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Morphogenesis And Histogenesis Of The Mesentery Proper And Its Clinical Significance

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Abstract

Introduction: The mesentery is a fan-shaped double fold of peritoneum. It is a mobile structure that connects the organ to the body wall and conveys vessels, lacteals, adipose tissue and nerves to it. The dorsal mesenteries of jejunal and ileal loops are termed as the mesentery proper. Mesenteric events are important in the pathobiology of diverse abdominal and non-abdominal disorders. Recently, the mesentery has been defined as a new organ.

Materials And Methods: 47 foetuses of different gestational ages ranging from 10-40 weeks were examined morphologically and histologically after taking the ethical clearance. The length and level of the root of mesentery (ROM), height of mesentery proper, length of mesentery proper, number of arterial arcades and length of vasa recta were measured and examined. H&E and Masson's trichrome stain were used. Statistical analysis was done.

Results: In this study, it was observed that the level of ROM descended laterally and towards the right with advancing gestational ages. There was significant increase in the thickening of the vasculature of the mesentery with increase in gestational age. The height of mesentery was gradual increased; the increase was abrupt at term. The lymphatic vessels were present more towards the mesothelium. The lymph nodes were more condensed with advancing gestational ages.

Conclusion: The change in the extent and level of the ROM corresponding to the gut rotation showed its importance in developmental abnormalities of the gut. The mesentery proper is a continuous structure and it has shown the features of an organ.

Keywords: Mesenteropathies, root of mesentery (ROM), arterial arcades.

Introduction

The mesentery is a double fold of the peritoneum that encloses the intestine and keeps it suspended from the posterior body wall in the peritoneal cavity. Its two peritoneal layers contain the jejunal and ileal branches of the superior mesenteric vessels, nerves related to the superior mesenteric plexus, adipose fatty tissue, lymphatics, and regional mesenteric lymph nodes. The dorsal mesenteries of the jejunal and ileal loops are termed mesentery proper. The mesentery proper is arranged in a complex, fan-shaped structure.[1,2,3,4]

The root of mesentery (ROM) lies along a line running diagonally from the duodenojejunal flexure on the left side of the second lumbar vertebral body to the right sacroiliac joint. The average length of the root of the mesentery is 15cm in adults while along its intestinal attachment the mesentery measures the same length as the small intestine (approximately 5m).[3,5]

The average depth of the mesentery from the root to the intestinal border is 20 cm, but this varies along the length of the small intestine and the maximal height is 10 inches (25 cm). It is shortest at the proximal jejunum and terminal ileum, and longest in the mid-ileal region.[3]

Within the mesentery, the branches of the superior mesenteric artery anastomose with each other to form arterial arcades. The jejunal mesenteric vessels form only one or two arcades. The ileal mesenteric vessels form three or four or even more arcades. On each side of the small intestine, the last arcade sends branches known as vasa recta which anastomose in the wall and supply the jejunum and ileum.[5,6] The mesentery proper is drained by the superior mesenteric vein.[7]

There are numerous nodes lie between the layers of the mesentery and gradually increase in size towards the root. The lymph vessels of the small intestine, called lacteals converge on, and drain through, a series of lymph nodes, which finally unite at the root of the mesentery in the intestinal lymph trunk. The intestinal lymph trunk empties into the cisterna chyli. The most common causes of mesenteric lymphadenopathy are neoplastic, inflammatory, and infectious processes.[3,6,8]

The mesenteric fat is thin towards the intestinal attachment but heavier and wider toward the root of the mesentery and also the blood vessels and lymph nodes were larger toward the root of the mesentery.[9] The development sequence of the mesentery spans 1.5 months of gestational age to the perinatal period.[3,4,5,10]

Histologically, the mesentery consists of a thin layer of typical loose (areolar) connective tissue. It is bounded on the upper and lower surfaces by the mesothelium consisting of flattened epithelial-like simple squamous epithelium cells. Other microstructures in the mesentery consist of fibroblasts, mast cells, macrophages, lymphocytes, plasma cells, etc. In association with the different cell types, the extracellular matrix consists of collagen fibre, elastic fibre blood vessels, lymphatic tissue, adipose tissue and nerve trunks.[3,11,12,13]

