Journal of Medical Sciences

ISSN 1682-4474

science alert

ANSInet
an open access publisher
http://ansinet.com

Research Paper

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued six times per year on paper and in electronic format.

For further information about this article or if you need reprints, please contact:

Dr. A.I. Shugaba
Department of Human Anatomy,
Faculty of Medical Sciences,
University of Jos, Jos Nigeria

J. Med. Sci., 6 (3): 445-451
May-June, 2006

Histomorphometric Profile of the Human Vermiform Appendix

A.I. Shugaba, M.B.T. Umar and S.P. Singh

The mucosal, luminal and lymphoid follicle diameters of the vermiform appendix were measured in micrometers from the basal, middle and terminal segments and their relationships analyzed and plotted. There is a strong relationship between these diameters, especially between lymphoid follicle diameter and the thickness on one hand and that between the luminal diameter and the lymphoid follicle diameter on the other. The lumen decreases when either the thickness or the lymphoid follicle diameter increases in size, suggesting that obstruction can occur at such sites with the resulting microscopic and macroscopic changes that come to bear on normal subjects. This segmental profile shows that, histomorphological and histomorphometric changes in the appendix are capable of explaining the basis and indeed the likely sites of obstruction in appendicitis.

Key words: Histomorphology, histomorphometry, luminal, lymphoid follicle, serosa-mucosal diameters, micrometers, segments

ANSInet
Asian Network for Scientific Information

Department of Human Anatomy, Faculty of Medical Sciences,
University of Jos, Jos Nigeria

INTRODUCTION

The vermiform appendix is described as a narrow blind tube usually about three or four inches (7.6 to 10.2 cm) long that extends from the caecum in the lower right hand part of the abdomen, has much lymphoid wall tissue, normally communicates with the cavity of the caecum and represents an atrophied terminal part of the caecum (Roper, 1987).

Beyond this simple definition is the myriad of clinical presentations associated with this tube so much so that many lives have been lost in the past as a result of either misdiagnosis or mis-management of conditions associated with it. In ordinary situations any structure attached to a larger more important part is referred to as an appendix.

But as far as anatomy, surgery and histopathology are concerned this worm-like appendix and indeed its attaching larger part are very important.

Although, grossly, the vermiform appendix has been described to help both the student and clinician, a lot more has been done and needs to be done at the microanatomy level to actually understand its structure and also give us the likely trends of events that lead to clinical conditions and the basis for further research.

Many factors in the past were thought to cause appendicitis which is the clinical condition as a result of its inflammation, which include diet, bacterial infection and parasitic infestation (Farquharson, 1978; Charles *et al*., 1975).

But this condition does not occur or arise *de novo* except as a consequence of the interplay of various factors that involve either its wall, length, diameter positions in the abdomen or pelvis or its blood supply (Charles *et al*., 1984; Sabiston, 1981; Williams, 1983). That is to say that the luminal, intraluminal or extra luminal structures of this organ far more than anything else are more responsible for the causation of clinical states.

Therefore, the histologic detail of this organ has to be fully understood. And this is exactly what I have set out to do. Especially also that the occurrence of appendicitis now cuts across race, social status, age and sex.

MATERIALS AND METHODS

This study was done in 2002 in Abnira Medical Centre, Jos, Plateau State, Nigeria as part of my thesis for the award of MSc Human Anatomy by the Ahmadu Bello University, Zaria. Two human Vermiform appendices were taken at operation from two patients who had no symptoms and signs at all for appendicitis but came for elective surgery; one for left ovarian cyst and the other for ventrosuspension of the Uterus after obtaining an informed consent for both the surgery and the removal of the appendix.

Under general anaesthesia, each appendix was carefully dissected, noting in the process the position of the appendicular artery and its branches within the meso appendix. This was then stretched and measured in centimeters before immersing in a medium containing 10% formol saline as fixative. Both borders of the appendix were freed and the two ends were then pinned down inside the Petri dish to allow for fixation in a straight tubal position for 4 h. Each appendix was processed for microscopic demonstration in the straight intact form by dehydration in graded series of alcohol (50, 70, 80, 90, 95%, Absolute), clearing in xylene for 3 h, embedding in paraffin wax and sectioning at 5 nm on a rotatory microtome. About 300 serial sections from the tip to the base of the appendix were taken and one out of every 10 sections was taken and measured out of which again one was then stained in Haematoxylin and Eosin.

