Morphological Investigation of the Ganglia Celiaca, Ganglion Mesentericum Craniale and Ganglia Aorticorenalia in the New Zealand Rabbit (*Oryctolagus Cuniculus L.*) *, **

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Abstract: The aim of this study was to search morphological structure of ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia in the New Zealand Rabbits. Twenty rabbits were used equally each sex. The rabbits were sacrificed and fixed under 10% formaldehyde solution. The adipose tissue was eliminated by maintaining the cadavers in 1% KOH solution at 30 ^{0}C for 24 hours. Ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia were examined under stereomicroscope. Ganglia celiaca were settled in different places around the arteria celiaca allocated from aorta. Ganglia celiaca was absent in one of the animals examined, one ganglia in 13 animals and two ganglia in 6 animals. Ganglion mesentericum craniale was counted as 24 in animals examined. There were 2 ganglions in 8 animals, one ganglion in 8 animals and in 4 animals ganglion structure were not observed. There were totally 28 ganglions of ganglia aorticorenalia located, both right and left side of arteria renalis. Ganglia aorticorenalia was not observed in two animals. It was seen that parasympathetic extensions of the branches arrived to these ganglions were originated from nervus vagus and sympathetic structure was composed by nervus splanchnicus major, minor, imus and nervus splanchnicus lumbales 1-2. The examination of the ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia in the New Zealand Rabbit demonstrated variances in the localization and shape of these ganglia as well as in the branches they received.
Keywords**:** *Ganglia aorticorenale, Ganglia celiaca, Ganglion mesentericum craniale, Morphology.*

Yeni Zelanda Tavşanında (*Oryctolagus Cuniculus L.*) Ganglia Celiaca, Ganglion Mesentericum Craniale ve Ganglia Aorticorenalia'nın Morfolojik İncelenmesi

Özet: Bu çalışmanın amacı Yeni Zelanda Tavşanlarında ganglia celiaca, ganglion mesentericum craniale ve ganglia aorticorenalia'nın morfolojik yapılarının araştırılmasıdır. Çalışmada her iki cinsiyetten eşit olarak 20 tavşan kullanıldı. Tavşanlar sakrifiye edildikten sonra %10 formaldehit çözeltisi ile tespit edildi. Adipoz dokusu, kadavranın 30 °C'de 24 saat boyunca%1 KOH çözeltisinde tutulmasıyla elimine edildi. Ganglia celiaca, ganglion mesentericum craniale ve ganglia aorticorenalia stereomikroskop kullanılarak incelendi. Ganglia celiaca bir hayvanda bulunmamakta, 13 hayvanda bir ganglia ve 6 hayvanda iki ganglia bulunmaktaydı. Ganglion mesentericum craniale 24 adet görüldü. Sekiz hayvanda 2, 8 hayvanda 1 adet ganglion görülmekle beraber 4 hayvanda ganglion yapısı görülmedi. Arteria renalis'in sağında ve solunda 28 adet ganglia aorticorenalia tespit edildi. İki hayvanda ganglia aorticorenalia görülmedi. Nervus splanchnicus major, minor, imus ve nervus splanchnicus lumbales 1-2'den köken alan sempatik sinirler ile nervus vagus'tan köken alan parasempatik sinirlerin bu gangliyonlara katıldığı tespit edildi. Bu çalışma Yeni Zelanda Tavşanında ganglia celiaca, ganglion mesentericum craniale ve ganglia aorticorenalia'nın lokalizasyonu ve şekil bakımından farklılıklar olduğunu göstermiştir.
Anahtar kelimeler: *Ganglia aorticorenale, Ganglia celiaca, Ganglion mesentericum craniale, Morfoloji.*

Introduction

The ganglia celiaca are involved in the vasoconstriction of the gastric, hepatic and pancreatic blood vessels, and the stimulation of the peristaltic movements and formation of glandular secretion in the intestines (Tais et al., 2003). The ganglia aorticorenalia, nervus splanchnicus major et minor, and nervi splanchnici lumbales are connected to the pars lumbalis of the truncus sympathicus and the plexus renalis (Arıncı and Elhan 1995; Dursun, 2000; Nawrot et al., 2009; Patestas and Gartner 2006). The ganglia aorticorenalia are formed by the contribution of the nervus splanchnicus minor and are involved in the formation of the plexus celiacus (Arıncı and Elhan 1995; Bhamburkar and Prakash 1993; Dursun, 2000; Duzler et al., 2003; Nawrot et al., 2009; Ozgel et al., 2008). It is known that, branches arising from the ganglia aorticorenalia extend to both the kidneys and the glandulae adrenales. The ganglia aorticorenalia, which are located in the right and

left of the body, are either 2 (Pasquini, 2003) or 3 (Crafts, 1979; Pospieszny et al., 2002; Pospieszny et al., 2003) in number. These ganglia are located in or between the kidney and the arteria renalis. It has been reported that the ganglia aorticorenalia can be found in 4 different conformations, including the elongated, circular, triangular and oval forms (Patestas and Gartner 2006).

