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Gross anatomical study on the liver of the one humped camel (*Camelus dromedarius*)

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Abstract

Thirty five livers of adult dromedary camels were grossly examined. The topography of the liver and the extrahepatic blood supply were studied in two foetuses (third trimester). The intrahepatic portal blood supply was studied in a liver injected with 12% Vinylite through the portal vein. The dromedary liver appeared characteristically as an enlarged irregular prism, and had a very high content of interlobular connective tissues, which lent a firmer consistency to the liver, acharacteristic which was not found in the liver of any other domestic mammal. In the foetus, the liver protruded beyond the thoracic cage on the right and left sides of the abdominal cavity, but the bulk was on the right side. The liver of the adult camel looked dark brown in colour. It weighed about 7.5 kgs, measured 67 cm in length and 48 cm in width. The dromedary liver showed four distinct lobes namely; left (lateral and medial), right, caudate, and quadrate. The liver was supplied by the hepatic artery, and by the portal vein which terminated at the porta by dividing into three branches; right dorsal, right ventral, and a much larger left branch. The liver was drained by many hepatic veins. These veins are of three categories, two large, six to eight medium, and thirty four to thirty eight small ones.

Keywords: Dromedary camel, Liver, Gross morphology, Blood vessels.

المستخلص

فحصت الكبد عيانيا فى خمس وثلاثون من الابل البالغة وحيدة السنام بينما درست طبوغرافية الكبد وامدادها الدموى الخارجى فى اثنين من الاجنة (المرحلة الثالثة مسن الحمل). كما درس الامداد الدموى البابى داخل الكبد بحقن مادة الفينالايت عن طريق الوريد البابى.
تتميز كبد الابل بشكلها المنشورى المتضخم غير المنتظم. كما تحتوى على قدر كبير من النسيج الضام بين الفصيصات والذى يعطى بدوره ملمسا صلبا للكبد مقارنة بكبد الثدييات الاخرى.

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يتضح من الدراسة الطبوغرافية للكبد فى الجنين انها تتجاوز القفص الصدري على جانبى تجويف البطن، الايمن والايسر لكن معظمها يقع على الجانب الايمن.
يكون لون الكبد فى الحيوان البالغ بني غامق، وتزن حوالى 7.5 كيلو جرام، ويبلغ طولها 67 سم وعرضها 48 سم. تتكون الكبد من أربعة فصوص: أيسر (انسى ووحشى)، و أيمن، ومربع، ومذيل.
تغذى الكبد بالشريان الكبدي وبالوريد البابى. ينقسم الوريد البابى عند بواب الكبد الى ثلاثة فروع ايمن ظهرى، وأيمن بطني، وأيسر كبير. تنزح الكبد بواسطة اوردة كبدية كثيرة والتى قسمت الى ثلاثة اصناف: وريدان كبيران، وستة الى ثمانية اوردة متوسطة، واربعة وثلاثون الى ثمانية وثلاثون وريدا صغيرا.

Introduction

The liver is a vital organ since it is the site of metabolic processes of all nutrients consumed by the animal. The gross anatomy of the dromedary liver has been studied by many authors. Lesbre (1903) mentioned some of its differentiating features in comparison to the liver of other animals. Grossman (1960) gave a brief description without mentioning about its lobes. Hegazi (1954) reported some gross and microscopic characteristics. Abdalla *et al.* (1971) and Ouhsine and Zguigal (1983) described the external conformation and lobation of the dromedary liver. Nagpal *et al.* (1985) and Smuts and Bezuidenhout (1987) gave a report deals with detailed gross anatomy and relationship of the liver of camel. However, all these reports vary regarding the lobation of the liver of camel. On the other hand, anatomical information on the blood supply of the dromedary liver is merging. Only two reports are available (Arnautovic *et al.*, 1972; Fahmy *et al.*, 1972). Thus, the present work is intended to be a further contribution to the understanding of the gross anatomy and blood supply of the liver of the camel with especial emphasis on the portal vein.

