Anatomical Study and Proportional Analysis of the Pig Spleen Arterial Segments

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**Key Words**
Spleen · Splenic artery · Partial splenectomy · Pig

**Abstract**
A systematic study was performed in 31 pig spleens to provide an analysis of the splenic arterial segmentation and an analysis of the proportional area of each segment. There were two independent arterial segments in all cases, a dorsal and a ventral. The dorsal segment was smaller than the ventral segment, presenting 16.81 and 83.19\% as the median percentage of the total area of the spleen, respectively. In conclusion, the pig arterial segments are quite similar to those of dog, buffalo, goat, and sheep, where there is a small dorsal segment and a large ventral segment, and somewhat similar to the human spleen, where there are two segments as well, though with a similar area.

**Introduction**
Partial splenectomy can be indicated in animals with local injury in the spleen, nonmalignant disease, or if there is a need for biopsy [Waldron and Robertson, 1995]. Hematologic alterations in white blood cells, red blood cells, and platelet levels are less pronounced in partial splenectomy when compared with total splenectomy [de-Boer et al., 1972]. The advantage of partial splenectomy is the retention of the splenic function, which is important to the immunologic response, and the preservation of the hematological values [Lipowitz and Blue, 1993]. On the other hand, partial splenectomy carries the potential risk of hemorrhage from remaining splenic parenchyma and increases operative time [Waldron and Robertson, 1995].

The knowledge of the independent vascular segments in lungs, liver and kidney, as well as the success in partial resections of these organs, led anatomists and surgeons to investigate the splenic segments [Katritsis et al., 1982]. Many studies have been done on the splenic arterial segments in man [Katritsis et al., 1982; Mandarim-de-Lacerda et al., 1983; Garcia-Porrero and Lemes, 1988; Sow et al., 1991; Liu et al., 1996], buffalo [Gupta et al., 1978a], dog [Gupta et al., 1978b], goat [Gupta et al., 1978b], goat [Gupta et al., 1978c], opossum [Silva, 1999], cat [Holzchuh, 1977], sheep [Ocal and Takci, 1991], armadillo [Schimming and Abreu, 2001], and pig [Silva and Martins, 2000].

The pig is often used in research and training due to easy procurement and handling. Nevertheless, there are no specific anatomic studies on the swine splenic arterial segments, and the anatomical data available are not very accurate and do not assist partial splenectomy investigation.
The aim of this study was to provide an analysis of the splenic arterial segmentation in pigs and an analysis of the proportional area of each segment.

**Material and Methods**

Thirty-one spleens from 7-month-old pigs (Duroc and Large-White mixed breed) were studied. Spleens were obtained from a slaughterhouse immediately after the animals’ deaths. The institutional animal review committee approved the research protocol.

Colored acrylic ink was injected through the primary branches of the splenic artery that could be identified and isolated outside the hilus (yellow in the dorsal branch and blue in the ventral branch) until the whole parenchyma was filled. After that, the spleens were fixed in a 10% formaldehyde solution for 48 h. Both spleen surfaces, parietal and visceral, were photographed. A B-100 translucent Weibel grid was placed over the photographs (fig.1) in order to evaluate the surface area of each segment by using the ‘point-counting planimetry method’ [Mathieu et al., 1981].

**Results**

In all cases, the splenic artery was divided close to the surface of the hilus into two primary branches, one to the dorsal extremity, and the other to the ventral extremity. The dorsal branch was smaller than the ventral branch.

In all cases, there were two independent arterial segments. The dorsal segment was smaller than the ventral segment ($p < 0.01$), presenting 16.81 and 83.19% as the median percentage of the total area of the spleen, respectively (fig. 2). Table 1 shows the results of the statistical analysis.