It is known that, the ganglia located in the abdominal cavity are involved in common diseases in humans, including cortisol and cortisone induced disorders, diabetes, hypertension, disorders caused by the increased production of gastric acid, and sexual development disorders of both males and females. The abdominal cavity presents with the risk of the development of multiple carcinogenic structures. In the advanced stages of cancer, abdominal pain can be either relieved or minimized by the blockage of ganglia (Mercadante, 1993). In this respect, this study was aimed at providing reference data for researchers (clinicians, preclinicians and paraclinicians) on the localization of the ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia, and the variations observed in the anatomical structure of these ganglia in the New Zealand Rabbit.

Materials and Methods

Twenty New Zealand Rabbits, 10 of each sex, constituted the material of this study. While the body weight of the female animals ranged between 3750-4300 g, the body weight of the male animals ranged between 4075-4750 g. Dead rabbits, which were sacrificed with methods approved by the Ethics Board of Mehmet Akif Ersoy University (Approval number: 013-40) constituted the material of the study. The cadavers were fixed in 10% formaldehyde solution. The adipose tissue was eliminated by maintaining the cadavers in 1% KOH solution at 30 ^{0}C for 24 hours. Subsequently, the ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia were examined under a Leica SD6 model stereomicroscope. The findings were photographed using a Leica DC160 model camera compatible with Leica SD6 (1.1).

Anatomical nomenclature in this study was based on Nomina Anatomica Veterinaria (World Association of the Veterinary Anatomists 2017).

