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THE HUMAN VERMIFORM APPENDIX: MORPHOLOGICAL AND ANATOMICAL REVIEW

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The article covers aspects of morphological, anatomical, embryological, histological aspects and origin, types, blood supply, innervation, lymph drainage of human vermiform appendix. The purpose of the study is to understand real function and to summarize this information for positive impact on clinical decision in case of appendicitis. Although characteristic features of normal and diseased appendix have been reported for many previous centuries, it still the most common challenge facing every day in operation room. The appendectomy, commonest surgical emergency procedure, may cause little confusion in surgeons due to highly variable situations of it inside the abdominal cavity. However, the recent imaging techniques have increased ability of surgeon for crucial diagnosis of the diseased appendix.

K e y w o r d s : vermiform appendix; mesoappendix; gross anatomy.

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Introduction

A vermiform appendix occurs only in humans and anthropoid apes, although some other mammals may have a similar organ. It is a narrow, hollow, and muscular structure [1]. It is the narrowest part of the digestive tract, having failed to keep pace in growth with the rest of the caecum, and it develops as a continuation of the caecum and particularly the tip of the caecum, which failed to enlarge [2, 3]. It is regarded as a vestigial structure with an unclear function [4].

The appendix typically emerges from the posteromedial side of the human caecum at the junction of the three taenia coli (taenia means flat bands) about one to two cm below the ileum. So it is a dead-end that opens into the caecum a little below the ileocaecal orifice or valve that lets unabsorbed food from the ileum into the caecum from time to time [5].

The appendix has a base, which is the spot of a concourse of the three taenia coli situated at the posteromedial border of the caecum, below the ileocaecal valve [6]. On the surface of the abdomen, the base of human appendix lies one-third of distance above an oblique line that joins the right anterior superior iliac spine with the umbilicus, this point is known as “McBurney’s point” which is a significant surgical approach [7]. While the base of appendix is simply found within the abdomen by distinguishing the three taenia coli of caecum and following them to the appendix base where they gather to establish a complete longitudinal muscular coat [8].

Embryological development of human vermiform appendix

The vermiform appendix develops from the caecal bud that reveals at the 6th week of embryonic development, in embryos of about twelve millimeters crown-rump length, as a little conical expansion at caudal limb of the primitive intestinal loop [9]. The appendix forms at the apex of this expansion or dilatation and becomes displaced into the right iliac fossa during the growth, rotation, and descends of the caecum that occurs in a sequent manner starting at the tenth week of embryonic development when the herniated loops of an intestine initiate to return into the cavity of the abdomen [10].

Despite the imprecise factors that produce this return, it is supposed that mesonephric kidney regression, liver reduced growth, and actual expansion in abdominal cavity size may play characteristic roles. The proximal jejunal part is the first portion that re-enters to abdominal cavity and comes to locate at its left side. The ultimate returning intestinal loops settle further and further to right, and the caecal bud is regarded as the last portion of human gut that re-enters inside its abdominal cavity [11, 12].

Temporarily, this caecal bud is located inside the right upper abdominal quadrant immediately down the right hepatic lobe, and from this point it directs to right iliac fossa, thereby setting the right colic flexure and the ascending part of colon on right side in human abdominal cavity [13]. During this operation the distal extremity of the caecal bud creates a narrow diverticulum, the primitive appendix that develops as a continuation of the caecum at its inferior tip; therefore the appendix represents the tip of the caecum which fails to enlarge [14].

Classification of the origin of human vermiform appendix [15–18]

Type I: It is the fetal type; characterized by the conical-shaped caecum, the vermiform appendix emerges from its apical part at the longitudinal axis of colon, and the three taenia coli which converge at the vermiform appendix base are separated with almost equal distances.

Type II: It is characterized by more quadrilateral-shaped caecum than that of the fetal type, the three taenia coli possess their relative position, and the appendix arises between the two bulging sacculi.

Type III: The caecal part located lateral to a structure known as taenia libera, which is the anterior band, develops in proportion to the other part situated medial to this band. The dorsal wall developed lesser than the ventral; therefore, the caecal apex is turned dorso-medially and almost meets up with ileocaecal junction.

Type IV: This type is characterized by excessive caecal development on the lateral side of taenia libera with atrophied medial segment; the taenia libera directs to a caudal angle of the ileocaecal junction, and the appendix base situated dorsal to this angle and seems to spring from that junction.

