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SOME ANATOMICAL STUDIES ON THE MESENTERIC ARTERIES IN THE RED FOX (VULPES VULPES)

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SUMMARY

The present study was carried out on four healthy adult red foxes to clarify the obscure mesenteric arteries, which and their branches which are usually involved in intestinal surgery. A suspension of 5% Barium sulphate was used in this work as both radio-opaque and vessel filler material. The results proved that the cranial mesenteric artery of the red fox arose from the abdominal aorta, at the level of the second lumbar vertebra, entered the cranial mesentery forming its root,then proceeded caudoventrally in the mesojejunum and continued as the last ileal artery. The cranial mesenteric artery gave off: 1-Caudal pancreaticoduodenal artery to the right lobe of the pancreas and the descending and ascending parts of the duodenum, 2- Eight jejunal arteries, 3- Three to four ileal arteries to the ileum, 4-Ileocolic artery to the ileum, cecum, ascending colon, transverse colon and the cranial part of the descending colon. The caudal mesenteric artery arose from the abdominal aorta at the level of the caudal border of the root of the 6th lumbar transverse process, passed caudoventrally in the descending mesocolon, then divided into: left colic artery to the caudal two thirds of the descending colon, and cranial rectal artery to the cranial segment of the rectum. Several photographs and radiographs were prepared. The obtained results were compared with their corresponding, especially in the domestic carnivores.

INTRODUCTION

Not only the red fox is an important zoo animal, but also has a great situation among wild animals as well, owing to its valuable fur. So specimens of fox -as a wild animal- are rare.

The relevance of the arterial blood supply of the intestine in surgery necessitates awareness with its branching pattern (Dyce et al., 1996).

As example, the caudal pancreaticoduodenal artery is involved in pancreatic transplantation in dog (Barr et al., 1989). Also, the right colic, middle colic and caudal mesenteric arteries are transected during performing colectomy and ileorectal anastomosis due to oncologic causes in canines (Bohm et al., 1994). Such cases can occur in the red fox, which necessitates adequate awareness with the course and distribution of these vessels.

Barium sulphate is used as radio-opaque material, usually prepared in a fine colloidal suspension for the investigation of the alimentary tract (Douglas et al., 1987). It appears excellent as a vessel filler in demonstrating the small vessels, but poorly hardened in the large vessels and may ooze when intended vessel cutting is necessary, though this can be avoided by legation of large vessels before purposed cutting.

Because of rareness of fox specimens and its inadequate available literature, the present work was carried out in order to throw light on the obscure mesenteric arteries in the red fox to fill a gap in the field of comparative anatomy and to help the veterinary surgeons and internists.

MATERIALS AND METHODS

The present work was carried out on four healthy adult red foxes (three males and a female), were obtained from the Libyan Al-Hamada Desert. The animals were anaesthetized by chloroform, then bled via the common carotid artery.

The thoracic aorta was approached via an incision through the dorsal end of the left 7th intercostal space, cannulated then gently injected with a convenient amount of 5% barium sulphate suspension (Micropaque® Guerbet) as indicated for barium meal before bowel radiography.

The specimens were radiographed, then a longitudinal incision through the ventral midline of the abdominal wall, was done in all fox specimens, where they were kept in a solution of 10% formalin, 4 % phenol and 1% glycerin in a chilling room. Thence, the formalized red fox cadavers were thoroughly dissected, and the cranial and caudal mesenteric arteries and their branches were perfectly described.

The mesenteric arteries and the bowel parts they supply were isolated from the cadavers, to be radiographed lonely, away from the shadow of the abdominal wall and the other crowded viscera.

The obtained results were discussed with those of the other animals especially the domestic

carnivores The nomenclature used in this work was that adopted by the Nomina Anatomica Veterinaria (N.A.V., 2005).

RESULTS

I- A. mesenterica cranialis:

The cranial mesenteric artery (1/2, 2/1, 3/1, 4/1, 5/1, 6/1, 7/1& 10/4) was a stout vessel that arose from the ventral aspect of the abdominal aorta at the level of the caudal border of the arch of the 2nd lumbar vertebra. It entered the cranial mesentery forming its root, being caudal to the transverse colon, flanked by the ascending colon and descending duodenum on the right, and the descending colon and ascending duodenum on the left. It proceeded caudoventrally -more centrally situated- between the two layers of the mesojejunum, forming a gentle curve with a concavity facing caudodorsally. It continued along the mesenteric border of the ileum as the last ileal artery. Along its course, the cranial mesenteric artery detached the following branches:-

A. pancreaticoduodenalis caudalis:

The caudal pancreaticoduodenal artery (1/3, 2/2, 3/2, 4/2, 5/2, 6/2& 7/2) was the first branch that arose from the cranial mesenteric artery, at 2-3 cm after its origin from the abdominal aorta. It divided into a right and a left branches after a short course of about 0.5- 1 cm in the mesoduodenum.

The right branch of the caudal pancreaticoduodenal artery (1/6, 2/10, 3/3& 5/6) coursed dextrad for about 6-7 cm, towards the descending duodenum, where it divided into a right and a left branches. The former branch divided into a cranial and a caudal twigs that followed the mesenteric border of the descending duodenum, offering several twigs to its wall and to the right lobe of the pancreas (1/8, 2/12, 3/5& 5/7). The cranial twig of the right branch anastomosed with the cranial pancreaticoduodenal artery of the hepatic artery in the vicinity of the cranial duodenal flexure. The caudal twig of the right branch anastomosed with the caudal twig of the left branch of the parent artery (caudal pancreaticoduodenal) in the vicinity of the caudal duodenal flexure.

