A morphological and morphometrical study on the sacculus rotundus and ileum of the Angora rabbit

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ABSTRACT: The aim of this study was to reveal morphological and morphometrical properties of the sacculus rotundus (SR) and ileum in the Angora rabbit. For this purpose, a total of thirteen adult healthy Angora rabbits of both sexes were used. At the level of the junction of the ileum and SR, the ileum invaginated into the SR by protruding in 9 Angora rabbits, but joined directly the SR in 21. Numerous aggregate lymph follicles located just under the tunica serosa formed outstanding macroscopic polygonal areas on the external surface of the SR. In the inner wall of the SR, irregular projections were seen grossly. The saccorotundocecal orifice was found to be bordered laterally by two folds facing the cecum. These folds enclosed small polygonal spaces with mushroom shaped protrusions. The mean lengths and weights of SR and ileum in male were larger than those in female, and the related values also had statistical significance ($P < 0.05$). Compared with the ileum, the SR had short and thick villi, had a large amount of crypts and aggregated lymphoid follicles, and had a much thicker wall and much wider lumen. The crescent-like-hollows were detected between the lamina propria and the apical portions of the lymph follicles. The results from this study are thought to shed light on future studies on the digestive system and proper diagnosis of pathological disorders related to it in the Angora rabbit, and to contribute to the present morphological knowledge on the SR and ileum in this species.

Keywords: sacculus rotundus; ampulla ilei; ileum; morphology; Angora rabbit

Angora rabbits (*Oryctolagus cuniculus*), one of the oldest known domesticated breeds of rabbit, is a species of the order *Lagomorpha*. They were introduced into Europe from the town of Ankara in Turkey, toward the end of the eighteenth century. Its long wool was selectively bred over hundreds of years and is called angora fibre, which is the third largest animal fibre industry in the world (Leader et al., 1998). Rabbits are hind gut fermenters, with a large and complex digestive system. They practice cecotrophy, which is the reingestion of mucous coated night feces, which occurs daily, and is a method of recycling cecotrophs that are rich in B vitamins and proteins (Irlbeck, 2001). Researchers stressed that rabbit is a very favourable animal for immunological works because of its good response to different antigens (Alboghobeish and Zabiehy, 1996; Vajdy et al., 1998).

The terminal portion of the ileum of the rabbit is enlarged to form the sacculus rotundus (SR), known as the ampulla ilei or ileocecal tonsil. The SR, a round, sac-like structure, possesses abundant gut associated lymphoid tissue (GALT) (Craigie, 1969; She et al., 1994; Yildiz et al., 2001).

Immunological (Aita et al., 1978; Mokresh et al., 1989), pathological (She et al., 1994; Simeonov and Simeonova, 2003) and pharmacological (McClean et al., 1998) studies were carried out on the SR, and it is of clinical significance as there are sometimes pathologic changes (Gregory and Catchpole, 1986). Moreover, to avoid metabolic and severe nutritional disturbance in animals which undergo an intestine resection, the preservation of the ileocecal junction and also the last centimetres of the terminal ileum is fundamental (Bellon-Caneiro et al., 1987).Therefore, the exact anatomical knowledge

of the SR is necessary for further studies on it, and for proper diagnosis of its pathologic disorders. In the literature, however, very little was known on the morphology of the SR in rabbits, and no study existed on the digestive system of the Angora rabbit. Considering this, we have aimed to investigate the composition of the SR and ileum in the Angora rabbit.

