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## Prenatal, Gross Anatomical and Topographical Studies on the Small Intestine of the Dromedary Camel (*Camelus dromedarius*)

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### ABSTRACT

The primary functions of the small intestine are digestion and absorption. This investigation aimed to study the gross anatomical structure and topography of camel small intestine including the duodenum, jejunum and ileum in first trimester, second trimester and third trimester. It was conducted on fifteen specimens of camel foeti of both sexes in different trimesters; the specimens were fresh and fixed in formalin (10%) to study the gross features in all trimesters and topography of small intestine especially in third trimester. Grossly the fetal small intestine was divided into three parts duodenum, jejunum and ileum and the duodenum was divided into three parts; ampulla, descending and ascending duodenum. The small intestinal tube was situated mainly in the right side and in the caudal left part of the abdominal cavity. During the third trimester, the ampulla was the widest portion of the small intestine and slender-shaped. The mucosa of the ampulla was pink to grayish in colour possessing circular and longitudinal folds. The descending and ascending parts were convoluted, grayish to white in colour, consisted long and thin parts; the mucosa was pink in colour but whitish during the first trimester and contained longitudinal folds during the second and the third trimesters. The mucosa of jejunum was pink to grayish in colour containing circular folds during the third trimester but was absent during the second trimester. The mucosa of ileum was pink in colour and consisted of dome shaped the Peyers' Patches which were projected into the lumen. Whereas they were absent during the first trimester. This study has observed the gross features of parts of small intestine of foeti in all trimesters and situation of these parts in third trimester. In conclusion the topographical results revealed the small intestine in the abdominal cavity mainly lodged on the right side and extended towards the left side caudally and grossly consisted of different anatomical features including all trimesters.

**Keywords:** dromedary foetuses, small intestine, gross anatomy, topography.



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## INTRODUCTION

The duodenum in adult dromedary camel began at the pylorus which was situated below the tenth costochondral junction. The cranial part lay against the visceral surface of the liver. It consisted of a prominent duodenal ampulla followed by a slender sigmoid flexure which is directed craniodorsally. At the cranial duodenal flexure the strongly convoluted descending duodenum commenced in a caudal direction (Smuts and Bezuidenhout, 1987) and Getty (1975) in other domestic animals. According to Smuts and Bezuidenhout (1987) the adult camel convoluted jejunum was placed mainly in the right flank and right abdominal region, and on the sternum in the median plane. The short ileum ended at the ileal orifice which demarcated the cecocolic junction. The latter was on the right of the midline at the level of the caudal pole of the left kidney. There is a short peritoneal fold, ileocecal fold, attaching the ileum to the lesser curvature of caecum and marks the beginning of the ileum.

In the adult she-camel the cranial duodenum began at the pylorus. The ampulla was located at the level of the caudal border near to the distal end of the 11<sup>th</sup> rib and on the right aspect of the rumen and it ran dorsal and cranial to the

visceral surface of the liver forming a sigmoid flexure (Mohamed, 2012).

In adult she-camel the intestinal tract is situated mainly in the right side and in the caudal left part of the abdominal cavity. The cranial duodenum started by an ampulla at the level of the distal end of the 11<sup>th</sup> rib. It extended dorsocranially and formed a sigmoid flexure ventral to the visceral surface of the liver. The descending duodenum extended from the 2<sup>nd</sup> curvature of the sigmoid flexure caudoventral to the transverse process of the lumbar vertebra until the caudal flexure at the level of the cranial border of transverse process of the 6<sup>th</sup> lumbar vertebra. The ascending duodenum extended from the end of the previous part cranioventrally until it joined the jejunum ventral to the right kidney at the level of the transverse process of the 3<sup>rd</sup> lumbar vertebrae (Mohamed, 2012). According to Mohamed, (2012) in adult she-camel the coils of the jejunum occupied the right side of the abdominal cavity (between the last rib cranially, at the level of the last lumbar vertebra caudally, ventral to a line extending from the 2<sup>nd</sup> lumbar vertebra until transverse process of the 7<sup>th</sup> lumbar vertebra dorsally and it lay on the floor of the abdominal cavity. Mohamed, (2012) reported that the ileum



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extended from the pelvic inlet cranially until the caecum at the level of the 5<sup>th</sup> lumbar vertebra in the right side of the abdominal cavity. It was straight and connected to the caecum by the ileocecal fold.