The entire appendicular length was divided into three equal segments (base, middle and tip).

Each section representing a segment was then examined carefully under microscope for the general histomorphology and the following Histomorphometric parameters; the luminal diameter, mucosa-serosa thickness and the diameter of the lymphoid follicle in the submucosa at the points of maximal diameters and/or thickness were taken. Microtome direct measurements of these parameters preceded the microscopic measurements in order to find the shrinking factor all in micrometers which was then added overboard to all the values before statistical analysis.

For each parameter the micrometer calibration was checked and ensured to be within 0.00 before taking the ocular micrometer reading and multiplying both to get the actual morphometric reading

Using analysis of (ANOVA), these parameters were compared at the various zones of the vermiform appendix. Using this the values of the observed parameters were compared to examine for significance.

The profiles of these variables were studied to see their relations individually and in groups along the three segments of the organ.

RESULTS

Grossly, both appendices measured between 8 and 11 cm in length. Subject one, 24 years old 8.80 cm and subject two 32 years old, 10.60 cm. Their diameters were 0.64 cm for subject one and 0.76 cm for subject tow.

Table 1: The mean luminal, lymphoid follicle, mucosa-serosa diameters of the vermiform appendix in micrometers

	Base			Middle			Tip		
Diameter	Lumen (um)	Lymphoid follicle	Mucosa serosa	Lumen	Lymphoid follicle	Mucosa serosa	Lumen	Lymphoid follicle	Mucosa serosa
Subject A	124.630	40.833	254.39	256.10	42.680	110.97	73.41	25.65	221.95
	123.870	40.670	254.403	256.23	41.766	110.860	73.09	25.58	220.86
	124.701	40.818	254.60	256.09	42.873	110.872	73.38	25.506	222.02
	124.643	41.002	254.40	256.18	42.360	110.853	73.46	25.503	221.86
	124.901	39.001	253.96	256.02	42.090	110.866	73.389	24.980	221.864
	124.900	40.734	253.88	256.001	42.472	110.903	73.009	25.496	221.796
	124.456	40.564	254.30	256.021	42.600	110.918	74.010	25.563	221.863
	123.802	40.863	255.001	256.08	42.601	110.900	73.368	25.601	221.901
	125.010	40.796	254.08	255.87	42.594	111.003	73.300	25.630	221.800
	124.520	40.828	254.36	255.74	42.001	110.020	73.396	25.487	221.831
	150.24	49.41	220.24	199.760	179.93	192.93	235.61	20.492	105.85
	150.30	49.36	220.23	199.673	179.265	192.85	235.58	20.503	104.060
	150.180	49.48	220.18	199.801	179.208	192.900	235.490	20.612	104.960
Subject B	150.206	49.483	220.160	199.680	179.312	193.001	236.020	21.002	106.024
	150.239	49.201	220.160	199.706	179.258	192.600	234.964	20.500	105.70
	150.301	50.001	220.300	199.746	179.256	192.634	235.520	19.802	105.69
	150.021	49.000	220.301	199.504	179.200	192.860	235.490	19.700	105.79
	150.146	49.326	220.200	199.400	178.960	192.825	235.472	20.700	105.40
	150.230	49.300	220.30	199.923	179.200	192.940	235.640	20.560	105.556
	149.906	49.490	221.001	199.866	180.001	192.870	235.660	20.352	105.790

