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MORPHOMETRY OF THE NEPHROSPLENIC LIGAMENT IN HORSES AND THE QUANTIFICATION OF SOME FACTORS THAT INFLUENCE IT

MORFOMETRIA LIGAMENTULUI NEFROSPLENIC LA CABALINE ȘI CUANTIFICAREA UNOR FACTORI CARE O INFLUENȚEAZĂ

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ABSTRACT | REZUMAT

Nephrosplenic entrapment is a pathology commonly found as part of the gastrointestinal colic syndrome in horses. Within different populations of horses, there are certain individuals more prone to develop nephrosplenic entrapment. This individual predisposition is based on several factors, among which of interest to this study is the anatomical variability of the nephrosplenic space. The aim of this study was to identify, in a population of six horses directed towards slaughter, certain factors that determine the different morphology of the nephrosplenic ligament and nephrosplenic space between individuals. The horses were weighed individually, and after slaughter, from each horse, the spleen and the left kidney were harvested in block, reunited by the nephrosplenic ligament. Measurements were made of the length of the base of the spleen, the length and width of the left kidney, the length and width of the nephrosplenic ligament, the length of the ligament insertion on the spleen and the depth of the nephrosplenic space. Thus, this study was aimed at identifying the existence or absence of a relationship of interdependence between the body weight, the weight of the spleen, the weight of the left kidney, the length of the spleen base, the length of the left kidney, the length of the insertion of the nephrosplenic ligament on the spleen, on the one hand and the length of the nephrosplenic ligament, the width of the nephrosplenic ligament and the depth of the nephrosplenic space, on the other hand. Following the statistical processing of the data obtained, using Pearson`s correlation coefficient, a positive correlation was observed between the length of the nephrosplenic ligament and the following factors: the weight of the spleen, the weight of the left kidney, the length of the base of the spleen and the length of the left kidney. There is a negative correlation between the width of the nephrosplenic ligament and all the factors to which it has been reported, namely, the weight of the spleen, the weight of the left kidney, the length of the left kidney and the length of the ligament insertion on the spleen. Between the depth of the nephrosplenic space and the weight of the horse, the weight of the spleen and the length of the base of the spleen, the results show a weak correlation between the variable.

Keywords: horse, colic, nephrosplenic entrapment, nephrosplenic ligament, spleen

Încarcerarea nefrosplenică este o patologie frecvent întâlnită ca parte a sindromului de colică gastrointestinală la cabaline. În cadrul diferitelor populații de cai, există anumiți indivizi mai predispuși la apariția încarcerării nefrosplenice. Această predispoziție individuală este pusă pe baza mai multor factori, dintre care de interes pentru acest studiu este variabilitatea anatomică a spațiului nefrosplenic. Scopul acestui studiu a fost identificarea, într-o populație de șase cai direcționați înspre abatorizare, a unor factori care determină morfologia diferită a ligamentului nefrosplenic și spațiului nefrosplenic între indivizi. Caii au fost cântăriți individual, iar după sacrificare, de la fiecare cal s-au recoltat în bloc splina și rinichiul stâng, reunite prin ligamentul nefrosplenic. S-au efectuat măsurători ale lungimii bazei splinei, lungimii și lățimii rinichiului stâng, lungimii și lățimii ligamentului nefrosplenic, lungimea inserției ligamentului pe splină și ale adâncimii spațiului nefrosplenic. Astfel, s-a urmărit identificarea existenței sau absenței unei relații de interdependență între greutatea corporală, greutatea splinei, greutatea rinichiului stâng, lungimea bazei splinei, lungimea rinichiului stâng, lungimea inserției ligamentului nefrosplenic pe splină, pe de o parte și lungimea ligamentului nefrosplenic, lățimea ligamentului nefrosplenic și adâncimea spațiului nefrosplenic, pe de altă parte. În urma prelucrării statistice a datelor obținute, utilizând coeficientul de corelație al lui Pearson (R), s-a observant o corelație pozitivă între lungimea ligamentului nefrosplenic și următorii factori: greutatea splinei, greutatea rinchiului stâng, lungimea bazei splinei și lungimea rinichiului stâng. Există o corelație negativă între lățimea ligamentului nefrosplenic și toți factorii la care s-a raportat aceasta, și anume, greutatea splinei, greutatea rinichiului stâng, lungimea rinichiului stâng și lungimea inserției ligamentului pe splină. Între adâncimea spațiului nefrosplenic și greutatea cailor, greutatea splinei și lungimea bazei spline s-a obținut o corelație slabă între variabile.