The left branch of the cranial pancreaticoduodenal artery (1/7, 2/11, 3/4& 5/5) coursed sinisterly for about 4-5 cm, towards the ascending duodenum. Shortly before reaching the ascending duodenum, the left branch divided into a cranial and a caudal twigs that followed the mesenteric border of the ascending duodenum, offering several twigs to its wall. The cranial twig of the left branch anastomosed with the first jejunal artery in the vicinity of the duodenojejunal flexure. The caudal twig of the left branch anastomosed with the caudal twig of the right branch of the parent artery (caudal pancreaticoduodenal) in the vicinity of the caudal duodenal flexure.

2- Aa. jejunales:

Eight jejunal arteries (1/4, 2/3, 3/6, 4/7, 5/4& 6/4) arose from the convex cranioventral border of the cranial mesenteric artery, at nearly regular intervals. They coursed radially in the mesojejunum towards the jejunal loops. As it approached the jejunum, each jejunal artery connected with its adjacent ones by means of vascular arches. The latter became smaller as they get close to the mesenteric border of the jejunum. Consequently a vascular net was established, from its smallest arches, large number of twigs reached the jejunum, supplying its wall. The first jejunal artery anastomosed with the cranial twig of the left branch of the caudal pancreaticoduodenal artery in the vicinity of the duodenojejunal flexure. The last jejunal artery anastomosed with the first ileal artery in the vicinity of the free border of the ileocecal fold.

3- Aa. ilei:

The ileal arteries (2/4, 3/7& 6/5) were represented by 3-4 branches: two or three of them arose from the convex ventral aspect of the terminal portion of the cranial mesenteric artery, and the rest was the continuation of the cranial mesenteric artery itself. The ileal arteries form together vascular arches, from their convex aspect, several twigs sprang supplying the ileal wall. The first ileal artery was given immediately next to the last jejunal, gained the mesenteric border of the ileum opposite to the free border of the ileocecal fold, anastomosed with both the last jejunal and second ileal arteries. The last ileal artery (continuation of the cranial mesenteric artery) followed the mesenteric border of the ileum towards the ceco-colic junction and anastomosed with the mesenteric ileal branch of the ileocolic artery.

4- A. ileocolica:

The ileocolic artery (1/5, 2/5, 3/8, 4/3, 5/3, 6/3, 7/3& 10/5) was the second branch that given from the cranial aspect of the cranial mesenteric artery, at about 0.5 cm after the origin of the caudal pancreaticoduodenal artery. It proceeded caudoventrally towards the cecocolic junction, where it detached Ramus ilei mesenterialis and continued as *A. cecalis*. About 1 cm after its origin, the ileocolic artery detached the middle colic artery, then a stem vessel (6/7& 7/10) of about 1-1.5 cm long, which divided into: colic branch and right colic artery. On reaching the mesenteric border of the corresponding gut segment, each artery divided into short branches, that formed small arches with each other. From these arches, twigs sprang to supply the corresponding gut wall.

The *A. colica* media (2/7, 3/11, 4/6, 5/6, 7/4& 10/6) was the first branch that given from the ileocolic artery. It proceeded towards the mesenteric border of the transverse colon. It ramified in the left colic flexure and the adjacent portion of the transverse colon as well as the cranial part of the descending colon. It anastomosed with the right colic and the left colic arteries.

The *Ramus colicus* (3/9, 6/8& 7/6) was the caudal smaller branch of the stem vessel of the ileocolic artery. After a short course of about 2 cm, it gained the mesenteric border of the caudal half of the ascending colon, where it ramified.

The *A. colica dextra* (3/10, 6/9& 7/5) was the cranial larger branch that given from the stem vessel of the ileocolic artery. After a short course of about 1.5-2 cm, it reached the mesenteric border of the cranial half of the ascending colon. It ramified in the latter and the right colic flexure as well as the adjacent part of the transverse colon. It anastomosed with the colic branch and the middle colic artery.

The *Ramus ilei mesenterialis* (2/8, 4/4& 7/9) followed the mesenteric border of the ileum towards the jejunum supplied several branches to the ileal wall, and anastomosed with the last ileal artery of the cranial mesenteric artery.

The *A. cecalis* (2/9, 3/12, 4/5& 7/7) represented the continuation of the ileocolic artery after the origin of the mesenteric ileal branch. It crossed the right aspect of the termination of the ileum, close to the ileocolic junction to gain the ileocecal ligament, where it detached the antemesenteric ileal branch. After that, the cecal artery proceeded towards the apex ceci, being axial to the cecal coils (along the lesser curvature of the screw shaped cecum). It detached branches to both sides of the cecal wall.

The *Ramus ilei antemesenterialis* (7/8) arose from the cecal artery at the caudal aspect of the termination of the ileum. It proceeded - within the ileocecal ligament- towards the jejunum, following and ramifying in the antemesenteric border of the ileum.

II- A. mesenterica caudalis:

The caudal mesenteric artery (8/2, 9/5& 10/1) arose from the ventral aspect of the abdominal aorta, opposite to the caudal border of the root of the 6th lumbar transverse process. It proceeded caudoventrally within the descending mesocolon for 2-3 cm, then divided into a cranial branch (left colic artery) and a caudal branch (cranial rectal artery).

The *A. colica* sinistra (9/6 & 10/2) proceeded cranially along the mesenteric border of the descending colon, where it supplied its caudal two thirds and anastomosed with the middle colic artery.

The *A. rectalis cranialis* (9/7 & 10/3) proceeded caudally in the descending mesocolon, then entered the pelvic cavity, where it continued in the mesorectum. It supplied the cranial segment of the rectum and anastomosed with the middle rectal artery of the prostatic or vaginal artery.