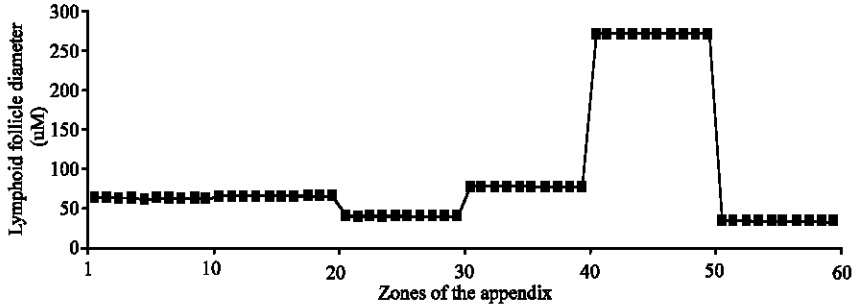

Fig. 1: Lymphoid follicle along the three segments and zones of the appendix

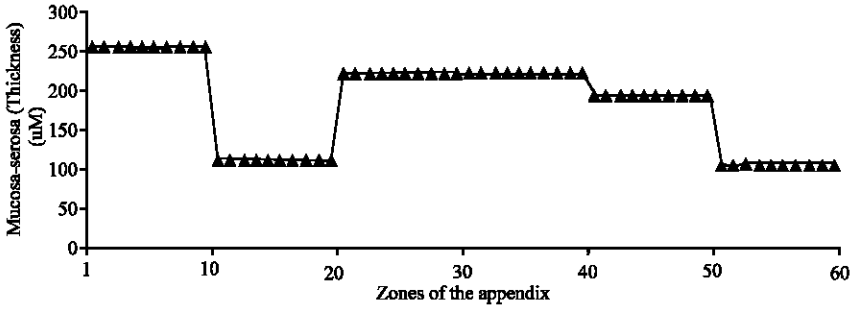

Fig. 2: Thickness (Mucosa-serosa) of the appendix along its length

All the specimens were found to be truly retrocaecal and not to be adherent either to the posterior abdominal wall as the caecum by fibrous tissues.

These specimens showed complete peritoneal covering of well formed mesentery, the mesoappendix. Within its were the appendicular arteries running along the free margin with that of Salamatu giving low branches along its course and Rabiatu's giving two branches. The mesenteries ended at the tips of the appendices. Rabiatu's showed profuse anastomosis at the base.

The slides stained with Haematoxolin and Eosin (H and E) and the observed parameters; the luminal diameter, lymphoid follicle diameter and serosa-mucosa diameter or thickness measured as shown in Table 1.

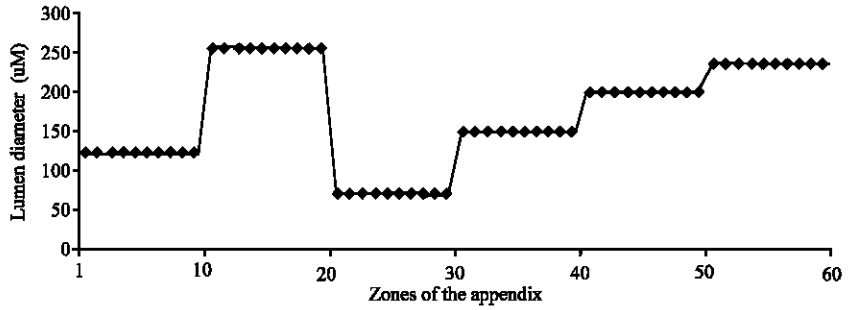

Fig. 3: Luminal diameter of the appendix from its base in the tip

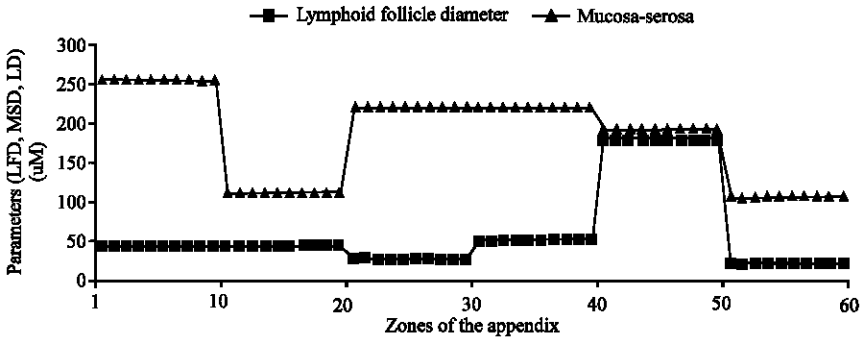

Fig. 4: Relationship between the lymphoid follicle diameter (LFD) and the mucosa-serosa thickness (MSD) along the different segments of the vermiform appendix

