

Dept. of Anatomy and Embryology,  
Fac. of Vet. Med., Suez Canal University

**SOME MORPHOLOGICAL STUDIES ON THE  
SPLEEN AND ITS ARTERIAL SEGMENTATION  
IN BABOON MONKEY (HAMADRYAS BABOON)**

(With 1 Table and 6 Figures)

By

**H.M.E. IMAM**

(Received at 11/3/2000)

بعض الدراسات المورفولوجية على الطحال وتقسيماته الشريانية  
في قرد البابون

هشام محمد السعيد إمام

أجريت الدراسة الراهنة على عشرة من قردة البابون البالغة والسليمة صحياً ( خمس ذكور - خمس إناث) تم الحصول عليها من أسواق الحيوانات من منطقة التوسى بمحافظة القاهرة. تم إجراء مسح صوتي تاجي للبطن لدراسة نموذج الصدى الصوتي ، مقاسات الطحال وكذلك معدل تدفق الدم وشكل الموج الطيفي للاوعية الدموية الطحالية. كما تم قياس قمة السرعة الانقباضية ، نهاية السرعة الانساطية ، المتوسط الزمن لسرعة تدفق الدم، الدليل النبضي، دليل المقاومة والمعدل الانقباضي الانساطي للمدد الدموي للطحال وجدولت هذه القياسات إحصائياً. هذا وقد تم دراسة مورفولوجية الطحال وكذا القالب التأكلي للشريان الطحالي وفروعه. ولقد أجرى فحص مجهري للطحال للتأكد من عدم وجود أى ظواهر مرضية بداخله. أوضحت الدراسة أن طحال قرد البابون الطبيعي له شكل حبة الفاصوليا المستطيلة غير المنتظمة ، محاطة بحافظة ليفية رقيقة لها قدرة كبيرة على بعث صدى الموجات فوق الصوتية مع وجود برتسمية منقطة متجانسة . كما تبين من دراسة التوزيع الداخلي للشريان الطحالي أنه يمكن تقسيم برتسمية الطحال إلى أربع أقسام ( اثنتان أماميان واثنتان خلفيان).

**SUMMARY**

The present study was carried out on ten adult healthy Baboon monkeys (five of each sex) obtained from animal's markets at EL-Tonsey Area, Cairo Governorate. Coronal abdominal scan was conducted for studying echo pattern, dimensions, Colour Doppler flow mapping and Spectral

Waveform of the splenic vasculature. The various obtained vascular parameters (Peak Systolic Velocity (MAX), end Diastolic Velocity (MIN), Time Average Maximum Velocity (TAMX), Pulsatility Index (PI), Resistivity Index (RI) and Systolic/ Diastolic Ratio (S/D)) were measured and statistically tabulated. Morphological studies of the spleen and corrosion cast for the splenic artery was performed. Histological examination was conducted to assure of the absence of pathological abnormalities. The study revealed that the normal Baboon monkey's spleen possessed approximately an irregular elongated bean-shaped appearance, encapsulated by a thin hyperechoic fibrous capsule with homogenous finely speckled parenchyma. The distribution of the splenic artery indicated that the splenic parenchyma might be divided into four segments (two cranial and two caudal).

*Key words: Morphological studies on the spleen of Baboon monkey*

## INTRODUCTION

The Baboon monkey is a member of primates (Klos and Lang, 1982). The ancient Egyptians divined it in their religion as a symbol of fertility (Zein EL-Dein, 1951). Nowadays, it is considered as an important experimental animal (Martin, 1972).

The spleen as a vital haemopoietic organ is involved in many diseases in animals and human (Abd EL-Wahab, 1982). Its vasculature and segmentation attracted the attention of many investigators in human (Gupta, Gupta, Arora, and Jeyasingh, 1976 and Fadel, 1985) and in different animals (Gupta, Gupta and Gupta, 1978 b,c and 1979, Osman, EL-Ayat and EL-Khaligi, 1987, Abu-Zaid, EL-Khaligi and EL-Nahla, 1987, Abu-Zaid, EL-Nahla, Osman and Erasha, 1989 and Wally and Gad, 1998). Recently, the splenic sonography was used as a simple non-invasive technique for the descriptive examination of the normal and diseased picture of spleen in human (Koga, 1979 and Kotb and Hussein, 1997) and animals (Yamaga and Too, 1984, Barr, 1990 and Abu-Zaid, 1995).