Mesenteric events are important in the pathobiology of diverse abdominal and non-abdominal disorders, including malrotations, volvulus, congenital anomalies, colorectal cancer, inflammatory bowel disease, diverticular disease, cardiovascular disease, diabetes, obesity, and metabolic syndrome. The mesentery is involved in many primary mesenteropathies where the disease is originated from the mesentery itself like panniculitis, cavitation syndrome and mesothelioma. The secondary mesenteropathies where the mesentery is involved in diseases like intestinal tumors, diverticulitis, etc were also observed.[2,14]

The mesentery was previously thought to be a collection of discrete structures each with separate insertions into the posterior abdominal wall. However, recent research has found the mesentery to be one contiguous structure, which has led to proposals for its reclassification as an organ. The mesentery distal to the duodenojejunal flexure is a contiguous and extra-retroperitoneal organ.[2,14]

Materials And Methods:

The study was conducted from Jan. 2021 to Sept. 2022 at the Department of Anatomy, RIMS, Imphal, Manipur, India. 47 apparently normal foetuses of different gestational ages ranging from 10-40 weeks which were the product of MTP and stillbirth were collected from Department of Obstretrics and Gynaecology, RIMS, Imphal after taking the ethical clearance from the Research Ethics Board.

The foetuses were grouped into 6 clusters viz., Cluster 1 (10-12 weeks), Cluster 2 (13-18 weeks), Cluster 3 (19-24 weeks), Cluster 4 (25-30 weeks), Cluster 5 (31-36 weeks), and Cluster 6 (>36 weeks).

The mesentery was separated from the intestine and the length of the intestine was measured as the length of the intestine equal to the length of the mesentery. The height of the mesentery was measured at the mid-ileal region from the root of the mesentery to the intestinal border[2,15]. The extent and the alignment of the root of the mesentery were measured using the vertebral body and the sacral promontory as the reference.

A glass petridish was prepared with a layer of candle wax. The mesentery was then spread on the prepared glass petridish. The light was thrown from the bottom of the petridish enabling the counting of arterial arcades and measurement of vasa recta.

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Histological staining using H&E and Masson's Trichrome stain were done. The slides were examined under a trinocular research microscope and detailed histological findings were recorded.

Statistical analysis is performed using SPSS statistical software (version 21.0). The data were presented in means with standard deviations of the length of the root of the mesentery, the length of the parts of the mesentery, the height of the parts of the mesentery, the number of the arterial arcades and the length of the vasa recta. To compare variables across six clusters, one-way ANOVA test was used for the continuous data. A P-value of less than 0.05 was considered statistically significant.

Results:

A total of 47 foetuses who met the inclusion criteria were studied. Out of which 21 (44.68%) were male and 26 (55.32%) were female. The foetuses were allocated into 6 clusters of different gestational periods. In cluster 1(10-12 weeks), 5 foetuses (10.64%) were studied (3 male and 2 female). In cluster 2(13-18 weeks), 9 foetuses (19.15%) were studied (4 male and 5 female). In cluster 3(19-24 weeks), 12 foetuses (25.53%) were studied (5 male and 7 female). In cluster 4(25-30 weeks), 7 foetuses (14.89%) were studied (3 male and 4 female). In cluster 5(31-36 weeks), 8 foetuses (17.02%) were studied (4 male and 4 female). In cluster 6(>36 weeks), 6 foetuses (12.77%) were studied (2 male and 4 female)

Morphology (Fig.2-9):

In the study, it was found that the alignment of the ROM was paramedian till the 18th week of gestation and started to shift downwards and towards the right sacroiliac joint. The upper limit of the attachment of the ROM was T11 at 10-12 weeks of gestation. It gradually shifted downwards and was found at the L1 vertebra at >36 weeks of gestation. The lower limit of attachment of ROM was at 0.3cm on the right side of the L3 vertebra at 10-12 weeks of gestation. It gradually shifted towards the sacroiliac joint and was found on 3 cm on the right side L5 vertebra at term (Tab.1) (Fig.1). The length of the ROM was significantly increased from 0.6cm±0.12cm at 10-12 weeks of gestation to 4.87cm±0.08cm at >36 weeks of gestation (P-value=0.00 at a 5% level of significance) (Tab.2).

The height of the jejunal mesentery was 0.56cm±0.13cm at 10-12 weeks of gestation. It significantly increased with the increase in gestational age and was found to be 4.78cm±0.16cm at term (P-value=0.00 at a 5% level of significance). The height of the ileal mesentery was 0.66cm±0.17cm at 10-12 weeks of gestation and it significantly increased and was found to be 4.42cm±0.13cm at term (P-value=0.00 at 5% level of significance). The height of ileal mesentery was more at early gestational age and at term, the height of jejunal mesentery was more (Tab.3).