MATERIAL AND METHODS

A total of thirteen adult healthy Angora rabbits of both sexes aged 1.5–2 years and weighing between 3.2 and 5.4 kg were used. All rabbits were obtained from Erciyes University, Veterinary Faculty, Kayseri, Turkey. They were fed *ad libitum* with pelleted laboratory chows and supplemented with lettuce greens. The animals were intramuscularly anaesthetized with 10 mg/kg xylazin HCl (Rompun®, BAYER) and 50 mg/kg ketamin HCl (Ketanez®, ALKE). Under anaesthesia, they were killed by exsanguination from the abdominal aorta without regaining consciousness, following the opening of the abdominal cavity with a median incision. After topographic examinations of the SR and ileum situ were recorded and photographed, they and the initial portion of the cecum were removed. They were straightened, with care taken not to stretch the tract. The contents were removed by careful hand stripping. After they were thoroughly washed, transverse sections were performed at 10 cm intervals in order to check whether all contents were removed or not. The width and axial lengths of the SR were measured in middle portion and between its colour differentiations, at which points the diameter of the SR was presently narrowed, respectively. After an average of measurements of partial ileal widths obtained of about at 5 cm intervals was determined in each material, the total mean value of the width of the ileum was determined. The measurement of the length of the SR and the widths of the SR and ileum were carried out using a digital calliper (Mitutoyo 500 171-1 Digimatic Calliper 150mm/6in, Japan). The wall thickness of the SR was also measured using an ocular micrometer (Olympus). The sections of the SR and the crossing point of the SR and ileum were prepared in order to compare the histological differences were subgrossly observed under a stereomicroscope (Nikon SMZ-2T, Nikon Corp., Tokyo, Japan). For routine histological examinations, the tissue samples were fixed in 10% buffered-formaldehyde (pH 7.4), dehydrated, cleared and embedded in paraffin blocks and cut in 6-μm thick longitudinal sections, which were stained with haematoxylin-eosin. The histological preparations were examined using a light microscope (Nikon E-400 attached with DS-5M digital camera and DS-L1 Camera control unit).

Regarding the weights, widths, lengths and wall thicknesses of SR and ileum, all statistical analyses were accomplished with the Statistical Package for the Social Sciences (SPSS 9.0, SPSS Inc. Corp, Chiago, IL, USA) computer package.

RESULTS

Macroscopical findings

The ileum of the Angora rabbit was located in the median plane of the abdominal cavity. It, a cranial continuation of the jejunum at the beginning of the ileocecal ligament, was caudal mouthed U – shaped. The right part of the U was in close contact with the vermiform appendix dorsally, and with the ascending colon and the right portion of the cecum ventrally. The left part of the U was related to the descending colon dorsally, and to the left part of the cecum ventrally. Near its terminal portion, the ileum curved sharply in cranial direction and ran in a spiral manner for a short distance to form the SR, a very evident ampullary dilatation (Figure 1).

At the junction of the ileum and SR (at the level of ileal orifice), the ileum protruded about 2 mm in length and 1.1 mm in diameter into the lumen of the SR in 9 materials (5 males and 4 females), but it opened directly into the SR without any protrusion in the remaining samples. The protrusion mentioned was nominated as the ileal papilla in this study, and was suggested to prevent retrograde flow of intestinal content by serving as a partial valve. The SR opened dorsally to the second gyrus of the cecum. Although other bowels were dark grey in colour, the SR had a light rose coloured appearance due to a result of dense aggregations of lymphoid tissue in its wall. Polygonal areas of approximately 3 mm length and 2 mm width were mostly visible on the external surface of the SR because numerous aggregate lymph follicles were very close to the tunica serosa. We recorded that they were readily seen near the junction of the SR and cecum. Moreover, these polygonal areas also consisted of

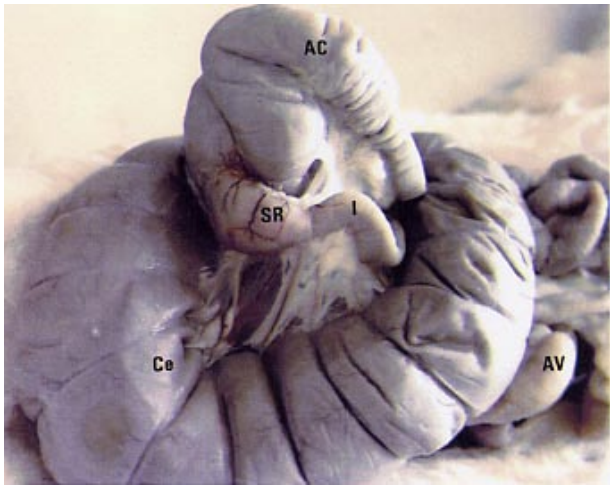

Figure 1. Left ventrolateral view, ascending colon was drawn ventrally

AC = ascending colon; AV = appendix vermiformis; Ce = cecum; I = ileum; SR = sacculus rotundus