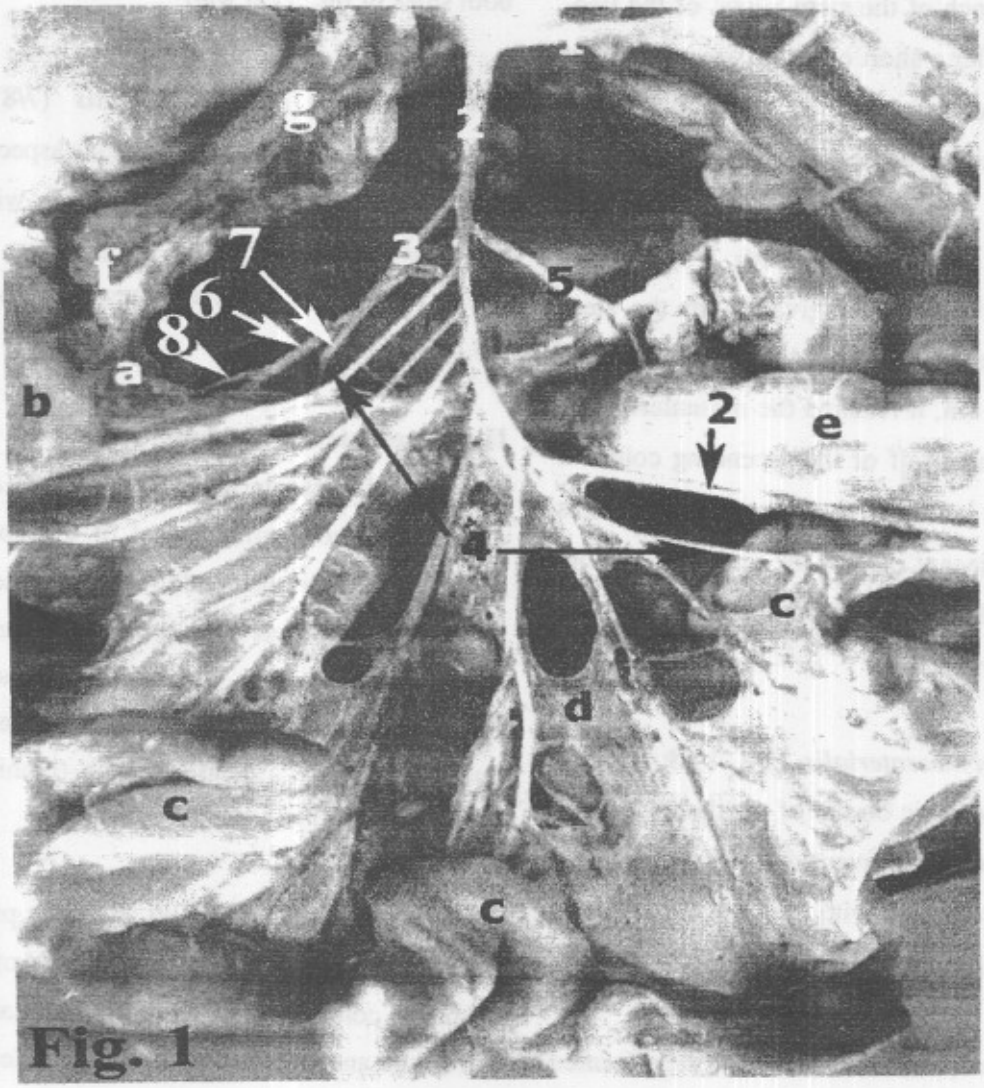

Fig. 1: A photograph of a formalized fox cadaver showing the origin and distribution of the cranial mesenteric artery. a- Lobus pancreatis dexter, b- Duodenum (pars descendens), c- Jejunum, d- Mesojejunum, e- Ileum, f- Corpus Pancreatis, g- Lobus pancreatis sinister, 1- Aorta abdominalis, 2- A. mesenterica cranialis, 3- A. pancreaticoduodenalis caudalis, 4- Aa. Jejunales, 5- A. ileocolica, 6- Right branch of (3), 7- left branch of (3), 8- Pancreatic branch of (6).

