RAMIFICATION AND DISTRIBUTION OF THE PHRENIC NERVES IN MULES (*Equus caballus* X *Equus asinus*) DIAPHRAGMS

RAMIFICAÇÃO E DISTRIBUIÇÃO DOS NERVOS FRÊNICOS EM DIAFRAGMAS DE MUARES (*Equus caballus* X *Equus asinus*)

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SUMMARY: It is the objective with this study the ramification of the ramification and distribution of phrenic nerves (right and left), when it reaches the muscle. It was used 40 diaphragms of mules (*Equus caballus* X *Equus asinus*) removed from adults animals; the diaphragms were isolated, washed and fixed in aqueous solution of phormoldehyde 10%, than the dissection of the pieces was made. In all the study it was observed that the phrenic nerve in mules give origin to laterodorsal trunk 35 times at right side (43.7%) and one time at left side (1.25%); simultaneous origin of the dorsal, lateral and ventral branches 15 times at left side (18.75%) and 5 times at right side (6.25%); it was also observed that the phrenic nerve form the lateroventral trunk 24 times at left side (30%), the symmetric behavior of left and right phrenic nerves were found one time (1.25%). The dorsal branches of both sides have distribution on the lombar part of the muscle, the lateral branches of left and right side have its distribution on the costal and sternal parts of the correspondent side. It was also observed the presence of connections 30 times (37.5%), being 15 connections on the left side (18.75%), 14 times on the right side (15.5%), and one time between the dorsal branches of the left and rights sides (1,25%).

UNITERMS: Mules, Phrenic nerve, Diaphragm muscle.

INTRODUCTION

The objective with this research work is to verify the ramification and distribution of right and left phrenic nerves when it reaches the diaphragm muscle.

The mules, animal that is a result of the cross-breeding between equine (*Equus caballus*) and asinine (*Equus asinus*), are widely utilized in brazilian country as traction element , above all in small and average properties, because of its wide work capacity and illness resistence, producing considerable economic and social resources to our country.

Regarding these aspects and the slenderness of informations about this subject, our objective is not only to complete the literature informs, as well to contribute for the development of the Comparative Anatomy, specially among equideous.

Consulting the abridgments reserved to Veterinary Anatomy, we verified that Bossi et al. (1909); Zimmerl (1930a); Lesbre (1923); Funaoka (1930); Zimmerl (1930b); Ellenberger; Baum (1932); Bruni; Zimmerl (1947); Gonzalez y Garcia; Gonzalez Alvarez (1961); Dobberstein; Hoffman (1964); Sisson; Grossman (1963); Schwarze; Schröder (1972) and Getty (1975), generically report that phrenic nerves get at tendineous center, leading, after successive divisions, to the muscular part of diaphragm. From the mentionated authors, only Zimmerl (1930a); Lesbre (1923) and Bruni; Zimmerl (1947); allude to the presence of one or more nervous fillets destined to the lombar part of the referred muscle.

As to specialized literature, referred to this subject, it is important to detach the works of Pancrazi (1926), studied the disposition of phrenic nerves in ants, bovines, equines, rabbits, dogs and cats, it was concluded that the main nervous contingents are in number of three, denominating them ventral, lateral and dorsal.

Other authors like Lutnicki (1950) studied the phrenic nerves in sheeps and the same author studied this

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nerve (LUTNICKI, 1953) in swines. Neves (1968) observed the phrenic nerves in bovines.

In the other way, Santiago; Pereira (1983), when studying diaphragm's innervation, using 30 equines PSI, 15 males and 15 females, adults, reached the following conclusions: the phrenic nerves ending in ventral branch and dorsolateral trunk of the right side (96.7%) and at the left side (3.3%).

Santiago (1986) studying the ramification and distribution of phrenic nerves in equine diaphragms, without defined bred, verified that: the phrenic nerves give the ventral branch and dorsolateral trunk 42 times (82%) at the right side and 5 times (19%) at the left side; the dorsal branch and ventrolateral trunk 40 times (80%) at the left side and 2 times (4%) at the right side.