At birth, both the appendix with the caecum still have the fetal form but after birth, the caecal portion located lateral to the appendix shows significant growth, on contrary, the medial portion does not undergo any expansion or it may retrogress [19].

The evolutionary history and function of the vermiform appendix

Berengario da Carpi was the first who described the human appendix in 1521, while Claudins Amyand was the first who performed appendectomy in 1735 at S. George's hospital in London; however, Lawson Tait was the first surgeon who was removed the diseased appendix in 1880 with a successful procedure [20].

Nowadays appendectomy represents the most common case faced in surgical emergency wards when acute appendicitis is recorded in 4–6% of community individuals [21]. Although, the evolutionary history and exact functions of this structure are not well-known but the precise diagnosis and the curative treatment of the diseased appendix are well assured [22].

The functions of appendix had been an issue of much debate across history and different theories had been cited like neuromuscular, endocrine, or exocrine roles of this structure [23].

On contrary, other researchers suggested that the human appendix lacks any function completely [24]. The elicited consensus reveals that the vermiform appendix assists as a component of the immunity system, as the recent evidence suggests that it is a principal site for the differentiation of immunocompetent B-lymphocytes [25]. In infancy and childhood, it has the semblance of a well-established lymphoid structure with a remarkable immunological function [26].

The human appendix resembles the tonsils, indeed it has been called "tonsil of the abdomen"; and like the tonsils, the appendix is frequently infected and then becomes a menace [27]. This name reflects the actuality that it contains an excessive amount of lymphoid tissues, besides its location close to the large intestine entrance which sustains the appendix primary entrance of antigens accessing to the caecum. The evolutionary history of the vermiform appendix proves hard to trace [28]. Details of this history appear complicated link to its functions; some suggesting this structure is functionless in human beings and tend to declare it as a vestigial organ. This opinion is established mainly on the existence of significantly developed vermiform appendix in the "lower" animals, like a rabbit, resulting in some researchers considering the small human vermiform appendix as a vestigial or rudimentary structure. However, many primate anatomists accept the fact to regard the vermiform appendix as an evolutionarily derived structure present just in humans and apes [29].

The morphological aspect of the vermiform appendix

The vermiform appendix is a worm-shape narrow tubal structure that emerges from the posteromedial caecal border, two cm or less under the ileal end, and may present in one of various following positions [30–33]:

It can be located behind the caecum (retrocaecal) and the lower portion of ascending colon (retrocolic).

It can descend above the lesser pelvis brim (descending or pelvic), in which the appendix situates closely related to the right ovary and uterine tube of the female.

It can situate under the caecum (subcaecal).

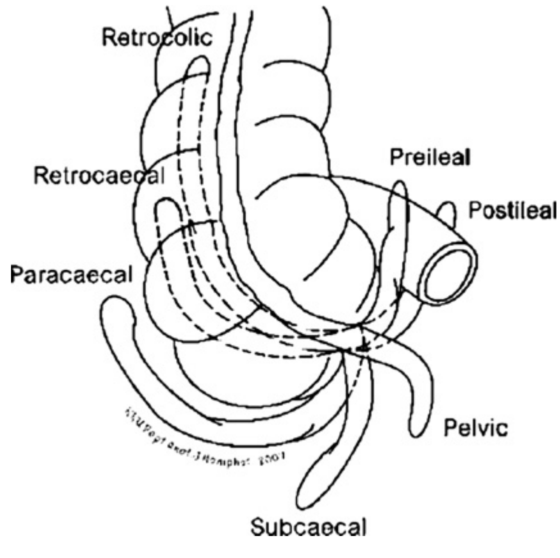
It can situate anterior to the terminal ileal part and can then be very close or in contact with anterior wall of the abdomen (pre-ileal).

It can situate posterior to the terminal ileal part (post-ileal).

Although these classical figures were based upon a very large variation shows much contradiction, and with all these positions classification was found into two groups [34]:

- anterior (which represent pelvic and ileocaecal) and
- posterior (which represents retrocaecal and subcaecal).

At birth, the vermiform appendix is broad and short at the junction to the caecum, while distinctive caecal growth yields a representative tubular-like structure by approximately two-year age. Furthermore, during childhood period caecal continued growth usually turns the human appendix to a retrocaecal position but still intraperitoneal [35].



Shows various positions assumed by the vermiform appendix and its relation to the caecum and the ileum [11].