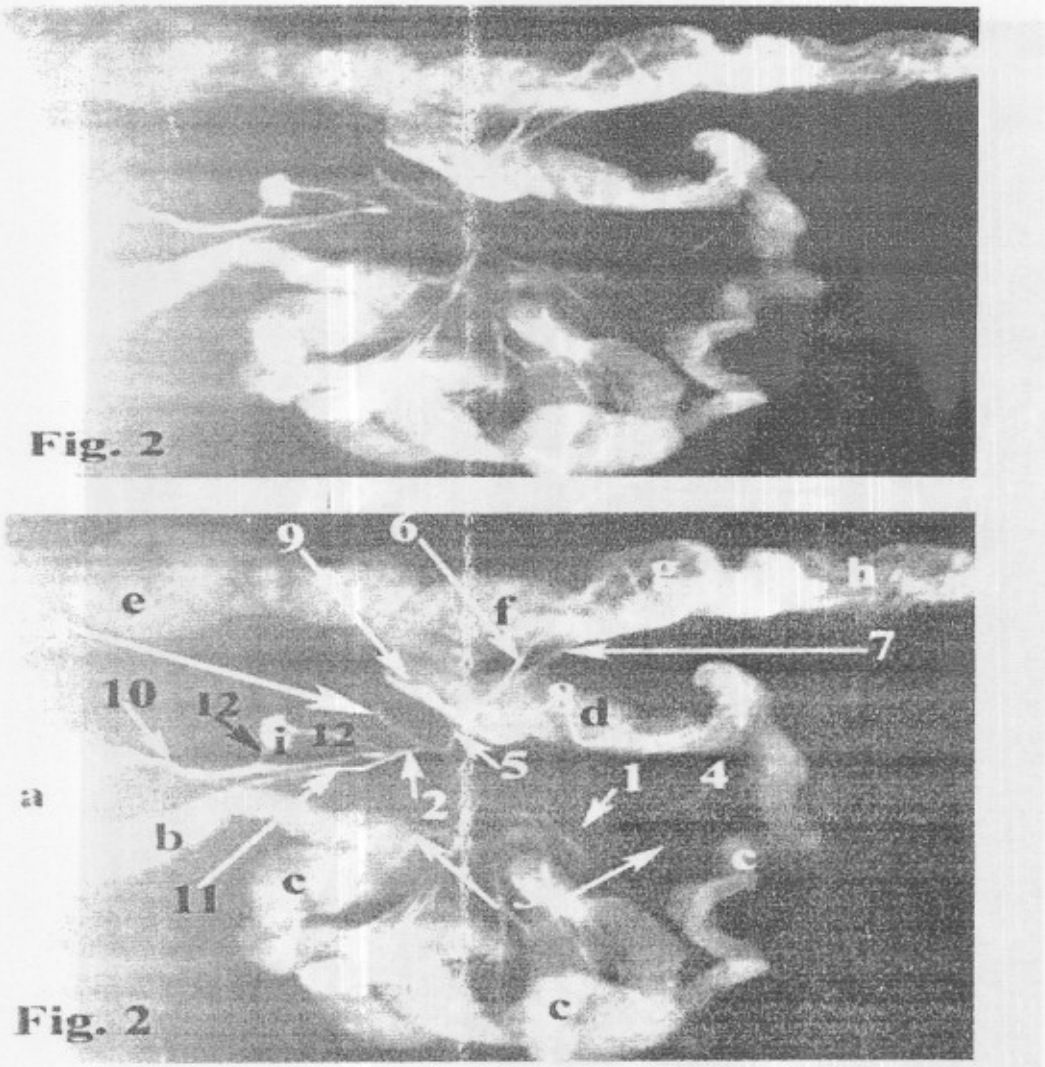

Fig. 2: A radiograph of isolated fox intestine, showing the distribution of the cranial mesenteric artery. The upper photo is the same as the lower but without labeling. a- Duodenum (Pars descendens), b- Duodenum (Pars ascendens) c- Jejunum, d-Ileum, e- Cecum, f- Colon ascendens, g- Colon transversus, h- Colon descendens, i- Pancreatic lobule, 1- A. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3-Aa. jejunales, 4- Aa. ilei (one of), 5- A. ileocolica, 6- A. colica dextra, 7- A. colica media, 8- Ramus ilei mesenterialis, 9- A. cecalis, 10- Right branch of (2), 11-Left branch of (2), 12- Pancreatic branches of (10).

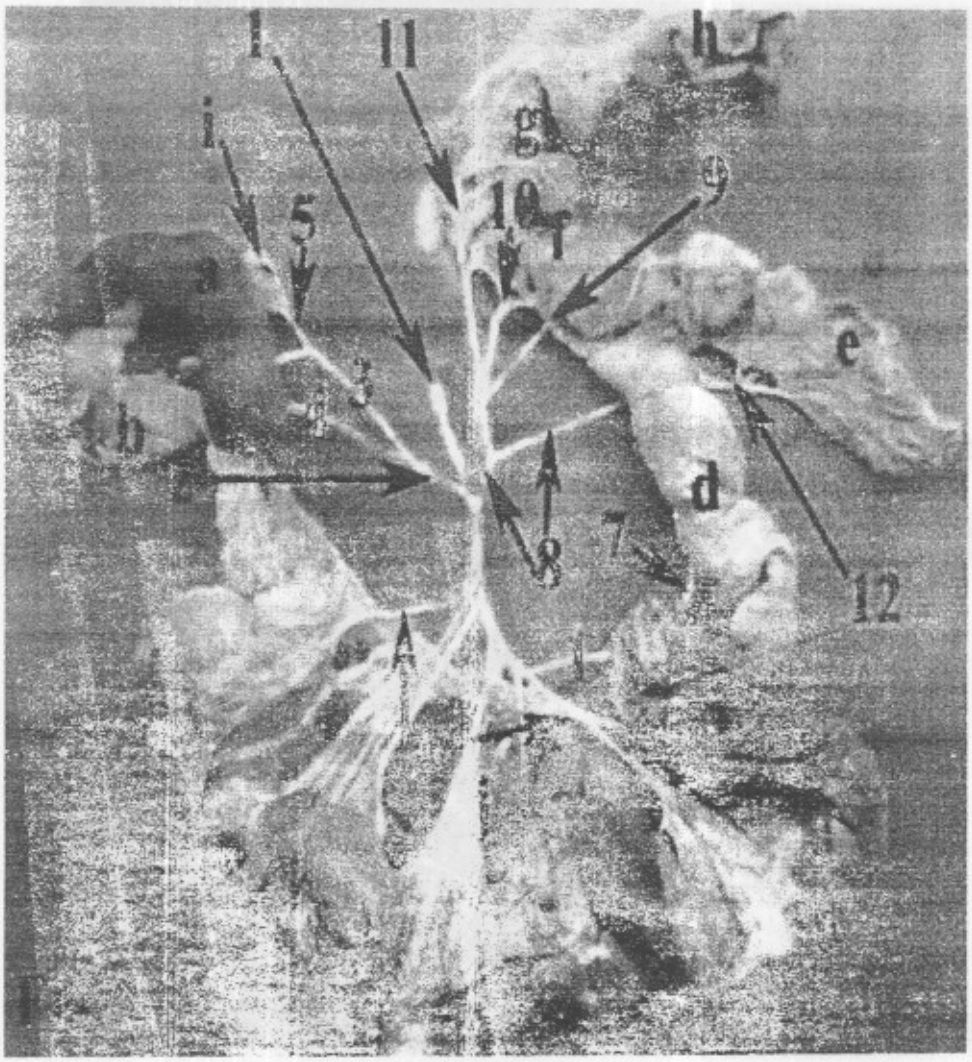

Fig. 3: A photograph of isolated fox intestine, showing the distribution of the cranial mesenteric artery. a- Duodenum (pars descendens), b- Duodenum (pars ascendens) c- Jejunum, d-Ileum, e- Cecum, f- Colon ascendens, g- Colon transversus, h- Colon descendens, i- Pancreatic lobule, j- Mesojejunum, 1- A. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3- Right branch of (2). 4- Left branch of (2), 5- Pancreatic branch of (3), 6- Aa. Jejunales, 7- Aa. ilei (one of), 8- A. ileocolica, 9- Ramus colicus, 10-A. colica dextra, 11- A. colica media.

