RAMIFICATION OF THE HEPATIC ARTERY IN SWINE (*Sus scrofa domestica*)

RAMIFICACIÓN DE LA ARTERIA HEPÁTICA EN CERDOS (*Sus scrofa domestica*)

*Büchler, Jussara Almeida Bruno; **Prates, José Carlos & ***Fragoso Neto, Raul Antonio

BÜCHLER, J. A. B.; PRATES, J. C. & FRAGOSO NETO, R. A. Ramification of the hepatic artery in swine (*Sus scrofa domestica*). *Int. J. Morphol.*, 22(4):263-266, 2004.

SUMMARY: We have described the anatomical variations in the ramification of the hepatic artery of males and females adult pigs. The hepatic artery of in block removed – stomach, liver and duodenum specimens (n=30), was injected of neoprene latex and dissected. The ramification of the hepatic artery in these animals presented three basic patterns: trifurcation, bifurcation and quadruple ramification, giving origin to vessels supplying the lobes of the liver and neighboring structures. In these three patterns the hepatic artery may or may not posses collateral branches.

KEY WORDS: 1. Hepatic artery; 2. Visceral anatomy; 3. *Sus scrofa domestica*.

INTRODUCTION

In the training of surgeons, researches and others professionals, the swine have been used as experimental model in different types of surgeries and transplants (Triviño *et al.*, 1992; Richer *et al.*, 1994; Filipponi *et al.*, 1995; Minh, 1996; Bhutani, 1998; Taniguchi *et al.*, 1998), interpretations of abdominal arteriography (Nayar *et al.*, 1983), in laparoscopic cholecystectomy (Batista *et al.*, 1993) and in morphologic and angiographic studies (Innocenti *et al.*, 1997; Sun and Zhang, 1989; Sanches *et al.*, 1994). Therefore it is extremely necessary to have the knowledge of its visceral anatomy.

The target of this work is to research the anatomical variations of the hepatic artery and of their branches that contribute to the irrigation of the liver of this animal.

MATERIAL AND METHOD

We have gathered thirty specimens, removed in block – stomach, liver and duodenum, from pigs of the Landrace and Large White Breeds, adult males and females, slaughtered at the slaughtering house Leguthi, located I the city of Presidente Prudente, in the State of São Paulo, Brazil.

A cannula was place in the celiac artery, and injected with a solution of neoprene latex. The blocks were fixed in 10% formaldehyde solution. Then, the hepatic artery was dissected to superficial parenchyma of the visceral face of the organ, as well as the cystic duct and the gall bladder. In the observation of the external segmentation of the liver, of their lobes and grooves, we adopted the Veterinary Anatomical Nomenclature (International Committee on Veterinary Gross Anatomical Nomenclature, 1999) for designation of the referred structures. To verifv any association between ramification pattern and collateral ramification , the Cochran-Mantel-Haenszel statistical test was used.

RESULTS

The ramification of the hepatic artery is characterised by three basic patterns, which can be observed in Table I. In those three patterns, the hepatic artery collateral branch was present in 43.33% of the time and absent in 56.66% of the time. The hepatic artery has a single collateral branch in 26.67% and two collateral branches in 16.66% of the sample.

* Department of Anatomy, Universidade do Oeste Paulista (UNOESTE), Presidente Prudente, SP – Brazil.

** Department of Anatomy and Morphology, Universidade Federal de São Paulo (Unifesp), SP – Brazil.

*** Department of Physiotherapy, Paulista State University “Júlio de Mesquita Filho” (UNESP), Presidente Prudente, SP – Brazil.

In the first type, by trifurcation of the hepatic artery (3 livers studied), before penetrating in the hepatic lobes, and free from collateral branches (Fig.1), becomes the gastroduodenal artery and originates two more arteries, one with branches for the caudate, right lateral, right medial lobes and the gall bladder (cystic artery).

The other one, supply with branches for the quadrate, left medial, left lateral lobes and branches for the stomach including the right gastric artery.

In some others subtypes of this first type (5 livers), with quite accentuated variations from one liver to another, the hepatic artery supplies terminal branches for the caudate, right lateral, right medial, quadrate, left medial and left lateral lobes, as well as, for the gall bladder, the stomach, the cystic and gastric right arteries, respectively.

In the second type, by trifurcation (7 livers), one or more collateral branches of the trunk of the hepatic artery are variably observed supplying the caudate, right medial, right lateral, quadrate lobes and the gall bladder (cystic artery), as a result it follows the trifurcation of the hepatic artery or tripod, namely, the gastroduodenal artery, two more arteries that ramify with accentuated variation in the six hepatic lobes of the swine.