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Frequency and number of the position of the adult vermiform appendix by different investigators [35]

Authors	Country	No. of cases	Position %							
			Anterior			Posterior			Paracaecal	Ectopic
			Pelvic	Ileocaecal	Preileal	Postileal	Subcaecal	Retrocaecal		
Collins	USA	4680	7.9	78.5			1.3	20.2		
Peterson	Finland	373	42.2	26.8			—	31.0		
Maisel	South Africa	300	58.0		1.3	3.3	5.0	26.7		
Shah &Shah autopsy	India	186	34.9	28.0			7.0	30.1		
Liertz	Germany	2092	42.1		13.9		9.0	35.0		
Buschard	CSSR	93	44.1	11.8			0.0	44.1		
Waas	Ceylon	266	24.1	28.6			13.0	35.3		
Solanke	Nigeria	125	31.2	19.2			11.2	38.4		
Buschard	Denmark	141	33.4	7.8			2.1	56.7		
Shah &Shah operation	India	405	8.2	26.9			3.7	61.2		
Wakeley	Great Britain	10.000	31.0	1.4	1	0.4	2.3	65.3		0.05
Katzarski	Zambia	103	43.6				—	20.3		
Ajmani	India	100	23	—	2	10	5	58	2	
Ojeifo	Nigeria	548	25	—	1.8	14.8	2.4	45	6.4	4.7

In about one-quarter of individuals, appendicular rotation does not take place leading to a paracaecal, subcaecal, or pelvic position; and sometimes the appendicular tip becomes extraperitoneal in position locating posterior to the ascending colon or caecum [32].

Infrequently during caecal development, it does not emigrate toward its normal anatomical position at the right lower abdominal quadrant, and at this situation, the appendix may be observed close to the right ureter or the gall bladder; therefore the ileocaecal position includes appendices in the pre-ileal, post-ileal, paracaecal and left-sided positions [30].

However positional percentages for the vermiform appendix is unreliable and the surface marking must be utilized for the appendicular base which is the union of the middle and lateral thirds of an imaginary line connecting the umbilicus to the right anterior superior iliac spine (McBurney's point); but considerable variation may occur [36].

The appendix ranges 2–20 cm in length and the average in the adults approximately 9 cm [3, 10, 12, 14, 18, 22]; while in children longer than adults, and it can be atrophied to become significantly smaller about the mid-adult age [26].

The vermiform appendix is joined by a short "mesoappendix" to the inferior or lower part of the ileal mesentery; this fold, in the majority of cases, is less or more triangular and extends throughout the whole length of this tube as an observed rule [17, 37].

Therefore, the appendix has a complete peritoneal coat that is bind to the small intestine mesentery through a short own mesentery that suspends the appendix from the dorsal body wall making this organ an intra-peritoneal structure [28]. This mesoappendix allows considerable freedom of movement to the appendix, which may be found lying over the pelvic brim or tucked behind the caecum or ascending colon and any other position, is often affected by the length and mesenteric attachment of the appendix [16].

The canal of human vermiform appendix is narrow, and communicates to the caecum through an orifice that is situated under (about 2.5 cm) and a little posterior to the ileocaecal valve; this orifice is occasionally guarded with a mucous membrane fold forming a semilunar valve [33, 38]. So the region of the vermiform appendix adjacent to the caecum has a thickened muscular coat and slightly narrow lumen [29].

The lumenal diameter varies with age [10, 16, 20, 22, 37]:

a. The lumen tends to be rather wide (6–8 mm) in infants and young children.

b. It is often entirely obliterated by middle age.

c. The lumen is dangerous narrow in adolescents and young adults; because of that during this period it may be occluded by a fecalith or even by edema and swollen lymphatic tissue associated with mild inflammation and this explains the high frequency of acute and chronic appendicitis in teenagers and young adults.

Blood vessels of the vermiform appendix

There is no general agreement about the arterial supplying for the human vermiform appendix. The inferior and superior mesenteric arteries are supplying the large intestine [34, 39].

The ileocolic artery is the lowest branch on the right of superior mesenteric artery; it directs right and downward at the back of the peritoneum, toward the right iliac fossa where this artery undergoes division into inferior and superior branches [40]. The inferior branch is anastomosed with the termination of superior mesenteric artery, while the superior is anastomosed with right colic artery. The psoas major muscle, testicular (or ovarian) vessels, and right ureter are anteriorly crossed by the ileocolic artery throughout its course [39]. The ileocolic artery which is the end branch of superior mesenteric artery has four sets of branches [9, 30, 34, 40]:

1. The ascending colic artery directs over the ascending colon to supply its basal portion.
2. Posterior and anterior caecal arteries distribute to the back and front of the caecum and supplying the caecum.
3. Ileal branches that run to left and upwards above the lower ileal portion (the terminal ileum), and supplying this part of the small intestine; then it ends by anastomosing to the termination of superior mesenteric artery.

