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The Macroanatomical Evaluation of *N. splanchnicus* Major, Minor and Imus in Donkeys (*Equus asinus* L.)

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Abstract: Eight adult donkeys of both sexes, used in applied anatomy classes, constituted the material of the study. The greater splanchnic nerve (*N. splanchnicus* major) was determined to ramify from the truncus sympathicus from the space between the 13th thoracic sympathetic ganglion and the 17-18th thoracic interganglionic connection on the right side and the space between the 12-13th thoracic interganglionic connection and the 16-17th thoracic interganglionic connection on the left side. The lesser splanchnic nerve (*N. splanchnicus* minor) was determined to be formed by fibres originating from the 14-15th thoracic interganglionic connection and the 17-18th thoracic interganglionic connection on the right side and the 13-14th thoracic interganglionic connection, the 15-16th thoracic interganglionic connection and the 17th thoracic sympathetic ganglion on the left side. The lesser splanchnic nerve (*N. splanchnicus* minor) was determined not to exist on the right side in one of the materials examined. The lowest splanchnic nerve (*N. splanchnicus* imus) was demonstrated to exist on the right side in 4 (50%) and on the left side in 3 (37.5%) of the 8 materials examined. The thoracic splanchnic nerves were determined to give off branches to the suprarenal gland (glandula suprarenalis), behind the diaphragm and to extend to the celiac ganglion (*ganglion celiaca*). No marked difference was observed between the right and left sides.

Key words: Splanchnic nerve, donkey, Macroanatomy

INTRODUCTION

Preganglionic fibres that enter the ggl. trunci sympathici leave the truncus sympathicus without making synapses with the respective sympathetic ganglia that are equal to number in them. These fibre groups located in the thoracal region appear as white coloured bands, due to their myelin sheath, beneath the pleura in the thoracal cavity and at the ventral surface of columna vertebralis beneath the peritoneum in the abdominal cavity. These nerves that innervate the internal organs are named as splanchnic nerves (*N. splanchnicus* major, minor, imus) (Arinci and Elhan, 1995; Dyce *et al*., 2002).

The nerve formed by the mergence of preganglionic fibres that originating from the 6-9th thoracal sympathetic ganglia in carnivores, 6-10th sympathetic ganglia in ruminants, 6-15th sympathetic ganglia in equidae (Dursun, 2000), 13th sympathetic ganglion in sheep and dogs (Evans and Christensen, 1979; Turkmenoglu, 2001; Bozkurt *et al*., 2003), 9-13th sympathetic ganglia in coypu (Langelfeld, 1988), 7-12th (Langelfeld, 1990; Duzler *et al*., 2003) or 11-12th (McLaughlin and Chiasson, 1990) sympathetic ganglia in rabbits, 11-12th sympathetic ganglia in rats (Isomura *et al*., 1985), 5-9th (Arinci and Elhan, 1995; Chung, 1995; Taner, 1999) or 6-10th (Krolikowska and Zawodniak, 1979) sympathetic ganglia in humans is called *N. splanchnicus* major. This nerve twists in caudal direction beneath the corpus vertebrae and enters the abdominal cavity between the crura diaphragmatica. *N. splanchnicus* major makes synapses with ganglia found within the plexus coeliacus that is located in the ventral wall of columna vertebralis in the abdominal cavity and supplies the smooth muscle of organs and glands as postganglionic fibres surrounding blood vessels.

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N. splanchnicus minor is formed by the mergence of preganglionic fibres originating from the last 2nd-3rd thoracal ganglia in domestic mammals (Dursun, 2000), T12-L2 in coypu (Langelfeld, 1990), T9-L2 (Langelfeld, 1988) or T10-T13 (Duzler *et al*., 2003) in rabbits, L1 in sheep and dogs (Turkmenoglu and Dursun, 2001; Bozkurt *et al*., 2003), 10-11th (Arinci and Elhan, 1995; Chung, 1995; Taner, 1999) or 11-12th (Krolikowska and Zawodniak, 1979) thoracal sympathetic ganglia in humans. It enters the abdominal cavity in association with *N. splanchnicus* major, between the crura diaphragmatica and terminates either at ganglion aorticorenale found caudal of the plexus coeliacus (Arinci and Elhan, 1995; Dursun, 2000), or plexus coeliacomesentericus (Evans and Christensen, 1979; Turkmenoglu and Dursun, 2001) or at plexus coeliacus (Duzler *et al*., 2003). *N. splanchnicus* imus does not always exist. In case it is present, it originates either from the last thoracal sympathetic ganglion (Dursun, 2000; Duzler *et al*., 2003) or *N. splanchnicus* minor. It enters the abdominal cavity in association with truncus sympathicus and terminates either at plexus renalis (Arinci and Elhan, 1995; Chung, 1995; Dursun, 2000) or ganglia celiaca (Duzler *et al*., 2003).