Materials and Methods

Material for this study was collected from El Gadaref, Omdurman, El Obayed and Port Sudan slaughterhouses, and from Tamboul camel market. Thirty five adult dromedary camels, of both sexes were used. The anatomical features were studied in thirty five livers. The shape, colour, lobation and ligaments were noted in each liver. Measurements including weight, length and width of ten livers were made by using a simple balance and tape meter respectively.

For studying the intrahepatic portal blood vessels, a cast was prepared by the injection of 12% Vinylite via the portal vein (Arnautovic *et al.*, 1972). Following the injection, the liver was transferred to a fridge for 24 hours to allow the vinylite to set. Then the liver was transferred to a container filled with concentrated hydrochloric acid. The liver remained in the container for two days until the tissues were well rotted. The acid was then drained leaving the cast in the container. The cast was then washed well to get rid of the rotted tissues.

The number and diameter of the openings of the hepatic veins into the caudal vena cava were noted in ten organs of adult animals.

Two foetuses were used to study the topography of the liver as well as the extrahepatic blood supply. Each foetus was perfused first via the common carotid artery and was then preserved in 5% formalin. The curved crown-rump length (CVRL) equation Y =0.366 X-23.99, which was described by El Wishy *et al.* (1981) was used for the determination of the foetal age (X) in days from the known (Y) crown-rump length (CVRL) in centimeters using tape meter. The measurement of the CVRL started from the crown of the foetus, followed the contour of the hump and ended at the root of the tail.

Results

The liver of the adult camel was dark brown, tough, elastic and irregularly prismatic in shape, and was

clearly lobulated by a high content of the interlobar and interlobular connective tissue (Fig. 1). The average length of the liver was 67 cm, the average width was 48 cm and the average weight was 7.5 kg. The gall bladder was absent. The diaphragmatic surface (Fig. 2) was convex, showed some incisures of varying depths, particularly on the left lobe. The visceral surface (Fig. 1) was concave presenting an elongated depression, the porta hepatis, through which the portal vein, hepatic artery and nerves entered and the hepatic ducts and lymphatics leaved. The liver was divided into distinct lobes; a left (lateral and medial), a right, a caudate, and a quadrate (Fig. 1). These lobes appeared clearly on the visceral surface of the liver. The right lobe formed the bulk of the organ. The left lobe was divided by a wide ventral shallow incisures into two parts; a left cranial one and a left caudal one, and its visceral surface showed numerous small and deep incisures. The caudate lobe was visible only on the visceral surface, and was situated dorsal to the porta. It consisted of a small caudate process and a well developed flap-like papillary process. The quadrate lobe was divided into two parts; a lateral one and a medial one by a shallow fissure. The medial part was the larger and was mostly tongue-shaped (Figs. 1 and 2). In some specimens it had the heart-shape. The dorsal border of the liver was thick and included part of the renal impression, the groove for the caudal vena cava, and the oesophageal notch. The thickest part of the dorsal border was the part lying between the oesophageal notch and the renal impression. The right, left, and ventral borders were sharp.

Figure 1: Visceral surface of the Iiver of Camel:

A. Left lobe; a: Cranial Subdivision. b: Caudal Subdivision. B. Medial part of quadrate lobe (tongue-shape). C. Caudate lobe; c: papillary process. d: Caudate Process. D. Right Iobe. E. Porta hepatis. F. Renal impression.

The arrowhead shows a wide shallow incisures which divides the left lobe into two Subdivions.

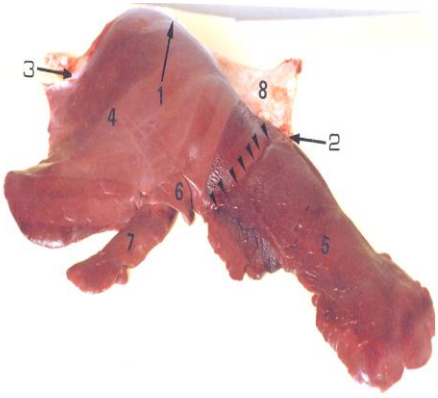

Figure 2: Diaphragmatic surface of the Iiver of camel:

1. Coronary ligament. 2. Left triangular ligament. 3. Right triangular ligament. 4. Right lobe. 5. Left lobe. 6. Lateral subdivision of the quadrate lobe 7. Medial subdivision of the quadrate lobe. 8. The diaphragm (tendinous part)
The arrowheads point to falciform Ligament.

