %) specimens shows both polar arteries and 6 (20 %) specimens has no polar artery.

### Special observations:

1. In one specimen two lobar arteries are directly entering in to the spleen and one lobar artery dividing into two segmental arteries which are directly entering into the spleen without dividing into trabecular arteries.
2. In another specimen one lobar artery directly entering into the spleen and two lobar arteries are dividing into two segmental arteries each which in turn divided into two trabecular arteries each and enters into the hilum of spleen

## DISCUSSION

Embryologically, Ventral splanchnic arteries are originally paired vessels. After fusion of the dorsal aortae they merge as unpaired trunks that are supplied to the viscera with the advent of longitudinal anastomotic channels (dorsal channel persists as gastroepiploic, pancreaticoduodenal and marginal arteries of large gut; ventral channel persists as right and left gastric arteries). Numerous ventral splanchnic branches joined together and persist as celiac trunk, superior mesenteric artery & inferior mesenteric artery<sup>4</sup>.

Morita hypothesised that celiac trunk is formed by union of 1<sup>st</sup>, 2<sup>nd</sup> & 3<sup>rd</sup> root along with longitudinal anastomotic artery. 1<sup>st</sup> root corresponds with left gastric artery, 2<sup>nd</sup> root with splenic artery and 3<sup>rd</sup> root with common hepatic artery<sup>5</sup>.

Splenic artery usually arises from the celiac trunk. But sometimes it even arises from abdominal aorta directly around 1.3% of cases<sup>6, 7, 8</sup>. And sometimes it arises along with hepatic and superior mesenteric artery as a common trunk<sup>9, 10</sup>. Shoumura et al have found in their study that splenic artery was arising in common with gastric artery as gastrohepatic trunk in 4 cases out of 184 cases; they also found in one case, the splenic artery was arising in common with superior mesenteric trunk as spleno-mesenteric trunk<sup>11</sup>. Pandey S K et al have found that the splenic artery was arising from the celiac trunk in 90.6%, abdominal aorta in 8.1% and either from common hepatic artery or superior mesenteric artery in 1.3%<sup>12</sup>. Sometimes it even arises from superior mesenteric artery (2%) and sometimes it arises in common with left gastric artery forming gastrohepatic trunk (2%)<sup>13</sup>. In our study the splenic artery was arising from the celiac trunk in all the cases.

Splenic artery runs as multiple loops or coils, one of the most tortuous arteries in the body. It runs along the superior border of the pancreas in the posterior aspect of the border, behind the omental bursa, and passes between the two layers of the splenorenal ligament to reach the hilum<sup>1, 14, 15, 16, 17, 18, 19</sup>. The course can be named as supra pancreatic and retro pancreatic based on major part of splenic artery running above or behind the pancreas. Splenic artery has shown supra pancreatic course in 68% and retro pancreatic course in 32% of specimens study conducted by ashoka et al<sup>13</sup>. In our study splenic artery has shown supra pancreatic course in 63.3% (19 specimens) and retro pancreatic course in 36.3% (11 specimens) of specimens. Pandey S K et have found supra pancreatic course in 74.1%, intrapancreatic course in 4.6%, anteropaneatic course in 18.5%, and retro-pancreatic course in 2.8%<sup>12</sup>. Muzaffer Sindel et al have divided the course of the splenic artery in to four segments. Supra pancreatic segment is between the origin of splenic artery and pancreas, pancreatic segment is most tortuous part and extends along a groove located on the posterosuperior surface of pancreas, prepancreatic segment which crosses the upper border of the pancreas and finally prehilum segment lies between the pancreatic tail and the splenic hilum<sup>20</sup>.

The splenic artery divides in to 2 main branches which are superior and inferior primary branches<sup>21</sup>. Some authors even mentioned the primary branches as upper and lower polar arteries. These branches travel in radial direction & dissection in parallel to the vessels make partial splenectomy possible<sup>22</sup>. Some authors even named the primary branches in to superior and inferior segmental arteries and supplies its own segment of spleen and even mentions that the superior and inferior segments of spleen are separated by a avascular plane perpendicular to the long axis of the spleen<sup>15</sup>. Some authors even mentioned that the splenic artery divides in to 2-3 primary main branches<sup>1, 19</sup>. Daisy Sahni et al have named the primary main branches of splenic artery as lobar arteries<sup>23</sup>

### Pattern of division of splenic artery trunk in various studies is shown in the table below

Study	Bifurcation	Trifurcation	Quadrifurcation
Daisy Sahni et al <sup>23</sup>	180/200 (90%)	20/200 (10%)	
Karl H Truetner et al <sup>24</sup>	93.8%	6.2%	
Liana Ferreira et al <sup>3</sup>	93.3%	6.7%	
Katristsis E et al <sup>25</sup>	85.7%	14.3%	
Sow ML et al <sup>26</sup>	84%	16%	
Present study	80%	16.66%	3.33%

Results of our study are slightly low compared to other studies but we have seen the Quadrifurcation of splenic artery showing the spleen can have up to 4 lobes.