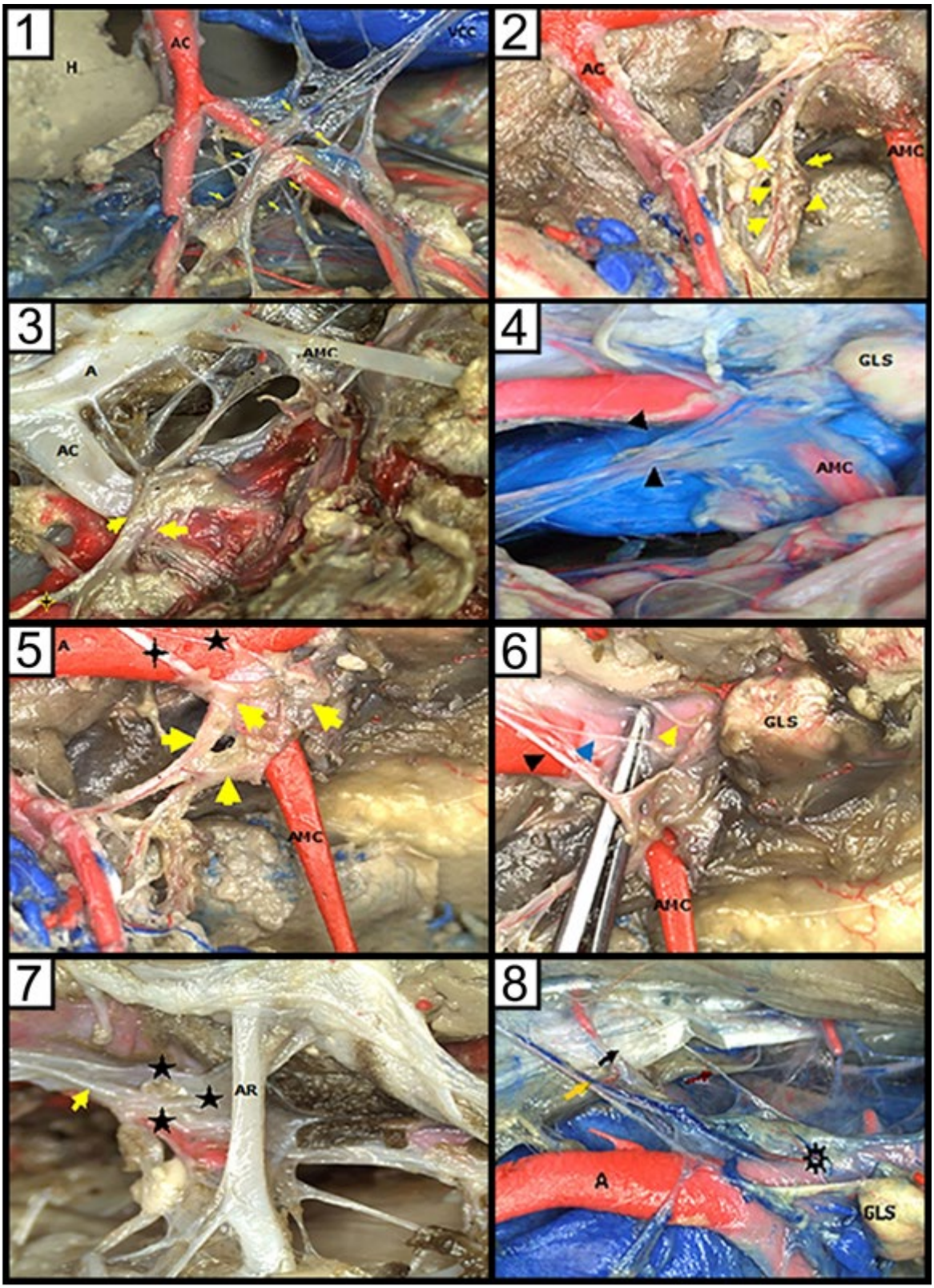
Results

Ganglia celiaca: The ganglia celiaca were localized to the site of origin of the arteria celiaca from the aorta in 2 of the animals, the ramification site of the arteria celiaca (beneath the crura of the diaphragm) in 3 of the animals, and the area in between the origin and the ramification site of the arteria celiaca in the other animals (1.1, 1.2, 1.3-AC). On the other hand, in one of the animals examined, it was observed that the ganglia celiaca did not display the typical structure of a ganglion and that the nerves had formed a dense network. Out of 20 of the animals examined, 6 were determined to have 2 ganglia celiaca. These ganglia were observed to have a spindle-like or irregular quadrilateral shape (1.1-Yellow arrow). Furthermore, the shape of the ganglia was triangular in 4 animals, circular in 3 animals, and irregularly quadrilateral in the remaining 7 animals.

The branches stemming from the truncus vagalis dorsalis and truncus vagalis ventralis, extending above the oesophagus, and the branches originating from the truncus sympathicus at the level of the 8th and 13th thoracic nerves, were determined to firstly join the plexus celiacus. After leaving the plexus celiacus, these branches were determined to have terminated in the ganglia celiaca. In 2 of the animals, a fine nervous branch, originating in between the 13th and 14th thoracic nerves, was determined to join firstly the plexus celiacus and secondly the left ganglion celiaca. In two of the animals, the nervus splanchnicus major was observed to have divided into two fine branches, which passed the ganglion mesentericum craniale and extended to the ganglia celiaca. Furthermore, it was observed that, in 7 of the animals, the 1st lumbar nerve firstly entered the nervous network surrounding the ganglia celiaca and then coursed to these ganglia. In one animal, the truncus vagalis ventralis, which had fused with the truncus vagalis dorsalis, extended to the ganglia celiaca, from where it was further distributed.

Observations demonstrated that the branches arising from the ganglia celiaca gave off fine branches in the periphery of the arteria celiaca, which coursed to the arteria mesenterica cranialis (1.2, 1.3, 1.4, 1.5, 1.6-AMC). These fine branches surrounding the arteria mesenterica cranialis were observed to have formed a network, and to have terminated in the ganglion mesentericum craniale. Furthermore, it was observed that the branches stemming from the ganglia celiaca had given off fine branches, which extended parallel to branch of arteria celiaca (the arteria hepatica, arteria gastrica sinistra and arteria lienalis) (1.1-AC).

Ganglion mesentericum craniale: It was observed that the ganglion mesentericum craniale was distributed densely and diffusely. In general, this ganglion was ascertained to have fused with the ganglia celiaca (1.3-Yellow arrow). It was determined that the total number of these ganglia on the right and left in the body was 24. Four of the



1. 1. Eight different anatomical images of rabbit.