The length of the mesentery proper significantly increased with gestational age and ranged from 21.2cm±6.3cm at 10-12 weeks of gestation to 252.2cm±5.1cm at term (P-value=0.00 at a 5% level of significance) (Tab.4).

The arterial arcades were absent till the 12th week of gestation. The numbers of the arterial arcades at ileal and jejunal mesentery were 2.3±0.5 and 3.4±0.5 respectively. The number of arterial arcades gradually increased to 2.9±0.4 and 4.1±0.7 respectively at 25-30 weeks of gestation. The numbers decreased at 31-36 weeks of gestation and were found to be 2.6±0.5 and 3.6±0.5 respectively for jejunal and ileal mesenteries. The numbers of jejunal and ileal mesenteries increased further to 3.0±0 and 4.0±0 respectively at term (Tab.5).The lengths of the vasa recta of jejunal and ileal mesenteries were found to be 0.10cm and 0.10cm respectively at 10-12weeks of gestation. The length increased up to 0.7cm±0.1cm and 0.3cm ±0 at term.

The numbers of arterial arcades were more in the ileal mesentery than in the jejunal mesentery. The increase in the number of arterial arcades in the jejunal and ileal mesenteries with the increase in the gestational age were not statistically significant (P-value=0.44 and 0.49, respectively at a 5% level of significance).

The length of the vasa recta was more in the jejunal end than in the ileal end. The increase in the lengths of the vasa recta in the jejunal and ileal mesenteries with the increase in the gestational age were statistically significant (P-value=0.00 and 0.00, respectively at a 5% level of significance) (Tab.5).

Visible lymph node was absent at 10-11 weeks of gestation (Fig.2). Lymph nodes were observed near

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the root of mesentery at 12 weeks of gestation (Fig.3). The lymph nodes in the mesentery proper increased in size and number as the gestational age increases. Different sizes of lymph nodes which are more towards the root of the mesentery are present (Fig.6). The lymph nodes were spread throughout the height of the mesentery. Numerous milky spots were visible at ≥35 weeks of gestation (Fig.8&9). Lymph nodes were seen encroaching towards the intestine as the gestational age increases.

Histology (Fig.10-20):

The mesentery was lined on either side by a monolayer of mesothelium (Fig.11) within which the interstitium consisting of fibroblast was present wherein blood vessels (Fig.12-15), lymphatic vessels (Fig.16), nerve fibres (Fig.16), adipocytes (Fig.16&17) and lymph nodes (Fig.18-20) were observed. Thin-walled blood vessels were observed at the 10th week of gestation (Fig.10&11). Blood vessels were seen traversing the muscle layer of the intestine (Fig.12). The thick-walled muscular arteries were first observed at the 19th week of gestation. The nerve fibres were first observed at the 13th week of gestation in mesentery proper. The lymph nodes were observed since the 13th week of gestation and at the 15th week of gestation lymph nodes at different developmental stages were observed. The adipose tissue with thick surrounding connective tissue was first observed at the 29th week of gestation.

Tables And Figures:

Table 1: Showing the differential level of the root of mesentery (ROM) among the different clusters (N=47)

Clusters (Gestational weeks)		1 (10-12)	2 (13-18)	3 (19-24)	4 (25-30)	5 (31-36)	6 (>36)
Level	UL (On left margin)	T11 UB	T11UB	T12 UB	T12 UB	T12 LB	L1 UB
	LL (On right)	L3 UB (0.3cm)	L3 UB (0.5cm)	L4UB (2cm)	L5 MB (2.5cm)	L5 MB (2cm)	L5 MB (3cm)

(UL- Upper limit, LL- Lower limit, UB- Upper border of the body of the vertebra, MB- Middle of the body of the vertebra, LB- Lower border of the body of the vertebra

Table 2: Showing the mean differential length of the ROM among the different clusters (N=47)

Clusters (Gestational weeks)	1 (10-12)	2 (13-18)	3 (19-24)	4 (25-30)	5 (31-36)	6 (>36)	P-value *
Length (mean ± SD) (cms)	0.60±0.12	1.61±0.43	2.68±0.22	3.70±0.23	4.68±0.15	4.87±0.08	0.00

*One-way ANOVA test. Significant when P value <0.05.