In dromedary camel the topographical study of the small intestine was made in one adult healthy dromedary fixed by perfusion with 10% formalin. While the long axis of the body measured 2.87 m, the small intestine measured  $10.97 \pm 0.66$  m only. It was observed that the major part of the small intestine was situated in the right side of the abdomen. This study has designated a palpable bony structure to each part of the small intestine and hence the position of all segments can easily be determined (Mohamed *et al.*, 2017).

In the one-humped camel AL-Ani and Qureshi, (2008) stated that the duodenum started with a dilatation and then formed a loop and began from the pylorus, which was situated below the 10<sup>th</sup> costochondral junction. The cranial part lay against the visceral surface of the liver. It consisted of duodenal ampulla followed by a slender sigmoid flexure, which was directed craniodorsally. At the cranial duodenal flexure it was strongly convoluted descending duodenum. Anteriorly, at the junction of the ampulla and sigmoid portion, a shelf-like

partition projected into the lumen as the wall of the two portions were attached to each other. The jejunum in the one-humped camel occupied most of the abdomen and is situated along the mesentery on the right side. The convoluted jejunum is placed mainly in the right flank of the abdominal region, and on the sternum along the median plane. Its suspensory fold, the mesojejunum, was fused with the mesocolon. The short ileum ended at the ileal orifice, which demarcated the cecocolic junction. The latter was on the right of the midline, at the level of the caudal pole of the left kidney (AL-Ani and Qureshi, 2008).

Althnaian *et al.*, (2012) observed that the adult camel duodenum is grayish to white in colour. It was divided into two parts; ampulla and a thin part which formed the long part. The thin part was divided into three units; descending part, transverse duodenal flexure and ascending unit. The duodenum began at the pylorus and ended at the beginning of jejunum. Its mucosa was pink to grayish in color with circular and longitudinal folds at the ampulla and longitudinal folds at the thin part.

According to Bello *et al.*, (2015. a) grossly, the colour of the small intestine in camel fetuses was whitish at first trimester and grayish to white in second and third trimester. The



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duodenum was divided into two main portions, dilated (ampulla) and thin (straight). The later formed the long part of the duodenum in the all trimesters. At the first trimester the thin part was not differentiated but divided into the descending part, caudal duodenal flexure (transverse part) and the ascending part was differentiated at the second and the third trimester. Grossly the jejunum was characterized by having an extensive coiling in the second and the third trimester, with no evidence of segmental differentiation in the first trimester (Bello *et al.*, 2015. b).

Grossly, the colour of the small intestine was whitish at first trimester and greenish in second and third trimester. The ileum was divided into two main portions namely the dilated ampulla and the thin straight part which formed the long part of the ileum in all the trimesters. At first trimester the thin part was not differentiated but divided into three parts such as the descending part, caudal duodenal flexure (transverse part) and ascending part at second and third trimester (Bello *et al.*, 2017).

## MATERIAL AND METHODS

Fifteen specimens of camel foeti of both sexes in different trimesters were fresh and used formalin fixed (10%) were collected from Tamboul slaughterhouse, Sudan were used in

study of the gross features and topography of small intestine.

After dissecting the uteruses, the approximate age of the foeti was estimated using the formula used by El-wishy *et al.*, (1981):  $GA = (CVRL + 23.99) \div 0.366$ , where GA is age in days and CVRL is the Crown Vertebral Rump Length; following the first trimester; 1– 23.5 cm (68 – 130 days), second trimester; 24 – 71 cm (131 – 260 days) and third trimester; 71.5 – 132 cm (261 – 426 days).

## RESULTS

### Topography

The small intestine of the camel was divided into three parts duodenum, jejunum and ileum and the duodenum was divided into three parts, these are (in craniocaudal sequence) ampulla, descending and ascending duodenum. The small intestinal tube was situated mainly in the right side and in the caudal left part of the abdominal cavity.

In foeti of 270 and 380 days of age (75 cm and 115 cm CVRL) during the third trimester, the duodenum started at the pylorus which was situated below the tenth costochondrial junction, extending between the pylorus and jejunum constriction. The cranial part of duodenum was attached to the visceral surface



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of the liver and right kidney. The cranial duodenum began ampulla and formed a sigmoid flexure ventral to the visceral surface of the liver.