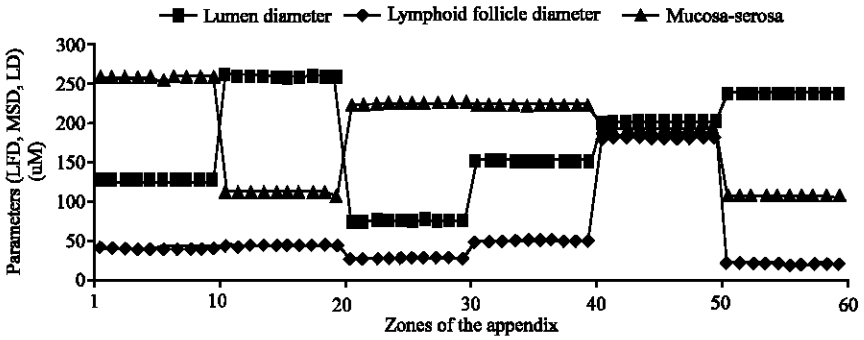

Fig. 5: Relationship between the lymphoid diameter (LFD), luminal diameter (LD) and the mucosa-serosa diameter (MSD) along the zones of the vermiform appendix from the base to the tip

This stain clearly showed the glands, various layers of the appendicular wall including areas of vascular deficiencies and distribution of the epithelium (Table 1).

The observed parameters were each plotted against the zones of the appendix from the base to the tip (Fig. 1-5).

A total of 60 zones were compared for the lymphoid follicle diameter, thickness (mucosa-serosa diameter) and luminal diameter. Individually and finally all these parameters compared together on a graph.

The lumen diameter has seen in the various segments is interestingly not largest in the middle zones of the organ. Within zones 1 to 30 this diameter is greatest in the middle zone whereas from zones 1 to 60 the lumen diameter is largest in the tip.

The lymphoid follicle diameter in the three segments of each subject does not particularly follow a certain trend.

The most interesting observation is that of the organ thickness (serosa-mucosa) where the natural trend of the thickness of the caecum does not follow by decreasing from the base of the appendix towards its tip.

The thickness from zones 31-60 shows an expected trend of decreasing along the length of the appendix, but

in zones 1 to 30, there is an initial rise at the base, then decreased in the middle segment before increasing in the tip.

DISCUSSION

The general Anatomical Morphology of the vermiform appendix as described in standard anatomy textbooks, journals and other studies is not analyzed and discussed here since it is the histomorphological and histomorphometric profile and variations of the observed parameters that are being considered. And there are not also computed between different individuals being foundation research in this area of the organ.

Such detail as the general disposition of the organ within the abdominal cavity and the noted variations and compliance of the normal vascular supply of the organ cannot also not be analysed in this study, because the number needed for such is not considered when doing histomorphometry.

The figures obtained for the lengths and diameters of these specimens fit into the normal range for the human appendix and rightly in those of the age groups of these subjects. Meaning therefore that the studied appendices can be said to be "normal". Infect, if these organs were pelvic in position they might have shown some evidence of inflammation due to recurrent sub clinical pelvic inflammatory disease (Okojie, 1979; Ojo *et al*., 1991; Robins and Cotran *et al*., 1979; Shigang *et al*., 2000).

Using analysis of variance (ANOVA), these diameters were compared at the various zones of the appendices. Using this statistical analysis, the values of the observed parameters as shown in Table 1 were compared to examine for significance in their relationship. Either individually along the entire course of the organ or when two or three at these diameters are combined along the course of this very important part of the gastro intestinal tract.