In the 85.81 cm and 96.79 cm CVRL foetuses (300 and 330 days old, respectively). The liver was relatively large and the borders were rounded (Figs. 3, 4, 5 and 6). Its long axis was sagittal in direction with dorsolateral convexity. The right lobe protruded beyond the costal arch and was in contact with the abdominal wall. The bulk of the liver was situated on the right side of the abdominal cavity, and extended from the 5th rib to the pelvic inlet in a caudo-dorsal direction (Figs. 3, 4 and 5). The cranial (left) part of the liver curved ventromedially, and lied directly caudal to the diaphragm and ventral to the rumen (Fig. 6). There were three borders; dorsal, ventral, and caudal borders, and two angles; caudodorsal, and caudoventral angles (Fig. 5). The liver presented two surfaces; a convex diaphragmatic surface and a concave visceral surface which was mainly directed medially. It was very irregular in conformity with the other related organs (Fig. 7). The right lobe was the largest and showed abomasal, duodenal and jujenal impressions. The left lobe was related to the compartment (1) (rumen) laterally, the compartment (3) (omasum) medially and the jejunum ventrally. The caudate process was related to the duodenum and jejunum. The papillary process was circular in outline and concave at its centre. Its peripheral border was grooved. The concavity of the centre was for the reticulum and the groove on the border was for the

compartment (3). The quadrate lobe was related to the jejunum.

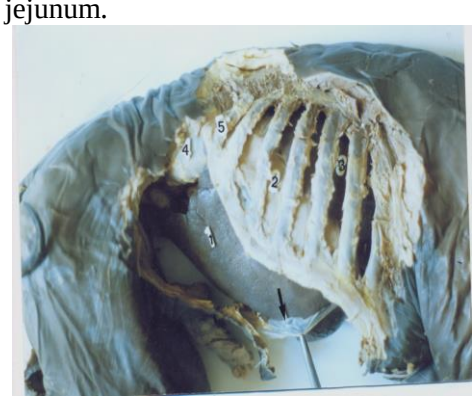

Figure 3: right view of the thorax and abdomen (foetus)

1. Liver. 2. Diaphragm. 3. Right lung. 4. Right Kidney. 5. Twelfth rib.
The arrow point to falciform ligament.

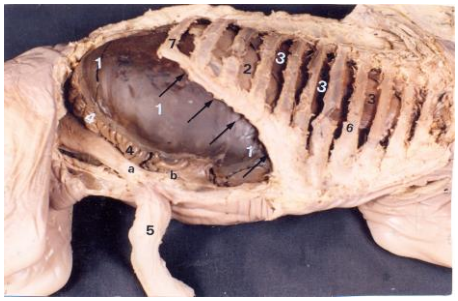

Figure 4. Right view of the thorax and abdomen (foetus):

1. Liver. 2. Diaphragm. 3. Right lung 4. Intestine. 5. Umbilical cord. a: Umbilical arteries b: Umbilical vein. 6. Fifth rib. 7. Twelfth rib.
The arrows show the costal arch.

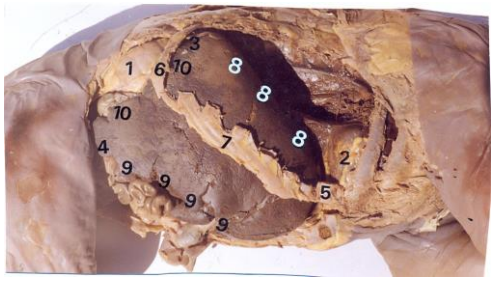

Figure 5. Right View of the liver of the camel *in situ* (foetus)

1. Right Kidney. 2. Pericardium covering the heart. 3. Caudo-dorsal angle. 4. Caudo-ventral angle. 5. Fifth rib. 6. Twefth rib. 7. Rib cage. 8. Dorsal border. 9. Ventral border. 10. Caudal border.

