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Formation of the Bovine Spiral Colon

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(Received 29 March 1985/Accepted 28 May 1985)

ABSTRACT. Formation of the bovine spiral colon was studied in fetuses between 2.1 cm and 25.0 cm crown-rump length. The first evidence of looping of the proximal colon was seen at 3.5 cm. By 6.5 cm the looping colon was beginning to assume the form of a coil, and by 9.3 cm the coiling colon was beginning to appear conical. The conical proximal colon achieved the elliptical disc-like adult form with centripetal and centrifugal coils between the 13 cm to 23 cm stage.—**KEY WORDS:** bovine spiral colon, organogenesis.

Jpn. J. Vet. Sci. 47(5): 803–806, 1985

It is well known that ruminants as well as the pig, have an elongated and coiled spiral colon. The spiral colon is formed as the result of an elongation of the proximal portion of the colon during development.

The development of the large intestine in ruminants, particularly the formation of the spiral loop of the proximal colon, was described by Martin and Schauder [2], and Zietzschmann and Krölling [6]. However, the exact fetal period when the spiral loop assumed its adult arrangement in the bovine fetus has not been described.

The purpose of this paper is to correlate the size of the bovine fetus with the development of the spiral colon.

Twenty bovine fetuses of the Holstein breed between 2.1 cm and 25 cm crown-rump length (CRL) were used in this study. The age of the fetus was estimated from the CRL data cited by Evans and Sack [1] and Takeishi [5] (Table 1).

Observations were made under a dissecting microscope, on fresh and 10% formalin fixed intestine. Photographs were taken with a Medical Nikkor (Nikon).

By CRL 2.1 cm the primitive intestine is situated caudally to the huge liver and primitive stomach. At this stage, the primitive

Table 1. Crown-rump length of bovine fetuses

Material No.	CRL ^{a)} (cm)	Estimated age (days)
1	2.1	
2	2.3	
3	3.4	
4	3.5	40–60
5	5.2	
6	5.6	
7	6.2	
8	6.5	
9	7.2	
10	7.6	
11	8.3	60–75
12	9.3	
13	9.7	
14	10.0	
15	13.0	80
16	16.5	
17	17.0	90–100
18	21.0	
19	23.0	115–120
20	25.0	

a) Crown-rump length.

intestine undergoes some torsion, considerable elongation, twisting, and herniation into the umbilical cord on the midline. In the umbilical cord, the small intestine is already coiled, yet the whole complex can be considered as 2 or 3 primary loops. In contrast, the

Fig. 1. A fetus of 3.5 cm CRL. Loops of the intestine and the first evidence (arrow) of loop of the proximal colon are observed.

Fig. 2. A fetus of 6.5 cm CRL. The proximal colon is beginning to be brought together, and the loop is forming a coil.

Fig. 3. A fetus of 8.8 cm CRL. The proximal colon forms a coil in various manners.

Fig. 4. A fetus of 9.3 cm CRL. The coiling proximal colon is beginning to be brought together as a conical shape in various manners. At this stage, the cecum is located dorsally in the abdominal cavity, and its apex turns in a caudal direction (arrow).

large intestine and its associated mesentery grow relatively slowly at this stage. At 3.5 cm CRL the coiling of the small intestine becomes more marked and the first evidence of looping of the proximal colon is seen. However, the ventral flexing of the intestinal loop is still in the umbilical cord (Fig. 1). By 5.4 cm CRL the small intestine has returned to the abdominal cavity and its extensive

loops occupy the posterior part of the cavity and cover the large intestine. The looping of ascending colon continues independently on the left side of the mesentery. The cecum remains in the umbilical cord at this stage. By 6.5 cm CRL the proximal colon is beginning to be brought together, and the loop is forming a coil. The cecum is returned to the abdominal cavity although its location is not

Fig. 5. A fetus of 13 cm CRL. The proximal colon is already coiled up in a conical shape.

Fig. 6. A fetus of 16.5 cm CRL. The proximal colon is coiled up in a more conical shape.