1.1. Left side view of the ganglia celiaca. **AC;** A. celiaca, **H;** Hepar, **VCC;** Vena cava caudalis, **Yellow arrow;** Ganglia celiaca. **1.2:** Left side view of the ganglia celiaca. **AC;** A. celiaca, **AMC**; A. mesenterica cranialis, **Yellow arrow;** Ganglia celiaca. 1.3: Left side view of the ganglia celiaca. A; Aorta, AC; A. celiaca, AMC; A. mesenterica cranialis, Yellow arrow; Ganglion mesentericum craniale, ✦ ; Truncus vagalis dorsalis. 1.4: Left side view of the ganglion mesentericum craniale. AMC; A. mesenterica cranialis, GLS; Glandulae adrenalis, Back arrow; Ganglion mesentericum craniale (2 pieces). 1.5: Left side view of the ganglion mesentericum craniale. A; Aorta, AMC; A. mesenterica cranialis, Yellow arrow; Ganglion mesentericum craniale, ✧; Nervus splanchnicus major, ☆ Nervus splanchnicus minor. 1.6: Left side view of the ganglion mesentericum craniale. AMC; A. mesenterica cranialis, GLS; Glandulae adrenalis, Yellow arrow; Nervus splanchnicus imus, Blue arrow; Nervus splanchnicus minor, Black arrow; Nervus splanchnicus major. 1.7: Right side view of the ganglia aorticorenalia. AR; A. renalis, Yellow arrow; Branch of the ganglion mesentericum craniale, ★; Plexus renalis. 1.8: Left side view of branches involved in the plexus adrenalis and plexus renalis. A; Aorta, GLS; Glandulae adrenalis, Yellow arrow; Nervus splanchnicus major, Black arrow; Nervus splanchnicus minor, Red arrow; Nervus splanchnicus imus, ✸; Plexus adrenalis.

animals examined, lacked this ganglionic structure. On the other hand, in 8 of the animals, 2 ganglia were observed on both the right and left of these structures (1.5-Yellow arrow). In the remaining 8 animals, the presence of only one ganglion was detected. In 10 of the animals examined, this ganglion was localized to the site of origin of the arteria mesenterica cranialis from the aorta. In 4 of the animals, this ganglion was located between the arteria celiaca and arteria mesenterica cranialis, but in closer proximity to the latter. In two animals, the ganglion was located just behind the a. mesenterica cranialis. In the remaining 4 animals, this structure was observed in the form of a network. Variations were observed in the shape of the ganglion. Out of the 24 ganglia examined, 16 were triangular, 6 were irregularly quadrilateral, and 2 resembled the shape of the letter "L". It was determined that the branches, which stemmed from the truncus sympathicus and extended to the ganglia celiaca, were composed of branches following a course in between the plexus celiacus and the plexus intermesentericus. The extensions of these branches and the ganglia aorticorenalia were also connected to each other. Furthermore, it was observed that the branches, which stemmed from this ganglion and formed the plexus mesentericus cranialis, extended parallel to the blood vessels forming the arteria mesenterica cranialis.

In 4 of the animals examined, branches extending from the nervus splanchnicus major et minor were determined to have terminated in the ganglion mesentericum craniale (1.6-Black arrow). In one animal, only the nervus splanchnicus imus (1.6-Yellow arrow) was determined to have contributed. These nerves were observed to have been distributed in the plexus mesentericus cranialis.

Ganglia aorticorenalia: It was observed that the ganglia aorticorenalia were positioned between the crura diaphragmatica and the deep portions of the glandulae adrenales, in the form of a diffuse network (1.7-★). The ganglia aorticorenalia, which were 2 in number and were found in the right and left side of the body, were localized to the site of origin of the arteria renalis from the aorta. It was determined that these ganglia were positioned differently along the course of the right and left arteriae renales, starting from their point of origin. The shape of the ganglia aorticorenalia was spindle-like in 9 animals, circular in 6 animals, and triangular in 3 animals. Only 2 of the animals lacked this ganglionic structure. In these two animals, the nerve fibres were observed to have formed a network. In 14 of the animals examined, in total 28 ganglionic structures were identified on the right and left antimeres. While 3 animals lacked the right ganglion, 1 animal lacked the left ganglion, and 2 animals presented with only a plexus (1.8-✸). The L_2 branch received by the ganglia aorticorenalia from the nervus splanchnicus lumbalis was observed to have been composed of branches arising from the plexus intermesentericus, ganglia celiaca and ganglion mesentericum craniale.