Further the lobar artery divides into 4-5 or several segmental arteries and each supply a segment of splenic tissue<sup>1, 21, 23</sup>. And even mentions there is little collateral circulation at the segmental level and occlusion of one of these arteries usually is associated with infarction of the corresponding region of the spleen<sup>1, 19</sup>. Further ahead it is mentioned that these segmental arteries divide into trabecular arteries with no collateral circulation<sup>19</sup>.

In our study we have observed the branching of splenic artery slight differently. The splenic artery was dividing mainly in to lobar arteries. Lobar arteries were in turn divided into segmental arteries and most importantly in most of the specimens the segmental artery was dividing into trabecular arteries outside the splenic parenchyma, at hilum before entering into the spleen. And there was little anastomosis between the segmental arteries but never between trabecular arteries. We have found the splenic artery dividing into 2-4 lobar arteries. We have seen the lobar artery bifurcation, trifurcation and even Quadrifurcation. And we have observed origin of 2-7 segmental arteries on an average (Table 2 & 4).the segmental arteries were bifurcating and trifurcating and giving around 2-8 trabecular arteries. It shows that spleen consists of 2-4 lobes and 2-7 segments supplied by a separate arterial segment.

Some authors even mention differently that the splenic artery after reaching the splenic hilum divides in to 5-8 terminal branches and enters into the spleen, without mentioning the different levels of branching pattern of splenic artery<sup>14, 16, 17</sup>.

Splenic artery branching pattern can be even classified in to two different types. Distributed type which is most common around 70%, distinguished by short trunk and too long branches entering in to the spleen and magistral/bundled type which is less common type, around 30%, where the splenic artery has got long trunk and short branches arises at hilum and enters the spleen<sup>18, 27, 28</sup>. Similar results were found in our study. Karl H Truettner et al has found distributed type around 84% and magistral type in rest<sup>24</sup>. Similarly ashoka et al have found distributed type in 54% and magistral type in 34% but have found the splenic artery entering without branching in 12%<sup>13</sup>.

A vessel is considered polar artery if it is penetrating the upper/ lower pole of spleen without entering the hilum, it may be superior polar artery or inferior polar artery<sup>29</sup>. Katritsis E et al have found polar arteries arising from the trunk of splenic artery or from its primary branch<sup>25</sup>. Segments of the spleen are supplied by polar arteries known as polar segments<sup>30</sup>.

## Occurrence of polar arteries in various studies

Study	Superior polar artery alone	Inferior polar artery alone	Both polar arteries
Mikhail Y et al <sup>31</sup>	12%	50%	12%
Garcia et al <sup>30</sup>	29.28%	44.75%	10.49%
Jauregui E et al <sup>32</sup>	53%	33%	
Shashikala R et al <sup>33</sup>	30%	59%	11%
Karl H Truettner <sup>24</sup>	28.1%	46.9%	
Ashoka et al <sup>13</sup>	14%	10%	12%
Michels NA et al <sup>29</sup>	65%	82%	
Katritsis E et al <sup>25</sup>	60%	80%	
Daisy Sahni et al <sup>23</sup>	52.5%	86%	
Our study	26.6%	36.6%	16.6%

Liana Ferreira et al has classified the polar arteries in to two varieties based on their artery of origin. Polar artery type I- collateral branch of the splenic artery originated prior to their terminal division being long & relatively wide, directed to one of these spleen extremities. Polar type II artery- secondary/ tertiary branch of terminal division of the splenic artery, being short & thinner, also directed to one pole of the spleen. They have found the occurrence of polar artery type I in 10%, polar artery type II in 28.3% and polar artery type I and type II together in 8.3% of specimens<sup>3</sup>.

So there is no uniform description of branching pattern of splenic artery is mentioned in the standard text books, that need to be updated for proper understanding of splenic artery anatomy as well spleen

The length of the splenic artery from its origin to dividing into lobar arteries is 76.5mm in males and with a slight difference in females around 76.05mm<sup>23</sup>. Ashoka et al have found the length of splenic artery < 8cms- 10%, 8.1-9cms – 34%, 9.1-10cms – 44%, 10.1- 11cms – 06%, >11.1 cms- 06% of specimens<sup>13</sup>. Jauregui E et al have mentioned the average length of the splenic artery is 10.6cms<sup>32</sup>. In our study we have found the mean length of the splenic artery 7.45cms and range is 2-11cms.