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Table 3: Showing the mean differential height of the jejunal and the ileal mesenteries among the different clusters. (N=47)

Clusters (Gestational weeks)	1 (10-12)	2 (13-18)	3 (19-24)	4 (25-30)	5 (31-36)	6 (>36)	P-value *
JMH (mean ± SD)(cms)	0.56±0.13	1.32±0.38	2.43±0.34	2.80±0.21	3.36±0.74	4.78±0.16	0.00
IMH (mean ± SD)(cms)	0.66±0.17	1.51±0.57	2.29±0.45	2.76±0.50	3.30±0.66	4.42±0.13	0.00

*One-way ANOVA test. Significant when P value <0.05.(JMH-Jejunal mesentery height, IMH-Ileal mesentery height)

Table 4: Showing the mean differential length of the mesentery proper among the different clusters. (N=47)

Clusters (Gestational weeks)	1 (10-12)	2 (13-18)	3 (19-24)	4 (25-30)	5 (31-36)	6 (>36)	P-value *
MPL (mean ± SD) (cm)	21.2±6.3	71.2±16.8	141.7±20.5	182.6±5.9	225.1±17.5	252.2±5.1	0.00

*One-way ANOVA test. Significant when P value <0.05. (MPL-mesentery proper length)

Table 5: Showing the mean differential number of the arterial arcades and the mean differential length of the vasa recta in the jejunal and ileal mesenteries among the different clusters. (N=47)

Clusters (Gestational weeks)	1 (10-12)	2 (13-18)	3 (19-24)	4 (25-30)	5 (31-36)	6 (>36)	P-value*
JMAA (mean ± SD) (cm)	NA	2.3±0.5	2.8±0.5	2.9±0.4	2.6±0.5	3.0±0.0	0.44
IMAA (mean ± SD) (cm)	NA	3.4±0.5	3.8±0.6	4.1±0.7	3.6±0.5	4.0±0.0	0.49
JMVR (mean ± SD) (cm)	0.10	0.3±0.1	0.4±0.1	0.5±0.1	0.5±0.1	0.7±0.1	0.00
IMVR (mean ± SD) (cm)	0.10	0.1±0.1	0.2±0.0	0.3±0.1	0.3±0.0	0.3±0.0	0.00

*One-way ANOVA test. Significant when P value <0.05. (JMAA- Jejunal mesentery arterial arcade, IMAA- Ileal mesentery arterial arcade, JMVR- Jejunal mesentery vasa recta and IMVR- Ileal mesentery vasa recta, NA-Not applicable).

Fig.1: Schematic diagram showing the changes in the level of ROM with reference to the vertebral column in different gestational ages.

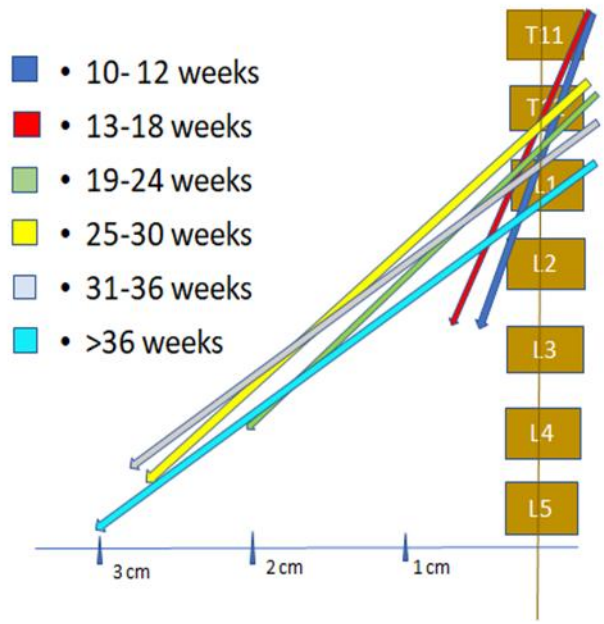

Fig.2: Absence of arterial arcade and vasa recta in the jejunal mesentery in a 10-week-old foetus.

Fig.3: Vasa recta (A) and lymph nodes towards the ROM (B) in the jejunal mesentery in a 12-week-old foetus.

