Guinea pig cecum structure in relation to digestion function

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Abstract
Guinea pigs are often usen as animal models in investigations, thus there is an acute interest in these animals. The apartenence of guinea pigs in the Rodentia order is still a matter of debate, which determined us to shed a light on the microscopical structure of the cecum in order to understand whether this segment is responsible for most of the digestion in this species. We harvested the cecum from 5 adult guinea pigs, brought for necropsy examination in the Department of Necropsy (UASVM Cluj-Napoca). The samples were processed for paraffin embedding and stained with three different procedures: Goldner's trichrome method, PAS reaction and Alcian blue stain. The cecum in guinea pigs presents the four characteristic tunics for the digestive tract. The cecum has a rather thin wall in guinea pigs, the mucosa being the best represented tunic. PAS-positive and Alcian blue-positive goblet cells are present in small numbers in both the surface and glandular epithelium. The obtained structural information suggests that the digestion is only partially taking place in the cecum in guinea pigs, completing the one taking place in the small intestine.
Keywords*: cecum, digestion, guinea pig, structure.*

Introduction

The classification of guinea pigs as a species was performed at the end of the 17th century and is due to a naturalist named Johann Polycarp Erxleben. The guinea pig is part of the kingdom Animalia, phylum Cordata, class Mammalia, order Rodentia, suborder Hystricomorpha, family Caviidae, subfamily Caviinae, genus Cavia (Marcus et al., 2018; Narayana et al., 2018). The suborder Hystricomorpha also includes animals such as chinchilla, hedgehog, capibara and even some porcupine-like rodents. The morphological particularities of the animals included in this suborder are the presence of a zygomatic arch and a large infraorbital canal (Cox and Hautier, 2015). Animals within the Caviidae family are characterized by the presence of 4 fingers for the anterior limbs and 3 fingers in the posterior limbs (Harkness et al., 2013).

In recent years, other views have also emerged regarding the classification of guinea pigs. Moreover, as a result of molecular biology research, researchers have concluded that the chemical structure of insulin in guinea pigs differs from the chemical structure of insulin of other mammalian species (Suckow et al., 2011). Following these findings, some researchers proposed moving the guinea pig to a separate mammalian order called polyphilic rodents (Graur et al., 1991). These findings and proposals have succeeded triggered many controversies, but the vast majority of researchers claim that this animal is properly categorized as a rodent. They affirm that taxonomic classification of guinea pigs is correct, due to the fact that rodent-specific nucleotide sequences have been identified in *Cavia porcellus* (Konno et al., 1999). Some authors have also questioned the apartenence of guinea pigs in the Rodentia order (D'Erchia et al., 1996; Graur et al., 1991; Kurtz and Travlos, 2017). Others state that in rodents, as in most of the herbivores, most of the digestion takes place in the cecum, which can store up to 65% of the gastrointestinal contents. This organ occupies the left side of the abdomen and has a sack-like aspect with thin walls (15-20 cm length) (Ritzman, 2014; Marcus et al., 2018). We aimed to shed a light on the microscopical structure of the cecum in order to understand whether this segment is truly responsible for most of the digestion in this species.

Materials and methods

We harvested the cecum from 5 adult guinea pigs, brought for necropsy examination in the Department of Necropsy (University of Agricultural Sciences and Veterinary Medicine in Cluj-Napoca). The samples were fixed in 10% buffered formalin and then processed for paraffin embedding. We dehydrated the tissue specimens with alcohol in increasing concentrations and then clarified them with n-butanol. The infiltration was performed with melted paraffin at 56^{o}C.

After performing 5µm sections from the samples using a Leica rotary microtome, we contrasted them with three different procedures: Goldner's trichrome method, PAS reaction and Alcian blue stain. PAS reaction identifies neutral mucosubstances and Alcian blue stain the acid mucosubstances (sulfated and non-sulfated) (Kiernan, 1999).

The stained slides were examined under a light microscope (Olympus BX 40) and the images were captured with an Olympus E330 camera, attached to the microscope. The photographs were processed utilizing Adobe Photoshop CS2 software.