The zones of the organ were numbered from the most proximal segment (1 and 31) to the most distal segment at the tip of each specimen (30 and 60). Similarly, Fig. 1-5 of these measured diameters were each plotted against the appendicular zones from the base to the tip and also for the lymphoid follicle diameter and thickness and finally for all the observed parameters.

The human vermiform appendix has been grossly understudied as not really studied in relation to the profile of these parameters along its course thereby making available data for within species comparison scanty. This infect leaves me with the burden of setting some sort of foundation data at least for this environment for further research and discourse.

The Table 1 and Fig. 1-5 for these diameters give us and overview of their profiles along the entire length of the appendix and their relationships that bear on clinical conditions in diseased situations.

The luminal diameter does not show uniformity along this organ. So other factors like the thickness, amount of lymphoid follicle in the submucosa, the age of the subject or indeed the normality of the processed organ must be playing roles in determining the luminal diameter. Unfortunately these factors have not yet been studied and documented in the literature as those of other lower animals like the human oviduct (Ogunranti, 1988a; 1991; Seckinger, 1923).

In the same way, the lymphoid follicle diameter in the three segments of the appendix does not particularly follow a certain trend. Herein lies the area for further research both in the human appendix and those of the lower animals especially now that diseases of the appendix are beginning to be understood in the light of nutrition and immunology. These two together with both the age and other concurrent diseased conditions of the subjects go a long way in determining the amount of the lymphoid follicle and thereby the diameter. Of course, this diameter will together interplay with either the luminal diameter or the thickness of the organ to determine the probable site or sites of obstruction of this organ as shown in both the figures plotted for lymphoid follicle diameter and thickness against the zones and that of the three observed parameters against the zones.

The most interesting observation is that of the organ thickness (serosa-mucosa) It would have been naturally assumed that this thickness should decrease from the base to the tip (i.e., from zones 1-30 and 31-60) since the base is directly from the thick walled caecum but this is not the case as shown in Table 1 for the subjects and the analysis of both data and the plotted graphs.

The thickness of the second subject has shown the expected trend from the base to the tip (i.e., zones 31-60) where the thickness decreases along the course. whereas that of the first subject shows an initial rise at the base, then decreased in the middle segment before increasing in the tip.

All these observed variations have well been illustrated in the preceding interaction bars. But by far the most interesting finding of this study is the relationship between the observed parameters especially as seen in the middle segment zones of the second subject (zones 40-50) and to some extent also the middle segment zones of the first subject (zones 10-20)

A veritable ground for further exploration of the roles of the lymphoid follicle and thickness (Serosa-Mucosa diameter) of the organ has been shown in the plotted

figures and thickness against the zones where an explicit finding has been illustrated in the middle segment zones of both subjects (zones 10-20 and zones 40-50). This will probably explain the occurrence of appendicular obstruction in the middle segments of the vermiform appendix. This finding has not been reported in the literature apart from the usual knowledge that appendicular obstruction is either as a result of arterial blockage or luminal obstruction caused by either faecalith or foreign bodies or parasites. (Farquharson, 1978; Glover, 1984; Kelly and Hurdon, 1905; Okojie, 1979; Schwartz, 1984; Sleisenger and Fordtran, 1983; Shigang *et al*., 2000; Charles *et al*., 1975; Wilson *et al*., 1978; Williams, 1983). This finding seems to me both convincing and scientific in the sense that these two parameters; the thickness of the organ and lymphoid follicle diameter ultimately determine the calibre of the luminal diameter and hence its affectation.

What needs to be investigated however the factors both *in vivo* are (if possible) and *in vitro* that affect these parameters. Together with such a research is also the comparative study of these parameters between human vermiform appendix and those of lower animals like the rat and rabbit with similar appendicular gross and microscopic structures.