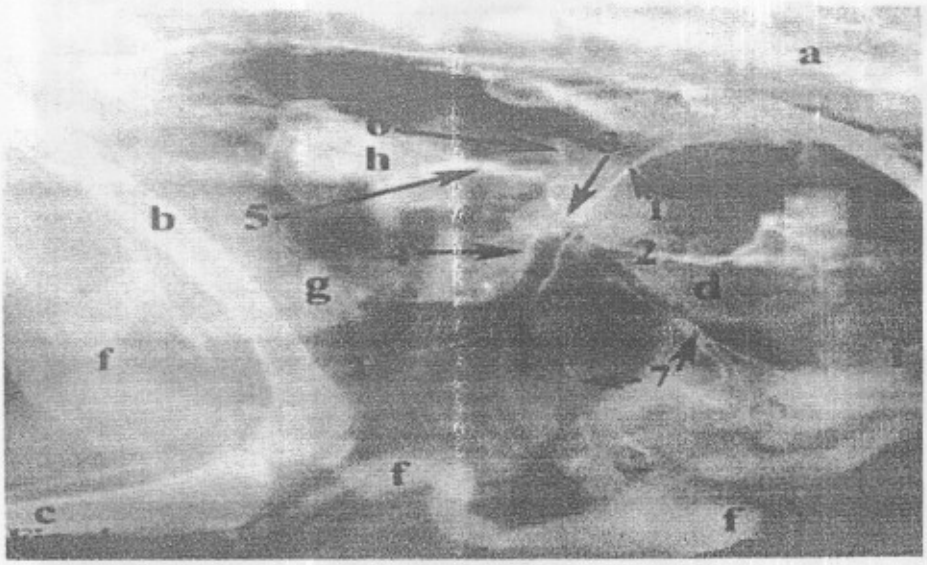

Fig. 4: A radiograph showing some branches of the cranial mesenteric artery in situ. a- Vertebra lumbalis II, b- Femur, c- Tibia, d- Duodenum (Pars descendens), e- Duodenum (Pars ascendens), f- Jejunum, g- Ileum, h- Cecum, 1- A. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3- A. ileocolica, 4- Ramus ilei mesenterialis, 5- A. cecalis, 6- A. colica media, 7- Aa. jejunales.

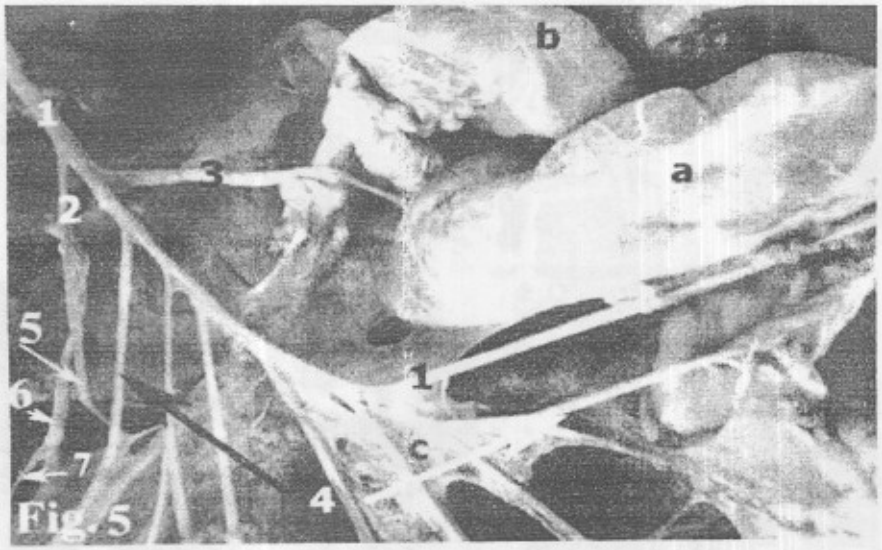

Fig. 5: A photograph of a formalized fox cadaver showing the jejunal arteries. a- Ileum, b- Cecum, c- Mesojejunum, 1- A. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3- A. ileocolica, 4- Aa. jejunales, 5- Left branch of (2), 6- Right branch of (2), 7- Pancreatic branch of (6).

