

牛胎仔第二胃溝底における縦走ひだの形態形成

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Morphogenesis of Longitudinal Folds Situated on the Floor of the Reticular Groove

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In the adult ruminant stomach, the floor of the reticular groove presents dozen or more folds which extend longitudinally from the cardia to the reticulo-omasal orifice [1, 4]. These folds joined the folds of the esophageal mucosa and the omasal laminae, and thereby, the continuity of their alignment is recognized throughout the esophagus, reticulum and omasum. This feature seems as if it were inconsistent with the concept in recent embryology that the ruminant forestomach is not an outgrowth of the esophagus but it has been derived from a single gastric primordium. Although there are many descriptions of the developmental manner of compartmentalization [5, 6, 10], embryological interpretation of the continuity of folds-alignment still seems to be inadequate.

This study was undertaken in order to elucidate the morphogenesis of these folds, especially of those situated on the floor of the reticular groove. Knowledge of their morphogenesis is considered to be closely related with the understanding of the nature of the omasal laminae and of the origin of the gastric groove.

The animals studied were 46 Holstein fetuses ranging from 1.5 to 88 cm in crown-rump length (CRL). The ages of fetuses were estimated from CRL as proposed by Evans and Sack[2] and Takeishi [9]. For making reconstructed models to show the surface structure of the epithelium and lamina propria, tissues of the stomach were fixed in 10% formalin, embedded in paraffin, serially sectioned at 10 μ m, and stained with hematoxylin and eosin. In fetuses at late fetal stages, 40-80 cm in CRL, observation of the formalin-fixed stomachs was made under a dissecting microscope or by the naked eyes.

Terminology: An accurate description of the interior of the ruminant stomach requires a clear terminology. The cardia is the junction between the esophagus and the rumen. The reticulo-omasal orifice (*Ostium reticulo-omasicum*) is the

opening between the reticulum and the omasum. The pylorus is the junction between the abomasum and the duodenum. Between the cardia and the reticulo-omasal orifice is the reticular groove (*Sulcus reticuli*) that is flanked by two ridges (left and right lips). Between these lips is the floor of the reticular groove (FR, *Fundus sulci reticuli*), which is marked by dozen or more longitudinal folds. In the omasum, between the reticulo-omasal orifice and the omasoabomasal orifice (the opening between the omasum and the abomasum) is the omasal groove (*Sulcus omasi*). It lies opposite the free borders of the omasal laminae, which are the longitudinal mucosal folds of varying sizes arising from the wall and projecting with their free borders into the interior. The largest of these are the 1st order laminae. The 4th ones are smallest. In this report, two kinds of mucosal folds and two subdivisions are described; 1) longitudinal folds of the esophageal mucosa (esophageal folds) and 2) longitudinal folds of FR (folds of FR), the latter being subdivided into two kinds of folds, a) those continued from the esophageal folds and b) those from the omasal laminae. The greater or lesser curvature of the simple-shaped primordium of the ruminant stomach is defined as the side of the attachment of the primary dorsal or ventral mesentery [5].

Observation: At 1.5 and 2 cm CRL (estimated to be 1 month of fetal age), two parallel ridges of the mucosa were present along the whole length of the lesser curvature of the simple-shaped primordium of the stomach. The FR was free of folds at this stage, but the first evidence of the omasal laminae were found (Fig. 1). At 8 cm CRL (2months), the first evidence of 3 or 4 folds appeared in the lamina propria of FR near the reticulo-omasal orifice, seeming to be continued from the omasal laminae (Fig. 2). The boundary between the reticulum and the omasum was still obscure. In the middle part of the omasum, the 1st, the 2nd and the 3rd order laminae were present on the enlarged innersurface flanked by the ridges of the primitive gastric groove. At 10

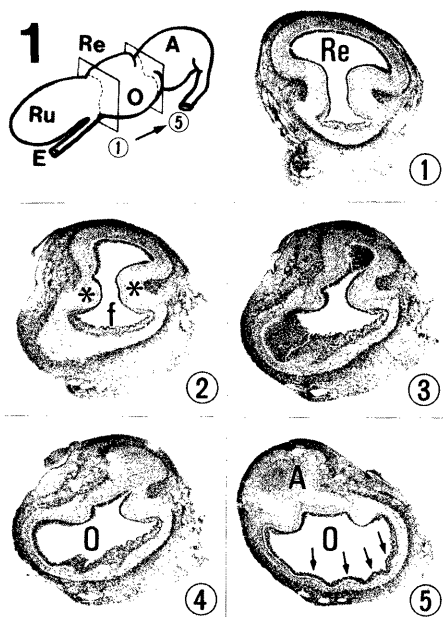


Fig. 1. 2 cm CRL. Cross sections of the reticulum and omasum. The floor of the reticular groove (f) and the omasal laminae (arrows) are formed on a continuous floor. Ru: rumen, Re: reticulum, O: omasum, A: abomasum, asterisks: lips of the reticular groove, Hematoxylin and eosin stain. $\times 25$.