CONCLUSIONS

This analysis of the segmental profile of the vermiform appendix has provided histomorphometric changes in its structure capable of answering the age long question of whether diseases associated with it are caused only by vascular phenomenon and luminal intrusion of extra appendicular substances or as a result of the interplay of its structural configurations with other factors. This is so because of the noted strong expression of relationship between the observed parameters, more especially the ones existing between the lymphoid follicle diameter and the thickness on one hand and that between the luminal diameter and the lymphoid follicle diameter on the other. For example, the lumen decreases when either the thickness or more importantly the lymphoid follicle diameter increases in size suggesting that obstruction can occur at such sites with the resulting microscopic and macroscopic changes that come to bear on normal subjects. The basis for further studies of the vermiform appendix has been established from this study especially in the areas of comparative histomorphometry and finding the effects of hyper cholesterol diet on the lymphoid follicle. Because other variables like the vascular pattern of the appendix, the various positions seen in our local areas both for the living surgical patients and dead are being looked at more than these parameters.

This study will also give a basis for caution especially when teaching students the basis for and occurrence of appendicitis and its related sequelae in clinical medicine. For those interested in appendix transplantation and endoscopic studies of the appendix, these are the results for guidance and future manipulations.

RECOMMENDATIONS

One will in the light of the preceding therefore recommend further histomorphological, histomorphometric and histochemical studies of the vermiform appendix in various age groups, sexes and if possible races.

Apart from this it will be worthwhile studying these parameters *in vivo* using modern harmless radio active substances and comparing same with Cadaveric Specimens. The effects of hyper cholesterol diet on the lymphoid follicles of the appendix should be studied and also the variation of the lymphoid follicle in clinical cases of perforated appendix will be another area of interesting research.

REFERENCES

Alexander-Williams, I. and H.I. Binder, 1983. Large Intestine. B. I. M. R Gastroent. 3: Butterworth

Archer, O.K., D.R. Sutherland and R.A. Good, 1963. The appendix in rabbits after neonatal thymectomy. Nature, 200: 337f.

Baron, D.N., 1980. Short Textbook of Chemical Pathology. ELBS Reprinted Edn., pp: 144-145.

Berry, R.J., 1900. The true caecal apex or the vermiform appendix. It's minute and comparative anatomy. J. Anat. Physiol., 35: 83f.

Buchman, I.G. and G.D. Zuidema, 1984. Reasons for delay of diagnosis of acute appendicitis. J. Surg. Gyn. Obst., 158: 260-266.

Cahrles, M.A. and H.H. Alden, 2002. Surgical Secrets. 2nd Edn., 47:159-162.

Chadwick, V.S. and S. Phillips, 1982. Small Intestine. B.I.M.R Gastroent. 2. Butterworth.

Chaurasia, B.D., 2002. Human Anatomy. 3rd Edn. CBS., pp: 223-226.

Curtis, H., 1984. Biology. 4th Edn., ELBS., pp: 120-125.

Doe, W., 1986. Immunology of the gastrointestinal tract. Med. Intl., 2: 1044f.

England, M.A., 1983. A colour atlas of life before birth. 2nd Edn. ELBS., 3: 70-75.

Farquharson, E.L. 1978. Textbook of Operative Surgery. 6th Edn., ELBS., 21: 615-617.

Glover, J.W., 1984. The appendix revisited. 20th AGM proceedings of the provincial surgeons of Australia, pp: 1-5.

Glover, J.W. 1988.The Human vermiform appendix.A General Surgeonsreflections, creation. Ex Nihilo Technol. J., 3: 31-38.

Ham, A.W., 1965. Histology. 5th Edn., J.B. Lippincott Philadelphia and Montreal, pp: 700-701.

Heiner, E.E. and C.L.H. Foster, 1960. Textbook of Histology for Medical Students. 8th Edn., ELBS., pp: 303.

Henrikson, R.C., G.I. Kaye and J.E. Mazurkiewicz, 1988. Histology (National Medical Series for independent study). 1st Edn., pp: 284-285.

Kavanagh, M., 1983. A Complete Guide to Monkeys, Apes and other Primates. 2nd Edn., ELBS., pp: 85-90.

Kelly, H.A. and E. Hurdon, 1905. The Vermiform Appendix and its Disease 1st Edn., W.B. Saunders, Philadelphia, pp: 150-155.

Leeson, C.R. and T.S. Leeson, 1976. Histology. 3rd Edn. W.B. Saunders, pp: 361-363.

