

Anatomical bases of medical, radiological and surgical techniques

Anatomic basis for conservative surgery of the spleen

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Summary. 100 pancreatico-splenic blocks obtained at autopsy were treated by the injection-corrosion method. The splenic artery ended in the lienorenal ligament in 64% of cases, in the pancreatic segment in 32% and in the hilar segment in 4%. In 84% of cases, the artery divided into two lobar arteries, upper and lower. In 16% the artery trifurcated. The pedicle was 20 to 60 mm long (mean 35 mm). The branches of the splenic artery were in three successive stages: the primary or lobar arteries were each associated with a lobe; the secondary or segmental arteries each supplied one of the constituent segments of a lobe; the tertiary or subsegmental arteries supplied the various areas which made up a splenic segment. Nine cases of extraparenchymal anastomoses were found. There were 32 intraparenchymal anastomoses, being either interlobar or intersegmental. There were a few interlobar anastomoses. The findings support the notion of upper and lower intersegmental and interlobar planes. The latter is almost avascular, while the former has limited vascularity. These planes make conservative surgery of the spleen possible.

Bases anatomiques de la chirurgie conservatrice de la rate

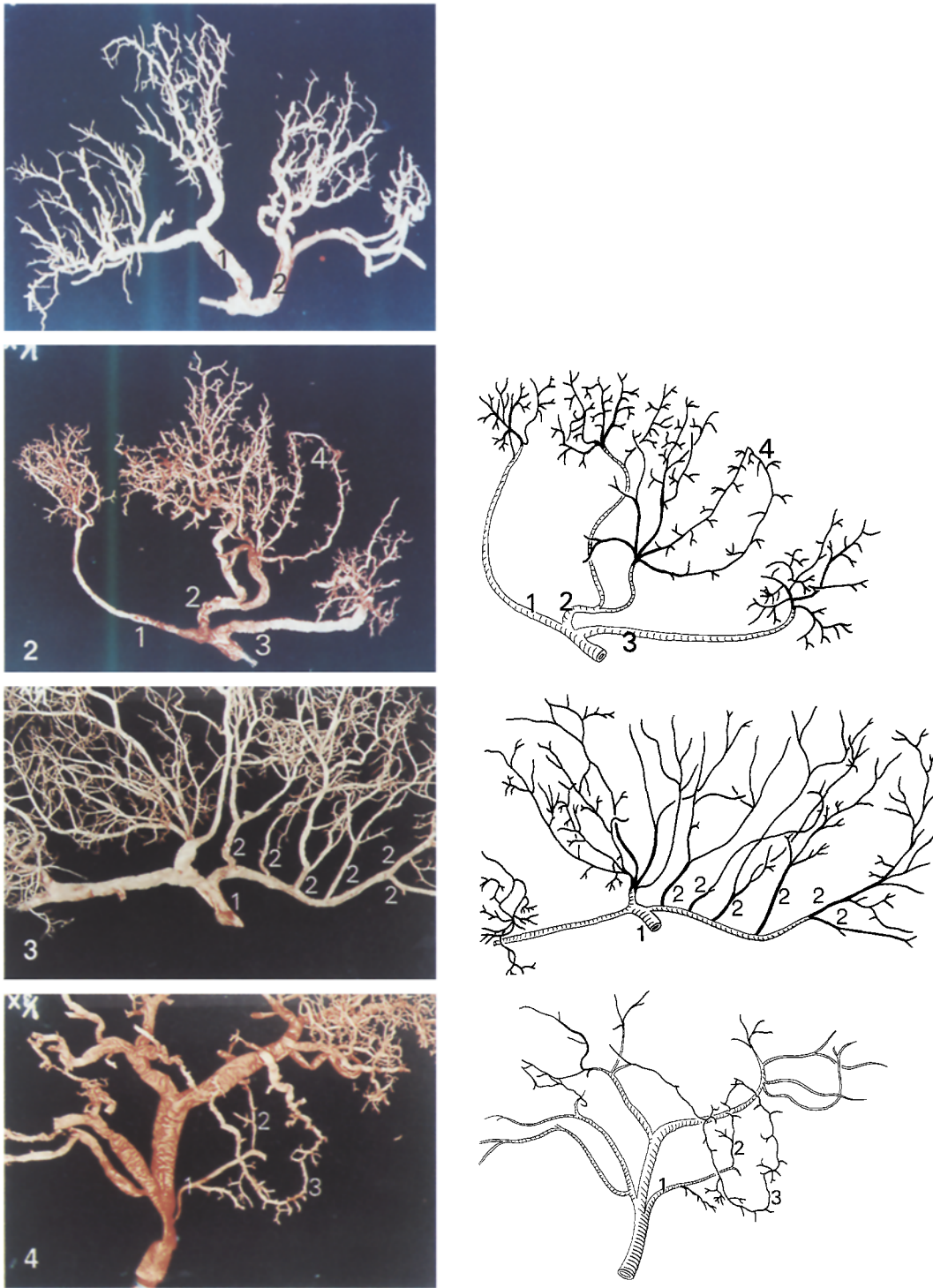
Résumé. 100 pièces pancréatico-spléniques, prélevées par autopsie, ont été traitées par la méthode d'injection-corrosion. L'artère splénique se terminait le plus souvent dans l'épiploon pancréatico-splénique dans 64 % des cas, contre 32 % dans le segment pancréatique et 4 % dans le segment hilare. Dans 84 %, l'artère se bifurquait en deux artères lobaires, supérieure et inférieure, dans 16 % des cas, elle se trifurquait. La longueur du pédicule s'échelonnait entre 20 et 60 mm avec une moyenne de 35 mm. Les ramifications de l'artère splénique constituaient trois étages successifs : les artères primaires ou artères lobaires destinées chacune à un lobe; les artères secondaires ou artères segmentaires se distribuant chacune à un des segments constitutifs d'un lobe splénique; les artères tertiaires ou sous-segmentaires se rendant aux différents territoires qui s'empilent les uns sur les autres à l'intérieur d'un segment splénique. Nous avons noté au total 9 cas d'anastomoses extraparenchymateuses et 32 anastomoses intraparenchymateuses réalisant soit des anastomoses interramales, soit des anastomoses intersegmentaires, soit