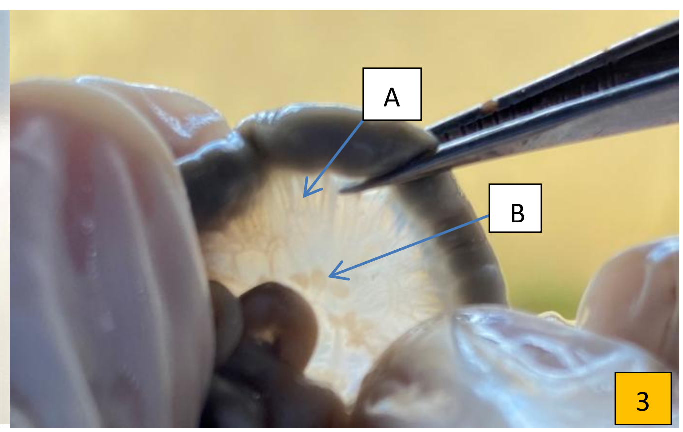

Fig.4: Arterial arcades (A) and vasa recta (B) in the jejunal mesentery in a 15-week-old foetus. Lymph nodes can be seen toward the ROM (C).

Fig.5: Arterial arcades (A) and vasa recta (B) in the jejunal mesentery in a 22-week-old foetus. The number of arterial arcades has increased. The lymph node can be identified towards the ROM (C).

Fig.6: Lymph nodes (arrow) clustering toward the root of the mesentery in the ileal mesentery of a 22-week-old foetus.

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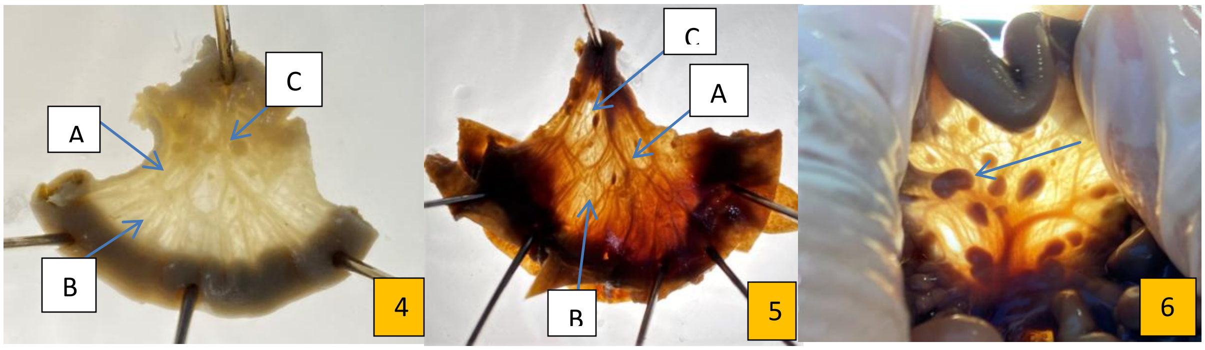

Fig.7: Arterial arcade (A) and vasa recta (B) in the ileal mesentery of a 31-week-old foetus.

Fig.8: A lymph node (A) and numerous milky spots (B) in the jejunal mesentery of a 34-week-old foetus. There is decreased number of arterial arcades as compared to the ileal mesentery of same gestational age.

Fig.9: Arterial arcades (A) and vasa recta (B) in the jejunal mesentery of a 37-week-old foetus. Lymph nodes (C) and milky spots (D) are seen.

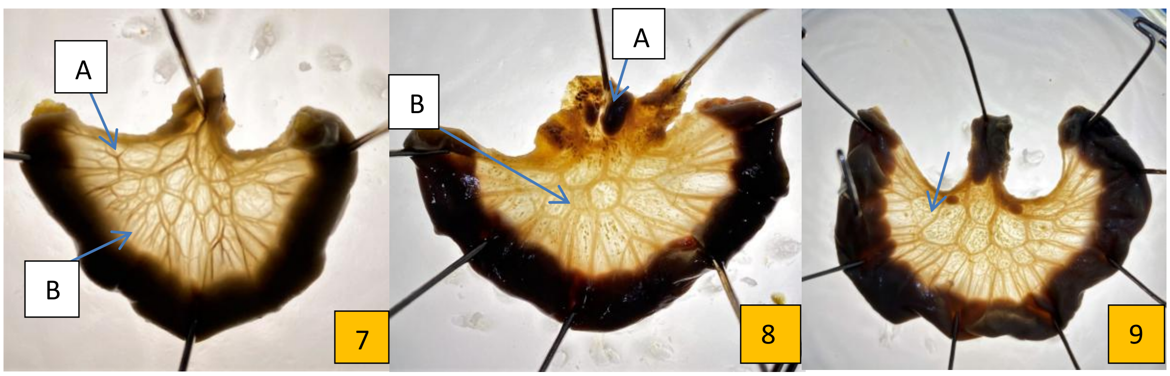

Fig.10: Transverse section of the ileal mesentery (arrow) of a 10-week-old human foetus showing its continuity with the intestine. H&E stain. X100.