Results and discussions

The cecum in guinea pig has a thin wall and does not contain villi. The mucosa is the most developed tunica of the cecal wall and contains a surface epithelium, glands, lamina propria and muscularis mucosae (Figure 1). The surface epithelium is formed of one layer of enterocytes presenting microvilli, arranged on the basement membrane. This epithelium infolds from place to place and forms glands, disposed between the surface epithelium and muscularis mucosae. The superficial part of the glands presents a larger lumen, which gradually becomes narrower, thus the opening of the glands resembles to a certain extent the gastric crypts. On the histological images, the cells lining the superficial part of these crypts seem to be identical to the ones from the surface of the mucosa. The crypts have a medium length and are disposed at a certain distance one from another, thus the lamina propria is well represented and contains cellular infiltrates.

Fig. 1. Cecum wall in guinea pig – Mucosa (1); Submucosa (2);
Muscularis externa (3); Serosa (black arrow) (Goldner's trichrome stain)

Goblet cells are present, but in small numbers (scarce). In some of the glands, small groups of mucus-secreting cells can be identified, located at the bottom of the gland. Muscularis mucosae

is thin but continuous. In the cecum there is a reduced number of goblet cells, which present a PAS-positive reaction (Figure 2). They are scarce in the surface epithelium and slightly better represented in the glandular one, especially in the deeper half of the glands. The goblet cells in the guinea pig's cecum are Alcian blue-positive cells (Figure 3), suggesting they are synthesizing neutral mucosubstances.

Fig. 2. Cecum – PAS-positive goblet cells in the superficial epithelium (black arrow) and glandular epithelium (white arrow) (PAS reaction)

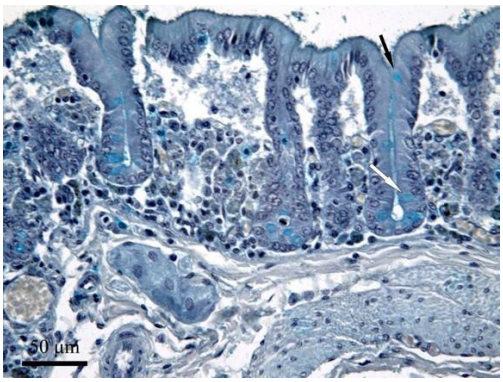

Fig. 3. Cecum – Alcian blue-positive goblet cells in the superficial epithelium (black arrow) and glandular epithelium (white arrow) (Alcian blue stain)

All in all, the cecal mucosa in guinea pig has a relatively simple structure, which does not entirely sustain some researcher's affirmations that in rodents, the digestion is mainly happening in the cecum (Marcus, 2018; Snipes, 1982). This aspect is debatable, at least regarding the extent of the digestion processes taking place in the cecum in comparison to those taking place in the small intestine. Some of the components of the food cannot be digested in the small intestine because of their particular structure, a known and undisputable aspect. More specifically, lignin and cellulose can only be decomposed in the cecum mostly through fermentation processes and less enzymatic ones. The fact that these components are decomposed in the cecum and the resulted substances are absorbed here is clear, but the simple structure of the guinea pigs cecum makes us consider that it is not possible for the majority of the food to be decomposed here. The confusion may arise from the fact that some authors sustain that more than 65% of the digestive tube's content is stored in the cecum, which is highly possible, but we have to consider the processing state of the stored material in the lumen. This material passed through the small intestine, already underwent digestion processes, and is basically formed out of debris which will be eliminated as faeces. Along with this material, there are lignin and cellulose in the cecum, which cannot be broken down through intestinal digestion. These substances are the ones subdued to fermentation in the cecum, not all the material stored here.

Conclusion

Based on the structural information obtained from this investigation, it seems like in guinea pigs, the digestion is mainly happening in the small intestine and only partially in the cecum.

Assessing the participation of the cecum in the digestion processes, we can state that it completes the one from the small intestine, which is predominant, but is not mainly happening here.

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