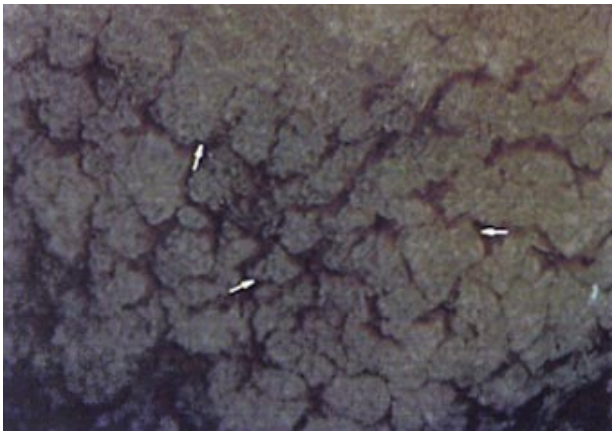

Figure 2. Inner wall of SR (sacculus rotundus). Arrows show irregular protrusions

7–9 irregular cork-like-projections bordered by dimly capillary vessels. The inner surface of the SR had irregular projections that were even seen with the naked eye (Figure 2).

The saccorotundocecal orifice was found to be bordered laterally by two folds facing the cecum (Figure 3). Between these folds, small polygonal spaces (Figure 4), each of them consisted of mush-room-like-protrusion(s) either singly or in a pair or triple, existed dorsally in 26 animals, or both dorsally and ventrally in 4 animals. An annular protrusion that we called the saccorotundal papilla (Figure 4) existed around the orifice mentioned above. The mean lengths (male: 26.81 ± 0.26 mm, female: 23.85 ± 0.15 mm, $P < 0.05$) of SR had statistical significance.

We found that a statistical difference existed between mean lengths (male: 29.44 ± 0.32 mm, female:

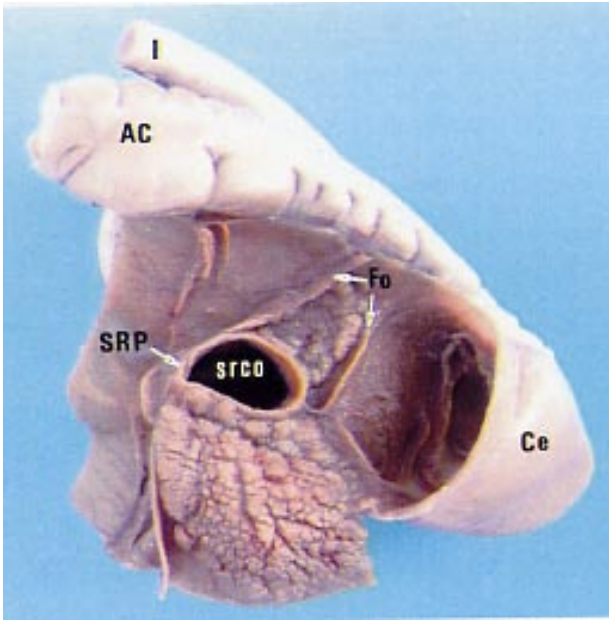

Figure 3. View of saccorotundocecal orifice from cecal cavity

AC = ascending colon; Ce = cecum; Fo = fold; I = ileum; SRCO = saccorotundocecal orifice; SRP = saccorotundal papilla