Therefore, the current work was planned to investigate the normal anatomical features and echopattern of the spleen as well as description of the intrasplenic distribution of the splenic artery, and intern splenic segmentation.

## **MATERIAL and METHODS**

### **Experimental animals:**

The present work was performed on ten adult clinically healthy Baboon monkeys (5 males and 5 females) ranging from 10-15 kg. body weight. The monkeys were obtained from animal's markets at EL-Tonsey Area, Cairo Governorate. Handling, species identification, aging and clinical examination of the monkeys, were adopted according to Klos and lang (1982).

### **Splenic sonography:**

The monkeys tranquilized by intramuscular injection of Ketamine hydrochloride® at a dose of 10 mg/ kg body weigh (Martin, 1972). The abdominal hair were clipped, then sonographical examination of the spleen was conducted while the animal was in right lateral recumbancy, with transducer- skin contact close to the last left rib (Kotb and Hussein, 1997). Further rotation of the left side forward with elevation of the left arm above the head was done to facilitate visualization of the spleen. The echopattern, ultrasonic measurement, and arteries of the spleens were scanned using Acuson 128x P10 Colour Doppler computed sonography scanner\*, equipped with 5 M Hz linear transducer.

### **Morphology of the spleen:**

Animals were well bled via the common carotid artery after being euthanized by thiopentol sodium® (Fowler, 1993). The abdominal wall was incised and the shape, colour, consistency, topographical position and weight of each spleen were recorded.

### **Arterial Segmentation:**

Corrosive morphological study of the splenic artery was performed in eight resected spleens. The splenic artery was cannulated, flushed with warm saline solution and injected with a commercial plastic material, Astrallon\*\* (Fadel, 1985). The splenic tissue, then was corroded by immersing in 50% hydrochloric acid.

\*: Acuson computed sonography, Acuson Corporation, 1220 charleston road Mountain view, California 94039-7393.

\*\* Astrallon is a copolymer of 70% vinylchloride and 30% vinylacetate produced by National plastic company Giza Governorate.



**Microscopical examination:**

Specimens for microscopical studies of splenic tissue were taken from the other two resected spleens. The samples were fixed in 10% neutral buffered formalin, dehydrated in ascending grades of ethyl alcohol, (70-100%) cleared in xylene, embedded in paraffin and then 4-6 $\mu$  sections were cut and stained with Haematoxylin and Eosin (Bancroft and Cook, 1984).

The arterial segmentation was adopted according to Gupta *et al.* (1976) through (1979) and Fadel (1985) and the nomenclature was adopted according to the Nomina Anatomica Veterinaria (1994).

**RESULTS**

The present work revealed that the spleen of the monkey (Fig. 1) was soft, friable and of intense red colour, being insinuated between the fundus of the stomach, diaphragm and the posterior portion of the left 8<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup> and 11<sup>th</sup> ribs. It had an irregular elongated bean-shaped appearance. Its weight was about  $190.55 \pm 5.11$  gm. The spleen presented cranial and caudal rounded ends, dorsal and ventral borders and parietal and visceral surfaces. The cranial end was wider than the caudal one. The dorsal border was convex, while the ventral one was irregularly undulated. The parietal surface of the spleen was contiguous to the left abdominal wall. Meanwhile the visceral surface related to the stomach and intestine. The splenic hilus was situated along the midline of the visceral surface.

**Lieno- Sonography:**

The ultrasonographic picture of the normal monkey's spleen showed thin hyper-echoic fibrous capsule contoured homogeneous fine speckled parenchyma (Fig.2). The splenic hilus appeared as hyperechoic longitudinal area along the mid-visceral surface. The spleen of adult monkey, recorded  $12.00 \pm 1.82$  cm. Length and  $5.20 \pm 1.01$  cm width as measured sonographically.