In the pattern of the bifurcation type of the hepatic artery (43.33%, Fig.2), which is free from collateral branches (first type), there is a characterised distribution by a right branch that is the gastroduodenal artery, and a left branch from where some trunks originate which irrigate in an extremely variable way the six lobes of the liver, the gall bladder (cystic artery) and the stomach, where it then branches off in the right gastric artery.

Occasionally (3 pieces studied), the gastroduodenal artery can also give rise to collateral artery that distributes to the lesser curvature of the stomach and in the caudate, right lateral and right medial lobes.

In the second type of the bifurcation of the hepatic artery, in which it emits collaterals which supply the caudate, right lateral, right medial lobes and the gall bladder (cystic artery), the hepatic artery branches off in the gastroduodenal artery and in the left branch.

The gastroduodenal artery can supply branches for the caudate, right lateral, right medial, quadrate lobes, gall bladder (cystic artery) and branches for the lesser stomach curvature. The left branch originates vessels that

are variably distributed to all of the lobes of the liver and, in a single case, (3.33%) it does not supply the right gastric artery.

In the two specimens which presented a pattern of the quadruple ramification type of the hepatic artery, in one case only it emits a collateral branch initially for the caudate lobe following by its quadruple division in gastroduodenal artery and three arteries. The gastroduodenal artery can originate branches for the caudate, right lateral lobe and a gastric branch for the lesser curvature of the stomach (3.33%).

The most proximal of the three branches mentioned above, supplies the cystic artery and terminal branches for the right lateral and medial lobes; the intermediate one emits other cystic artery and branches for the quadrate, left medial and lateral lobes. The distal artery is the left branch itself supplies the left lateral anastomosing in the right gastric artery.

In the other case of this pattern (3.33%), the hepatic artery, free from collateral branches, becomes the gastroduodenal artery, and originates the gastric branch, an intermediate branch and a left branch. The gastroduodenal artery ramifies in the caudate, right lateral lobes and it emits a branch for the lesser curvature of the stomach. The gastric branch goes to the lesser curvature of the stomach. The intermediate branch emits the cystic artery and branches for the right medial and quadrate lobes. The left branch, before finishing in right gastric artery, emits branches for the quadrate, left medial and left lateral lobes of the liver.

The frequency distribution for the type of branching of the hepatic artery (bifurcation, trifurcation and quadruple ramification) and the presence or absence of collateral ramification is specified in Table I. The Cochran-Mantel-Haenszel statistical test to verify if association exists among these patterns presented the p -value calculated of 0,895. Therefore, there does not exist any relationship between the ramification type and the occurrence of collateral ramification.

Table I. Distribution of the pieces for ramification type and collateral ramification of the hepatic artery in the swine.

Ramification of hepatic artery	Ramification collateral branches		Total
	Absent n (%)	Presents n (%)	
Bifurcation	8 (61.54)	5 (38.46)	13 (43.33)
Trifurcation	8 (53.33)	7 (46.67)	15 (50.00)
Quadruple	1 (50.00)	1 (50.00)	2 (6.67)
Total	17 (56.67)	13 (43.33)	30 (100.00)

Fig. 1. Injected and dissected preparation (*Sus scrofa domestica*) by visceral view and natural size of the liver. It is showing the trifurcation of the hepatic artery (1) characterized by the artery gastroduodenal (2), a left branch (3) and a medium branch (4). This, among other branches, supplies the cystic artery (5) for the gall bladder (6) and cystic duct (7).

Fig. 2. Injected end dissected preparation (*Sus scrofa domestica*) by visceral view and natural size of the liver. It is showing the bifurcation of the hepatic artery (1), a left branch (2) and the gastroduodenal artery (3), from which a branch is supplied (4) for the lesser curvature of the stomach.

DISCUSSION

The swine, beings the chosen animals for the training of the laparoscopy (Triviño *et al.*; Batista *et al.*; Richer *et al.*; Filipponi *et al.*; Bhutani *et al.*; Taniguchi *et al.*), as well as biological models in liver transplants (Minh), we aimed at accomplishing a systematic research of the hepatic artery and of their branches in this animal.

This dissection has shown that hepatic artery provides branches for all of the segments of the liver in the swine. The data indicate, however, that variations exist in the process of the hepatic artery as Innocenti *et al.* mentioned. Although we agree, as well with the observations of Richer *et al.*, when they affirm that the hepatic branches terminate in the six lobes of the swine's liver; in our material, it was not

founded that the branches for the left lobe originate the left gastric artery, but, they originate the right gastric artery that lies close to the cardia and to the lesser stomach curvature. In the same way, the independent left hepatic artery, that would be born of the left gastric artery irrigating the whole left lobe, was not verified in any of our livers, such as it was described by Filipponi *et al.*

In the liver of the swine, it presents one or two collateral branches for hepatic lobes, as can be observed in the specimens presents here, with a frequency of 43.33%. These collateral vessels are not described in the literature in mammals (Innocenti *et al.*; Nayar *et al.*; Sun & Zhang; Sanches *et al.*; Richer *et al.*, Filipponi *et al.*).