Cuvinte cheie: cal, colică, încarcerare nefrosplenică, ligament nefrosplenic, splină

Horses are susceptible to colic due to digestive tract particularities (5). Nephrosplenic entrapment is known as a common cause of gastrointestinal colic syndrome in horses. The literature describes various causes that predispose certain individuals to the occurrence of this pathology, including anatomical differences of nephrosplenic space, and the location of entrapment of the left segment of the ascending colon, among certain individuals. Although the anatomical variability of nephrosplenic space is known to be present in different horses, there are a few data describing the factors that lead to this difference. The prevalence of nephrosplenic entrapment is variable, with reports of 2.5% (4), 2.7% (3), 3% (9), 4% (3), 6% (17), reaching up to 9% (12). The risk of recurrence of this condition is 3.2% (8), 8.1% (11) to 21% (17). Thus, nephrosplenic entrapment has been described as having a higher prevalence in "middle-aged" horses (1,10) with the age range of 4-8 years also being reported (3). Even if the most vulnerable period in the horse's lifetime is the first weeks of life (6) there are not publication that reports nephrosplenic entrapment in foals although the colonic motility dysfunction or an accumulation of gas is present. Regarding the sex of the individuals, an increased frequency was recorded in castrated males, but the exact cause of this link is not known (1,2,10,17). From a breed point of view, horses from sports breeds, "Warmbloods" (2) and, in general, horses of large size with a large volume of the abdo-

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minal cavity are predisposed (1,10). Nephrosplenic entrapment is part of the category of non-strangulated intestinal obstructions. However, in some cases, the colon trapped in the nephrosplenic space can be torsion with a 180-degree, with the position of the II loop dorsally, a situation in which the entrapment falls into the category of strangulated obstructions (1,2,11,14,18). Situations that require surgical intervention to reposition the loops of the colon in the anatomical position and complications of surgery include intraoperative rupture of the colon, postoperative diarrhoea, incisional drainage, and, rarely, septic peritonitis (15).

This study aimed to identify the factors that influence the morphology of the nephrosplenic ligament and the anatomical variability of the nephrosplenic space. Measurements of the spleen's base length, left kidney length and width, spleen and left kidney weight have been done in order to identify how these numbers influence the shape and size of the ligament and the nephrosplenic space. The depth of the nephrosplenic space is also assessed by measuring the length of the distance from the insertion area of the nephrosplenic ligament at the medial face of the spleen to the upper edge of the spleen.

MATERIALS AND METHODS

The biological material used in this study was a batch of 6 horses directed toward slaughter. Since the horses were of different origins, no data are known about their breeding and feeding regime. The group consisted of mares, stallions, and castrated males. The horse selection criteria considered a minimum weight of 500 kg, results from individual weighing using a BEURER BY80 20 kg weight scale for large animals and a body weight score of 3/5, results obtained from the evaluation by general inspection and palpation of the body areas of interest, neck, trunk, croup region of each animal. The working material evaluated were the spleen, left kidney, and nephrosplenic ligament collected in a block from each animal.