The ampulla was located at the level of caudal border of rib near to the distal end of the 9<sup>th</sup> rib and on the right aspect of the stomach compartment 1 and extended dorsally and cranially to visceral surface of the liver and was attached to lesser curvature of the stomach compartment 4, and contained sigmoid flexure (Fig. 1).

The descending duodenum extended from the curvature of the sigmoid flexure caudally and ventrally to the transverse process of the lumbar vertebra and to the cranial border of transverse process of the 3<sup>rd</sup> lumbar vertebra.

The ascending duodenum extended from the end of descending duodenum and joined the cranial part of jejunum ventral to the right kidney at the level of the transverse process of the 5<sup>th</sup> lumbar vertebra.

The coils of jejunum were situated in the right side of the abdominal cavity between ascending duodenum cranially and ileum caudally, extending from the 3<sup>rd</sup> to the 7<sup>th</sup> transverse process of the lumbar vertebrae dorsally and it lied on the floor of the abdominal cavity. The convoluted jejunum was

placed mainly in the right flank of the abdominal region, and on the sternum in the median plane (Fig. 2).

The ileum extended from the pelvic inlet cranially until the caecum at the level of the 5<sup>th</sup> lumbar vertebra in the right side of the abdominal cavity. The ileum was straight and connected to the caecum by the ileocecal fold (Fig. 3).

### Gross Features

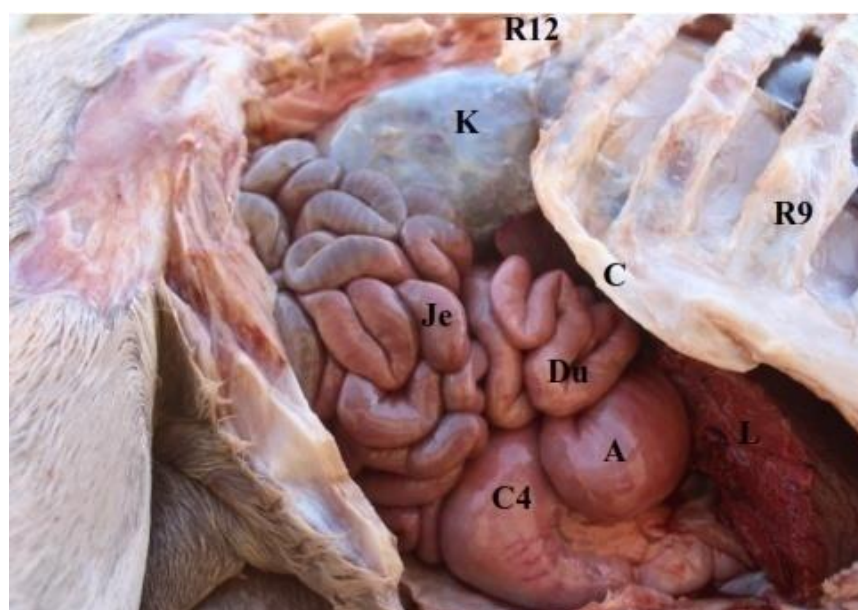
The duodenum was grayish to white in colour and began at the pylorus and ended at the beginning of jejunum. In foeti of 270, 371 and 380 days of age (75 cm, 112 and 115 cm CVRL) during the third trimester, the ampulla was the widest portion of the small intestine and slender-shaped. The mucosa of the ampulla was pink to grayish in colour possessing circular and longitudinal folds (Fig. 4). The descending and ascending parts were convoluted, grayish to white in colour, consisted long and thin parts; the mucosa was pink in colour but whitish during the first trimester (87, 99, 117 and 128 days of age) and contained longitudinal folds during the second and the third trimesters (145, 188 and 205 days of age). In foeti of 145, 175, 188, 205 and 372 days (29, 40, 45, 51 and 112 cm CVRL), the jejunum occupied most of the abdomen and