We should still consider that studies about division and distribution of phrenic nerves in domestic and wild animals have already been objective of several researches, in canines (BERTELLI, 1894; CONDE, 1957), bovines (PANCRAZI, 1926; GIROLLA, 1955; NEVES, 1968; SOUZA; PEREIRA; ALBUQUERQUE, 1984), bubaline (MIGLINO; SOUZA, 1984 and TOCANTINS NETO, 1985), capybaras (MIGLINO,1984), dolmens (SOUZA, MIGLINO; SANTIS PRADA, 1982) and swines (CONDE, 1959; SOUZA, SANTIS PRADA; MIGLINO, 1983).

MATERIAL AND METHOD

Fourty diaphragms was used of adult mules (*Equus caballus* X *Equus asinus*), being 16 males and 24 females, the animals were killed at Abatedouro POMAR in the city of Araguari, MG; the animals came from different regions of breeding of the states of São Paulo, Goiás and Minas Gerais.

After sacrifying, the animal stayed with its head down and its abdominal cavity was widely opened trough one incision at the level of the white line. The abdominal viscera were removed, the liver and diaphragm remained fixed on there original places, being removed in only one block closed with the thoracic viscera.

Following this, the phrenic nerves (left and right) were identified and sectioned near 15 cm before they reach the muscle and than the diaphragm was isolated from the other thoracic organs and from liver.

Once totally isolated, the diaphragm was washed in current water and than extended in hard base, being shown its thoracic face, than was fixed in aqueous solution of phormoldehyde 10% where it remained for at least 72 hours.

The dissection of the 40 diaphragms was made using conventional surgical materials.At the finish of each dissecation, the muscle was designed, recording the division and distribution of the phrenic nerves.

For the description of the results, it was adopted the original nomenclature proposed by Bertelli (1894), calling the mainly branches of the division of the phrenic nerves as lateral, dorsal and ventral; also be employed the designations of right and left dorsolateral trunk and right and left ventrolateral trunk, used by Conde (1957), admitting the modifications made by Santiago (1986), that is, laterodorsal trunk and lateroventral trunk.

The division proposed was followed by Schmaltz (1928) that consider in the lombar part of the muscle, four pillars, being, right lateral, right medial, left medial and left lateral; the first three arising from a common tendon placed at the right, and the last one, at left. The behavior of the branches that goes to the costal part define by the occurrence of two variable dimension regions, that is named dorsal (dorsal foliolo) and ventral (ventral foliolo).

RESULTS

In the dissecation of the 40 diaphragms that:

- the phrenic nerve of the mules provides the laterodorsal trunk at 35 times on the right side (43.75%) and one time on the left side (1.25%);
- the phrenic nerves have simultaneous origin of the dorsal, lateral and ventral branches 15 times on the left (18.75%) and 5 times on the right (6.25%);
- it was found that phrenic nerve forms the lateroventral trunk 24 times on the left (30%);
- a symmetric behavior between right and left phrenic nerves were observed once (1.25%) when it give off the laterodorsal trunk and ventral branch;
- Distribution of the dorsal branches of phrenic nerves:
  . In 77 cases (38 at right side and 39 at left side) the dorsal branches are distributed only on the lombar parts that is correspondent to the medial and lateral pillar of diaphragm.
  . In 2 cases the dorsal branch gives off the one nervous fillet toward the right dorsal.
  . And once there were the emission of 2 nervous fillets toward tendineous center of the muscle, arising from the dorsal branch of the left phrenic nerve.
- Distribution of lateral branches of phrenic nerves:
  . In 78 cases (40 at the left side and 38 at the right side) the lateral branches were toward the costal part of the muscle, exactly on the laterodorsal region of the correspondent side.

. In only one case at the right side, the lateral branch give off one nervous fillet toward the right dorsal foliolo.

. In one case was observed the emission of one nervous fillet arising from the right lateral branch toward the right lombar part corresponding exactly to the right lateral pillar.