Fig.11: Transverse section of the ileal mesentery of a 10-week-old human foetus showing the thin-walled arteriole (A) and mesothelium (B). H&E stain. X200.

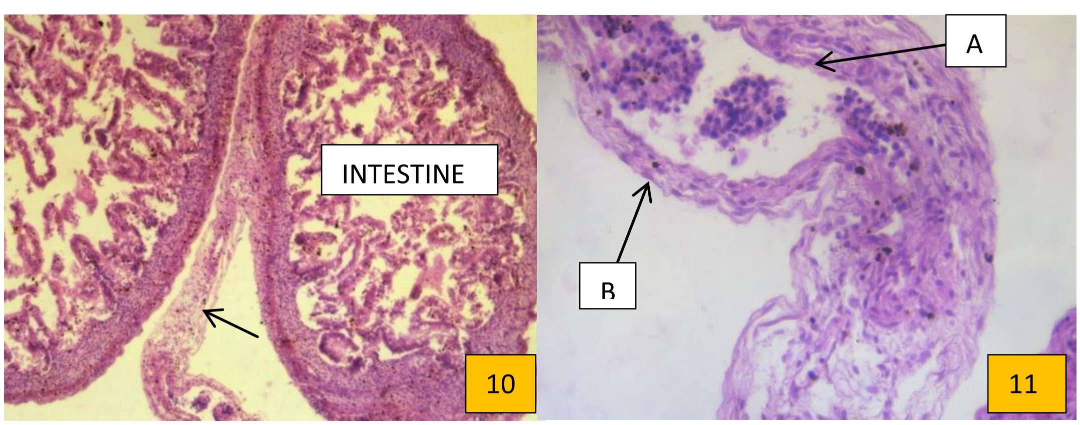

Fig.12: Transverse section of the jejunal mesentery of a 15-week-old human foetus showing sparse areolar tissue. Blood vessels traversing the muscular layer of the intestine (arrow) are seen. H&E stain. X100.

Fig.13: Transverse section of the jejunal mesentery of a 31-week-old foetus showing a muscular artery (arrow). H&E stain. X100.

Fig.14: Transverse section of the jejunal mesentery of a 37-week-old human foetus showing the smooth muscle thickening in the tunica media of a muscular artery (arrow). H&E stain. X100.

Fig.15: Longitudinal section of the ileal mesentery of a 37-week-oldfoetus mesentery showing arborization of blood vessels (arrow) in the matrix. H&E stain. X100.