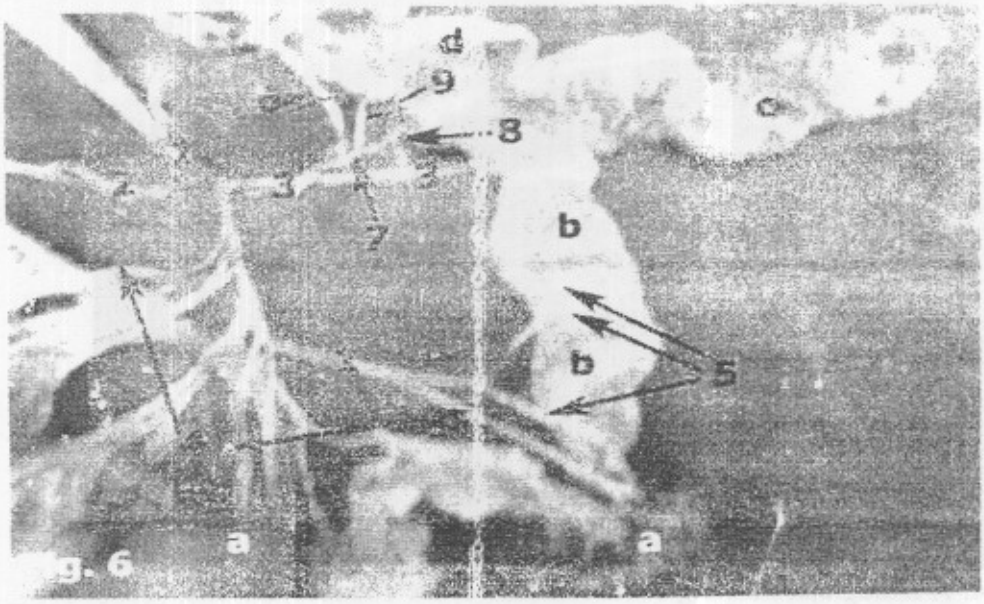

Fig. 6: a photograph showing the ileal arteries in isolated fox intestine. Jejunum, b- Ileum, c- Cecum, d- Colon ascendens, 1- a. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3- A. ileocolica, 4- Aa. jejunales, 5- Aa. ilei, 6- A. colica media, 7- A stem vessel for (8) & (9), 8- Ramus colicus, 9- A. colica dextra.

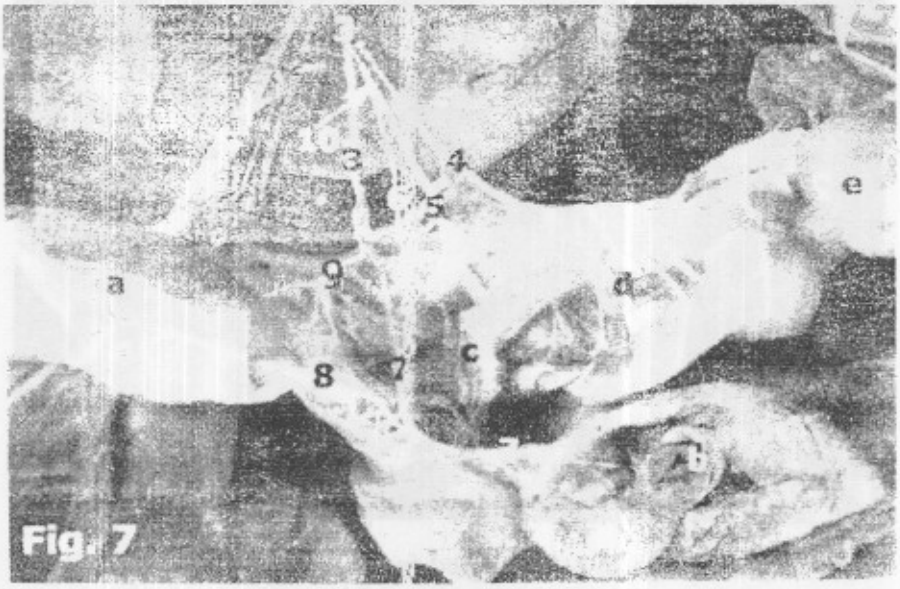

Fig. 7: A photograph of a formalized fox cadaver showing the branches of the ileocolic artery. a- Ileum, b- Cecum, c- Colon ascendens, d- Colon transversus, e- Colon descendens, 1- A. mesenterica cranialis, 2- A. pancreaticoduodenalis caudalis, 3- A. ileocolica, 4- A. colica media, 5- A. colica dextra, 6- Ramus colicus, 7- A. cecalis , 8- Ramus ilei antemesenterialis, 9- Ramus ilei mesenterialis, 10- Stem vessel for (5)&(6).

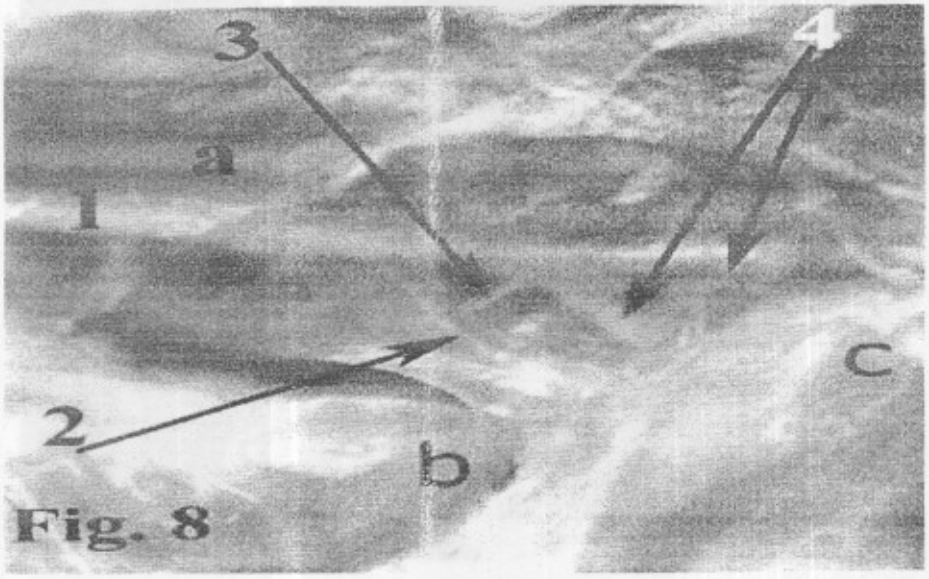

Fig. 8: A photograph showing the caudal mesenteric artery in a fresh fox cadaver. a- M. psoas minor, b- Cecum, c- Colon descendens, 1- Aorta abdominalis, 2- A. mesenterica caudalis, 3- A. circumflexa ileum profunda, 4- A. iliaca externa.