4. The appendicular artery which supplies the appendix is the terminal branch of the ileocolic artery; and descends posterior to the terminal end of the ileum and gets inside the mesoappendix at a short interval close to the appendicular base. Following given off a small recurrent branch that gets anastomosed to a branch of posterior caecal artery, it directs -at first- near to and then enters into the meso-appendicular free border.

Occasionally an accessory appendicular artery can exist but, in the majority of the population, the appendicular artery is regarded as an "end-artery" and thrombosis of it leads to appendicular necrosis [41].

Therefore, the main appendicular artery is that one, which runs in the crescentic fold of the mesoappendix to the appendicular tip, whereas the accessory appendicular artery provides other parts of the appendix except for the tip. Branches of the appendicular artery divide into fine ramifications on the walls of the appendix and anastomose freely while the terminal part of the main appendicular artery supplying the tip is usually an end-artery with no anastomosis with other branches [34].

The venous drain system for the vermiform appendix is by those veins joining the previously mentioned arteries and their drainage into the portal vein through the way of the superior mesenteric with its appendicular vein [40].

The lymphatic drainage of the vermiform appendix

The appendix drains from its lymphatic follicles throughout the muscular wall into lymph nodes at mesoappendix, those lymph nodes drain to the paracolic lymph nodes situated along the ileocolic artery by four or more lymphatic channels which traverse the mesoappendix, and therefore, that paracolic lymph nodes also called ileocolic lymphatic nodes [24, 25, 42].

From these lymph nodes, lymph drains to the superior mesenteric lymphatic nodes; and this superior mesenteric group of pre-aortic lymphatic nodes surrounds the proximal part of superior mesenteric artery behind the neck of the pancreas; and they lie just below the celiac group, into which they send their efferent lymphatic vessels. They receive all the efferent vessels from the inferior mesenteric group [25].

The submucosa of the vermiform appendix includes multiple follicles or lymphatic aggregations; this excess of lymphatic tissues have promoted the significance that the vermiform appendix is the human being analogous to the avian bursa of Fabricius which is the site for thymus-independent lymphocyte maturation, therefore there is recent evidence suggests that the vermiform appendix is a principal site for the differentiation of the immunocompetent B-lymphocytes [43].

A few submucosal lymph follicles exist at birth, but their follicles with an excessive number to about 250 between the ages of twelve and twenty and reduce abruptly after the age of thirty with only a trace remaining after the age of sixty. Therefore lymphatic tissue is profuse in the child but becomes less in the adult and atrophies in old age [29, 42].

Innervation of the vermiform appendix

The autonomic and sensory fibers reach the small and large intestine by way of continuations of the celiac, superior mesenteric, and inferior mesenteric plexuses that accompany the colic arteries. The sensory fibers include pain fibers and fibers concerned with reflex regulation of movement and secretion. Although the intestine is quite insensitive to most painful stimuli, including cutting and burning, it is quite sensitive to distension; this distension results in a sensation of cramp [23, 28].

The pain fibers in the colon are activated by distension and enter to spinal cord through the way of the splanchnic nerves. Initially, visceral pain of the vermiform appendix is created by distension of the tubal lumen or spasm in its muscles; and the fibers of afferent pain enter at the 10^{th} thoracic segment level into the spinal cord, having ascended by the lesser splanchnic nerve and the superior mesenteric nerve plexus [15].

The preganglionic parasympathetic nerve fibers pass to the abdomen through the right (posterior) and left (anterior) vagal trunks, and these fibers are spread into different abdominal visceral structures and the alimentary (gastrointestinal) tract parts from the stomach to the left (splenic) colic flexure including the vermiform appendix [44].

The fibers which enter the alimentary tract ends in the postganglionic neurons at the Meissner's (submucosal) and Auerbach's (myenteric) plexuses; these postganglionic nerve fibers supply glands and smooth muscles, while the parasympathetic fibers stimulate the peristalsis process, relax the sphincter and stimulate secretions. The sympathetic preganglionic fibers enter by the sympathetic trunk (through its thoracic portion) and pass into the lesser and greater splanchnic nerves; then these fibers descend to the abdominal cavity where they synapse to the postganglionic fibers in the superior mesenteric and celiac ganglia [28].