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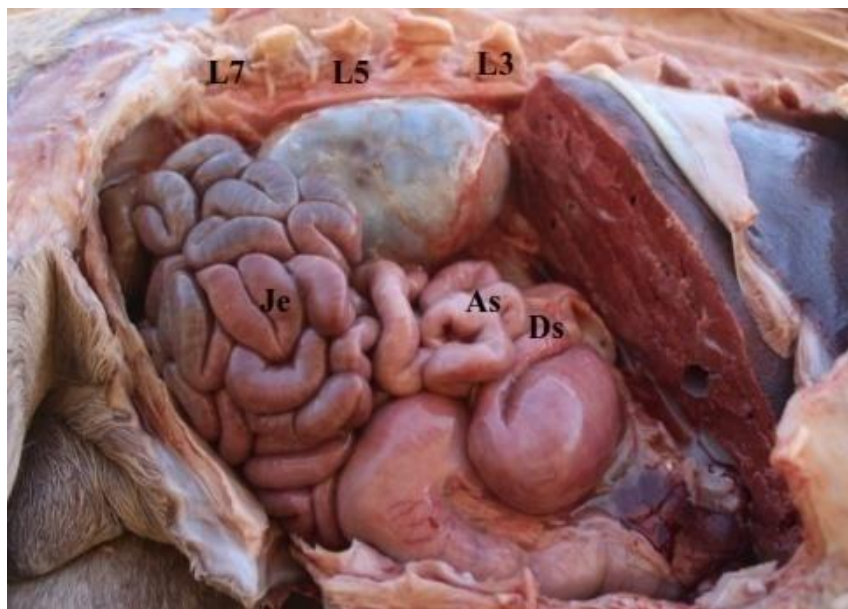
situated along the mesentery on the right side. The jejunum formed numerous close coils arranged in a festoon around the border of the mesentery. The mucosa of jejunum was pink to grayish in colour containing circular folds during the third trimester but was absent during the second trimester (Fig. 5). In foeti of 175, 188, 205 and 372 days (40, 45, 51 and 112 cm CVRL), the ileum was a short part extending from the ileal orifice, connected by a peritoneal fold ( ileocecal fold) to the lesser curvature of

caecum and marked the beginning of the ileum. The mucosa of ileum was pink in colour. In foeti of 175, 188, 205, 372 and 380 days (40, 45, 51, 112 and 115 cm), the ileum consisted of dome shaped the Peyers' patches which were projected into the lumen. Whereas they were absent during the first trimester. In foeti of 372 and 380 days (112 and 115 cm) during the third trimester, the ileum demonstrated circular mucosal folds whereas they were absent during the first and the second trimesters (Fig. 6).

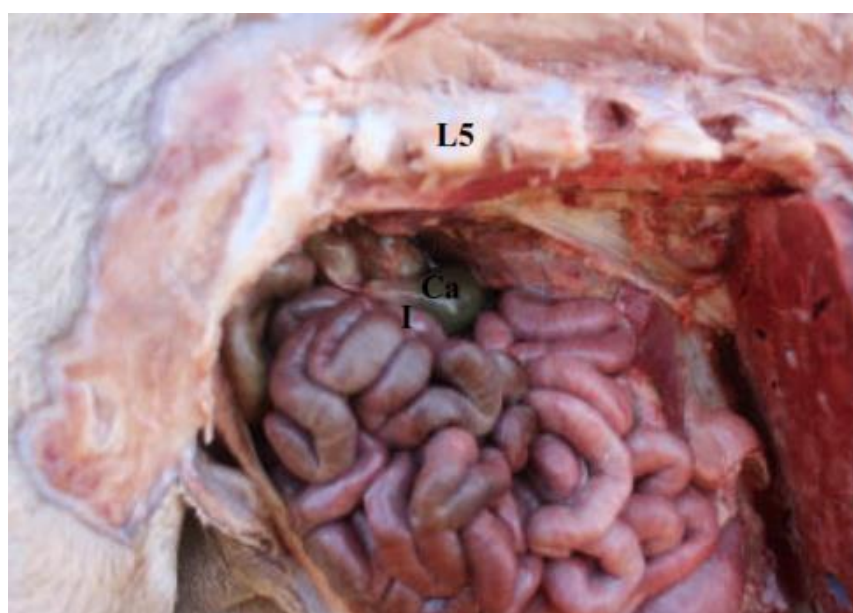


**Figure 1:** Right view of the abdominal cavity showing the fetal camel small intestine in third trimester (380 days of age; 115 cm CVRL); extension and attachment; costochondrial junction (C), right kidney (K), liver (L), compartment 4 (C4), ampulla (A), duodenum (Du), jejunum (Je) and 9<sup>th</sup> and 12<sup>th</sup> ribs.