**A. Lienalis:**

The splenic artery entered the splenic hilus and shortly within the parenchyma it divided into four segmental branches (two cranial and two caudal) in 50% of the examined specimens. Each segmental branch redivided into two small rami (Fig. 3A). In the other four specimens (50%), the two cranial segmental branches, of the splenic artery,

originated together by a short common cranial ramus, and the small rami of the most caudal segmental artery emanated directly from the parent splenic artery (Fig. 3B&4). The two cranial segmental arteries proceeded cranial and arborized within the cranial half of the spleen. Meanwhile, the two caudal segmental arteries coursed caudad and distributed into the caudal half of the spleen. Weak anastomoses were observed between the side branches of the adjacent segmental arteries (Fig. 3 A, B & 4). In all examined cases the vascular plan was perpendicular to the long axis of the spleen.

The Colour Doppler imaging of the normal monkey's spleen mapped its vessels from its hilus toward the splenic parenchyma (Fig. 5 A). Only the large arteries could be easily mapped, however the small vessels can be traced via the Spectral Wave Doppler (Fig. 5 B & C). The peak Systolic Velocity, end Diastolic Velocity, Time Average Maximum Velocity, Pulsatory Index, Resistality Index and Systolic/Diastolic Ratio of the Aorta, Coeliac trunk, Splenic artery and segmental branches of the splenic artery were measured and statistically tabulated (Table1).

The histological examination revealed normal structures of the spleen without any pathological lesions either in the white or red pulps. It was also seen that the splenic blood vessels were free from plaques and /or arteriosclerosis (Fig. 6).

#### DISCUSSION

The present study showed that the spleen of adult healthy Baboon monkey had an irregular elongated bean shape. This description was dissimilar to that of animals and human. It was described as elongated elliptical in bovine and triangular in sheep (Sisson, 1973), printed comma shape in horse and rectangle in outline in goat (Wilkens and Munster, 1981), Dumbbell shape in dog and cat and strap-like in pig (Dyce, Sack and Wensing, 1987), crecentic in camel (Smuts and Bezuidenhout, 1987) and lion (Abu-Zaid *et al*, 1989) and having the shape and size of a clenched fist in human (Last, 1978).

Concerning the ultrasonographical picture of the Baboon monkey's spleen, it was in a line with the descriptions of Koga (1979) in human, Nyland and Hager (1985) and Barr(1990) in dog and Abu-Zaid (1995) in goat as the splenic capsule appeared hyperchoic corresponding to its fibrous nature, while the parenchyma was homogenous finely

speckled which may be attributed to its vascular nature and trabeculae inside. The ultrasonographical measurement of the length and width of the Baboon monkey's spleen recorded  $12.00 \pm 1.82$  cm and  $5.20 \pm 1.01$  cm respectively. In this connection, Koga (1989) in human mentioned that the lieno-sonographical measurements might be equal to the actual gross measurements.

The current study revealed that, the splenic artery entered the splenic hilus and shortly within the parenchyma, it was divided into four segmental branches. Osman, El-Ayat and George (1981) in sheep and cattle and Osman *et al.* (1987) in buffalo calves recorded seemlier results. On the contrary, Fadel (1985) in human, Bolbol, Ali and Ibrahim (1985) in buffalo and Abu-Zaid *et al.* (1989) in lion described the splenic artery as divided extra-splenic just before reaching the splenic hilus.

From the present study, weak anastomoses were observed between the side branches of the segmental arteries. In this respect, Dyce *et al.* (1987) declared that the splenic artery, in dog and cat, divides into branches that vascularize splenic compartments which are normally independent although they do communicate. So, the current work is confirmed by the conclusion of Clausen (1958), Gutierrez- Cubillos (1969) and Gupta *et al.* (1976) in human, Gupta *et al.* (1978 b) in dog and Abu-Zaid *et al.* (1989) in lion that the mammalian spleen is generally segmented. On the other hand, Osman *et al.* (1987) in buffalo calves and Wally and Gad (1998) in goat described the spleen as unsegmented.

Colour Doppler imaging of the normal Baboon monkey's spleen mapped its large arteries from its hilus toward the parenchyma. However, and in accordance with Meritt (1992) in human, the superimposed intestinal gases obscured the smaller intrasplenic vessels. Thus, the Pulsed Doppler technique is essential for detecting the blood flow in the smaller intrasplenic arteries.

The normal vascular parameters (Peak Systolic Velocity, end Diastolic Velocity, Time Average Maximum Velocity, Pulsatility Index, Resistivity Index and Systolic/ Diastolic Ratio) of the aorta, coeliac trunk, splenic artery and its segmental branches provide a good picture for the physiological status of the splenic vessels in relation to the general circulation.