The postganglionic neurons are spread to the intestine (including the vermiform appendix) as nerve plexus around most of the branches belong to the superior mesenteric and celiac arteries. The sympathetic nerve fibers inhibit the peristalsis process, inhibit secretions, and cause contraction for the sphincters [45].

Histological structure of the vermiform appendix

The appendix is a diverticulum of the large intestine and its wall has the same general structure except that the longitudinal muscle coat is evenly distributed around the circumference [29]. The layers of the vermiform appendix from outside to inside are [4, 6, 9, 13, 23, 24, 29, 35]:

1. The serosa: establishes a complete covering for the tubal structure, except throughout the narrow attachment line of its mesentery; and beneath it lies a layer of the subserous areolar tissues.
2. The muscularis externa — which consists of:
   a. An outer longitudinal layer of smooth muscle that forms a thick uniform layer that invests the entire structure; except at specific one or two

spots where the circular and longitudinal layers can be absent; therefore, the submucosal and peritoneal coats are neighboring at small areas. At the base of the appendix, the longitudinal muscle becomes thickened around the perimeter to form incipient taenia coli which becomes continuous with these of the colon and caecum.
   b. An inner circular layer of smooth muscle which is thicker than longitudinal layer, and is isolated by very small amounts of connective tissues. The parasympathetic nervous ganglia of the Auerbach's (myenteric) plexus may be present between the outer and the inner smooth muscle layers.
3. The submucous layer: is a well-developed layer that includes a high number of lymphoid tissue masses that produce bulging of the mucous membrane into the tubal lumen and cause the latter to be irregular in shape and smaller in size.
4. The mucous (mucosa) layer — composed of the following parts:
   a. The muscularis mucosae: this layer has two parts of smooth muscle fibers, the outer longitudinal and the inner circular.
   b. The lamina propria: displays numerous lymphoid nodules and lymphoid cells.
   c. The epithelium: consists of simple columnar and contains goblet cells.

The appendix is characterized by a great increase in lymphoid tissue, the nodules occupying a large part of both mucosal and submucosal coats; the muscularis mucosae is rather deficient. The lymphatic nodules have germinal centers and are very numerous and highly characteristic of the appendix; these nodules because of their large sizes may extend from the surface epithelium to the submucosa [23].

The glands are much less carefully packed than those of large intestine; they are multiple in early life and tend to disappear in old age. Glands are few in numbers and perforate deeply amongst the lymphoid tissues [9].

In the vermiform appendix, the lymphatic tissue lies in its lamina propria and submucosa, where parafollicular and follicular zones can be distinguished; clusters of lymphocytes or immunoblasts are also lying within or between the surface epithelial cells where they possibly mature or differentiate into plasma cells [29].

The lymphoid tissues of the lamina propria have numerous plasma cells, together with acidophilic leukocytes, lymphocytes, macrophages, and mast cells are all implanted inside the fibrocellular reticulum. The germinal centers (submucosal follicles) contain immunoblasts, lymphocytes, macrophages, plasma cells, and dendritic reticular cells; the last two cells being most abundant in the central regions of the follicles; cells similar to the dendritic reticular cells have been found in the human thymus [13, 24, 35].

The parafollicular zones are distinguished by aggregations of small lymphocytes, some plasma cells, and by the presence of post-capillary venules lined by a tall endothelium through which lymphocytes may migrate. These endothelial cells have a surface covering of immunoglobulins that can be included within the control for lymphocyte recirculation [29].

The lymphatic masses provide a local defense against the infection and are also suggested to be a possible homolog to bursa of Fabricius of birds, which is concerned with the acquisition of immunological competence by certain lymphocytes [46].

In most adult individuals, the normal anatomical structure for the vermiform appendix is significantly lost causing the appendage is finally filled by fibrous tissues. The structure of its wall differs from that of the small intestine; however, its mucosa, on the other hand, is similar to that of the colon [20].