The method of work was the same for each horse taken into the study. In the first stage, a group exam was conducted by remote inspection, aiming to identify individuals who showed a minimum body condition score of 3/5. After the selection of the batch of horses, each animal was weighed, and the individuals with a body weight of at least 500 kg were selected. Following the slaughter of the animals, on the cutting line, after the abdominal cavity was opened, an inspection was carried out for the identification and *in-situ* evaluation of the spleen, left kidney, nephrosplenic ligament, and nephrosplenic space. Subsequently, the spleen and left kidney were collected and held together by the nephrosplenic ligament. The next step involved evaluating, one at a time, the anatomical parts collected from each horse, in a block, by inspecting them and taking the following measurements, in centimetres: the length of the base of the spleen, starting from its cranial edge to the caudal edge; the length of the nephrosplenic ligament, starting from the cranial edge to the caudal edge; the width of the nephrosplenic ligament, starting from its insertion at the spleen level, to its insertion at the left kidney; the measurement of the width of the nephrosplenic ligament was performed in the cranial, middle and caudal portion of the ligament; the depth of the nephrosplenic space, by measuring the distance from the nephrosplenic ligament insertion on the spleen to the upper edge of the spleen; these measurements were made in the cranial, middle and caudal portion; the length of the nephrosplenic ligament insertion at the spleen level.After the measurements, the detachment of the organs and the nephrosplenic ligament was performed, by cutting the nephrosplenic ligament along its insertion at the left spleen and kidney level. Next, the measurement in centimetres of the size of the left kidney of each horse, namely its length and width, after removing the fat in which it was embedded: the length of the left kidney was measured as the distance between the two poles of the kidney, the cranial pole and the caudal pole; the width of the left kidney was measured as the distance from the lateral edge to the medial edge, right at the renal hilum. After taking the left kidney measurements, the weight of the spleen and left kidney from each horse was measured one at a time, and the weight was recorded in kilograms.

RESULTS AND DISCUSSIONS

The study group included individuals with a body weight between 550-700 kg, above the value taken as the minimum level of inclusion of horses in this study, namely 500 kg. The group consisted of two females and four males, of which three castrated individuals and one uncastrated male (stallion) (Table 1). Thus, it was wanted to assess whether the body size, characterized in this study by body weight, influence the topography of the nephrosplenic space and the morphology of the organs in its structure: the spleen, the left kidney, and the nephrosplenic ligament.

Table 1

Sex and weight of horses

No.	Gender	Weight (kg)
1	Female	700
2	Male	600
3	Male, gelding	550
4	Female	655
5	Male, gelding	560
6	Male, gelding	620

For each animal, the spleen weight, and the left kidney weight were calculated, their average corresponding to the average weight described in the literature: 1.21 kg the average weight of the spleen and 0.74 kg the average weight of the kidneys (Tables 2 and 3).

Table 2

Left kidney weight

No.	Left Kidney Weight (kg)
1	0.785
2	0.790
3	0.665
4	1.055
5	0.550
6	0.650

Table 3

Spleen weight

No.	Spleen Weight (Kg)
1	1.520
2	1.075
3	0.950
4	1.610
5	0.965
6	1.165

The weight of the organs was measured individually, after their detachment from the nephrosplenic ligament. In addition to weight, the following measurements were made for each organ: Length and width of the left kidney (Table 4) and the length of the base of the spleen (Table 5). Kidney width was not included in the data analysis. The depth of the nephrosplenic space was measured on the medial face of the spleen, as the distance from the insertion area of the nephrosplenic ligament on the spleen to the dorsal edge of the spleen. Three measurements were made in the cranial, middle, caudal portions (Table 6). All three measurements were included in the study.