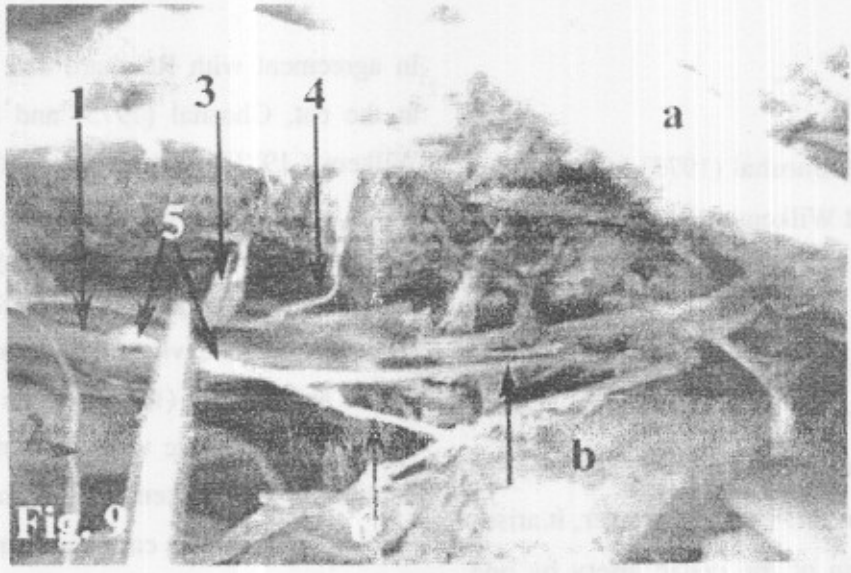

Fig. 9: A photograph showing the caudal mesenteric artery in a formalized fox cadaver. a- Ala ossis ilii, b- Colon descendens, 1- Aorta abdominalis, 2-A. testicularis, 3- A. lumbalis VI, 4- A. circumflexa ileum profunda, 5- A. mesenterica caudalis, 6- A. colica sinistra, 7- A. rectalis cranialis.

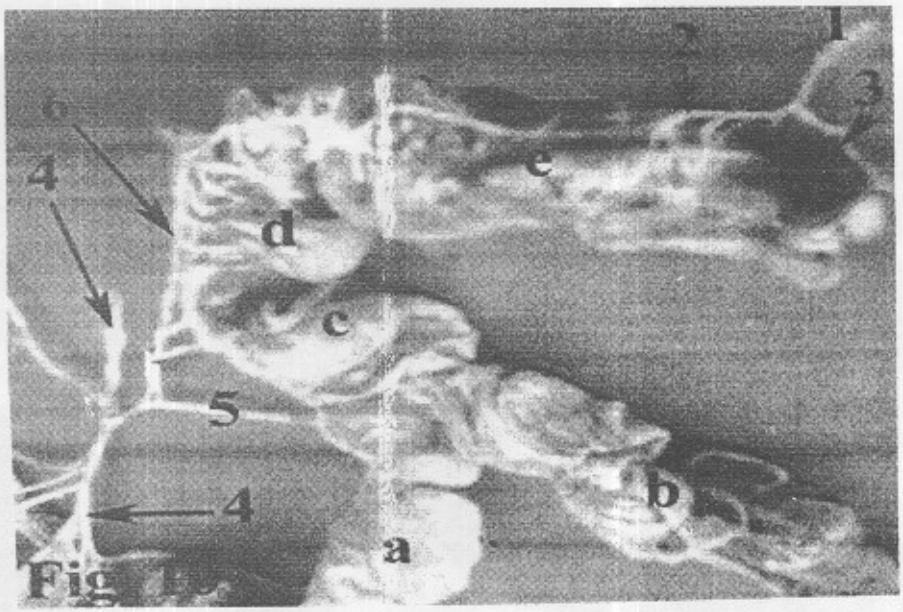

Fig. 10: A photograph of isolated fox intestines, showing the branches of the caudal mesenteric artery, and the anastomosis of the middle and left colic arteries. a-Ileum, b-Cecum, c- Colon ascendens, d- Colon transversus, e- Colon descendens, 1- A. mesenterica caudalis, 2- A. colica sinistra, 3- A. rectalis cranialis, 4- A. mesenterica cranialis, 5- A. ileocolica, 6- A. colica media.

DISCUSSION

In accordance with Ghoshal (1975) in carnivores and Schummer and Wilkens (1981) in carnivores and ruminants, the origin of the cranial mesenteric artery in the red fox was at the level of the second lumbar vertebra. It appears at the level of the first lumbar vertebra in the dog (Adams, 1986), pig and horse (Schummer and Wilkens, 1981) as well as in goat (Yousef, 1991). However, It arises caudal to the origin of the celiac artery by one cm in the cat (Reighard and Jennings, 1966), 12 cm in the camel (Smuts and Bezuidenhout, 1987), and just caudal to the celiac artery, sometimes by a common trunk with it in the ruminants (Habel, 1975).

In agreement with Reighard and Jenings (1966) in the cat, Ghoshal (1975) and Schummer and Wilkens (1981) in carnivores, and Adams (1986) in the dog, the cranial mesenteric artery proceeded caudoventrally between the layers of the mesentery. It passed more centrally, forming a gentle curve with a concavity facing caudodorsally. Reighard and Jenings (1966) in the cat, mentioned that it forms a curve with the convexity dextrad. Schummer and Wilkens (1981) stated that it runs more centrally in the carnivores and more peripherally in the pig. Levine et al. (1987) in the ox, mentioned that a large collateral branch (Ramus collateralis of the N.A.V., 2005) arises from the proximal segment of the cranial mesenteric artery, and anastomoses with its continuation distally.