des anastomoses interlobaires beaucoup plus rarement. Ces constatations permettent d'introduire la notion de plans intersegmentaires supérieur et inférieur et de plan interlobaire. Ce dernier plan est quasi « exsangué » alors que les plans intersegmentaires restent paucovasculaires. Ces différents plans autorisent actuellement une chirurgie conservatrice de la rate.

Key words : Anatomy — Conservative surgery — Spleen

Because patients (especially children) after splenectomy have a weakened defence against infection, and in view of the importance of the spleen in the immune system, the assumption that splenectomy is necessary after trauma of the spleen has been questioned. A more conservative attitude has become more prevalent as understanding of the splenic vasculature has improved.

Assolant [1] in 1802, introduced the notion of conservative surgery of the spleen through his discovery of the terminal character of the



Figs. 1-4

1 The termination of the splenic aa. into 2 lobar a. (1 upper lobar a. and 2 lower lobar a.) 2 The termination of the splenic a. into 3 lobar aa. (1 upper lobar a. 2 middle lobar a. 3 lower lobar a.) 4 intraparenchymal anastomosis linking together various terminal branches of the middle lobar a. 3 1 A spleen with a short arterial pedicle 2 Notice the 6 segmental aa. coming from the lower lobar a. 4 1 A polar a. which goes to the lower pole 2 Anastomosis between a polar a. and a segmental a. 3 Anastomosis between a segmental a. and a subsegmental a.

1 Terminaison de l'a. splénique en 2 aa. lobaires (1 a. lobaire supérieure et 2 a. lobaire inférieure) 2 Terminaison de l'a. splénique en 3 aa. lobaires (1 a. lobaire supérieure 2 a. lobaire moyenne 3 a. lobaire inférieure) 4 anastomose intraparenchymateuse reliant différentes branches terminales de l'a. lobaire moyenne 3 1 Rate avec un pédicule artériel court 2 Noter les 6 a. segmentaires naissant de l'artère lobaire inférieure 4 1 A. polaire à destinée polaire inférieure 2 Anastomose entre a. polaire et a. segmentaire 3 Anastomose entre a. segmentaire et a. sous segmentaire

splenic vessels. Nguyen [12, 15] between 1952 and 1959, Barry [2] and Simionescu [19] in 1960 provided definitive descriptions of the intraparenchymal pattern of the splenic vessels. More recently, Pina [17] in 1983, Dixon [7] in 1980, Nguyen [16] in 1982 and Mandarim-de-Lacerda [10] in 1983 found independent intrasplenic vascular territories which made partial resections possible, and thus laid the anatomic foundations for conservative surgery of the spleen. The clinical application was thanks to Campos Christo [4, 5] in 1960 and 1962, and Bourgeon [3] in 1966 among others, leading to a new era in splenic surgery.