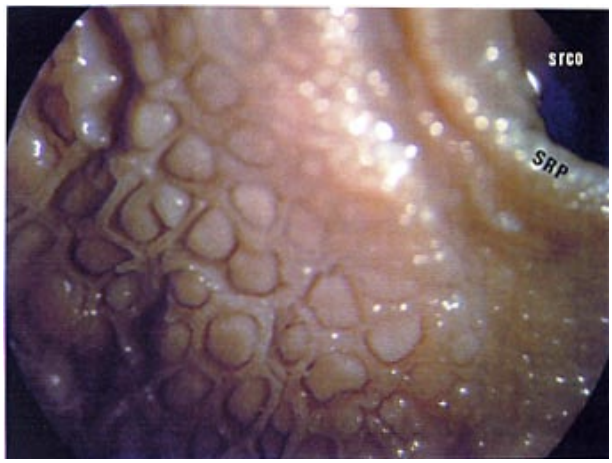

Figure 4. View of mushroom-like-protrusions around saccorotundocecal orifice

SRCO = saccorotundocecal orifice; SRP =: saccorotundal papilla

Table 1. Morphometrical measurements were analyzed by paired *t*-test

	Male (n = 15)	Female (n = 15)
L of SR (mm)*	26.81 ± 0.26	23.85 ± 0.15
Min–Max	25.58–29.26	23.19–25.23
L of ileum*	29.44 ± 0.32	25.41 ± 0.27
Min–Max	27.20–31.60	24.30–28.20
W of SR (mm)	18.68 ± 0.19	18.09 ± 0.25
Min–Max	17.13–20.42	16.73–20.42
W of ileum (mm)	7.46 ± 0.09	7.29 ± 0.09
Min–Max	6.73–8.06	6.62–8.04
We of SR (g)*	4.08 ± 0.10	2.60 ± 0.06
Min–Max	3.60–4.94	2.28–2.96
We of ileum (g)*	7.62 ± 0.11	4.73 ± 0.09
Range	6.93–8.32	4.14–5.47
WT of SR (mm)	2.95 ± 0.03	2.93 ± 0.02
Min–Max	2.83–3.23	2.78–2.98
WT of ileum (mm)	0.97 ± 0.02	0.95 ± 0.01
Min–Max	0.84–1.21	0.87–0.98

L = length, SR = sacculus rotundus, W = width, We = weight, WT = wall thickness

Data expressed as the mean ± SEM

*means that difference between two groups is statistically significant in value of $P < 0.05$

25.41 ± 0.27 mm, $P < 0.05$) of the ileum. Regarding the means of widths of the SR (male: 18.68 ± 0.19 mm, 18.09 ± 0.25 mm) and ileum (male: 7.46 ± 0.09, female: 7.29 ± 0.09 mm), there was no relation between sexes. The mean weights of the SR (male: 4.08 ± 0.10 g, female: 2.60 ± 0.06 g, $P < 0.05$) and ileum (male: 7.62 ± 0.11 g, female: 4.73 ± 0.09 g, $P < 0.05$) had statistical significance. We found no statistical significance in the wall thicknesses of the SR (male: 2.95 ± 0.03 mm, female: 2.93 ± 0.02 mm) and ileum (male: 0.97 ± 0.02 mm, female: 0.95 ± 0.01 mm). All morphometrical data of the present study are shown in Table 1.

Histological findings

The spindle shaped villi encircled by a tall columnar epithelium increased the height of the tunica mucosa, thus narrowing the lumen of the ileum. Numerous goblet cells were also seen to scatter between the columnar cells. In the transition of ileum to SR, the muscular layer was considerably thickened (Figure 5). The epithelial layer facing the lumen of the SR comprised columnar cells with infrequent goblet cells (Figure 6). It was very interesting that the crescent shaped hollows were seen between the lamina propria and the apical portions of the lymph follicles (Figure 7). The lamina propria was very thick and consisted of many crypts. The lymph follicles enclosed by a thin connective tissue were arranged in a mosaic

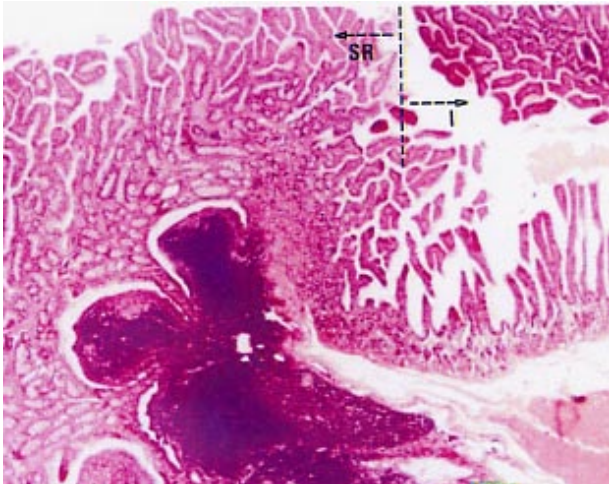

Figure 5. Border between I (ileum) and SR (sacculus rotundus)

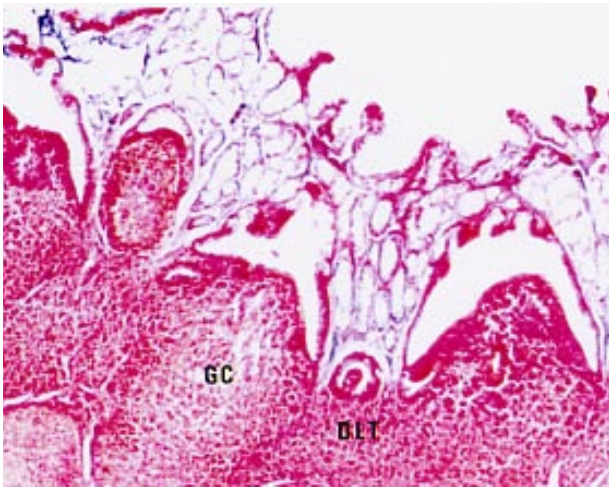

Figure 6. General aspect of lymphoid follicles in SR (sacculus rotundus)