and 11 cm CRL, the lamina propria of FR presented folds which were continuous from the omasal laminae (5–6 folds) and the esophageal folds (2–3 folds) (Figs. 3 and 4). Some of them extended over more than half of FR. At 12 and 13 cm CRL (3 months), folds in the lamina propria of FR were increased in number with those continued from the omasal laminae (8–9 folds) and those from the esophageal folds (3–4 folds). Some of the folds that were continued from the omasal laminae reached the cardia, and others joined the folds from the esophageal ones at the middle of FR (Figs. 5 and 6). The epithelial surface at this stage was slightly undulated corresponding to the growth of the connective tissue (lamina propria) folds. At 16 cm CRL, the number of folds that were continued from the omasal laminae was increased to 11 or 12, nearly corresponding to the number of the 1st order laminae. The epithelial surface of FR entirely lay in parallel with the folds of the lamina propria (Fig. 7). This arrangement-pattern persisted thereafter, with a slight modification of a forma-

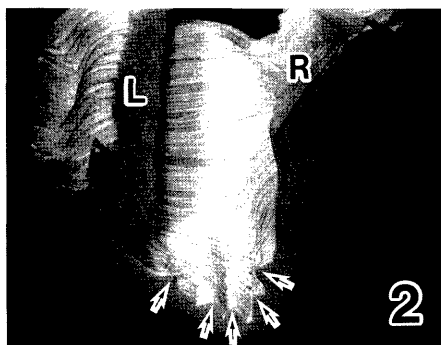
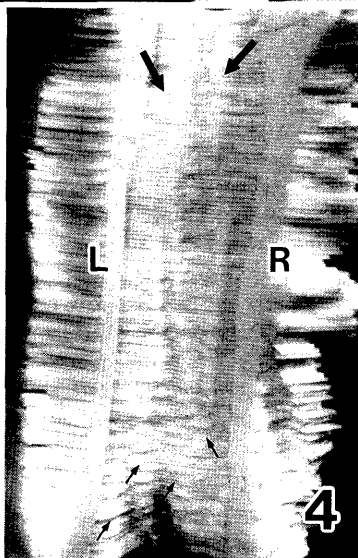
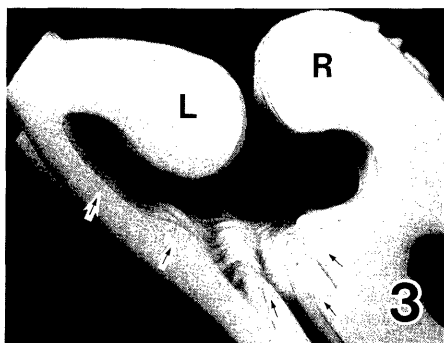


Fig. 2. 8 cm CRL. Reconstructed model viewed from the omasal side, revealing the surface of the lamina propria of the floor of the reticular groove. Lips have been cut off. A few folds continued from the omasal laminae (arrows) have been formed near the reticulo-omasal orifice. L: left lip, R: right lip.

tion of unguiculiform papillae on folds near the reticulo-omasal orifice (Figs. 8, 9 and 10). In the final form, most of the 1st order omasal laminae were related to the formation of the folds of FR, but the lesser ones, i.e. the 2nd, the 3rd and the 4th, were not. Since these 1st order laminae joined the folds continued from the esophageal ones, FR was marked by dozen or more longitudinal folds lying along the whole length of FR. As a result, a continuation from the esophageal folds through the folds of FR to the 1st order laminae was completed.

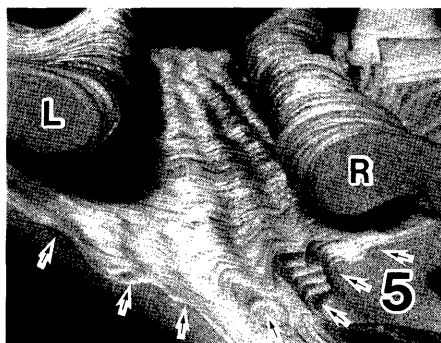
In the *Nomina Anatomica Veterinaria* [8], there is a footnote for the term *Sulcus ventriculi* (gastric groove) as follows. In Ruminantia, the *Sulcus ventriculi* is divided into three segments; *Sulcus reticuli*, *Sulcus omasi*, and *Sulcus abomasi*. The idea that the omasal groove is the second segment of the gastric groove has been incorporated into many recent textbooks [1, 3, 7]. Since there is no explanation for morphogenesis of the grooves in these textbooks, it is apt to be understood that these segments are derived from a single primordium. However, the embryological studies on the origin of the ruminant stomach have shown that the omasal groove is situated along the greater curvature of the simple-shaped primordium of the stomach, and that the reticular and the abomasal grooves extend along the lesser curvature. Martin and Schauder [6] and Warner [10] described that in the primordium of the ruminant stomach, the primitive groove flanked by two mucosal ridges was present