Generally the sympathectomy and excision of ganglion splanchnici are performed together with splanchnicectomy, in cases of hypotony of the sphincter of ampulla hepatopancreatica, pain arising from surgical operations of the pancreas (Krolikowska and Zavodniak, 1979) and chronic pancreatitis associated with intensive pain reactions (Krolikowska and Zavodniak, 1979; Naidoo *et al*., 2001). Furthermore, the anatomical variations of splanchnic nerves in cadavers may cause splanchnicectomy to not yield the expected results (Naidoo *et al*., 2001).

This study was aimed at the determination of the origin, formation and course of splanchnic nerve, as well as variations in the examined materials and the collections of data that may assist surgical operations.

MATERIALS AND METHODS

Cadavers pertaining to 8 adult donkeys of both sexes that were used in applied anatomy courses constituted the material of this study. The thoracic and abdominal cavities were incised from the level of the 8th thoracal vertebra to the level of the 4th lumbar vertebra. Furthermore, the costae were excised distal to the collum costae. Measurements were performed by using a Mitutoya Digimatic Caliper (IP-65, 500607, CD-20 GP 0, Made in Japan). Findings were photographed with a Canon A-1 camera. Anatomical terminology used in this study is in accordance with Nomina Anatomica Veterinaria (ICVGAN, 2005).

RESULTS

The diaphragm was determined to adhere to columna vertebralis at the level of the 18th thoracal and 1st-2nd lumbar vertebrae in donkeys.

In donkeys, truncus sympathicus was detected to follow a retropleural course to the diaphragm and to extend in caudal direction on both the right and left sides of columna vertebralis, near the ventral margin of corpus vertebrae and above aorta descendens. Truncus sympathicus was also observed to follow a course on the ventral surface of columna vertebralis beyond the diaphragm. The truncus sympathicus was determined to make a curve in ventral direction, behind the diaphragm and in the region between the 17th thoracic vertebra and the 1st lumbal vertebra and subsequently to return to its course at the level of the vertebrae and aorta (Fig. 1).

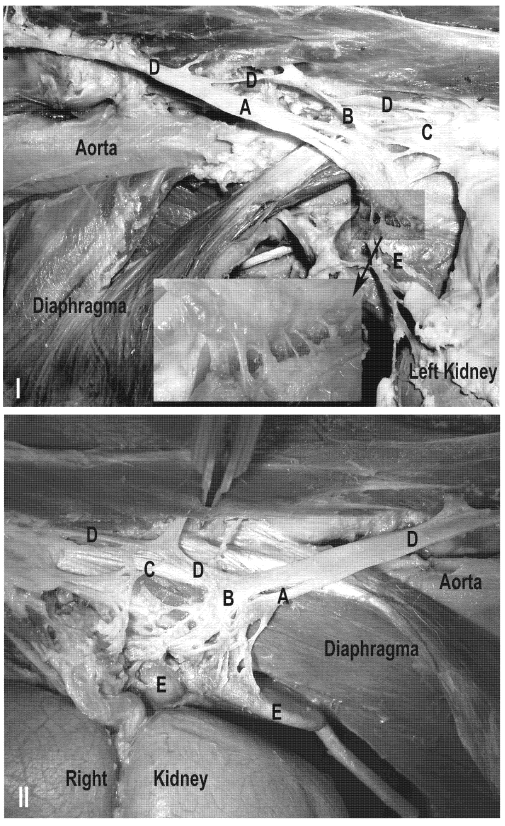

Fig. 1: Thoracic splanchnic nerves in donkey. I-Left side, II-Right side. A-*N. splanchnicus* major, B-*N. splanchnicus* minor, C-*N. splanchnicus* imus, D-Truncus sympathicus, E-Glandula suprarenalis