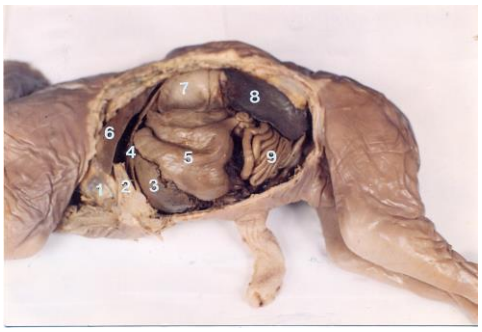

Figure 6: Left View of the thorax and abdomen of the camel (foetus)

1. Pericardium. 2. Distal part of the 5th rib. 3. Cranial end of the liver (Ieft Iobe) 4. Diaphragm. 5. Rumen.6. Left lung.7. Left Kidney. 8. Spleen. 9. Intestine.

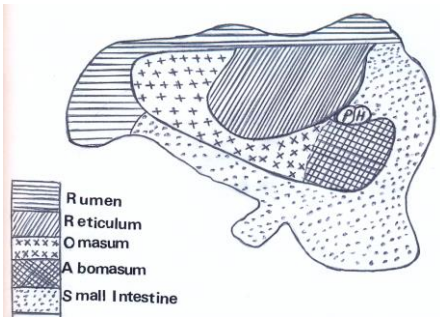

Figure7: A diagram showing the relation of other viscera to the visceral surface of liver (foetus). PH : porta hepatis

In both foetus and adult dromedary, the liver was kept in position by the pressure of the neighbouring organs, and also by the lesser omentum and the right and left triangular, falciform, coronary, round ligament and hepatorenal ligament (Figs. 1 and 2). In foetus the falciform ligament was well developed (Fig. 3). In addition to that, two umbilical vein and arteries were present (Fig. 4).

The dromedary liver was supplied by the hepatic artery and the portal vein. The hepatic artery arose as one of the three primary branches of the coeliac artery (the left gastric, the splenic and the hepatic) and terminated at the porta by dividing into right dorsal, right ventral, and left branches (Fig. 8). The portal vein was formed by splenic and cranial mesenteric veins which were joined a short distance from the porta. At the porta, the portal vein divided into three main trunks named right

dorsal, right ventral and left one (Figs. 9, 10). The left trunk was the largest branch. It ran towards the left lobe. It gave off small dorsal branches to the papillary process, and small ventral branch to the quadrate lobe, before it divided into two branches; the short branch ran towards the medial part of the left lobe and gave off a branch to the quadrate lobe. The other branch of the left trunk was long. It ran towards the lateral part of the left lobe, and gave off small branches to the dorsal part of the left lobe, and then it divided into two branches laterally; the left dorsal, and the left ventral one. The right dorsal branch of the portal vein gave off several branches to the dorsal part of the right lobe, the caudate process, and the papillary process. The right ventral branch of the portal vein divided into four main branches. One of the four branches ran towards the quadrate lobe while the other branches ran to the ventral and lateral parts of the right lobe (Figs. 9, 10). Venous blood was drained by a large number of hepatic veins of different sizes. These veins may be divided into three groups; 2 large veins, 4-9 medium-sized and 34-38 small veins. All of the hepatic veins opened into the caudal vena (Fig. 11).