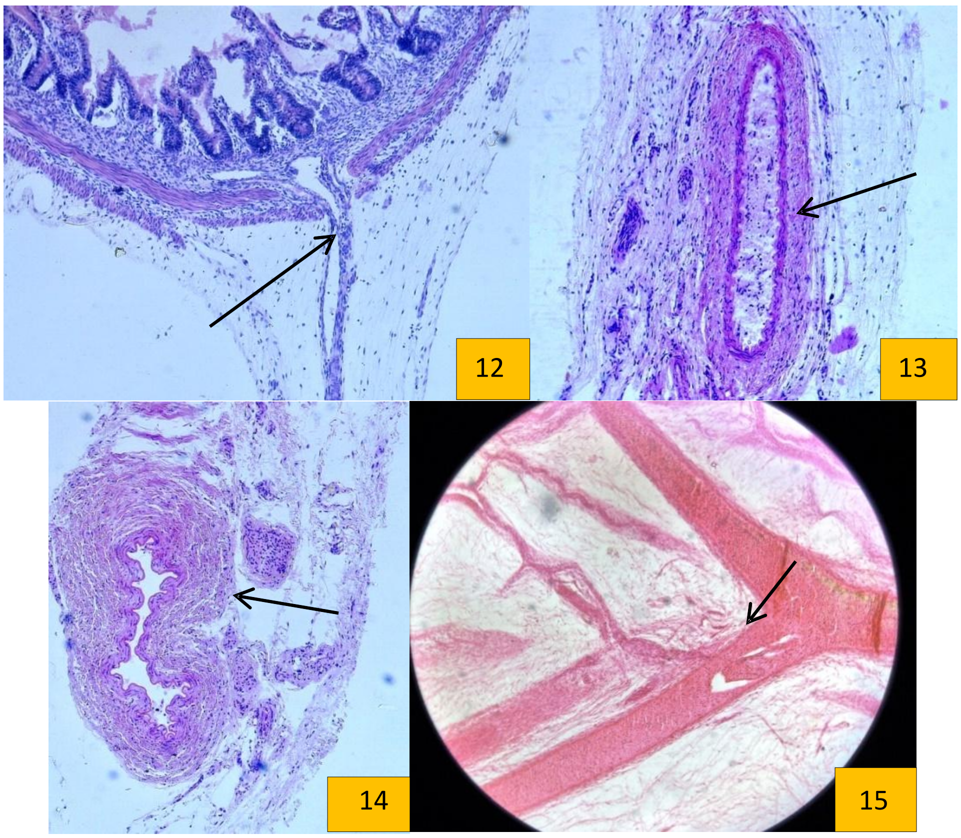

Fig.16: Transverse section of the jejunal mesentery of a 37-week-old foetus showing blood vessels (A), adipose tissue (B), nerve fibre (C) and lymphatic vessel (D). H&E stain. X100.

Fig.17: Transverse section of the jejunal mesentery of a 37-week-old human foetus showing the increase in the size of the adipocytes in adipose tissue (arrow). H&E stain. X100.

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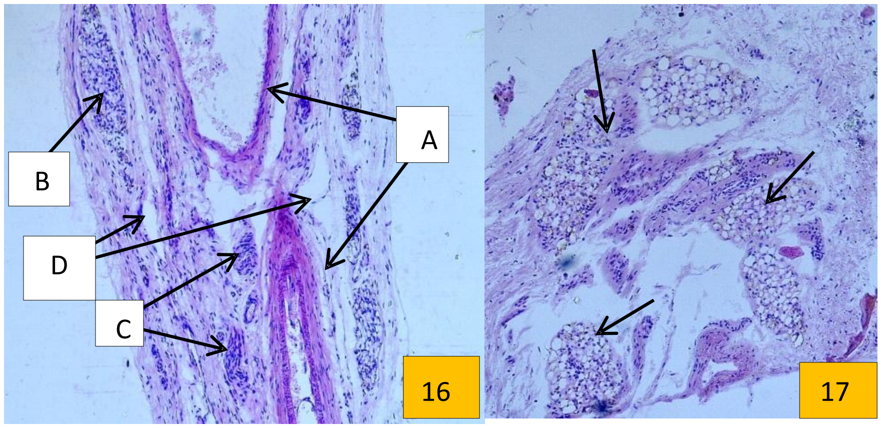
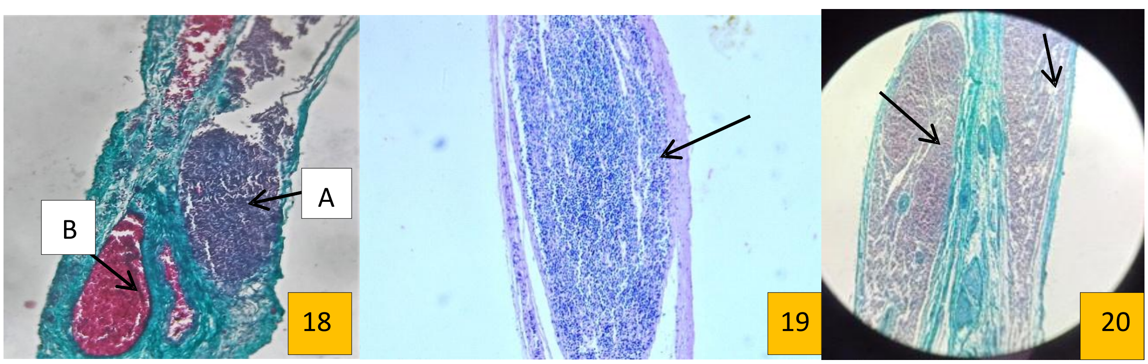


Fig.18: Transverse section of the ileal mesentery of a 15-week-old foetus showing the lymph node at early foetal node stage of development (A), thin-walled blood vessel (B) towards the ROM. Masson's trichrome stain. X100.