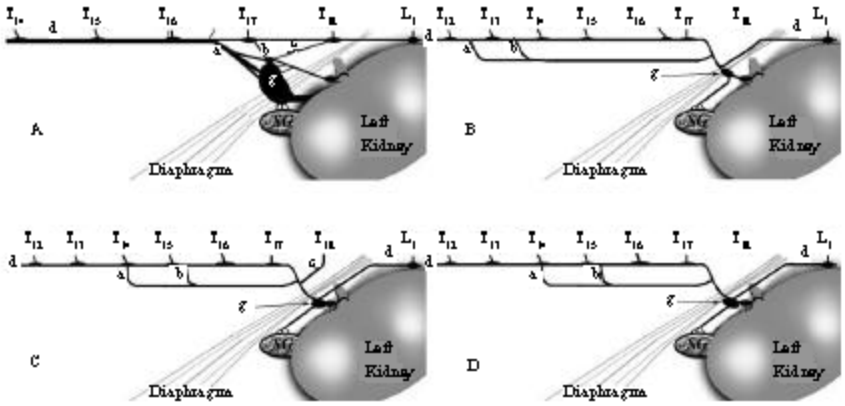

Fig. 2: Origin points of preganglionic fibres stemming from thoracal sympathetic ganglia for *N. splanchnicus* major, minor and imus at left side in donkeys. a-*N. splanchnicus* manor, b-*N. splanchnicus* minor, -*N. splanchnicus* imus, d-Truncus sympathicus, g-*ganglion celiaca*

Table 1: Origin points of the *N. splanchnicus* major, minor and imus in donkeys

	Left side		Right side	
	Cadaver number	Origin point	Cadaver number	Origin point
N. *splanchnicus* major	1	12^{Th}-13^{Th*k}	2	13^{Th}
	5	14^{Th}	3	13^{Th}-14^{Th*k}
	2	16^{Th}-17^{Th*k}	1	14^{Th}-15^{Th*k}
			2	17^{Th}-18^{Th*k}
N. *splanchnicus* minor	1	13^{Th}-14^{Th*k}	5	14^{Th}-15^{Th*k}
	5	15^{Th}-16^{Th*k}	2	17^{Th}-18^{Th*k}
	2	17^{Th}	1	-
N. *splanchnicus* imus	3	18^{Th}	2	18^{Th}
	5	-	2	18^{Th}-1^{L*k}
			4	-

*Interganglionic connections; Th-Thoracic sympathetic ganglia, L-Lumbal sympathetic ganglion

The left side: *N. splanchnicus* major which stems from truncus sympathicus, was determined to form by the mergence of preganglionic fibres originating from different levels. It was observed to arise at the level of the 12-13th interganglionic connection in 1 cadaver, the 14. thoracal sympathetic ganglion in 5 cadavers and the 17-18th interganglionic connection in 2 cadavers (Fig. 2 and Table 1). *N. splanchnicus* major was observed to follow a caudoventral course of 50-154 mm from its origin and to enter the abdominal cavity between the crus dextrum and crus sinistrum of the diaphragm, at the level of the first lumbar vertebra. *N. splanchnicus* major was detected to pass aorta abdominalis diagonally at its point of entry into the abdominal cavity and to join ganglia celiaca located at an approximate distance of 16 mm caudal to truncus coeliacus and cranial to glandula suprarenalis, found at the dorsomedial of left kidney. Here, numerous fine nerve fibres extending from the celiac ganglion (*ganglion celiaca*) to the suprarenal gland (glandula suprarenalis) can be seen (Fig. 1). *N. splanchnicus* major was determined to give off a small branch for glandula suprarenalis prior to the aforementioned mergence.

N. *splanchnicus* minor was determined to form by the mergence of preganglionic branches originating from the 13th-14th interganglionic connection in 1 cadaver, the 15-16th interganglionic connection in 5 cadavers and 17. thoracal sympathetic ganglion in 2 cadavers (Fig. 2 and Table 1). The nerve was observed to extend in caudoventral direction and pass the diaphragm. *N. splanchnicus* minor was detected to merge with *N. splanchnicus* major in all of the examined cadavers, at the level of the 17 and 18th thoracal vertebrae and the origin of m. psoas major and minor. The two nerves were detected to run along for an approximate distance of 46 mm and to enter the abdominal cavity between crura diaphragmatica, located at the level of the 18th thoracal or 1st lumbar vertebrae. This common root was determined to give off a small branch for glandula suprarenalis after a 23 mm course and to terminate at ganglia celiaca.