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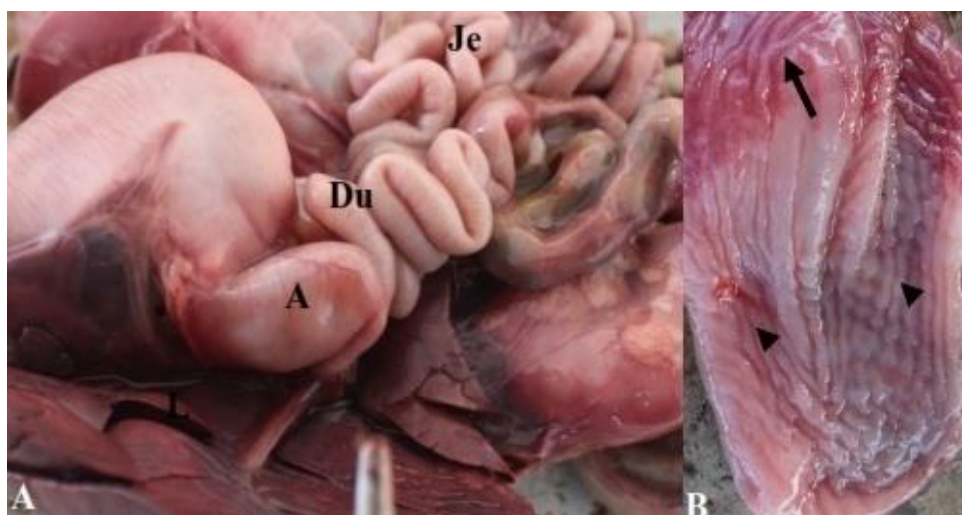


**Figure 2:** Right view of the abdominal cavity showing; descending duodenum (Ds), ascending duodenum (As), jejunum (Je) situated between 3<sup>rd</sup> and 7<sup>th</sup> transverse processes of lumbar vertebrae in third trimester (380 days of age; 115 cm CVRL).

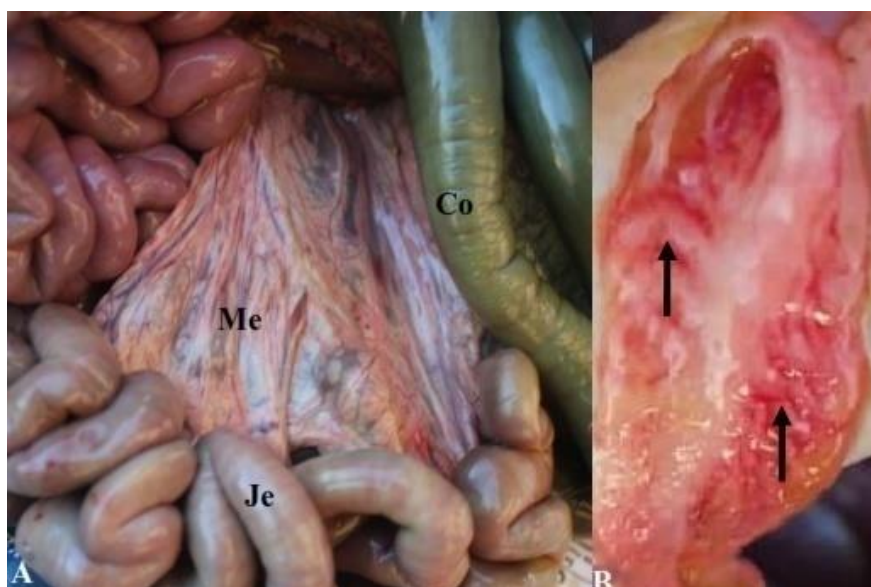


**Figure 3:** Right view of the abdominal cavity of camel fetus in third trimester (380 days of age; 115 cm CVRL), showing; ileum (I), caecum (Ca), 5<sup>th</sup> transverse process of lumbar vertebrae (L5).