We report a study of the arterial organization of the spleen, with the objective of making possible the most avascular conservative surgery of the spleen.

Material and methods

Splenopancreatic blocks of tissue were obtained at autopsy from 100 black Africans of various ages and of both sexes. Each block included the complete vascular pedicle of the spleen, that is, the terminal segment of the splenic a. and a piece of the tail of the pancreas. All the specimens were treated in the Laboratory of Anatomy of the Faculty of Medicine as follows:

- the splenic a. was cannulated with a catheter (Innotch International Laboratories) of appropriate caliber and rigidity,
- the artery was infused with water and then with acetone,
- a solution of Rhodpas AX 85:15 dissolved in acetone (in the proportion 2:1) colored with congo red, was injected,
- after injection the specimen was refrigerated to allow rapid polymerisation, and then corroded in a hydrochloric acid bath for 2-3 days.

In each case the following were noted:

- before corrosion the general appearance, the weight, the length and aspect of the hilum, the form and length of the vascular pedicle.
 - after corrosion, the number of terminal branches and the characteristics of the polar a., the examination of the intravascular system.
- Specimens from individuals with hematological or parasitic diseases were excluded from the study, because of the possible modification of the vasculature by disease.

Results

The termination of the splenic artery

We studied three segments of the terminal part of the splenic a. The first was associated with the body and tail of the pancreas, the second with the lienorenal ligament, the third with the hilum of the spleen. It was found that the splenic a. ended at the level of the pancreatic segment in 32% of the cases, at the level of the hilum in 4%, and at the level of the lienorenal ligament in 64%. The splenic a. divided as follows: into one upper and one lower lobar branch in 84% (Fig. 1), trifurcation into upper, middle and lower branches in 16% (Fig. 2).

We found a division of the upper lobar a. into 4 segmental branches in 3 cases, compared with 5 cases in the lower lobar a. However, it should be noted that the lobar a. ended in only two branches in 72 cases for the upper lobar a., in 14 for the middle a., and in 67 for the lower a. Also a termination in three branches was found in 24 of the upper lobe a., in 2 of the middle lobe a. and in 27 of the lower lobe a. In the one case where 6 branches arose from the lower lobe a., the pedicle was short (Fig. 3).

The subsegmental arteries: These are the final important derivatives of the splenic a. (Fig. 11).

A total of 7 polar a. was seen arising from the trunk of the splenic a., 5 going to the upper pole (Fig. 6) and two to the lower pole (Fig. 4).

The pattern of the arterial pedicle

The lobar arteries: The first divisions of the artery were in the proportions indicated above in the mode of division. However, the upper lobe a. was more developed than the lower or the middle in 66% of cases. The middle lobar a. was preponderant in 2%. In 13% the upper and lower lobar a. were of similar size.

The segmental arteries: These are the branches of the lobar a. Their mode of division is shown in Table 3.