We have even measured the length of lobar arteries, segmental arteries and trabecular arteries (Table:1). Length of terminal branches/ trabecular artery mentioned by

Liana Ferreira et al is Ave- 2.89cms, range 1.04-5.05cms<sup>3</sup> and which is slightly higher the length we found in our study.

Terminal branches are the branches from the segmental arteries which enter into the splenic tissue at hilum.

**It may be distributed type or bundled type, the number of terminal branches entering the spleen in various studies as follows**

Study	No of terminal branches					
	2	3	4	5	6	>6
Katritsis E <sup>25</sup>	85.7%	14.30%				
Garcia Por- rero <sup>30</sup>	92.82%	7.18%				
Sow ML <sup>26</sup>	84%	16%				
Karl H Truet- ner <sup>24</sup>	93.8%	6.20				
Daisy sahni <sup>23</sup>	80%	20%				
Pandey SK <sup>12</sup>	63.10	-	18.80		9.70	5.6
Ashoka <sup>13</sup>	52%	28%	8%			
Present study	16.6%	3.3%	33.3%	6.6%	16.6%	16.6%

## CONCLUSIONS

The spleen is very important organ physiologically which is very important for the maintenance of human immunity function. Spleen has to be retained without removing it completely whenever there is possibility. The knowledge of origin, course, length and branching pattern of splenic artery is very important for interpreting colour Doppler and arteriography of upper abdomen and also for performing the splenic artery embolism which is done preoperatively to reduce vascularity of spleen. The splenic artery embolism is also done sometimes alternative to the surgery for preserving the spleen in non-operative splenic injuries. The knowledge of segmental vascular anatomy of spleen including polar segments is very important for the limited resection/partial resection of the spleen.

We being anatomists feel proud to provide the findings of our study on splenic artery anatomy, its different branching pattern, morphometry of the artery and its branches will be a supplement to the existing knowledge and it is very useful for the surgeons and radiologists.

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**Table 1: Showing the length of splenic artery trunk, lobar artery, segmental artery and trabecular artery (Overall)**

Arterial tree	Mean length (cms)	Range (cms)
Splenic artery Trunk	7.45	2-11
Lobar artery	3.24	1.2-8
Segmental artery	1.21	0.4-3
Trabecular artery	0.59	0.3-2.5

**Table 2: Showing the division pattern of splenic artery, lobar artery and segmental artery (overall)**

Arterial tree	Bifurcation (%)	Trifurcation (%)	Quadrifurcation (%)
Trunk	24 (80%)	5 (16.66%)	1 (3.3%)
Lobar artery	19 (63.33%)	10 (33.33%)	1 (3.3%)
Segmental artery	28 (93.33%)	2 (6.66%)	-

**Table 3: Showing percentage occurrence of the lobar arteries.**

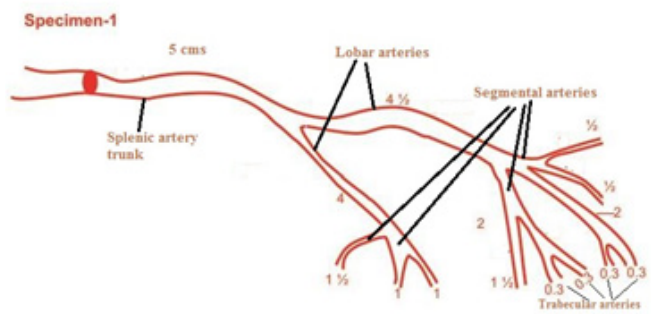
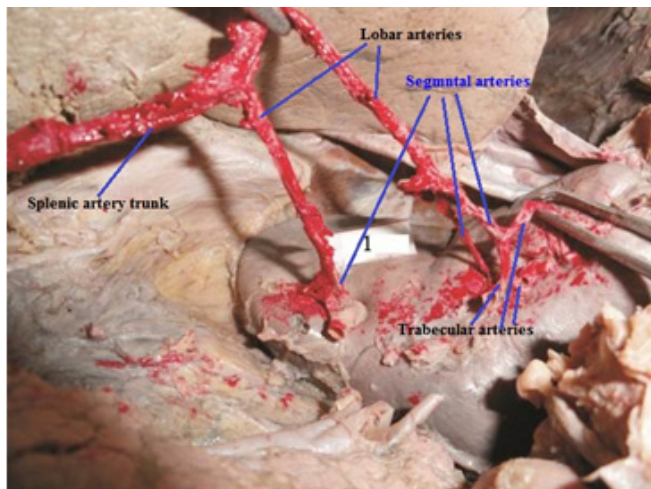
No of lobar arteries	Total no of specimens (n=30)
2 lobar arteries	24 (80%)
3 lobar arteries	05 (16.66%)
4 lobar arteries	01 (3.3%)