Truncus sympathicus was observed to form an oval shaped enlargement at the level of the 16 and 17th intercostal space prior to passing the diaphragm. The approximate length of the enlargement was detected to be 27 mm and the width measured at the widest location was measured as 4 mm. Two small branches were determined to merge with the enlargement of truncus sympathicus. One of these branches was detected to run along with a. intercostalis which extends within the indicated space. This nerve was detected to have a diameter of 1.5 mm and the length from the origin to the enlargement of truncus sympathicus was measured as 11 mm. This small branch was observed to be one of the branches forming

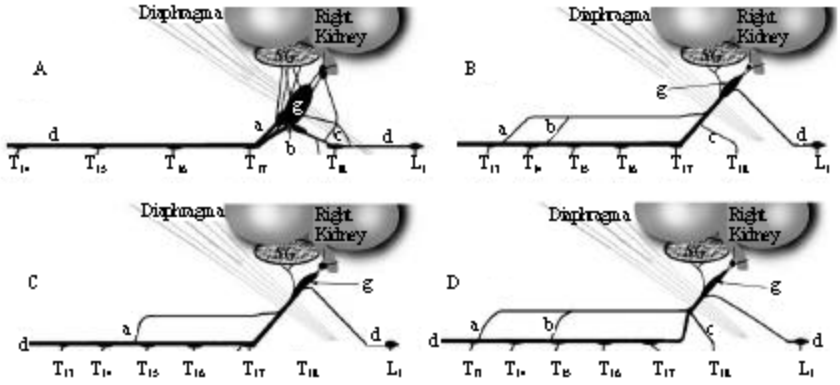

Fig. 3: Origin points of preganglionic fibres stemming from thoracal sympathetic ganglia for *N. splanchnicus* major, minor and imus at right side in donkeys. a-*N. splanchnicus* major, b-*N. splanchnicus* minor, c-*N. splanchnicus* imus, d-Truncus sympathicus, g-*ganglion celiaca*

N. splanchnicus minor. Similarly, the other small branch was found to be one of the branches forming *N. splanchnicus* minor, to stem near the origin of m. psoas major and minor at the level of the 17th thoracal vertebra and to extend to the cranial in caudoventral direction. The diameter and length of this small branch was measured as 2 and 12 mm, respectively. *N. splanchnicus* minor that joins the enlargement of truncus sympathicus, was determined to leave the enlargement at the caudal end and to join *N. splanchnicus* major at the level of the 17th vertebra and pass crura diaphragmatica in the form of a common root.

N. splanchnicus imus was determined to exist in only 3 of the 8 examined cadavers. The nerve was observed to originate from the 18th thoracal sympathetic ganglion and to join the caudal of the common root formed by *N. splanchnicus* major and minor at a distance of 14 mm in cranioventral direction and 21 mm cranial to the diaphragm. This nerve was also determined to join the common root and to run along to ganglia celiaca.

The right side: In the examined cadavers *N. splanchnicus* major was determined to originate from the 13. thoracal sympathetic ganglion in 2 cadavers, the 13-14th interganglionic connection in 3 cadavers, the 14-15th interganglionic connection and the 17-18th interganglionic connection in 2 cadavers (Fig. 3 and Table 1). The approximate length of *N. splanchnicus* major up to the diaphragm was measured as 48-146 mm. *N. splanchnicus* major was observed to leave truncus sympathicus after receiving fibres stemming from the 13th thoracal sympathetic ganglion at the origin and fibres originating from the 14th thoracal sympathetic ganglion, at an approximate distance of 41 mm to the point it leaves truncus sympathicus. An enlargement was observed at the point of mergence, near the origin of *M psoas* major and minor. The approximate length and width of this enlargement was measured as 34 and 4 mm, respectively. *N. splanchnicus* major was determined to pass the diaphragm after this enlargement and to terminate by joining ganglia celiaca, located between aorta descendens and *M. psoas* major and minor at approximately the mid-point of glandula suprarenalis, at a distance of 24 mm to the diaphragm. It was also detected to give off a small branch for glandula suprarenalis prior to merging with ganglia celiaca.

N. splanchnicus minor was determined to form by the mergence of branches originating from the 14-15th interganglionic connection in 5 cadavers, the 17-18th interganglionic connection in 2 cadavers and it was absent in one cadaver (Fig. 3 and Table 1). These branches were determined to unite with *N. splanchnicus* major and to reach crura diaphragmatica after an approximate distance of 42 mm in all of the examined cadavers. *N. splanchnicus* minor was observed to terminate by joining ganglia celiaca, as a common root with *N. splanchnicus* major, after passing the diaphragm.