- Distribution of the ventral branches of the phrenic nerves:

  . In 79 times (39 at the left side and 40 at the right side) the ventral branches have its distribution on the lateroventral regions of the costal and sternal parts of the muscle.

  . In only one case the left ventral branch gives off 2 nervous fillets toward the ventral foliolo.

- Connections:

  The presence of connections were found at 30 cases; being 15 connections on the left side and 14 connections between the branches of the right side and just only one connection was found between branches of the left and right sides.

DISCUSSION

The classic authors of a treatises like Bossi et al. (1909); Lesbre (1923); Zimmerl (1930b); Ellenberger; Baum (1932); Bruni; Zimmerl (1947); Gonzalez y Garcia; Gonzalez Alvarez (1931); Dobberstein; Hoffman (1964); Sisson; Grossman (1963); Schwarze; Schröder (1972); and Getty (1975), reported that generically, the phrenic nerve get at the tendineous center and after some divisions it goes forward the muscular part of the diaphragm, this kind of information is more detached in observed including the frequencies of the occurrence of the different nervous arrangements, further on the identification of the distribution area of each branch of the phrenic nerves.

In opposite of what Amorin Júnior (1988) observed for Nordestin ass, we did not observed neat separation between the costal and sternal parts, and at this point agree with the affirmative made by Nickel et al. (1986) that, in horses, the sternal part is not distinctly separable of the costal part.

In relation of the ramification of the phrenic nerves, Pancrazi (1926) observes the occurrence of the ventral, lateral and dorsal branches, fact that also find in pieces, beyond the formation of the laterodorsal and lateroventral trunks attested now in mules. In the other side, Amorin Júnior (1988) names that branches of lombar, costal and sternal.

According to the frequencies of the occurrence of the nervous arrangement in the muscle, we identified as did Santiago; Pereira (1983) and Santiago (1986) the formation of a ventral branch associated with the laterodorsal trunk, at the right side 35 times, however in less number.

The formation of the dorsal branch associated with the lateroventral trunk 24 times at the right side of our cases, and this kind of arrangement was also found by Santiago (1986) however with a major frequency. Beyond that, we still found a simultaneous origin of the dorsal, lateral and ventral branches in 18.75% of the cases at the left side and 6.25% of the cases at the right side.

At the end, the connections observed in 37.5% of the cases occurred more frequently in mules than in PSI equines (SANTIAGO; PEREIRA, 1983) and in equines without defined breed (SANTIAGO, 1986).

CONCLUSIONS

The phrenic nerve on the mules gives off the laterodorsal trunk and ventral branch 35 times (43,75%) at the right side and one time at the left side (1.25%); the lateroventral trunk and dorsal branch 24 times (30%) at the left side; simultaneous origin of the dorsal, lateral and ventral branches were found 15 times at the left side (18.75%) and 5 times at the right side (6.25%).

The right and left phrenic nerves have a symmetric behaviour in one case when it gives off the laterodorsal trunk and ventral branch.

The dorsal branches of phrenic nerves in all cases on both sides (left and right) have its distribution on the lombar part (medial and lateral pillar) of the correspondent side.

RESUMO: O objetivo deste estudo é a verificação da ramificação e distribuição dos nervos frênicos (direito e esquerdo) quando estes alcançam o músculo diafragma. Foram utilizados 40 diafragmas de muares (*Equus caballus X Equus asinus*) removidos de animais adultos. O diafragma foi isolado, lavado e fixado em solução aquosa de formol a 10%, para posterior dissecação das peças. O nervo frênico em muares originou o tronco laterodorsal 35 vezes pelo lado direito (43,7%) e 1 vez pelo lado esquerdo (1,25%); cedeu simultaneamente ramificações dorsais, laterais e ventrais 15 vezes pela esquerda (18,75%) e 5 vezes pelo lado direito (6,25%); o nervo frênico forma o tronco lateroventral

24 vezes pela esquerda (30%); o comportamento simétrico entre nervos frênicos direito e esquerdo foi observado uma vez (1,25%). As ramificações dorsais de ambos os lados têm sua distribuição pela porção lombar do músculo, as ramificações laterais distribuem-se pela porção costal (região laterodorsal) e as ramificações ventrais nas porções costais e esternais do lado correspondente. Foi observado presença de conecções 30 vezes (37,5%), sendo 15 conecções no lado esquerdo (18,75%), 14 no lado direito (15,5%) e 1 conecção entre ramificações dorsais dos lados direito e esquerdo (1,25%).