**Table 4: Showing percentage occurrence of the segmental arteries.**

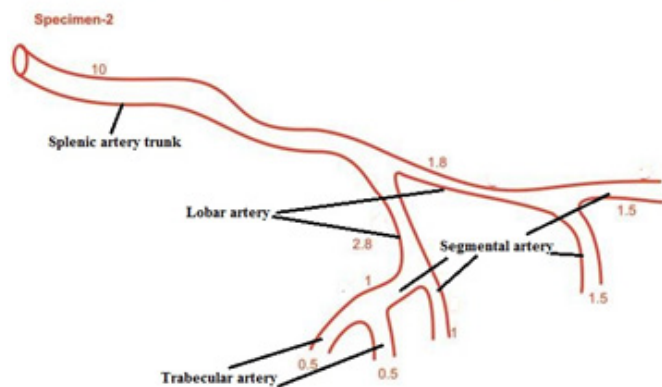
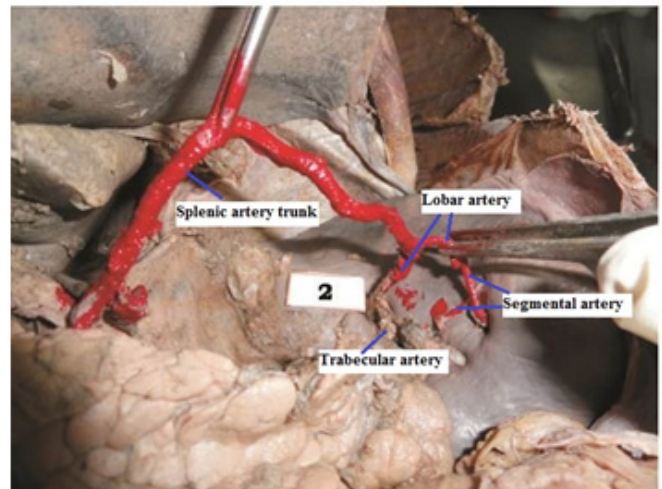
No of segmental arteries	Total no of specimens (n=30)
2 SA	01 (3.3%)
4 SA	18 (60%)
5 SA	06 (20%)
6 SA	04 (13.3%)
7 SA	01 (3.3%)

**Table 5: Showing the occurrence of origin, course and polar arteries**

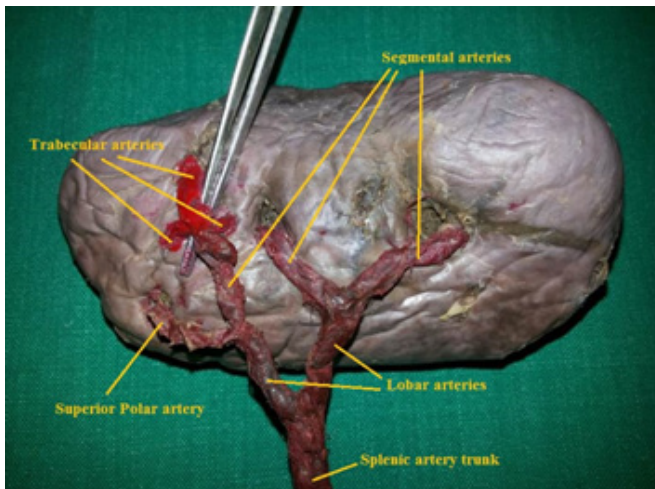
SI No.	Entity	Percentage of occurrence
1	Origin of splenic artery from celiac trunk	100% (30)
2	Suprapancreatic course of splenic artery	63.3% (19)
3	Retro pancreatic course of splenic artery	36.6% (11)
4	Superior polar artery alone	26.6% (8)
5	Inferior polar artery alone	36.6% (11)
6	Both superior and inferior polar arteries	16.6% (5)
7	Specimens without superior and inferior polar arteries	20% (6)



**Figure 1:** showing the photograph and sketch of the splenic artery and its branches & their length in cms. The branching pattern is Distributed type.



**Figure 2:** showing photograph and sketch of the splenic artery & its branches & their measurements in cms. Here the branching pattern is Bundled/ Magistral type.



**Figure 3:** showing the branching pattern of splenic artery & the Superior Polar Artery.