REFERENCES

1. Basmajian V. J. Primary Anatomy. 8th ed. Baltimore, Williams & Wilkins; 1985. P. 210–3.
2. Williams N. S., O'Connell P. R., McCaskie A. W. Bailey and Love's Short Practice of Surgery. 27th ed. London: CRC Press Taylor & Francis Group; 2018. P. 1076–95.
3. Patel S., Naik A. Study of the length of vermiform appendix. *Ind. J. Basic Appl. Med. Res*. 2016;(3):256–60.
4. Umamaheswara R., Narasamma K., Shahajeer B. Vermiform appendix in adults. J. Evid. Based Med. Healthcare. 2015;2(14):2047–51.
5. Golz R. A., Flum D. R., Sanchez S. E., et al. Geographic association between incidence of acute appendicitis and socioeconomic status. *JAMA Surg*. 2020;155:330.
6. Abdalla M. A., Abdullah S. A., Al-Samarai A. G. Various anatomical positions of the neonatal vermiform appendix. *Ann. Iraqi Sci. J.* 2008;1(2):244–51.
7. Takada T., Inokuchi R., Kim H. Is pain before vomiting useful? Diagnostic performance of the classic patient history item in acute appendicitis. *Am. J. Emerg. Med*. 2020;41:84.
8. Minneci P. C., Mahida J. B., Lodwick D. L., Sulkowski J. P., Nacion K. M., Cooper J. N., et al. Effectiveness of Patient Choice in Nonoperative vs Surgical Management of Pediatric Uncomplicated Acute Appendicitis. *JAMA Surg*. 2016;151:408–15.
9. Ashalatha K., Arunkumar S., Bilodi S. A study on the Gross features and different positions of adult's vermiform appendix. *J. Evid. Based Med. Health*. 2016;3(56):2869–75.
10. Salwe N. A., Kulkarni P. G., Sinha R. S. Study of Morphological Variations of vermiform appendix and caecum in cadavers of Western Maharashtra region. *Int. J. Adv. Physio Allied Sci*. 2014;2(1):31–41.
11. Chaisiwamongko K., Chanta-upalee T., Techataweewan N., Toomsan Y., Aranateerakul T., Teepsawang S., et al. Position Variation of Vermiform Appendix in Northeast Thai Cadavers. *Srinagarind Med. J*. 2010;25(3):250–5.
12. Nageswara S., Setty R. S., Katikireddi R. Morphometric study of human cadaveric caecum and vermiform appendix. *Int. J. Health Sci. Res*. 2013;3(10):48–55.
13. Banerjee A., Kumar A., Tapador A., Pranay M. Morphological Variations in the anatomy of caecum and appendix. A cadaveric study. *Nat. J. Clin. Ana*. 2012;(1):30–5.
14. Ghorbani A., Foroozesh M., Kazemifar A. M. Variation in Anatomical Position of vermiform appendix among Iranian population. *Ana Res. Int*. 2014;313575:4.
15. Williams P. L., Warwick R. Gray's Anatomy. 36th ed. Edinburgh: Churchill Livingstone; 1980. P. 1342–67.
16. Smith G. M. A statistical review of the variations in the anatomic positions of the caecum and the processus vermiformis in the infants. *Anat. Rec.* 1998;5:549–56.
17. Whitley S., Sookur P., McLean A., Power N. The appendix on CT. *Clin. Radiol.* 2009;64:190.
18. Ashindotiang J. A., Ibrahim N. A. Anatomical variation of appendix in patients with Acute Appendicitis among two major tribes in Lago's Nigeria. *Int. J. Med. Med. Sci.* 2019;2(3):672–6.
19. Das N. K., Kumar S., Mohanty P. Position of vermiform appendix in Indian population. *Trans. World Med. J*. 2014;2(1):6–9.
20. Abdalla M. A. Morphological, Anatomical and Surgical Features of the Vermiform Appendix: A Historical Review. *Problems of Social Hygiene, Public Health and History of Medicine*. 2022;30(5):926–32.