From the present study, it was concluded that the splenic artery of the adult healthy Baboon monkeys was divided into four branches (two cranial and two caudal). So, the spleen can be divided into four



segments (two cranial and two caudal), that makes the partial splenectomy is possible. The lieco-sonography and the Colour Doppler mapping, Spectral Waveform as well as the normal vascular parameters of the splenic vasculature may be considered as good tools for complete clinical diagnosis of the spleen.

#### REFERENCES

- Abd El-Wahab, M.F. (1982):* Schistosomiasis in Egypt. Florida: CRC press, 69-125.
- Abu-Zaid, S.M.S., El-Khaligi, G.E.M. and El-Nahla, S.M.M. (1987):* some gross anatomical studies on the topography, arterial supply and venous drainage of the spleen of the one humped camel (*Camelus dromedarius*) *Alex. J. of Vet. Sci.*, 1, (2): 45-59.
- Abu-Zaid, S.M.S., El-Nahla, S.M.M; Osman, A.K. and Erasha, A.M. (1989):* Some gross anatomical studies on the morphology and arterial segmentation of the spleen of the lion (*Panthera Leo*) In Giza Zoological Garden. *Assiut Vet. Med. J.*, 22, (43): 8-12.
- Abu-Zaid, R.M. (1995):* Radio-sonographic anatomy of the goat. Ph.D. Thesis, Fac. of Vet. Med., Suez Canal University.
- Bancroft, J.D. and Cook, H.C. (1984):* Manual of Histological Techniques. 1<sup>st</sup> ed., Churchill & Livingstone, Edinburgh, London, Melbourne and New York.
- Bolbol, A.E., Ali, A.M.A. and Ibrahim, I.A. (1985):* Some radiographic studies on spleen of ruminants. *First Int. Conf. App. Sci.*, Vol. II: 370-378
- Barr, F. (1990):* Diagnostic ultrasound in the dog and cat. 1<sup>st</sup> ed. Oxford Blackwell Scientific Publications, London, Edinburgh, Boston, Melbourne, Berlin, Vienna.
- Clausen, E. (1958):* Recent advances in Anatomy. 2<sup>nd</sup> ed. London; J. & A. Churchill Ltd.
- Dyce, K.M., Sack, W.O. and Wensing, C.J.G. (1987):* Textbook of Veterinary Anatomy. W.B. Saunders, Philadelphia, London, Toronto, Montreal, Sydney, Tokyo.
- Fadel, R.A.E. (1985):* Architectural pattern of the arterial supply in the human spleen. M.D.Thesis Fac.of Med., Suez Canal University.

- Fowler, A.E. (1993): Zoo and wild animal medicine. 2<sup>nd</sup> ed. Saunders Co., Div. Harcourt Brace and Company.*
- Gutierrez-Cubillos (1969): Segmentation of the spleen (Segmentation esplenica). Revista espanola de las enfermedades del aparato digestivo y la nutricion, 29:341-350.*
- Gupta, C.D., Gupta, S.C., Arora, A.K. and Jeyasingh, P. (1976): Vascular segments in the human spleen. J. Anat., 121: 613-616.*
- Gupta, C.D., Gupta, S.C., and Gupta, S.H. (1978b): Segmentation in the dog spleen. A study by corrosion cast. Acta Anatomica. 101: 380-382.*
- Gupta, C.D., Gupta, S.C., and Gupta, S.H. (1978c): Arterial segment in the goat (*Capra hircus*) spleen. A study by corrosion cast. Acta Anatomica, 102, (2): 102-104.*
- Gupta, C.D., Gupta, S.C., and Gupta, S.H. (1979): Arterial segmentation in the sheep (*Ovis aries*) spleen. A study by corrosion cast. J. Anat., 129, (2): 257-260.*
- Koga, T. (1979): Correlation between sectional area of the spleen by ultrasonic tomography and actual volume of the removed spleen. J. of Clinical Ultrasound, 7:119-120.*
- Klos, H.G. and Lang, E.M. (1982): Hand book of Zoo medicine. 2<sup>nd</sup> ed. Van. Nostrand Reinhold Co., New York.*
- Kotb, M. and Hussein, O. (1997): Normal splenic size in adult Egyptians (Ultrasonographic study). The Egyptian J. of Radiol. and Nuc. Med., 28 (2): 235-240.*
- Last, R.J. (1978): Anatomy Regional and Applied. 6<sup>th</sup> ed. Churchill living stone, Edinburgh & London.*
- Martin, D.P. (1972): Methods of anastasia in non-human primates. Lab. Anim. Sci., 22:837.*
- Meritt, P. (1992): Assessment of normal splenic size in children. Acta Radiol., 35:152-154.*
- Nyland, T.G and Hager, A.D. (1985): Sonography of the liver, gallbladder and spleen. Vet. Clin. North Am. Small Animal Pract, 15, (6): 1123-1130.*
- Nomina Anatomica Veterinaria (1994): 4<sup>th</sup> ed., Together with Nomina Histologica (revised 2<sup>nd</sup> ed.) and Nomina Embryologica Veterinaria (1994). Published by Int. Committee on Veterinary Gross Anatomy, Veterinary Histological Nomenclature and Veterinary Embryological Nomenclature. Under the Financial*