Table 4

Left kidney length and width

No.	Left Kidney Dimensions	
	Length (cm)	Width (cm)
1	19.1	15
2	20.5	14.5
3	17.2	13.7
4	21	15.4
5	15.8	13.6
6	17.4	13.6

Table 5

Length base of the spleen

No.	Length Base of the Spleen (cm)
1	24
2	22.5
3	18.5
4	19.5
5	18.5
6	20

Table 6

Nephrosplenic space depth

No.	Nephrosplenic Space Depth (cm)		
	Cranial	Middle	Caudal
1	5.5	6	7
2	4.5	5.5	5
3	5	5.5	6
4	4.5	5	5.8
5	5.7	7.9	7.8
6	4.4	5.6	7.3

Measurements of the length and width of the nephrosplenic ligament have been made (Table 7). Three measurements were made for the width: at the cranial end, at the middle, and the caudal end. Only width values from the cranial extremity and caudal extremity were included in the study. The insertion length of the nephrosplenic ligament was also measured at the medial face of the spleen (Table 8).

Table 7

Length and width of the nephrosplenic ligament

No.	Nephrosplenic Ligament Length (cm)	Nephrosplenic Ligament Width (cm)		
		Cranial	Middle	Caudal
1	19.5	6	6.5	8
2	17	6	5	6
3	13	7.5	4.3	7.5
4	16.5	5.7	4.3	4.8
5	10.5	8.3	6	7
6	11.4	8.3	6.2	4.6

Table 8

Ligament insertion length on the spleen

No.	Ligament Insertion Length on Spleen (cm)
1	17
2	16
3	13
4	15
5	11.7
6	15

After carrying out horses and organs weight measurements and dimensions of organs and nephrosplenic ligaments, the statistical analysis of the data recorded by graphical representation and correlation coefficient calculation was carried out. The aim was to establish the existence or absence of a dependency relationship between the recorded variables. The weight of the horses was used to establish whether the weight of the spleen (Fig. 1) and the left kidney (Fig. 2) depend on it.

It was aimed to identify the correlation between the length of the nephrosplenic ligament and the:

- spleen weight (Fig. 3);
- left kidney weight (Fig. 4);
- length of the base of the spleen (Fig. 5);
- left kidney length (Fig. 6).

The width of the ligament correlated according to the following values:

- spleen weight (Fig. 7);
- left kidney weight (Fig. 8);
- left kidney length (Fig. 9);
- the length of the ligament insertion on the spleen (Fig. 10).

The correlation between the length and width of the ligament was also performed (Fig. 11). The depth of the nephrosplenic space was correlated according to:

- weight of horses (Fig. 12);
- spleen weight (Fig. 13);
- length of the base of the spleen (Fig. 14).

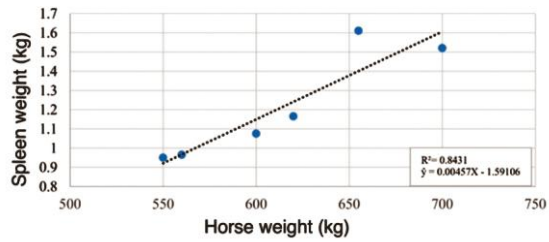

Fig. 1. Representation of the correlation between the weight of the horses and the weight of the spleen. The correlation coefficient for the weight of the horses versus the weight of the spleen is R=0.9182

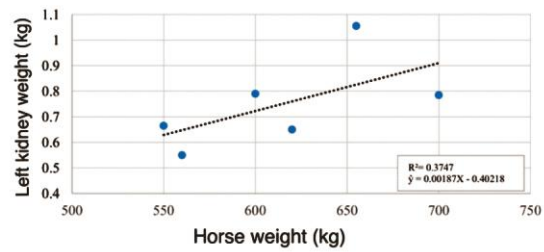

Fig. 2. Representation of the correlation between the weight of the horses and the weight of the left kidney. The correlation coefficient for the weight of the horses versus the weight of the left kidney is R = 0.6121