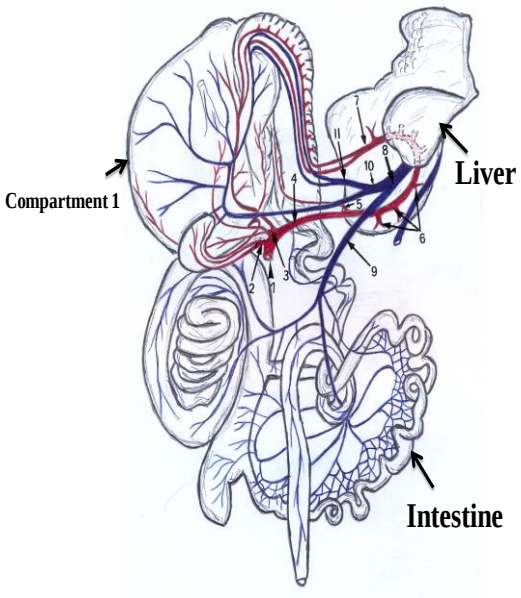

Figure 8: Main branches of the coeliac artery and portal vein

1. Coeliac artery. 2. Splenic artery. 3. Left gastric artery 4. Hepatic artery. 5. Gastro duodenal artery. 6. Hepatic branches. 7. Right gastric artery. 8. Portal vein. 9. Cranial mesenteric vein. 10. Splenic vein. 11. Right gastric vein.

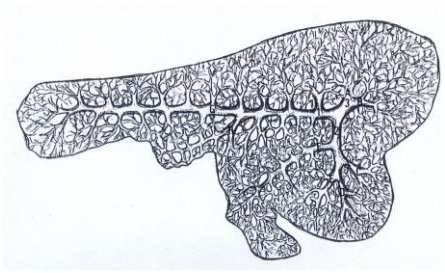

Figure 9: A diagram of Portal Vein:

1. Left portal venous trunk. 2. Right ventral portal venous trunk. 3. Right dorsal portal venous trunk. A, B: Branches of (3). C, D, E, F: Branches of (2). G, H: Branches of (1).

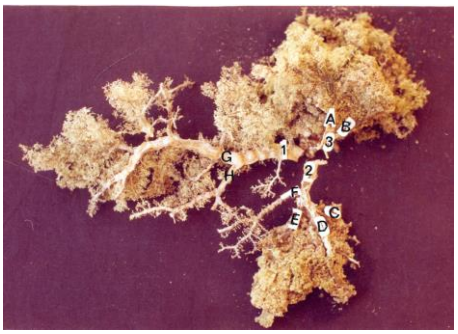

Figure 10: A cast of portal vein:

1. Left portal venous trunk. 2. Right ventral portal venous trunk. 3. Right dorsal portal venous trunk. A, B: Branches of (3). C, D, E, F: Branches of (2). G, H: Branches of (1).

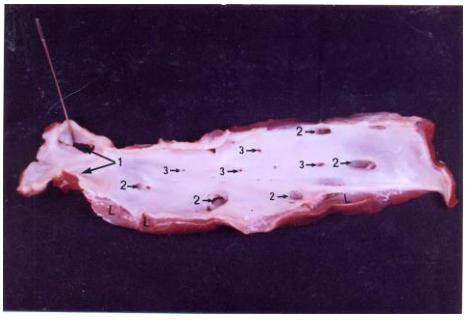

Figure 11: Caudal vena cava removed partially from the dorsal border of the liver (L) by longitudinal incision to show the openings of hepatic veins

1. Openings of the large venous trunks. 2. Openings of the medium-sized venous trunks. 3. Openings of the small-sized venous trunks. Note: The numerous openings of the small hepatic veins.

Discussion

The colour of the dromedary liver was dark brown. The average weight was 7.5 kg. This finding was similar to that reported by Hegazi (1954), Abdalla *et al.* (1971), Nagpal *et al.* (1985), and Smuts and Bezuidenhout (1987). The colour and weight of the liver varies not only with the species but also with the nutritional state of the animal (Nickel *et al.*, 1973). Because the liver stores fats and-glycogen, it weighs more in well fed animals; the weight of the liver also decreases with age (Nickel *et al.*, 1973). In the present study, the average measurements of the liver have been found to be 67 cm for the length, and 48 cm for the width. This agrees well with the average measurements reported by Droandi (1936), Hegazi (1954), Abdalla *et al.* (1971), and Nagpal *et al.* (1985). The findings of all these authors showed that the average length of the liver varied between 60 and 76 cm, and the average width between 34 and 55 cm.