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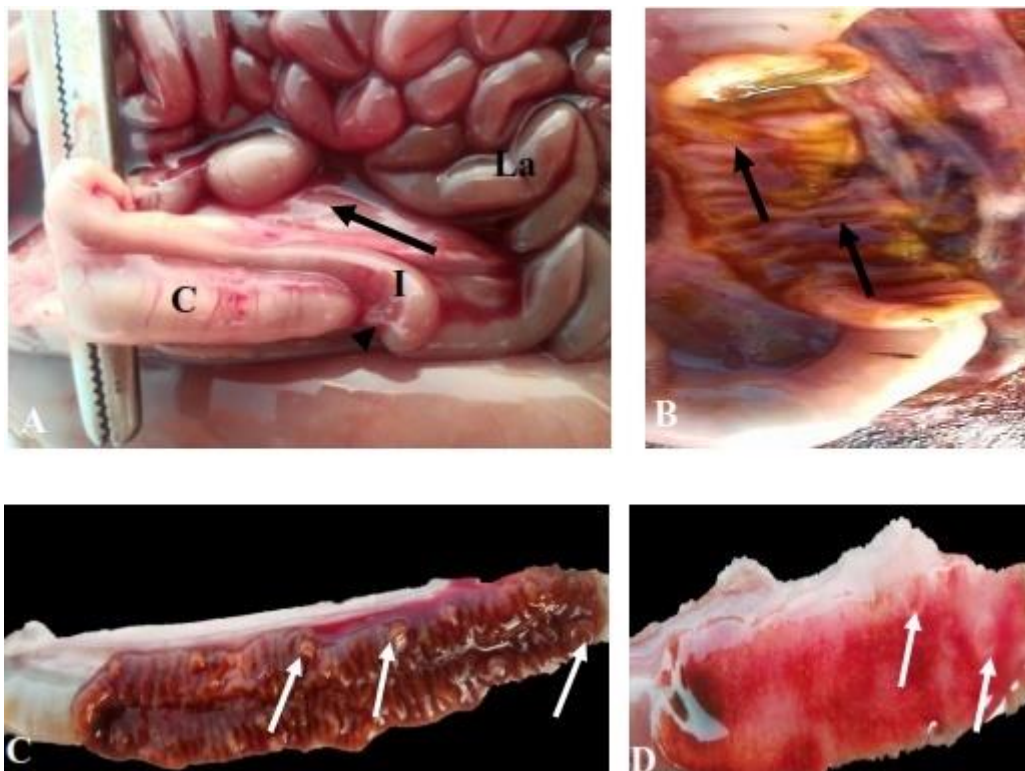
**Figure 4:** cranial part of duodenum in third trimester (270 and 380 days of age; 75 cm and 115 cm CVRL), showing; **A:** ampulla (A), duodenum (Du), jejunum (Je) and liver (L) (fixed specimen). **B:** ampulla with longitudinal folds (arrowheads) and circular folds (arrow) (fresh specimen).



**Figure 5:** jejunum in third trimester (371 and 380 days of age; 112 and 115 cm CVRL), showing; **A:** jejunum (Je), mesentery (Me) and colon (Co) (fixed specimen). **B:** circular folds (arrows) (fresh specimen).



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**Figure 6:** ileum in second and third trimesters showing; **A:** ileum (I), caecum (C), large intestine (La), ileocecal fold (arrowhead) and peritoneal fold (arrow) (fresh specimen) (175 days; 40 cm) in second trimester; **B:** circular folds (arrows) (fresh specimen) (372 days; 112 cm) in third trimester; **C:** Payers' patches (white arrows) (372 days ; 112 cm) in third trimester; **D:** Payers' Patches (white arrows) (188 days; 45 cm) in second trimester.

## DISCUSSION

The present study showed that the camel small intestine was situated mainly in the right side of the abdominal cavity and it was divided into three parts duodenum, jejunum and ileum. These findings are in agreement with Smuts and Bezuidenhout (1987) in dromedary camels and Getty (1975) in other domestic animals. In the present study during the third trimester the duodenum started at the pylorus which was situated below the tenth costochondrial junction, extending between pylorus and jejunum constriction. Smuts and Bezuidenhout (1987) and Mohamed (2012)

also stated that the duodenum which started at the pylorus was situated below the tenth costochondrial junction and it extended between the pylorus and jejunum constriction.