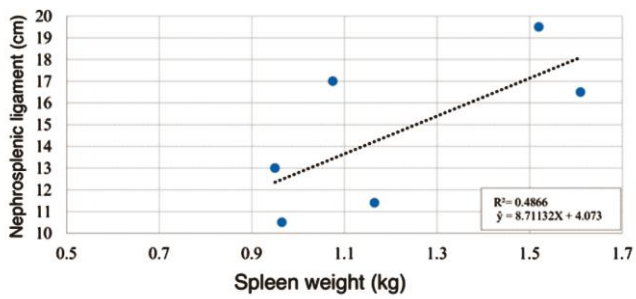

Fig. 3. Representation of the correlation between the length of the ligament and the weight of the spleen. The correlation coefficient for the weight of the spleen versus the length of the nephrosplenic ligament is R=0.6976

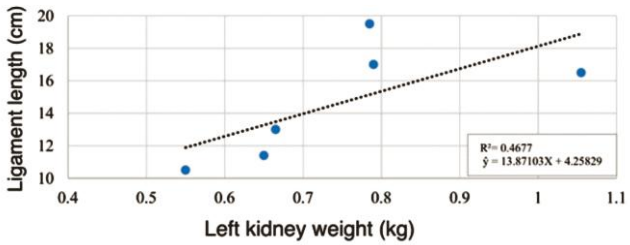

Fig. 4. Representation of the correlation between the length of the ligament and the weight of the left kidney. The correlation coefficient for the weight of the left kidney versus the length of the ligament is R=0.6839

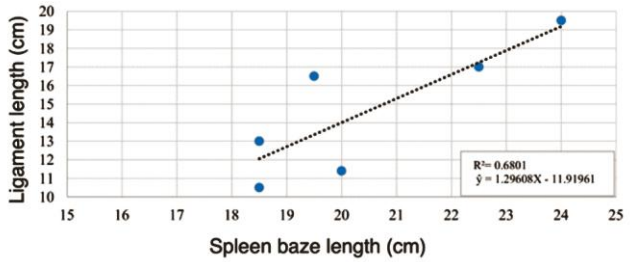

Fig. 5. Representation of the correlation between the spleen base length and the length of the ligament. The correlation coefficient for the length of the base of the spleen versus the length of the ligament is R=0.8247

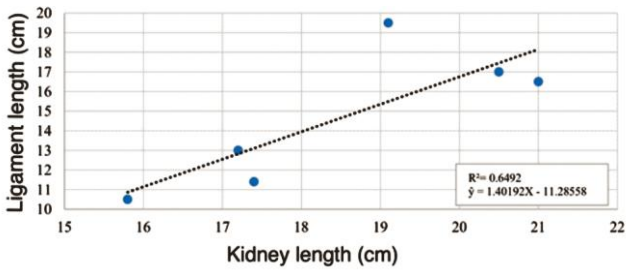

Fig. 6. Representation of the correlation between the length of the left kidney and the length of the ligament. The correlation coefficient for left kidney length versus ligament length is R=0.8057

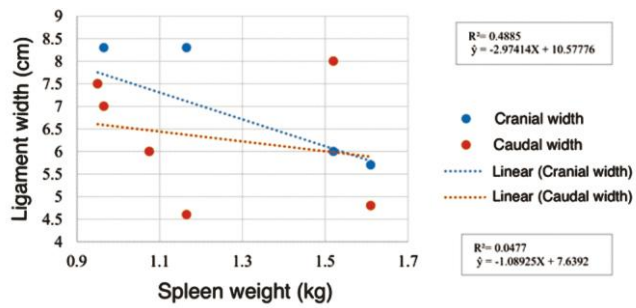

Fig. 7. Representation of the correlation between the weight of the spleen and the width of the ligament. The correlation coefficient between the weight of the spleen and the width of the ligament in the cranial portion is R= -0.6989 and in the caudal portion R= -0.2184

Body size is considered to be one of the factors that predispose certain individuals to the occurrence of nephrosplenic entrapment. This pathology is described as more common in horses with a large body constitution (4). Obesity is a common feature in horses suffering from metabolic syndrome (7). For this reason, the horse inclusion criterion in this study was a minimum body weight value of 500 kg in combination with a minimum body condition score of 3/5. All fat deposits lead to the modification of the normal anatomical relationships of this segment with the neighbouring abdominal viscera (16). Thus, it was wanted to assess whether the body size, characterized in this study by body weight, influence the topography of the nephrosplenic space and the morphology of the organs in its structure: the spleen, the left kidney, and the nephrosplenic ligament.