In the present study, and in agreement with the findings of Hegazi (1954), the liver of the camel had a firmer consistency than that of other domestic mammals. This was attributed to the high content of interlobular connective tissue which was visible to the naked eye; a feature it shared with that of the pig (Nickel *et al.*, 1973).

In agreement with the findings of Smuts and Bezuidenhout (1987) and Abdel-Moniem *et al.* (2000), the present study showed that the fetal liver protruded beyond the rib cage both on the right and left sides of the abdominal cavity, but the bulk of it was on the right side. This enlargement is due to the additional haemopoietic function of the liver in the foetus. The other reason is that the other visceral organs, specially the stomach, did not attain their full development. In this study, the liver was kept in position by ligaments which attached it to the diaphragm. These ligaments were; the right and left triangular, the coronary, the falciform, the round, and the hepatorenal. However, the falciform ligament in the camel is well developed. This study confirms the previous findings of Ouhsine and Zguigal (1983) and Smuts and Bezuidenhout (1987). However, Abdalla *et al.* (1971) did not mention the left triangular ligament and Nagpal *et al.* (1985) did not mention the round ligament. On the other hand, Hegazi (l954) denied the existence of a left triangular ligament, a falciform ligament and a round ligament in the liver of the camel.

The liver of the camel composed of four distinct lobes, viz. left (lateral and medial), right, caudate and the quadrate. The previous reports vary regarding lobation of the dromedary liver. Grossman (1960) in his brief description did not mention about the lobes of the liver of the camel. Hegazi (l954) reported that camel liver consisted chiefly of only one lobe, although it was divided into three lobes by faint fissures. Lesbre (1903) also reported three lobes but specific description or names were not provided. According to Abdalla *et al.* (1973), camel liver had 4 lobes only, viz. cranial, caudal, quadrate and the caudate. Ouhsine and Zguigal (1983) reported 6 lobes. They named the previously reported cranial and caudal lobes as left and right lobes because of such like disposition in the body and also observed that each of these lobes could be subdivided into the medial and lateral lobes. Nagpal *et al.* (1985) reported that the liver of camel had 5 lobes, viz. right medial, right lateral, quadrate, caudate and left lobes. It is probable that the conflicting reports about the number of lobes are due to individual variations.

The liver of the two-humped camel (Camelus bactrianus) had the same lobation of the liver of the one-humped camel (Camelus dromedarius) (Endo *et al.*, 2000).

The present study and that of Osman (1999) and Eisa (2000) showed that the hepatic artery rose as one of the three primary branches of the coeliac. However, Smuts and Bezuidenhout (1987) claimed that the hepatic artery of the camel arose by a common trunk with the splenic artery. In this study, the hepatic artery terminated at the porta by dividing into a right dorsal, a right ventral, and a left branch. This disagrees with the findings of Smuts and Bezuidenhout (1987) where the hepatic artery divided into right and left branches.

In all domestic mammals, the portal vein conveys blood containing the products of digestion from the stomach and intestine, and also from the spleen (Nickel *et al.*, 1973). In the present investigation, the portal vein is formed by splenic and cranial mesentric veins which joined a short distance from the liver. This confirmed the findings of Smuts and Bezuidenhout (1987). At the porta the portal vein divided into three trunks, namely right dorsal, right ventral, and the much larger left one. This is similar to the observations of Arnautovic *et al.* (1972).

The hepatic veins empty into the caudal vena cava, and are of three groups; 2 large-sized, 6-8 medium-sized, and 34-38 small veins. This is quite similar to the findings of Fahmy *et al.* (1972), in sheep

there are 2 large-sized veins and about 43 small veins (Arnautovic and Kremar, 1964) and in the horse there are 3-4 large veins, and a great number of small ones (Sisson, 1969). It seems that, apart from the large veins, the small veins show great variation in numbers among different species and within the same species.