In 18 animals, the nervus splanchnicus minor was determined to have contributed to the ganglia aorticorenalia (1.8-Black arrow). Furthermore, the nervus splanchnicus imus was determined to exist in 8 animals (1.8-Red arrow), 5 of which displayed the contribution of the nerve on the right antimere to the ganglion and the other 3 of which displayed the course of the nerve on the left antimere to the ganglion.

Discussion and Conclusions

The ganglia celiaca are involved in the vasoconstriction of the gastric, hepatic and pancreatic blood vessels, and in the stimulation of the peristaltic movements and formation of glandular secretion in the intestines (Tais et al., 2003). In a research conducted in guinea pigs, it was reported that the nervous structure forming the ganglia celiaca was composed of two lobes. It was indicated that these lobes were localized to the periphery of the arteria mesenterica cranialis (Messenger and Furness 1992). The ganglia aorticorenalia are connected to the nervus splanchnicus major et minor, nervi splanchnici lumbales, the pars lumbalis of the truncus sympathicus, and the plexus renalis (Arıncı and Elhan 1995; Dursun, 2000; Nawrot et al., 2009; Patestas and Gartner 2006). The ganglia aorticorenalia are formed by the contribution of the nervus splanchnicus minor, and contribute to the formation of the plexus celiacus (Arıncı and Elhan 1995; Bhamburkar and Prakash 1993; Dursun, 2000; Duzler et al., 2003; Nawrot et al., 2009; Ozgel et al., 2008). In humans, in some cases, the nervus splanchnicus minor may directly extend to the glandulae adrenalis without entering the ganglia aorticorenalia. It is known that the branches given off by the ganglia aorticorenalia extend to both the kidneys and the glandulae adrenales. The ganglia aorticorenalia have been reported to be two in number, one of which extends on the right antimere and the other on the left antimere (Crafts 1979). The ganglia aorticorenalia are located between the kidneys and the arteria renalis. Reports indicate this structure not to be composed of a single ganglion, but to be comprised of 2-3 small ganglia, which course to the level of the

ganglia celiaca and even fuse with these ganglia (Kuder, 2002). In a study carried out in cats, this structure was shown to be composed of 3 ganglia (Furuzawa et al., 1996). On the other hand, research conducted in sheep has demonstrated the ganglia aorticorenalia to be found in 4 different shape, including the elongated, circular, triangular and oval forms (Nawrot et al., 2009). Ganglia, and in particular the ganglia celiaca, ganglion mesenteria cranialis and ganglion celiaco-mesenterica, have been morphologically described in various animal species in research on the autonomous nervous system. These ganglia have been investigated in the cat (Bochenek and Reicher 1989; Furuzawa et al., 1996; Ribeiro et al., 2000b), buffalo (Ribeiro et al., 2000a), goat (Bhamburkar and Prakash 1993), rat (Hamer and Santer 1981), guinea pig (Messenger and Furness 1992), rabbit (Langenfeld, 1988), Chilean beaver (Langenfeld, 1991a; Langenfeld, 1991b) and buffalo for their structure, correlations in terms of infrastructure, and differences in macroscopic and microscopic size. Paz and Rosen (1989) determined that, in humans, the ganglia celiaca were mostly of a triangular shape. It was suggested that the interconnections between the ganglia contributed to the formation of this triangular shape. Hamer and Santer (1981) reported that, while the right ganglion celiaca of rats was round and resembled a pearl in shape, the left ganglion was smaller than the right ganglion and had a quadrilateral shape. In a study conducted in rabbits, Tais et al. (2003) determined that the left ganglion celiaca had a quadrilateral shape and circular connections. These researchers reported to have observed this structure in 90% of the cases they had examined. In the present study carried out in the New Zealand Rabbit, it was determined that the shape of the ganglia varied. In the present study, while an irregular quadrilateral shape was observed at a rate of 65% in 13 animals, a triangular shape, as previously reported by Paz and Rosen (1989) was observed at a rate of 20% in 4 animals. On the other hand, in 3 animals, the ganglia presented with a circular shape. Furthermore, it was ascertained that the number of ganglia found in the animals also varied. In a study in the buffalo, it was determined that the ganglia had fused and formed a single ganglion celia-mesenterica (Ribeiro et al., 2000a), while in another study in cats, it was ascertained that these ganglia were separate and existed in the form of the ganglia celiaca and the ganglion mesentericum craniale (Ribeiro et al., 2000b). Research conducted in rats demonstrated that the right ganglion celiaca and the right ganglion mesentericum craniale fused by means of nerve fibre fusion, and it was observed that the positions of the ganglia were similar (Hamer and Santer 1981).