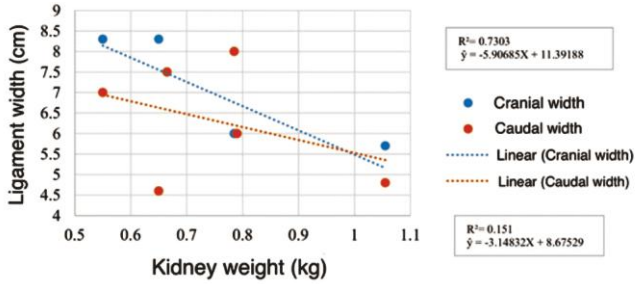

Fig. 8. Representation of the correlation between the weight of the kidney and the width of the ligament. The correlation coefficient between the weight of the left kidney and the width of the ligament in the cranial portion is R= -0.8546 and in the caudal portion R= -0.3886

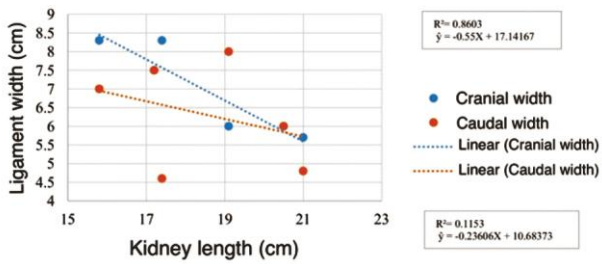

Fig. 9. Representation of the correlation between the left kidney length and the width of the nephrosplenic ligament. The correlation coefficient for the left kidney length versus the width of the nephrosplenic ligament is in the cranial portion R= -0.9275 and the caudal portion R= -0.3396

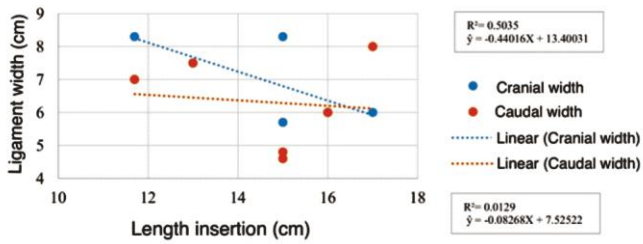

Fig. 10. Representation of the correlation between the length of the ligament insertion on the spleen and the width of the ligament. The correlation coefficient between the length of the ligament insert on the spleen versus the width of the ligament in the cranial portion is R= -0.7096 and in the caudal portion R= -0.1137

Marien et al. (2011) described in a study a laparoscopic surgery technique for closing the nephrosplenic space, identifying a considerable anatomical variability of the nephrosplenic space between horses, noting that this variability can influence the appearance, degree of relapse, and evolution of nephrosplenic entrapment of the left colon (13). Rocken et al. (2005) performed a study and note the depth of nephrosplenic space, namely, the distance from the insertion site of the nephrosplenic ligament on the spleen to the dorsal edge of the spleen, as an important factor for the appearance and evolution of nephrosplenic entrapment (17). More research on nephrosplenic entrapment mentions that although nephrosplenic entrapment may occur in any of the sexes, it is most common in castrated males, but the cause of this bond is unknown (1, 2, 10, 17).