Table 1. Length of the pedicle
Longueur du pédicule artériel

20-30 mm	32 cases
30-40 mm	48 cases
40-50 mm	12 cases
50-60 mm	8 cases

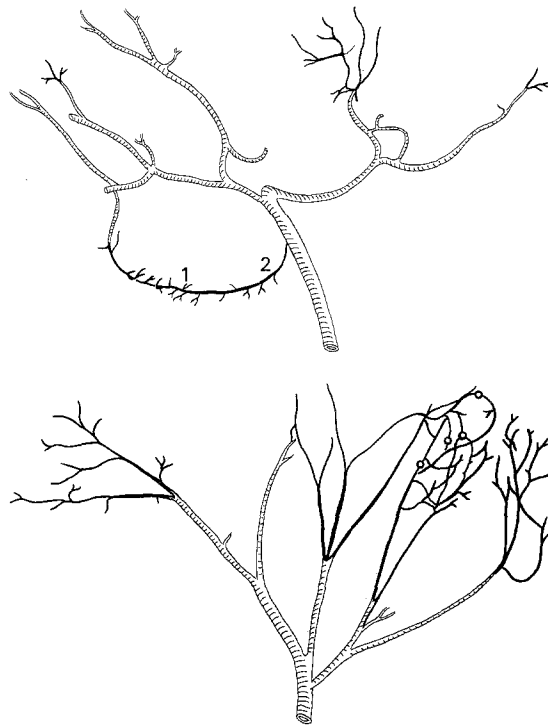
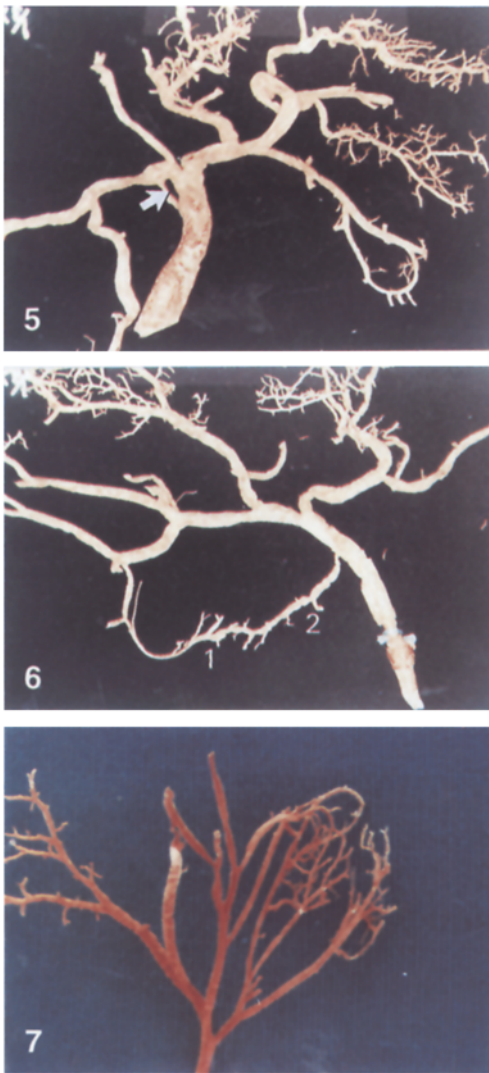
Table 2. Type of arterial pedicle
Type du pédicule artériel

Long	68%
Short	32%

Table 3 Mode of termination of the lobar arteries

Mode de terminaison des aa. lobaires

	Upper lobar a.	Middle lobar a.	Lower lobar a.
2 segmental a.	72	14	67
3 segmental a.	24	2	27
4 segmental a.	3		5
6 segmental a.			1
Total	99	16	100



Figs. 5-7

5 → Anastomosis between a polar a. and a lobar a. **6 1** Anastomosis between a polar a. and a subsegmental a. **2** A polar a. which goes to the upper pole **7 4** intraparenchymatic anastomosis on one piece