UNITERMOS: Muares, Nervo Frênico, Músculo diafragma.

REFERENCES

AMORIM JUNIOR, A, A. **Ramificação e distribuição dos nervos frênicos no diafragma de jumentos Nordestinos.** 1988. 86 f. Tese (Mestrado em Anatomia dos Animais Domésticos)-Universidade de São Paulo. São Paulo. 1988.

BERTELLI, D. Contributo alla anatomia del diafragma nei canovori. **Mondo Our Zool**. Ital., Itália, v.1, n.9-10, p.478, 1894.

BOSSI, V.; CARADONNA, G. B.; SPAMPANI, G.; VARALDI, L.; ZIMMERL, U. **Trattato di anatomia veterinária.** Milano: Francesco Vallardi, 1909. v.3. 477 p.

BRUNI, A. C.; ZIMMERL, U. **Anatomia degli animali domestici.** 2 ed. Milano: Francesco Vallardi, 1947. 736 p.

CONDE, R. Estudo anatômico sobre a distribuição dos nervos frênicos no músculo diafragma de *Canis familiaris*. **Arq. Esc. Sup. Vet. Univ. Rural Est Minas Gerais**, Belo Horizonte, v.10, p.329-365, 1957.

CONDE, R. Estudo anatômico com dados experimentais sobre a distribuição dos nervos frênicos no músculo diafragma de *Sus scrofa domesticus*. **Arq. Esc. Sup. Vet. Univ. Rural Est. Minas Gerais**, Belo Horizonte, v.12, p. 37-110, 1959.

DOBBERSTEIN, J.; HOFFMAN, G. **Lehnbuch der vergleichender anatomie der haustiere**. Leipzig: S. Hirzel, 1964. 967 p.

ELLENBERGER, W.; BAUM, H. **Handbuck der vergleichender anatomie der haustiere.** Berlim: Verlag J. Springer, 1932. 904 p.

FUNAOKA, S. Untersuchungen uber periphere nervenssis tem. *N. phrenicus*, von genpei Morita. **Arb. Anat. Imot.** Kioto, A., Kioto, v.1, 1930. Resumo do artigo publicado em: Biological Abstracts, v.8, 1652 p., 1934.

GETTY, R. **Sisson and Grossman's the anatomy of the domestic animals.** 5 ed. Philadelphia, W. B. Saunders, 1975. v.1. 1127 p.

GIROLLA, W. **Der nervus phrenicus der rindes**: seine morphology, Topik, Innervations- Und Funktionsafgaben. Wein: [s.n.], 1955. 44 p.

GONZALES, Y GARCIA, J.; GONZALEZ ALVAREZ, R. **Anatomia comparativa de los animales domésticos**. Madrid: Gráfica Canales, 1961. 774 p.

LESBRE, F. X. **Précis d'anatomie comparèe des animalx domestics**. Paris: J. B. Baillière, 1923. 822 p.

LUTNICKI, W. The phrenic nerve in the sheep. **Ann. Univ. M. Curie-Skolodowaska**, Lubin, v.5, n.4, p. 41-69, 1950.

LUTNICKI, W. Distribution phrenic nerves in diaphragm of pig. **Ann. Univ. M. Curie-Skolodowaska**, Lubin, v.8, p. 259-284, 1953.

MIGLINO, M. A. **Ramificação dos nervos frênicos do diafragma de capivara (*Hydrochoérus hydrochoéris*)**. 1984. Trabalho apresentado no 7°. Congresso e la Associación Panamericana de Anatomia, Mar del Plata, 1984.