response of world association of Veterinary Anatomist. Zurich and Ithaca, New York.

- Osman, F.A. El- Ayat, M.S. and George, A.N. (1981):* Comparative anatomical studies on the intrasplenic distribution of splenic artery in certain animals (Ox, sheep, camel, pig, and dog). Egypt Vet. Med. J., Vol. XXXIX. 29: 413- 424.
- Osman, F.A., El-Ayat, M.S. and El- Khaligi, G.M. (1987):* Parenchymal distribution of the splenic vessels in buffalo calves. Vet. Med.J, 35, (2): 175-181.
- Sisson, S. (1975):* Spleen of bovine and sheep. In Getty, Sisson and Grossman's. The anatomy of domestic animals. 5<sup>th</sup> ed., Vol. II&I. W.B. Saunders, Philadelphia, London, Toronto.
- Smuts, M.A.S. and Bezuidenhout, A.J. (1987):* Anatomy of the dromedary. Clarendon press, Oxford.
- Wilkens, H. and Munster, W. (1981):* The circulatory system. In Nickel, Schummer und Seiferle; Lehrbuch der Anatomie der Haustiere Band III, Verlag Paul Parey, Berlin und Hamburg.
- Wally, Y.R and Gad, M.R (1998):* Radiological studies on the parenchymal distribution of the splenic vessels in the goat. Beni- Suef Vet. Med. Res., Vol.VIII.(1):1-10.
- Yamaga, Y. and Too, K. (1984):* Diagnostic Ultrasound imaging in domestic animals: Fundamental studies on abdominal organs and Fetuses. Jap. J. Vet. Sci., 46, (2): 203-212.
- Zein El- Dein, H.F. (1951):* Animal life. Published by Dar El-Faker El-Araby, EGYPT.

Table (1):showing the various parameters of the Aorta, Coeliac trunk, Splenic artery and Segmental branches of the Splenic artery (Mean ± SD)

Artery	MAX	MIN	TAMX	PI	RI	S/D
Aorta	0.48±0.032	0.011±0.18	0.30±0.012	021.0±1.41	021.0±0.61	210.0±2.66
Coeliac trunk	0.45±0.013	0.17±0.050	0.30±0.028	010.0±1.31	071.0±0.60	300.0±2.64
Splenic artery	0.42±0.041	0.16±0.071	0.29±0.001	011.0±1.30	014.0±0.52	022.0±2.55
Segmental artery	0.40±0.041	0.16±0.041	0.074±0.25	091.0±1.20	021.0±0.51	122.0±2.50

MAX = Peak Systolic velocity.

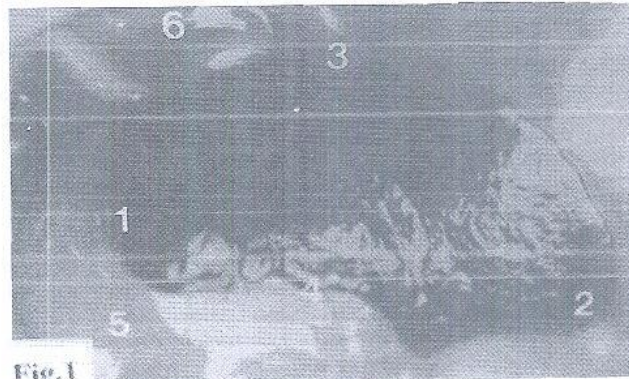
MIN= end Diastolic Velocity.