Fig.19: Transverse section of the ileal mesentery of a 22-week-old foetus showing a lymph node (arrow) midway between intestine and ROM. H&E stain. X100

Fig.20: Transverse section of the ileal mesentery of a 27-week-old human foetus showing arterioles, venules and lymphatic vessels on the capsule of the lymph node (arrow). Masson's trichrome stain. X100.



Discussion:

The mesentery is a largely ignored structure in the discussion of the abdomen due to its erroneous anatomical structure. It was recently recognized as an organ but is often argumentative due to the lack of research and the meagre literature in the field.

In the present study, the attachment of the mesentery in the posterior abdominal wall was paramedian till the 18th week of gestational age. Moore et al[1] described that the dorsal mesentery is in the median plane at early gestational age.

In the present study, the length of the ROM gradually increased with the advancing gestational age. The length ranged from 0.57±0.15 cm in 10-12 weeks foetuses to 4.87±0.09 cm in foetuses of the term. According to Stringer[3], the length of the ROM is 6 inches in adults. Okino et al[16] stated that the ROM is approximately 15cm long.

In our study, there was an increase in the length of the mesentery corresponding to the increase in the gestational age. Hamilton et al[17] described that the mesentery elongates pari-passu with the growth of the midgut.

In the present study, the arterial arcade at term foetuses attended a maximum number of 3 in the jejunal end which is comparatively more in number than that in the adults given by Snell[5] which were 1-2.

In the present study, it was observed that the mesentery on either side was lined by mesothelium in

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between which lies the interstitium. The interstitium consisted of collagen fibres and fibroblasts. Within the interstitium, lay the blood vessels, lymphatics, nerve fibres, adipocytes and lymph nodes. The findings were similarly stated by Koshi[7] and Ross et al[18].

In the present study, the nerve fibre bundle in the mesentery was first observed at the 13th week of gestational age. Fu et al[19] observed small ganglion plexuses in the foregut and midgut submucosa by the 12th week of gestation and by the 14th week of gestation in the hindgut.

In the present study, the lymph nodes in the mesentery were present from the 13th week of gestation. The cellular density and lymphocyte content in the lymph nodes increased gradually with an increase in gestational age. There was a gradual thickening of sub capsular connective tissue. From the 15th week of gestation onwards, there was the presence of lymph nodes at different stages. During the 19th -24th week of gestation, there was the presence of capillaries, arterioles, venules and lymphatic vessels in the capsule of the lymph node. The different stages were similarly described by Baily et al[20].

In the present study, blood vessels were observed traversing the muscular layer of the intestinal wall at the 15th week of gestational age. Ross et al[18] stated that large blood vessels, nerve fibres and lacteals travel through the mesentery to reach the digestive tract.

In the current study at mesentery, the adipocytes began to visualise at the 29th week of gestational age. According to Possionnet et al[21], the development of adipose tissue at buccal fat pad starts at the 14th week of gestation and progresses till the 23rd week of gestation. From the 24th-29th week of gestational age, there was an increase in the size of the fat lobules due to the increase in the number and size of the adipocytes. According to Fritsch[22], the adipose tissue developed at different compartments of the pelvic cavity from 21-38 weeks of gestational age.

Peyrin-Biroulet et al[23] mentioned that mesenteric fat is an important source of C-reactive protein in Crohn's disease. Wu et al[24] conducted a study in mice and mentioned that B Lymphocytes in the adipose tissue of mesentery help in maintaining the integrity of the intestinal barrier and protect against non-alcoholic fatty liver disease in mice.

The detailed knowledge of the morphological and histological development of the mesentery is essential to doctors dealing with cases of surgical emergencies of the abdomen, developmental malformations, cancers, obesity, kidney diseases, inflammatory bowel diseases and many other metabolic conditions of the body.

The present study will provide an anatomical framework for many surgical, radiological and clinical-related etiopathogenesis. In the study, the mesentery was observed to be a continuous structure lined by a layer of mesothelium on either side with a core of interstitium wherein lies blood vessels, lymphatic tissues, adipose tissue and nerve fibres which serves in the etiopathogenesis of primary and secondary mesenteropathies. Thus, we concluded from the current study that the mesentery can be called as an organ.

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