Fig. 7. A fetus of 23 cm CRL. Because of the obliteration of its mesocolon, the spiral loop of the colon is already flattened to an elliptical disc like that of the adult, having two full centripetal turns. The cecum extends dorsocaudally, and its apex lies on the spiral loop at the dorsal side of the pelvic inlet (arrow).

(1) Scale shows 1 mm.

(2) Small intestine is removed in Figs. 2–6.

the final portion (Fig. 2). By 9.3 cm CRL, although the mesocolon is still expanded, the coiling proximal colon begins to assume a conical shape. The cecum is located dorsally in the abdominal cavity with its apex turned caudally (Figs. 3, 4). Between 13 cm and 16.5 cm CRL the stomach compartments assume their adult positions. The stomach, liver and kidney at this stage are so large that they occupy the cranial and dorsocaudal portions of the abdominal cavity, and leave little room for the intestinal tract. The proximal colon is coiled in a more conical shape (Figs.

Table 2. The time of appearance of the proximal colon in domestic animals

Animal species	Appearance (month)	Gestation length (month)
Horse	9.0 cm (2.4)	125 cm (10.9)
Cow	21–23.0 cm (3.7)	90 cm (9.2)
Sheep	12.0 cm (2.1)	47 cm (4.9)
Pig	11.0 cm (1.8)	29 cm (3.7)

The data of the horse, sheep and pig are cited from Ziezschnmann and Krölling (1955)

5, 6). At 21 cm and 23 cm CRL, because of the obliteration of its mesocolon, the spiral loop of the colon flattens to the adult form of an elliptical disc with two full centripetal turns. The mass of the small intestine is located peripherally surrounding the spiral colon with its mesentery. The cecum extends dorsocaudally and its apex lies close to the spiral loop at the middle or left side of the pelvic inlet (Fig. 7).

A complex and voluminous large intestine allows for a more prolonged storage of digesta, providing the major site for microbial action in many herbivores [4]. Ruminants, as herbivores, have a unique large intestine (spiral loop of the proximal colon) which provides a great increase in length over that of carnivores. As for the formation of the spiral loop in the developmental stage, it is known that the center of the proximal colon, at first, expands around the root of the mesentery in

the early embryological stages, and then coils in a disc-shaped loop on the left side of the mesentery [3].

In the bovine fetuses observed in this study, the loop was beginning to be formed at 3.5 cm CRL on the left mesentery. Continued elongation of the proximal colon led to extensive looping, and then at between 13 and 15 cm CRL, the proximal colon coiled in a conical shape, and by 23 cm CRL, the elliptical disc-like shape of the adult colon was completed.

Referring to the description of Zietzschmann and Krölling [6] and the results in this study, it seems that the appearance of the unique form of the proximal colon is earliest in horses, latest in pigs, and intermediate in ruminants when correlated with the length of the gestation (Table 2).

ACKNOWLEDGEMENTS. The authors wish to express their cordial thanks to Prof. Howard Evans, Department

of Veterinary Anatomy, Cornell University, for his critical revision of the manuscript. This study was supported in part by a Grant-in-Aid No. 57760621 from the Scientific Research Fund of the Ministry of Education, Science and Culture of Japan.

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要 約

牛の結腸らせん巻の形成: 浅利将男・和久井 信・深谷幸作・鹿野 胖 (麻布大学 獣医学部 解剖学 第一講座)——牛の結腸らせん巻の形成について、頭尾長 2.1~25 cm の胎仔を用いて観察した。大腸では小腸に遅れ、頭尾長 3.5 cm 胎仔において近位結腸部に最初の折れ曲がり観察された。その後、頭尾長 6.5 cm に至るまでに、近位結腸部は巻き込みはじめ、これらの巻き込みは頭尾長 9.3 cm に至るまでに円錐状にまとまりはじめた。これらの近位結腸の円錐状の巻き込みは、およそ頭尾長 13~23 cm の間に、成牛型の円盤状の結腸として完成した。