MILIGNO, M.A.; SOUZA, W. M. **Ramificação e distribuição dos nervos frênicos do diafragma búfalos da raça Jaffarabadi.** 1984. Trabalho apresentado no 7º. Congresso de la Associación Panamericana de Anatomia, Mar del Plata, 1984.

NEVES, I. P. Estudo anatômico da distribuição dos nervos frênicos no músculo diafragma de bovinos (fetos). **Veterinária,** Rio de Janeiro, v.21, p. 30-45, 1968.

NICKEL, R; SCHUMMER, A; SEIFERLE, E ; SACK , W. O. **The anatomy of the domestic animals**. Berlim: Paul Parey, 1986. v.1. 499 p.

PANCRAZI, G. Sulla distribuzione del nerve frênico nei diafragma dei mammiferi. **Atti. Ist. Veneto Sci. , Veneto**, v. 85, n.2, p. 1926.

SANTIAGO, W. **Ramificação e distribuição dos nervos frênicos em diafragmas de eqüinos sem raça definida**. 1986. 48 f. Tese (Doutorado em Anatomia dos Animais Domésticos)- Universidade de São Paulo , São Paulo. 1986.

SANTIAGO, W. ; PEREIRA, J. G. Contribuição ao estudo da inervação do diafragma em eqüinos da raça Puro Sangue Inglês. **Ver. Fac. Med. Vet. Zoot. Univ. São Paulo**, São Paulo, v.20, n.2, p.143-153, 1983.

SCHMALTZ, R. **Anatomie des pferds.** Berlin: Von Richard Shoetz, 1928. 189 p.

SCHWARZE, E.; SCHRÖDER, L. **Compêndio de anatomia veterinária.** Zaragoza, Acribia, 1972 313 p.

SISSON, S.; GROSSMAN, J. D. **Anatomia de los animales domésticos.** Barcelona: Salvat , 1963 998 p.

SOUZA, W. M.; MIGLINO, M. A.; SANTIS PRADA , I. L. **Ramificação e distribuição dos nervos frênicos direito e esquerdo no diafragma de anta (*Tapirus americanus*).** 1982. Trabalho apresentado à 1ª. Semana de veterinária- São Paulo, 1982.

SOUZA, W. M.; PEREIRA, J. G. L.; ALBUQUERQUE , J. F. G. Contribution to the study of diaphragm innervation in Nelore bovines. **Anat. Anz.** Leipzig, v.155, p.317-323,1984.

SOUZA, W. M.; SANTIS PRADA, I. L.; MIGLINO, M. A. **Divisão e Distribuição dos nervos frênicos no diafragma, em suínos (*Sus scrofa domestica* L. 1758). da raça Landrace.** 1983. Trabalho apresentado à 2ª Semana de Veterinária, São Paulo, 1983.

TOCANTINS NETO, A. A. **Divisão e distribuição dos nervos frênicos no diafragma de búfalos (*Bubalus bubalis* L. 1758) da raça Murrah.** 1985. Tese (Doutorado em Anatomia dos Animais Domésticos)- Universidade de São Paulo, São Paulo. 1985.

ZIMMERL, U. Sistema nervoso. In: BOSSI, V.;CARADONNA, G. B.;SPAMPANI, G.;VARALDI, L.; ZIMMERL, U. **Trattato di anatomia veterinária.** Milano: Francesco Vallardi, 1930a. v.3. 674 p.

ZIMMERL, U. Apparecihio nervoso. In: ZIMMERL,U.; CARADONNA, G. B.; MANNU, A.; PREZIUSO, L. **Trattato di anatomia veterinária**. Milano: Francesco Vallardi, 1930b. v.3 674 p.