TAMX= Time Average Maximum Velocity.

PI = Pulsatory Index.

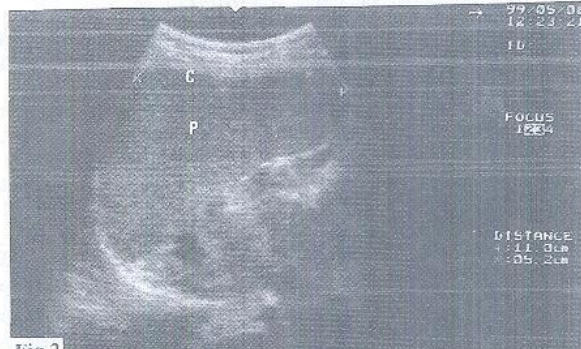
RI - Resistality Index.

S/D = Systolic/ Diastolic Ratio.



**Fig.1**

Fig. 1: Photographic representation of a Baboon monkey's spleen (Parietal surface).  
1- Extremitas cranialis      2- Extremitas caudalis.  
3- Margo dorsalis.      4- Margo ventralis.  
5- Stomach.



**Fig.2**

Fig. 2: Coronal ultrasonographical image of the normal spleen of an adult healthy monkey. Note the splenic capsule (C) and parenchyma (P).

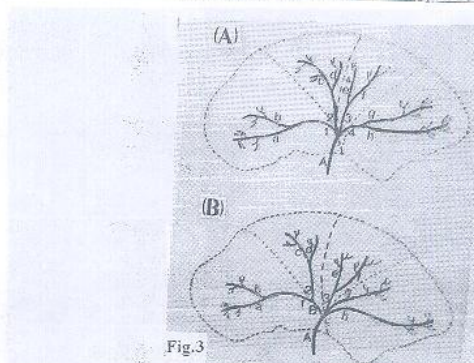


Fig.3

**Fig. 3 A & B:** Diagrammatic illustration showing two different patterns to the mode of division of the splenic artery.

A- A. Lienalis.

B- R. Cranialis.

1,2- Aa. Segmentales cranialis.

a,b,c,d- Rr. De Aa. Segmentales cranialis.

3,4- Segmentales caudalis.

e,f,g,h-Rr. De Aa. Segmentales caudalis.



**Fig. 4:** Photographic representation of a corrosion cast of a Baboon monkey's spleen, showing a mode of the intrasplenic distribution of the splenic artery.

A- A. Lienalis.

B- R. Cranialis.

1,2- Aa. Segmentales cranialis.

a,b,c,d- Rr. De Aa. Segmentales cranialis.

3- A. Segmentales caudalis.

e,f,g,h Rr. De Aa. Segmentales caudalis.





Fig.5

Fig. 5: Colour Doppler mapping of the splenic vasculature (A), showing Spectral Wave Doppler of the splenic artery (B) and segmental artery (C).

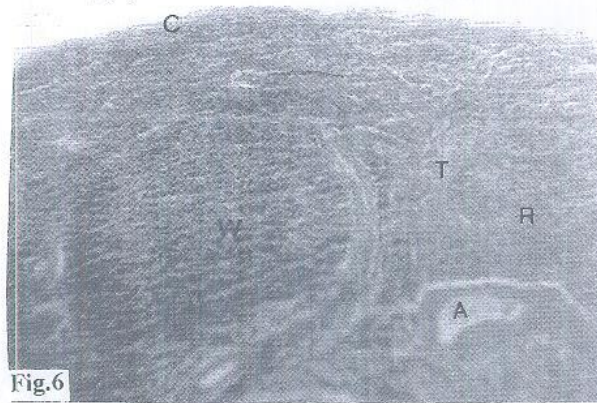


Fig.6

Fig. 6: Cross section in the normal spleen of a Baboon monkey, showing no pathological lesion (H&E. X.400).  
C- Splenic capsule                      T- Splenic trabeculae.  
W- White pulp.                          R- Red pulp.  
A- A small branch of the splenic artery.