AL-Ani and Qureshi (2008) found that the duodenum the adult one-humped camel, started with a dilatation and then formed a loop and began from the pylorus, which was situated below the 10<sup>th</sup> costochondrial junction; the cranial part was located against the visceral surface of the liver. However, in adult she-camel the ampulla was located at the level of the caudal border of rib near to the distal end of the 11<sup>th</sup> rib



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and on the right aspect of the rumen and it ran dorsally and cranially to the visceral surface of the liver forming a sigmoid flexure (Mohamed, 2012). In the current study, the coils of jejunum were situated in the right side of the abdominal cavity between ascending duodenum cranially and ileum caudally. Mohamed (2012) has also reported that the convoluted jejunum in camels was placed mainly in the right flank of the abdominal region and on the sternum in the medial plane. This study is in agreement with Mohamed (2012) in adult she-camel and Getty (1975) in other domestic animals that the ileum extended from the pelvic inlet cranially until the caecum at the level of the 5<sup>th</sup> lumbar vertebrae in the right side of the abdominal cavity. The ileum was straight and was connect to the caecum by an ileocecal fold. According to Bello *et al.*, (2015. a) the duodenum was divided into two main portions namely the dilated (ampullae) part and the thin (straight) part which formed the long part of the duodenum in all the trimesters. At first trimester the thin part was not differentiated but divided into three parts such as the descending part, caudal duodenal flexure (transverse part) and ascending part at second and third trimester.

According to the present results, the duodenum was grayish to white in color and its mucosa was pink and contained longitudinal folds in the second and third trimesters but it was whitish at the first trimester. This is in agreement with the reports of Mohamed, (2012) and Althnaian *et al.*, (2012). However, the color of the small intestine including the duodenum and its subdivisions was found to be whitish at first trimester and greenish in second and third trimester in dromedary fetus (Bello *et*

*al.*, (2015. a). The present study reported that the jejunum formed numerous close coils arranged in a festoon around the border of the mesentery. The mucosa of jejunum was pink to grayish in colour containing circular folds during the third trimester but was absent during the second trimester. These results are in agreement with the findings of (Getty 1975) in the different domestic animals. On the other hand, the jejunum was found to have an extensive coiling in the second and third trimesters, with no evidence of segmental differentiation in the first trimester in various animals at different gestational ages including dromedary camel (Bello *et al.*, 2015. b). Moreover, it has been stated that the coil part of the jejunum was not divided at the first trimester but it was differentiated into five parts (descending jejunal part, cranial jejunal flexure, transverse jejunal part, caudal jejunal flexure and ascending jejunal part) at the second and third trimesters in the different mammals including dromedary camel (Bello *et al.*, 2015. b).

In the current results the mucosa of ileum was pink in colour. The ileum consisted of dome shaped the Peyers' patches which were projected into the lumen. Whereas they were absent during the first trimester. In the third trimester, the ileum demonstrated circular mucosal folds whereas they were absent during the first and the second trimesters. These findings are in line with those of Mohamed (2012) and Getty (1975). However, previous developmental study on the dromedary (Bello *et al.*, 2017) divided the ileum into two main portions namely the dilated ampulla and the thin straight part which formed the long part of the ileum in all the trimesters; the first trimester the thin part



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was not differentiated but divided into three parts such as the descending part, caudal duodenal flexure (transverse part) and ascending part at second and third trimester.

### Conclusion

Grossly the foetal small intestine of camel foetus was divided into three parts duodenum, jejunum and ileum and duodenum was divided into three part cranial part (ampulla), ascending and descending duodenum. The small intestinal tract was situated mainly in the right side and in the caudal left part of the abdominal cavity. The mucosa of ampulla was pink to grayish in colour and made up circular and longitudinal folds during the third trimester. And the descending and ascending parts of duodenum were convoluted characterized by white grayish colour during the first trimester and pinkish during the second and the third trimesters possessing longitudinal folds. The mucosa of jejunum was pink to grayish in colour possessing circular folds during the third trimester. The mucosa of ileum was pink in colour during the gestational period and possessing circular folds interspersed by the dome of Payers' patches which projected into the lumen during the second and the third trimesters.

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