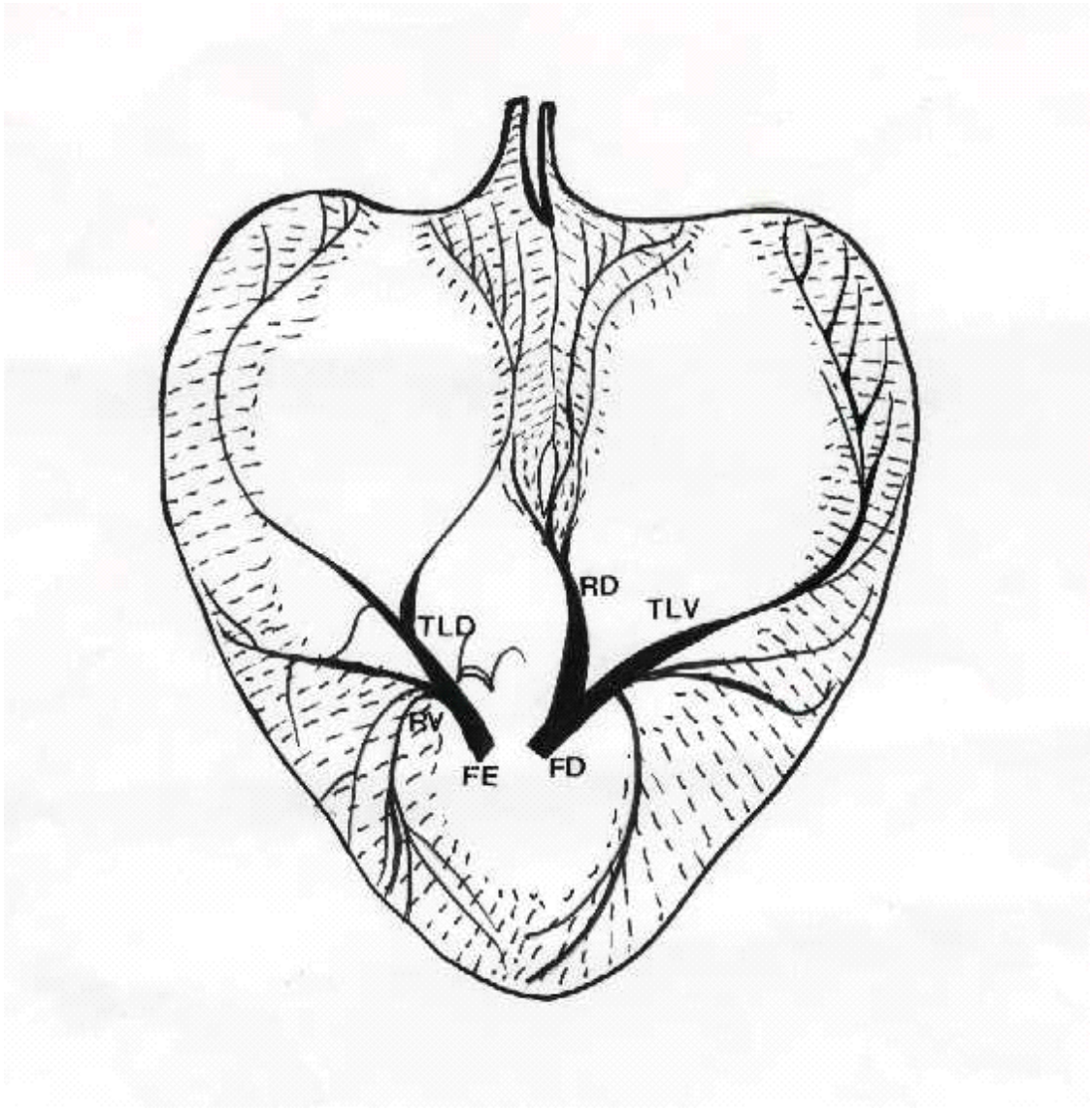

Figure 1 - Schematic drawing of one diaphragm model of mule (*Equus caballus X Equus asinus*).

FD: Right Phrenic Nerve
FE: Left Phrenic Nerve
RD: Dorsal Branch
TLV: Lateroventral Trunk
RV: Ventral Branch
TLD: Laterodorsal Trunk