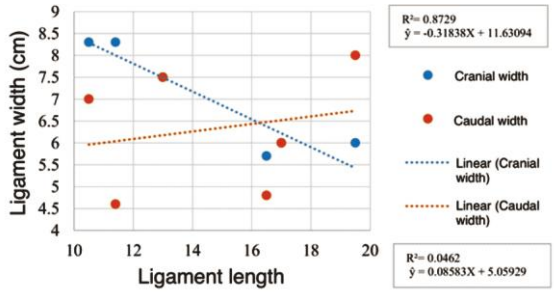

Fig. 11. Representation of the correlation between the length and the width of the nephrosplenic ligament. The correlation coefficient between the length versus width of the ligament in the cranial portion is R= -0.9343 and in the caudal portion R= 0.2146

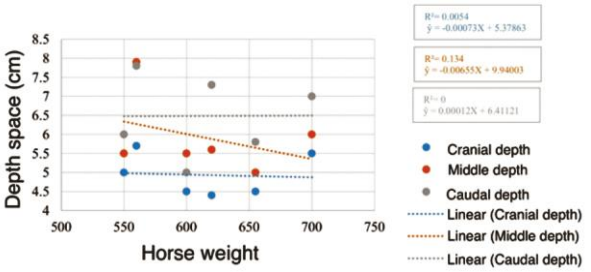

Fig. 12. Representation of the correlation between the weight of the horses and the depth of the nephrosplenic space. The correlation coefficient between the weight of the horses versus the depth of space is in the cranial portion R= -0.0738, in the middle portion R= -0.366, and the caudal R=0.0064

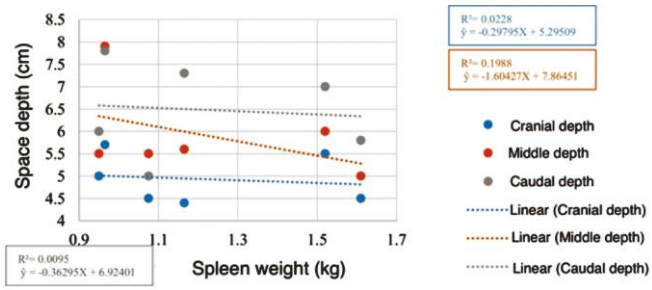

Fig. 13. Representation of the correlation between the weight of the spleen and the depth of the nephrosplenic space. The correlation coefficient between the weight of the spleen versus the depth of the nephrosplenic space is cranial R= -0,151, in the middle R= -0.4459, and caudal R=-0.0977

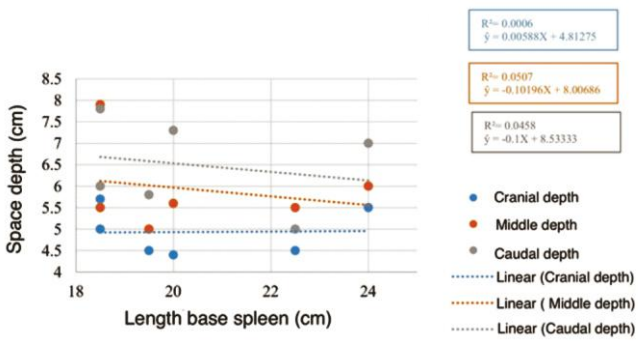

Fig. 14. Representation of the correlation between the length of the splenic base and the depth of the nephrosplenic space. The correlation coefficient between the length of the base of the spleen versus the depth of the nephrosplenic space is cranial R= 0.0237, in the middle R= -0.2252, and caudal R= -0.214

CONCLUSIONS

In this study, in order to interpret the link between the studied variables, Pearson's correlation coefficient was used.

Following the statistical processing of the data obtained, the length of the nephrosplenic ligament is influenced by the following factors: the weight of the spleen, the weight of the left kidney, the length of the base of the spleen and the length of the left kidney.

The width of the nephrosplenic ligament is not influenced by the weight of the spleen, the weight of the left kidney, the length of the left kidney and the length of the ligament insertion on the spleen.

Between the depth of the nephrosplenic space and the weight of the horse, the weight of the spleen and the length of the base of the spleen, the results show a weak correlation.

Moreover the weight of the spleen and the left kidney are influenced by the weight of the horse.

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