Luiz, C.J., J. Carneiro and R.O. Kelley 1988. Basic Histology. 9th Edn., Appleton and Lange, pp: 300-320.

Minocha *et al*., 1999. Previous appendectomy in Endoscopy subject. Southern Med. J., 92: 1.

Mitra, S., 1997. A Textbook of Anatomy 4th Edn., Academic. Publisher Calcutta, pp: 184-185.

Okojie, G., 1979. Aetiology of Appendicitis (letter). Br. Med. J.V. Page.

Ogunranti, J.O.,1988a. The oviduct as an endocrine gland. Lancet, 1: 1-17.

Ogunranti, J.O., 1991. Histomorphometric evidence of cyclic changes in the rat oviduct. Proc. Nigerian Acad. Sci., pp: 3.

Ojo, O.S., S.C. Udeh and W.O. Odesammi, 1991. Review of the histopathological findings in appendicitis removed for acute appendicitis in Nigerians. J. R. Col. Surg. Edin., 36: 245-248.

Perey, D.Y., M.D. Cooper and R.A. Good, 1968. The mammalian homologous of the avian bursa of fabricius. J. Surgery, 64: 614f.

Robins, S.L. and R.S. Cotran, 1979. Textbook of Pathology. 2nd Edn., Saunders.

Roper, N., 1987. Pocket Medical Dictionary. 14th Edn., 22, Churchill Livingstone.

Schwartz, S., 1984. Principles of Surgery. 4th Edn., McGraw Hill, pp: 1245f.

Singh, I., 2000. Human Embryology. 6th Edn., Macmillan, pp: 168-169.

Signh, S.P., 2003. Manual of Practical History. 2nd Edn., A.B.U. Press Zaria, pp: 43.

Sleisenger, M.H. and J.S. Fordtran, 1983. Gastrointestinal Diseases. 3rd Edn., Mc Graw Hill, pp:1268f.

Shigang Xiong, P.P., L. Nerneth, D.S. Britain and D.J. Reen 2000. Neuronal Hypertrophy in acute appendicitis. Arch. Path. Lab. Med., 124: 1429-1433.

Sussdorf, D.M. and I.R. Draper, 1956. Antibodies in rabbits after irradiation: Shielding the appendix. J. Inf. Dis., 99: 129f.

Steven, L. and J.D. Jeffrey, 2002. Vermiform appendix. http:// www.emedicine.com/md/topic 3327.htm.1-9

Sir Charles, L.L. Lingworth and B.M. Dick, 1975. Textbook of Surgical pathology. 11th Edn. ELBS., 14: 271-272.

Sabiston, D.C., 1981. Textbook of surgery. 1st Edn., Saunders, 1: 1048-1064.

Seckinger, D.L., 1923. Spontaneous Contractions of the fallopian tube in the domestic pig with reference to the estrous cycle. Bull. John Hopkins Hosp., 34: 236-240.

Tome, V.A. and F.P. Retief, 1978. Human vermiform appendix: Immunocompetent cell topography and cell to cell interactions *in situ*. J. Imm. Meth., 20: 333f.

Wangensteen, O.H. and C. Dennies, 1939. Experimental proof of the obstructive origin of appendix in man. Ann Surg., 110: 629 646.

Wheater, P.R., H.G. Burkitt and V.G. Daniels, 1982. Functional Histology. A Text and Colour Atlas. 1st Edn. ELBS., pp: 60-65.

William, A.B. 1977. Lecture Notes on Histology. 2nd Edn., Blackwell, pp: 156.

Williams, G.R., 1983. A History of Appendicitis. Ann Surg., 197: 495-506

Williams, P.L. and R. Warwick, 1989. Grays Anatomy. 37th Edn., Churchill Livingstone, pp: 233-1366.

Wilson, E.R.T. Eisner, W.R. Briggs, R.E. Dickerson, R.L. Metzenberg, R.D. Obrien, M. Susman and W.E. Boggs, 1978. Life on Earth. Biology. 2nd Edn., ELBS., pp: 175-176.