Figs. 3 and 4. 10 cm CRL. Reconstructed model showing the surface of the lamina propria. Fig. 3. Five folds which are continued from the omasal laminae are revealed in a view from the omasal side. Fig. 4. The lips have been cut off to show folds continued from the omasal laminae (small arrows) and those from the esophageal folds (large arrows). The esophageal side is oriented to the top of this figure.

extending along the lesser curvature from the cardia to the pylorus. They pointed out that the anlage of the reticular and abomasal groove were respectively the cranial and caudal segments of the primitive groove, and that opposite the middle part was the omasal groove. These observations involve the hypothesis that the omasal laminae lie against the omasal groove, i.e. they originate from the floor of the primitive gastric groove.

In this report, foundations by which the hypothesis mentioned above is confirmed were



Figs. 5 and 6. 12 cm CRL. Reconstructed model showing the surface of the lamina propria. Fig. 5 shows eight folds continued from the omasal laminae (arrows). Fig. 6 shows that the folds from the omasal laminae join those from the esophageal folds coming down from the upper side of this figure.

recognized as follows. (1) In early stages, the greater part of the omasal innersurface, from which the omasal laminae developed, was continued without demarcation from the FR and flanked with a continuous mucosal ridge on either side. (2) The folds of FR were formed as a proximal elongation of the omasal laminae. These findings clearly indicate that the folds of FR and the omasal laminae are homogeneous as they are longitudinal mucosal folds situated at the floor of the true gastric groove. The omasum is considered to be, in an embryological sense, an enhanced part of the gastric groove.

Additionally, this report revealed that the

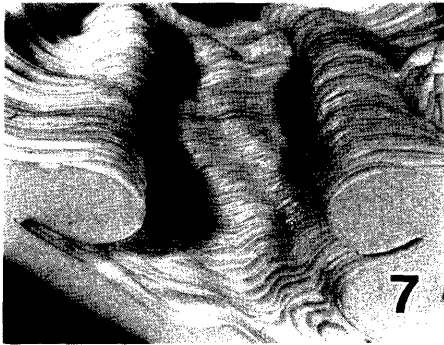


Fig. 7. 16 cm CRL. Reconstructed model showing the epithelial surface. It undulates corresponding to some large folds of the lamina propria.

folds of FR included, to a lesser extent, the distal elongation of the esophageal folds. In the adult, the FR is marked by several longitudinal folds which join the esophageal folds and the omasal laminae respectively at the proximal and distal ends, and therefore, these folds seem to be derived from a common morphogenetic origin. Our findings indicate that this adult feature of the folds of FR is a result of joining of folds with different origins, i.e. the esophageal folds and the omasal laminae.

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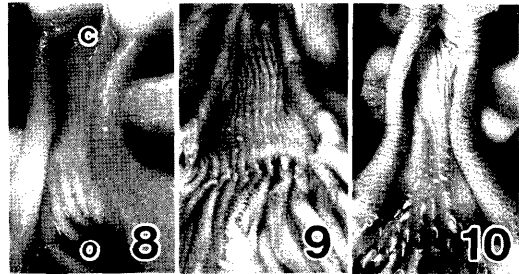


Fig. 8. 40 cm CRL. Formalin-fixed organ. This photograph clearly indicates the continuity of the folds and the 1st order omasal laminae. C: cardia. O: omasum. Dotted line indicates a border between the reticulum and the omasum.

Fig. 9. 70 cm CRL. Formalin-fixed organ. The folds near the reticulo-omasal orifice are partially displaced into a series of unguiculiform papillae.

Fig. 10. 88 cm CRL. Formalin-fixed organ. Unguiculiform papillae near the reticulo-omasal orifice are developed into nearly adult forms.

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要 約

牛胎仔第二胃溝底における縦走ひだの形態形成（短報）：鹿野 胖・川口直彦・浅利将男・和久井信（麻布大学獣医学部解剖学第一講座）——頭殿長1.5～88cmの牛胎仔について第二胃溝底に存在する粘膜ひだの発生を観察した。まず、第二・三胃口近くで第三胃葉に連続するひだと、噴門近くで食道粘膜ひだに連続するひだの2種類が発生し、両者はその後延長、合流して、第二胃溝全長に及ぶひだに成長した。ひだの多くは第三胃葉の延長として発生することが示唆された。