N. splanchnicus imus was found to exist only in 4 of the 8 examined cadavers. The nerve was observed to originate from the 18. thoracal sympathetic ganglion in 2 cadavers and the 18th-1.L. interganglionic connection in 2 cadavers (Fig. 3 and Table 1). In one of the cadavers, *N. splanchnicus* imus was observed to join *N. splanchnicus* minor after a cranioventral course. This common root was observed to join *N. splanchnicus* major and pass the diaphragm in the form of a common root. On the other hand, the nerve was detected to join at the point of mergence of *N. splanchnicus* minor and major and to reach the diaphragm at an approximate distance of 40 mm. These common roots were determined to end at ganglia celiaca.

DISCUSSION

As also reported in previous studies carried out in different animal species and in humans (Craigie, 1969; Evans and Christensen, 1979; Krolikowska and Zavodniak, 1979; Isomura *et al*., 1985; Langelfeld, 1988; Langelfeld, 1990; Arinci and Elhan, 1995; Chung, 1995; Naidoo *et al*., 2001; Turkmenoglu and Dursun, 2001; Bozkurt *et al*., 2003; Duzler *et al*., 2003), in the present study, the greater splanchnic nerve (*N. splanchnicus* major) was determined to originate from the truncus sympathicus, just cranial to the diaphragm and prior to its entrance into the abdominal cavity, but at different levels, in donkeys.

The origin of the greater splanchnic nerve (*N. splanchnicus* major) in donkeys was determined to be situated much more caudal than reported by Dursun (2000) for equidae and to have limits extending from the 12-13th thoracic interganglionic connection to the 16-17th thoracic interganglionic connection.

Contrary to studies carried out in (McLaughlin and Chiasson, 1990; Dursun, 2000; Duzler *et al*., 2003) rabbits, cattle, horses, etc., the greater splanchnic nerve (*N. splanchnicus* major) was determined not to receive many branches and to originate from the truncus sympathicus as a single branch, in compliance with studies (Evans and Christensen, 1979; Turkmenoglu and Dursun, 2001) conducted in dogs, sheep, etc. The localization of this origin differed among individuals and the indicated nerve was determined to have its origin at different levels of the truncus sympathicus in the materials examined.

The course and termination of *N. splanchnicus* major detected in this study, was in accordance with literature (Evans and Christensen, 1979; Isomura *et al*., 1985; Langelfeld, 1988; Langelfeld, 1990; Arinci and Elhan, 1995; Chung, 1995; Taner, 1999; Turkmenoglu and Dursun, 2001; Bozkurt *et al*., 2003; Duzler *et al*., 2003). However, in donkeys, the lesser splanchnic nerve (*N. splanchnicus* minor), was determined to give off a branch to the suprarenal gland (glandula suprarenalis) prior to reaching the celiac ganglion (*ganglion celiaca*).

In this study, similar to the report of Dursun (2000) for equidae, *N. splanchnicus* minor was determined to form by the mergence of branches originating form the 14-17th thoracal sympathetic ganglia. However, in one material, on the right side, the indicated nerve was determined to have its origin much more cranial to the limits reported and to originate from the 13-14th thoracic interganglionic connection. The nerve was determined to originate much more caudally and beyond the reported limits on the left side in 2 materials, at the level of the 17-18th thoracic interganglionic connection. Furthermore, in one material, the lesser splanchnic nerve (*N. splanchnicus* minor) was determined not to exist on the right side.

Similar to the report of Duzler *et al*. (2003) for a rabbit, in cadavers in which *N. splanchnicus* minor was determined to follow a course in association with *N. splanchnicus* major both on the right and left sides, the nerve was detected to terminate at ganglia celiaca. In donkeys, similar to the greater splanchnic nerve (*N. splanchnicus* major), the lesser splanchnic nerve (*N. splanchnicus* minor), was determined to give off a branch to the suprarenal gland (glandula suprarenalis) prior to reaching the celiac ganglion (*ganglion celiaca*).

The passage from the diaphragm in the form of a common root and the ramification for glandula suprarenalis prior to termination at ganglia celiaca, of *N. splanchnicus* major, minor and if existent imus was found to be in accordance with literature (Isomura *et al*., 1985).

This study was aimed at the determination of the origin, formation and course of splanchnic nerves and differences related to these nerves between the right and left sides in cadavers as well as variations in the examined material.

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