BÜCHLER, J.A.B; PRATES, J.C.; FRAGOSO NETO, R.A. Ramificação de la artéria hepática en cerdos (*Sus scrofa domestica*). *Int. J. Morphol.*, 22(4):263-266, 2004

RESUMEN: Estudiamos las variaciones anatómicas de la ramificación de la arteria hepática en 30 cerdos (*Sus scrofa domestica*) adultos, machos y hembras. Obtuvimos muestras en boque (estómago, hígado y duodeno). La arteria hepática fue inyectada con neoprene látex y, posteriormente, disecada. La ramificación de la arteria hepática presentó tres patrones básicos: trifurcación, bifurcación, y ramificación cuádruple, dando origen a ramas nutricias para los lóbulos del hígado y para las estructuras vecinas. En estos tres patrones, la arteria hepática puede poseer o no ramas colaterales.

PALABRAS CLAVE: 1. Arteria hepática; 2. Anatomía visceral; 3. *Sus scrofa domestica*.

REFERENCES

- Batista, E. F. N.; Carmo, J. W. C.; Silva, A. A.; Biccas Junior, L.; Carneiro, J. L. A. & Lemos, A. G. Colecistectomy laparoscópica: adestramento em modelo experimental vivo. *Revista do Colégio Brasileiro de Cirurgiões* 20:301-4, 1993.
- Bhutani, M. S.; Hoffman, B. J. & Hawes, R. H. A swine model for teaching endoscopic ultrasound (EUS) imaging and intervention under EUS guidance. *Endoscopy*, 30:605-9, 1998.
- Filipponi, F.; Leoncini, G.; Campatelli, A.; Bagnolesi, A & Perri, G. Segmental organization of the pig liver: anatomical basis of controlled partition for experimental grafting. *Eur. Sur. Res.*, 27:151-7, 1995.
- Innocenti, P.; Bonomo, L.; Caizzi, N.; Materrazo, D.; Piatelli, A. & Uchino, S. Anatomia chirurgica del fegato di maiale: studio angiográfico e morfológico. *Boll. Soc. It. Biol. Sper.*, 53:2182-8, 1977.
- Minh, T. V. Anatomic basis of pig liver partition for experimental transplantation and perspective in xenotransplantation. *Transplantation Proceedings*, 28: 61-2, 1996.
- Nayar, K. N. M.; Singh, G.; Singh, Y.; Singh A. P. & Singh, G. R. Comparative arteriographic anatomy of the abdominal viscera and lumbar region in goats, dogs, pigs and rabbits. *Indian J. Anim. Sci.*, 53:1310-4, 1983.
- Richer, J. P.; Silvain, C. H.; Rouffineau, J.; Péchier, F.; Caritez, J. C. & Kamina, P. Anatomic and radiologic bases of combined transplantation of liver and small intestine in the pig. *Surg. Radiol. Anat.*, 16:245-51, 1994.
- Ilustrada*. (Oskar Schaller). In: *Angiologia*. São Paulo, Manole, 1999. pp.306-7.
- Sanches, W. C.; Souza, W. M.; Miglino, M. A. & Souza, N. T. M. Arranjos configurados pela artéria celiaca e seus ramos em suínos. *Revista UNIMAR*, 16:405-10, 1994.
- Sun, Y. & Zhang, L. Types of the arterial ramification of the abdominal digestive organs in newborn piglets. *Acta Veterinaria et Zootechnica*, 20:134-8, 1989.
- Taniguchi, H.; Takada, Y.; Fukunaga, K.; Yuzawa, K; Otsuka M & Todoriki, K. Establishment of a swine model for auxiliary partial orthotopic liver transplantation. *Transplantation Proceedings*, 30: 3232-6, 1998.
- Triviño, T.; Lopes Filho, G. J.; Ferraro, J. R.; Goldenberg, A.; Lobo E. J. & Miranda, J. L.R. Instalação e desenvolvimento de um programa de transplante experimental de fígado em porcos. *Acta Cir. Bras.*, 7:35-7, 1992.

Correspondence to:
Prof. Dra. Jussara de Almeida Bruno Büchler
Department of Anatomy
Universidade do Oeste Paulista (UNOESTE)
Rua José Bongiovani, 700
Jd. Cidade Universitária
CEP: 19050-680
Presidente Prudente
SP - BRAZIL

e-mail: jussarabr@ig.com.br
raulafneto@uol.com.br

International Committee on Veterinary Gross Anatomical Nomenclature. *Nomenclatura Anatômica Veterinária*

Received : 24-03-2004

Accepted: 09-08-2004