References

Abdalla, O.; Arnautovic, I. and Fahmy, M.F.A. (1971). Anatomical study of the liver of the camel (*Camelus dromedarius*). 1. Topography and morphology. (*Acta Morphologica Neerlando Scandinavica*, 9: 85-100.

Abdel-Moniem, M.E.; Abdel-Rahman, Y.; Alam-Edin, M.A. and El-Nady, F.A.M. (2000). Changes in the topography of the liver of one-humped camel during the prenatal life. *Assuit Veterinary Medicine Journal*, 44: 22-34.

Arnautovic, I.; Fahmy, M.F.A. and Abdalla, O. (1972). Anatomical study of the liver of the camel. II. The course and distribution of the portal vein, hepatic artery and hepatic duct. *Acta Morphologica. Neuzland Scandinavica*, 9: 211-220.

Arnautovic, I. and Krcmar, 1. (1964). A contribution to the knowledge of the intrahepatic blood vessels and gall-ducts in sheep. *Veterinaria, Sarajevo*, 13: 15-28. (Cited by Fahmy *et al.*, 1972).

Droandi, I. (1936). II Camello. Instituto Agricolo Italiano, Firenze (Cited by Abdalla, Arnautovic and Fahmy, 1971).

Elwishy, A.B.; Hemeid, N.A.; Omer, M.A.; Mobarak,
A.M. and El Sayed, M.A.I. (1981). Functional changes in the pregnant camel with especial reference to foetal growth.Br. Vet. J., 137: 527-537.

Eisa, E.I. (2000). The Morphology and Morphometry of the Spleen of the One-humped Camel (*Camelus dromedarius*). M.Sc. Thesis, University of Khartoum.

Endo, H.; Gui-Fang, C.; Dugarsuren, B.; Erdemtu, B.; Manglai, D. and Hayashi, Y. (2000). On the morphology of the liver in the two-humped camel. Anatomia Histologia Embryologia, 29: 243-246.

Fahmy, M.F.A.; Abdalla, O.A. and Arnautovic, 1. (1972). Anatomical study of the liver of the camel (Camelus dromedarius): III. The hepatic veins. Acta Morphologica Neerlando Scandinavica, 9: 221-228.

Hegazi, A.E. (1954). The liver of the camel as revealed by macroscopic and microscopic examinations. American Journal of Veterinary Research, 15: 444-446.

Grossman, J. D. (1960). A Students Guide to Anatomy of the Camel. Indian Council of Agricultural Research, New Delhi.

Lesbre, F.X. (1903). Researchers Anatomique Sur Les Camelides. J.B. Bailliere et Fils, Paris (Cited by Abdalla, Arnautovic and Fahrny, 1971).

Nagpal, S.K.; Sudhakar, L.S.; Singh, G.; Dhingra, L.D. and Singh, Y. (1985). Gross morphology of the liver of camel (Camelus dromedarius). Indian-Journal of Animal Science, ·55:996-1001.

Nickel, R.; Schummer, A. and Seiferle, E. (1973). The Viscera of the Domestic Mammals. Translation and Revision by W.O. Sack. Verlag Paul Parey. Berlin, Hamburg.

Osman, E. El (1999). Morphological and Some Immunohistochemical Observations on the Stomach of the Camel (*Camelus dromedarius*). M.Sc. Thesis, University of Khartoum.

Ouhsine, A. and Zguigal, H. (1983). External conformation and lobation of the liver of the dromedary. Anatomia Histologia Embryologia. 12: 25-32.

Sisson, S. (1969). Anatomy of Domestic Animals. W.B. Saunders, Philadelphia - London.

Smuts, M.M.S. and Bezuidenhout, A.I (1987). Anatomy of the Dromedary. Clarendon Press, Oxford.