DLT = diffuse lymphoid tissue; GC = germinal centre

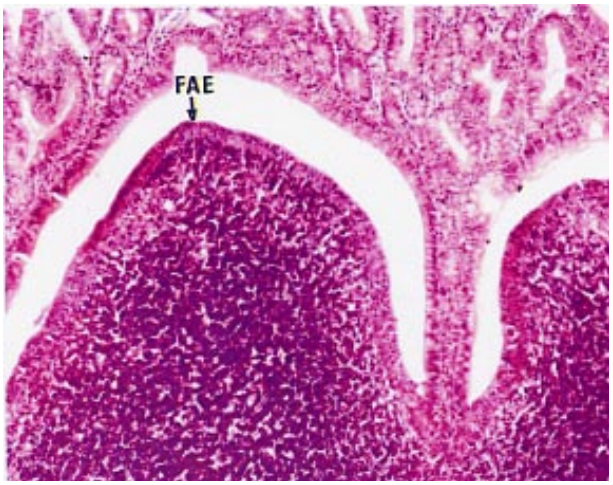

Figure 7. View of crescent-like-hollows and lymphoepithelium which covered apical portion of lymphoid follicle in SR (sacculus rotundus)

FAE = follicle associated epithelium

manner, and had intimate contact with the lamina serosa (Figure 6).

DISCUSSION

Although the ileums of Le-Lapin Albinos (Alboghobeish and Zabiehy, 1996) and New Zealand rabbits (Yildiz et al., 2001) were recorded to be around 6 and 31 cm in length, respectively, in this study its length was about 27 cm in the Angora rabbit. The SR of the Angora rabbit emptied directly into the cecum as in the New Zealand (Yildiz et al., 2001) and Le-Lapin Albinos (Alboghobeish and Zabiehy, 1996) other domesticated rabbits (Snipes, 1978). We found that a ring-like-saccorotundal papilla directed to the cecum existed around the saccorotundocecal orifice of the Angora rabbit; however, other researchers (Snipes, 1978; Alboghobeish and Zabiehy, 1996; Yildiz et al., 2001) did not mention such a papilla in rabbits that they examined.

The saccorotundocecal orifice of the Angora rabbit was surrounded laterally by two folds, which is consistent with the finding of Snipes (1978). Compared with the ileum, the SR had short and thick villi, had a large amount of crypts and aggregated lymphoid follicles, had a much thicker wall and much wider lumen, and had undistinguished muscular layer as recorded by Snipes (1978). However, Alboghobeish and Zabiehy (1996) pointed out that the wall of the SR was not of uniform thickness: the ventral wall was thin and had the lymphoid tissues in an aggregated form, the dorsal one was very thick and its lymphoid structures were arranged in a scattered form. The columnar epithelial cells lining the basis of the lamina propria jumped on the lymphoid follicles to cover the apical lymphoid portions, which is consistent with the findings of the authors (Snipes, 1978; Alboghobeish and Zabiehy, 1996).

The lamina muscularis of both the ileum and SR was seen in a dispersed manner and was difficult to see clearly, as reported earlier (Snipes, 1978). But, in the transition points of the ileum-SR and SR-cecum, joining firmly together, the lamina muscularis thicken to form an ileal and saccorotundal papillae, respectively. Based on the morphological structure of the SR, we have proposed that the SR may serve as a chymous halt zone and/or raw material store of the cecum, so that it can make ready intestinal content for cecal digestion. Therefore, we have also considered the SR a transition region just as the pylorus that places between the stomach and duodenum.

The histological findings showed that the SR differed partly from digestive system because of having dense lymphoid accumulations, so it may also be novel lymphoid organ in the Angora rabbit as reported by Snipes (1978) for other domesticated rabbits, and it may be comparable with those of other lymphoid tissues such as the Harderian gland and the palatine tonsil.

In conclusion, this study that is the first to be carried out on the ileum and SR of the Angora rabbit, reveals that the morphology of the related structures was nearly similar to that of other rabbits. The morphometrical and histological findings from this study seem to shed light on the future studies on the ileum and SR, and to offer a diagnostic approach when assessing intestinal rabbit pathology, and to contribute to the present anatomical knowledge in this species.

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