In coincidence with Reighard and Jenings (1966); Hudson and Hamilton (1993) in the cat and Ghoshal (1975) in the horse, the caudal pancreaticoduodenal artery was the first branch that arose from the cranial mesenteric artery. In carnivores, it arises distal to the ileocolic artery (Ghoshal, 1975 and Schummer and Wilkens, 1981). On the other hand, in the camel, it arises from a jejunal artery that supplies the initial part of the jejunum (Smuts and Bezuidenhout, 1987), and in the goat, a caudal duodenal artery and pancreatic branches are given separately from the cranial mesenteric artery (Yousef, 1991), However, May (1970) described in the sheep only one pancreaticoduodenal artery that arises from the gastroduodenal artery of the celiac, and anastomoses with the jejunal arteries .

In correspondence with Ghoshal (1975) in carnivores, the caudal pancreaticoduodenal artery divided into a right branch that supplied the right lobe of pancreas and the descending duodenum, and a left branch that supplied the ascending duodenum. In this view, it supplies the right lobe of pancreas and the descending duodenum in the cat (Hudson and Hamilton, 1993), In the ruminants it is divided into branches that run cranially and caudally on the descending duodenum (Habel, 1975). In the camel it supplies the descending, transverse and ascending parts of the duodenum and a small portion of the pancreas (Smuts and Bezuidenhout, 1987). In the domestic animals it supplies parts of pancreas and duodenum (Schaller, 1992).

As seen presently, the red fox possessed eight jejunal arteries. Their number is 15-19 in carnivores (Thamm, 1941), 15-20 in the horse (Ghoshal, 1975), 6 or 7 in the camel (Smuts& Bezuidenhout, 1987), 18- 28 in the sheep (Happich, 1961) and 24 in the goat (Yousef, 1991). However the number of the jejunal arteries varies from species to another according to Schummer and Wilkens (1981).

In agreement with Schummer and Wilkens (1981) in the domestic animals except horse, all the jejunal arteries of the red fox arose separately from the cranial mesenteric artery, at nearly regular intervals. On the other hand, in carnivores, they form a common trunk (Koch, 1970) or the first jejunal may arise together with the caudal pancreaticoduodenal artery and the last with the ileocolic artery (Ellenberger and Baum, 1891).

Regarding the ileal arteries, this study showed that they were represented by 3-4 branches: 2-3 of them arose from the cranial mesenteric artery and the last was represented by the continuation of the cranial mesenteric artery. A finding which contradicts Ghoshal (1975) in carnivores, who mentioned one ileal artery that arises as the last branch of the cranial mesenteric artery representing its continuation. Schummer and Wilkens, (1981) stated that the ileal arteries originate from

the terminal part of the cranial mesenteric artery in the domestic animals except horse, in which they arise together with the bundle of the jejunal arteries. However, Schaller (1992) in the domestic animals, said that they are variably arising branches of the cranial mesenteric and ileocolic arteries.

Concerning the ileocolic artery, the present study revealed that it was the second branch that given from the cranial mesenteric artery. However, it is the first branch from the cranial mesenteric artery in carnivores (Ghoshal, 1975) and Schummer and Wilkens, 1981).

In coincidence with de Lahunta and Habel (1986) in the dog, the ileocolic artery gave off colic branch, right colic artery, middle colic artery, mesenteric ileal branch and continued as the cecal artery.

The pancreatic branches arising from the middle colic artery in the sheep (Tanudimadja and Getty, 1970), could not observed in the red fox according to the present study.

The present work revealed that the caudal mesenteric artery arose from the abdominal aorta, opposite to the caudal border of the root of the 6th lumbar transverse process. A finding which partially agrees with the finding of Adams (1986) in the dog-who stated that it arises at the level of 5th to 6th lumbar vertebra. This was not in accordance with the finding of Ghoshal (1975) and Schummer and Wilkens (1981) in carnivores-who mentioned that this artery arises at the level of the 5th lumbar vertebra. Reighard and Jennings (1966) in the cat, stated that it arises at the level of the last lumbar vertebra.

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بعض الدراسات التشريحية على الشرايين المساريقية في الثعلب الأحمر

حاتم بهجات

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أجريت هذه الدراسة على أربعة ثعالب حمراء بالغة، لتوضيح الشرايين المساريقية، والتي –أو فروعها– تدخل ضمن مشتملات جراحة الأمعاء. تم استخدام مُعلق سلفات الباريوم بتركيز 5% كمادة معتمة للأشعة ومالئة للأوعية، للتغلب على نُدرة عينات هذا الحيوان البري. أظهرت النتائج أن الشريان المساريقي القحفي في الثعلب الأحمر نشأ من الأبهر البطني في مستوى الفقرة القطنية الثانية، ثم دخل المساريقا الأمامية، مكونا جذرها، ثم سار ذيليا و بطنيا في مسراق الصائم، وفي النهاية استمر مكونا الشريان اللفائفي الأخير. أعطى الشريان المساريقي الأمامي الفروع التالية: 1– الشريان المعثكلي العفجي الذيلي إلى الفص الأيمن للمعثكلة (البنكرياس) وكذا العفج (الاثناعشر) الهابط والصاعد. 2– ثمانية شرايين صائمية. 3–ثلاثة إلى أربعة شرايين لفائفية. 4–الشريان اللفائفي القولوني إلى اللفائفي والأعور والقولون الصاعد والقولون المستعرض والجزء الأمامي من القولون الهابط. نشأ الشريان المساريقي الذيلي من الأبهر البطني عند مستوى الحافة الخلفية لجذر النتوء المستعرض للفقرة القطنية السادسة، ثم مر ذيليا وبطنيا في مسراق القولون الهابط، ثم انقسم إلى: 1– الشريان القولوني الأيسر الذي أمد الثلثين الخلفيين من القولون الهابط ،2– الشريان المستقيمي القحفي إلى الجزء الأمامي من المستقيم. تم إعداد صور فوتوغرافية وشعاعية عديدة، هذا وقد نوقشت النتائج مع مثيلاتها في الحيوانات المستأنسة الأخرى وخصوصا آكلات اللحوم المستأنسة.