**Discussion**

The two segments identified in pig spleen were separated by an avascular plane. This is important, because the intrasplenic division provides an anatomical basis for highly selective conservative operations of the spleen, with minimal hemorrhage [Katritsis et al., 1982]. Certainly, the knowledge of the splenic segments and its corresponding arteries will help surgeons, because there are no surface landmarks (fissures and notches), and the ligation of the segmental arteries can be useful as guidelines in a partial splenectomy.

Although some authors have found polar arteries in human spleens [Katritsis et al., 1982; Garcia-Porrero and Lemes, 1988; Liu et al., 1996] and in the armadillo [Schimming and Abreu, 2001], we did not observe either dorsal or ventral polar arteries in the pig spleen.

**Table 1. Results of the statistical analysis**

<table>
<thead>
<tr>
<th></th>
<th>Dorsal segment</th>
<th>Ventral segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>16.81</td>
<td>83.19</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>20.82</td>
<td>4.21</td>
</tr>
<tr>
<td>Minimum</td>
<td>12.5</td>
<td>77.1</td>
</tr>
<tr>
<td>Maximum</td>
<td>22.9</td>
<td>87.5</td>
</tr>
</tbody>
</table>

Data are indicated as percentages.

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**Fig. 1.** Schematic drawing of a B-100 planimetry grid placed over the parietal surface of a spleen, illustrating the evaluation of the segmental area by the point-counting planimetry method.

**Fig. 2.** Proportional analysis of arterial segmental areas in pig spleen ($p < 0.01$).
Two segments were found in all spleens, and there was no anastomosis between them. This is different from the pattern found in adult humans [Sow et al., 1991], children [Mandarim-de Lacerda et al., 1983], and dogs [Gupta et al., 1978b], where the authors observed anastomoses between segments in 32, 16.7, and 2.5% of the spleens. The number of segments is similar to those reported in man [Katritsis et al., 1982; Mandarim-de Lacerda et al., 1983; Garcia-Porrero and Lemes, 1988; Sow et al., 1991; Liu et al., 1996], buffalo [Gupta et al., 1978a], dog [Gupta et al., 1978b], goat [Gupta et al., 1978c], and sheep [Ocal and Takci, 1991]. Furthermore, the two segments in the human spleen have the same proportional area, while in the other species, the dorsal segment is smaller than the ventral segment. Studies demonstrated that a third [Van Wyck et al., 1980] or even a half [Coil et al., 1980] of the original spleen is needed to prevent sepsis after challenging the animal with pneumococci. Furthermore, we could identify and isolate these branches outside the hilus. This is important, because when a partial splenectomy is performed, the segmental arteries are ligated, and this branching pattern allows for more comfortable operation for the surgeons than would a ‘T’ configuration [Liu et al., 1996]. Silva and Martins [2000], using Landrace and Large-White pigs, also observed three distinct regions of arterial irrigation in the spleen: dorsal, middle and ventral. However, they did not follow the arterial pattern and performed division by chance. In conclusion, the pig arterial segments are quite similar to dog, buffalo, goat, and sheep, where there is a small dorsal segment and a large ventral segment, and somewhat similar to the human spleen, where there are two segments as well, though with a similar area.

The four arterial regions reported in the opossum [Silva, 1999] and the three arterial regions described in the cat [Holzchuh, 1977] and armadillo [Schimming and Abreu, 2001] were different from our results.

Silva and Martins [2000] described the pig splenic artery without extra-hilar branches. However, we observed that the primary division of the pig splenic artery was close to the hilus, but outside the parenchyma, with a ‘Y’ configuration. Furthermore, we could identify and isolate these branches outside the hilus. This is important, because when a partial splenectomy is performed, the segmental arteries are ligated, and this branching pattern allows for more comfortable operation for the surgeons than would a ‘T’ configuration [Liu et al., 1996].

In conclusion, the pig arterial segments are quite similar to dog, buffalo, goat, and sheep, where there is a small dorsal segment and a large ventral segment, and somewhat similar to the human spleen, where there are two segments as well, though with a similar area.

References