21. Anderson K. D., Parry R. L. Appendicitis. In: Grosfeld J. L., O'Neill J. A., Coran A., Fonkalsurd E. Pediatric Surgery. 6th ed. Vol. 2. Missouri: Mosby Year Book, Inc.; 2006. P. 1369–79.
22. Chaudhari M. L., Divyesh M., Sanjay K. A study of Morphology of vermiform appendix in 200 cases. *Int. J. Med. Res. Health Sci.* 2013;2(4):780–5.
23. Grabowski J. T. Principles of Anatomy and Physiology. 9th ed. New York: John Wiley and Sons, Inc.; 2000. P. 857–72.
24. Duijvestijn A., Hamann A. Mechanisms and regulation of lymphocyte migration. *Immunol. Today*. 1989;10:23–8.
25. Carton J., Attwood S., Geghegan J. Adult human appendix: A unique T-lymphocyte environment. *Gastroenterology.* 1996;110(Suppl. 4):794.
26. Pogorelic Z., Rak S., Mrklic I., Juric I. Prospective validation of Alvarado score and Pediatric Appendicitis Score for the diagnosis of acute appendicitis in children. *Pediatr. Emerg. Care*. 2015;31:164–8.
27. Griebel P. J., Hein W. R. Expanding the role of Peyer's patches in B-cell ontogency. *Immunol. Today*. 1996;17:30–9.
28. Rija F. F., Hussein S. Z., Abdalla M. A. Physiological and immunological disturbance in rheumatoid arthritis patients. *Baghdad Sci. J.* 2021;18(2):247–52.
29. Bharti J. P., Omar S., Pandey N. K. Morphological and histological study on vermiform appendix in Rabbit, Goat and Human Being. *Ann. Int. Med. Res*. 2016;2(1):268–74.
30. Swargam N., Malvadi A., Madan S. A Study of anatomical variations in the caeco-appendicular position. *Sch. J. App. Med. Sci.* 2015;3(3):1376–9.
31. Ehah I., Amin E., Gamal Y., Waled A., Ahmed M. Lengths and positions of the vermiform appendix among Sudanese Cadavers. *AIMS Med. Sci.* 2015;2(3):222–7.
32. Abdalla M. A., Mohammad S. A., Mahdi A. J. J. Branches of the internal iliac artery in neonates: An anatomical study. *Tikrit Med. J.* 2013;19(1):57–60.
33. Tofighi H., Taghadosi, Nejad F., Abbaspour A. The Anatomical position of appendix in Iranian cadavers. *Int. J. Med. Toxic. Foren. Med.* 2013;3(4):126–30.
34. Patil B. G., Makandar U. K. Study of position, length and arterial supply of vermiform appendix in south Indian population. *Ind. J. Com*. 2014;14(2):109–13.
35. Souza S. C., Costa S. R., Souza I. G. Vermiform appendix: positions and length — a study of 377 cases and literature review. *Coloproctol. Rio J*. 2015;35(4):212–6.
36. Golz R. A., Flum D. R., Sanchez S. E., et al. Geographic Association Between Incidence of Acute Appendicitis and Socioeconomic Status. *JAMA Surg.* 2020;155:330.
37. Desouza S. C., Ricardo S., Dacosia M. R., Desouza I. G. S. Vermiform appendix: Position and length a study of 377 cases. *J. Coloproctol.* 2015;35(4):212– 6.
38. Craggs H. E. Anatomy as a Basis for Clinical Medicine. 5th ed. Munich: Urban & Schwarzenberg Co.; 2018. P. 263–98.
39. Veeresh H., Halasagi S. S., Shakuntala R., Mavishettar G. F. A study of arterial supply of vermiform appendix in Humans. *J. Evol. Med. Dent. Sci*. 2012;1(5):807–10.
40. Rao M., Reshma M. Variation in arterial supply of human vermiform appendix. *Int. J. Res. Med. Sci*. 2014;2(1):341–3.
41. Kulkarni U., Kulkarni D. Variations in arterial supply of vermiform appendix. *Int. J. Anat. Var*. 2019;4:52–4.
42. Marchesi V. T., Gowans J. L. The migration of lymphocytes through the endothelium of venules in lymph nodes. Proc. R. Soc. Lond. 1994;154:283–90.
43. Mebius R. E., Streeter P. R., Breve J. The influence of afferent lymphatic vessel interruption on vascular addression expression. *J. Cell. Biol.* 2017;115:85–95.
44. Hofler H., Kasper M., Heitz P. U. The neuroendocrine system of the normal human appendix, ileum and colon, and in neurogenic appendicopathy. Virchows Arch. (Pathol. Anat.). 2016;399:127–40.
45. Matsuo Y., Seki A. The coordination of gastrointestinal hormones and the autonomic nerves. *Am. J. Gastroenterol.* 2019;69:21–50.
46. Bjoergen H., Løken O. M., Hordvik I., Koppang E. O. A bursa of Fabricius structural analogue in the teleost fish Atlantic salmon. *Am. Assoc. Immnol.* 2020;204(1):92.

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