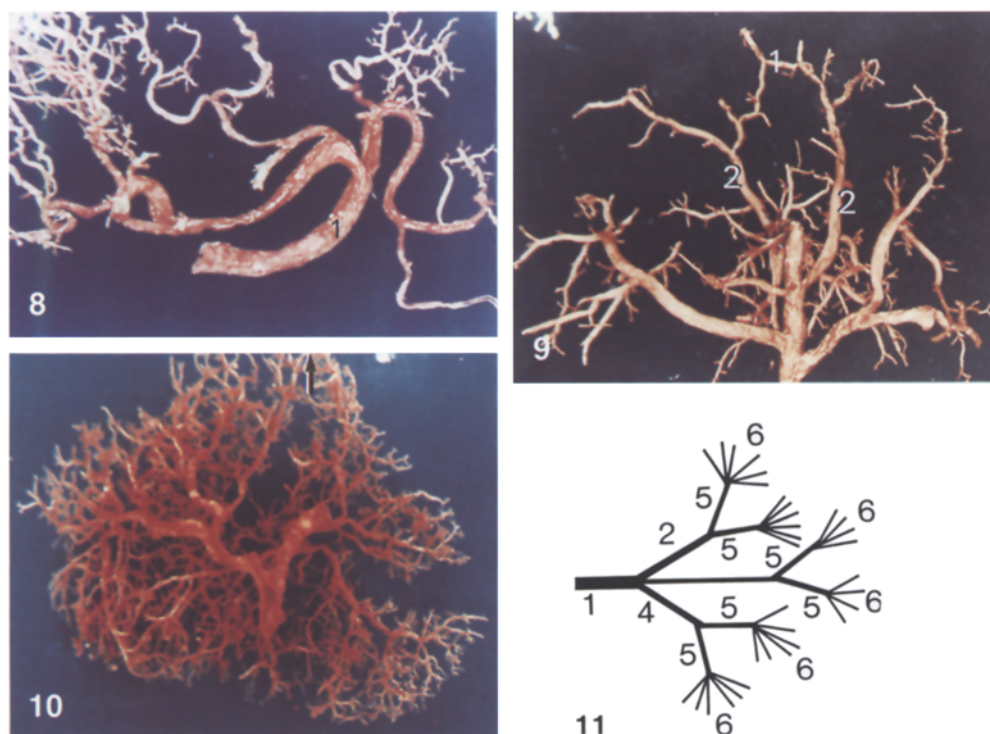
5 → Anastomose entre a. polaire et a. lobaire **6 1** Anastomose entre a. polaire et a. sous segmentaire **2** A. polaire à destinée lobaire supérieure **7 4** anastomoses intraparenchymateuses sur une pièce

The segmental arteries from the upper lobar a. gave 4 to 10 subsegmental vessels (average 6). The segmental a. from the lower lobar a. had 6 to 12 subsegmental branches, the average being 8. The middle lobar a. had an average of 4 subsegmental branches.

The arterioles were seen to diminish in size, corresponding to 4th to the 7th grade. Six accessory spleens were seen in the lienorenal ligament, near the hilum. Their blood supply came from either the lower or the upper lobar a.

The anastomoses

There were 9 cases of extraparenchymal anastomosis. These were either between upper and lower lobar aa. or some of their collateral branches, or between the upper lobar and the upper polar aa. Simi-



Figs. 8-11

8 A spleen with a long arterial pedicle **9** 1 Anastomosis between segmental a. 2 Anastomosis between the secondary division branches of the same lobar a. **10** Interlobar anastomosis **11** The splenic arterial tree. 1 splenic a. 2 upper lobar a. 3 median lobar a. 4 lower lobar a. 5 segmental aa. 6 subsegmental aa.

8 Rate avec un pédicule artériel long **9** 1 Anastomose entre a. segmentaires 2 Anastomose entre les branches de division secondaire d'une même a. lobaire **10** Anastomose interlobaire **11** Systématisation de l'arbre artériel splénique. 1 a. splénique 2 a. lobaire supérieure 3 a. lobaire moyenne 4 a. lobaire inférieure 5 aa. segmentaires 6 aa. sous-segmentaires

larly there were anastomoses between the lower lobar and the lower polar aa. Thus anastomoses were either between polar and lobar aa. (5 cases, Fig. 5), or between polar and segmental vessels (1 case, Fig. 4), or between polar and subsegmental aa. (1 case, Fig. 6).

Finally there were anastomoses between segmental and subsegmental aa. (1 case, Fig. 4), or between segmental aa. themselves (1 case, Fig. 9). These short extra-parenchymal anastomoses formed a criss-crossing system of arterial bridges between the branches of the splenic aa.

Intraparenchymal anastomoses were seen in 32 specimens. 23

linked various branches of the terminal aa. (Fig. 2). One showed 4 anastomoses of this type (Fig. 7); six contained interlobar anastomoses linking the second division branches of the same lobar aa. (Fig. 9). Three specimens showed interlobar anastomoses, linking the branches of the two lobar aa., forming a communication between the two splenic lobes (Fig. 10).

Comments

The termination of the splenic artery

This often ends in the lienorenal ligament (in 64% of our cases).

Others have made the same observation [3, 6]; only Pina [17] found the termination more often in the pancreatic segment, whereas Piquand (in 6) found no such preponderance. Only bifurcations or trifurcations were found.

The division of the artery into 4 lobar aa. was, however, found by Pina [17] (10 of 128 cases), by Gutierrez [9] (1 of 30 cases) and by Mandarim-de-Lacerda [10] (3 of 60 cases).

The length of the arterial pedicle

We called the pedicle short when it was between 20 and 30 mm, and long when it was over 30 mm.

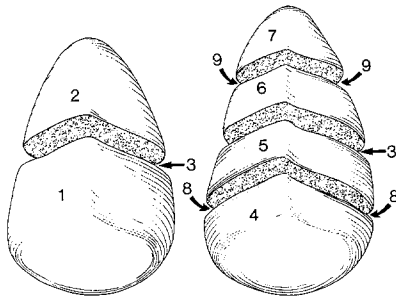


Fig. 12
Splenic systematization (by Nguyen Huu, 1952) 1 upper lobe 2 lower lobe 3 Interlobar plane 4, 5, 6, 7 splenic segments 8 lower intersegmentary plane 9 upper intersegmentary plane

Systématisation de la rate (d'après Nguyen Huu, 1952) 1 lobe inférieur 2 lobe supérieur 3 plan interlobaire 4, 5, 6, 7 segments spléniques 8 plan intersegmentaire inférieur 9 plan intersegmentaire supérieur

Nguyen [12-14] found the range to be between 30 and 60 mm, Cayotte [6] between 17 and 66 mm, and Bourgeon [3] between 30 and 60 mm. It is possible to classify the pedicle from a surgical point of view. In a long pedicle, division of the artery occurs early and is pre-hilar. Between the branches of a bifurcation the vessels pile on top of one another, numbering between 6 and 8. These vessels reach the hilum of the spleen and penetrate it. This fan-like arrangement of the branches makes splenectomy much easier, since hemostasis can be achieved branch by branch, of the different parts of the pedicle (Fig. 8).

With a short pedicle the splenic a. divides in the hilum, forming a T pattern, from which short branches emerge to penetrate the organ perpendicularly (Fig. 3). This arrangement causes difficulty in achieving hemostasis during splenectomy. The tail of the pancreas is at risk, as shown by a few cases of pancreatic necrosis after splenectomy with a short pedicle [8, 18].

Splenic systematization

The segmentary organization of the spleen depends on its arterial structure. The spleen is divided into two superimposed arterial territories or lobes that are distinct in most cases (84% in our series). Each of the lobes comprises many segments, each deriving its blood supply from one of the branches of the lobar aa. In general, there are four segments, two upper and two lower, piled on top of one another, separated by cleavage planes. The interlobar plane is more or less perpendicular to the main axis of the spleen. The upper intersegmentary plane divides the upper lobe into two segments, an upper and a lower. The lower intersegmentary plane similarly divides the lower lobe into upper and lower segments. The existence of very rare interlobar anastomoses, and the higher frequency of intersegmental anastomoses make the upper and lower intersegmental planes relatively avascular, whereas the interlobar plane remains vascular (Fig. 12). Each segment is divided into subsegments corresponding to the territory of irrigation of the terminal aa. Thus the spleen appears to be made up of 4 to 10 segments which are independent of each other. Nguyen [11, 13-15] likened this aspect to meat on a skewer or a pile of plates. Finally, when the splenic a. ends in a trifurcation (16% of our cases) the spleen comprises three lobes and six segments.

The general picture of a splenic segmentation is therefore as follows:

- the primary a., i.e. the branches of the splenic a., go to a particular lobe, the lobar a. Each lobe corresponds to about half the spleen and has a variable number of territories, each depending on an autonomous vascular circuit.
- the secondary a. supply one segment, the segmental a.
- the tertiary a. supply much smaller territories and constitute the terminal system, the subsegmental a.

Each territory has a double aspect:

- a morphological aspect, which consists of all the ramifications that have the same origin and go to the same territory;
- a functional or topographical aspect, which consists of all the ramifications going to the same territory regardless of their origins.

Conclusion

The distribution of the splenic a. determines the division of the spleen into two or three lobes. Each lobe is made of segments which contain a varying number of territories, each depending on an autonomous vascular circuit.

The existence of intersegmental planes and of an interlobar plane enables conservative surgery of the spleen to be performed.

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