The positions of the ganglia determined in the present study differed from that reported in previous research (Langenfeld, 1991a), and it was determined that the ganglia celiaca were localized to the ramification site of the arteria celiaca in 3 animals, and the site of origin of the arteria celiaca in 2 animals. In the remaining animals, the ganglia were located between the origin and the ramification site of the arteria celiaca. It was determined that the position of the ganglion mesentericum craniale along the arteria celiaca and arteria mesenterica cranialis varied. In a previous study performed in rabbits, it was observed that the ganglia celiaca were localized to the caudal border of the arteria mesenterica cranialis in 40% of the animals examined, and it was also ascertained that in 1 case, the ganglia celiaca had fibres fusing with the ganglion mesentaricum craniale on the right antimere (Tais et al., 2003). Tais et al. (2003) indicated that in 90% of the animals they had examined, the ganglia celiaca were not found on the right antimere. Out of the 20 animals examined in the present study, only 1 was determined to lack the ganglion celiaca. In this animal, instead of the ganglion, a network structure existed.

It has been reported that the ganglia celiaca and single ganglion mesenterica cranialis form the plexus celiacomesentericus. Furthermore, reports indicate that the left ganglion celiaca and the ganglion mesentericum craniale are localized to the periphery of the arteries referred to with similar names, and are connected to each other with rather short yet strong several nerve fibres (Dursun, 2000; Ghoshal and Getty 1969). Getty (1975) reported a circular shape for the ganglion celiaca and suggested that the ganglion mesentericum craniale was longer than the ganglia celiaca. This researcher also indicated the presence of interganglionic connections between these ganglia, which formed a plexus. In a study conducted by Lakshminarasimhan (1966) in the buffalo, it was reported that the nervus splanchnicus major and the cranial branches of the L_1 and L_2 splanchnic nerves extended to the plexus celiacomesentericus, and from this point coursed to the ganglia celiaca and ganglion mesentericum craniale. Furthermore, this research in the buffalo indicated that the ganglion mesentericum craniale was single in all species. In the present study, it was demonstrated that the ganglion mesentericum craniale was not single in rabbits, on the basis of 2 ganglia having been determined in 8 of the animals examined.

Similar findings were obtained in studies previously conducted by Duzler et al. (2003) and Ozgel et al. (2008), in the present study, it was

observed that the nervus splanchnicus minor and nervus splanchnicus imus extended to the ganglion celiaca.

According to Lakshminarasimhan (1966), the preganglionic parasympathetic fibres contributing to the plexus celiacomesentericus are formed by the truncus vagalis dorsalis. In the present study, in all of the rabbits examined, the fibres arising from the dorsal branch of the nervus vagus were determined to extend to the ganglia celiaca, in agreement with literature (Getty, 1975). However, in one of the animals examined, the presence of branches, which originated from the dorsally and ventrally extending nervus vagus and terminated in the ganglia celiaca, was detected.

In agreement with literature (Paz and Rosen 1989), it was ascertained that the ganglia aorticorenalia extended along the arteria renalis, which stemmed from the aorta abdominalis.

In compliance with literature (Paz and Rosen 1989), it was also determined that the second branch (L2) of the nervi splanchnici lumbales gave off branches to the plexus celiacomesentericus, ganglion mesentericum craniale and ganglia celiaca.

The examination of the ganglia celiaca, ganglion mesentericum craniale and ganglia aorticorenalia in the New Zealand Rabbit demonstrated variances in the localization and shape of these ganglia as well as in the branches they received. Accordingly, it was determined that only 1 of the animals lacked the ganglia celiaca, while the others had either 2 or 3 ganglia. While 6 of the animals had 2 ganglia celiaca, 14 of the animals presented with a single ganglion. In the animals examined in the present study, the total number of the ganglion mesentericum craniale was found to be 24, and only 4 of the animals displayed a typical ganglionic structure. Only 8 of the animals were determined to have 2 ganglia. Furthermore, while 2 animals were observed to lack the ganglia aorticorenalia, 28 ganglia were detected in the remaining 18 animals. It was observed that, in general, these ganglia received their parasympathetic fibres from the nervus vagus, and their sympathetic fibres from the nervus splanchnici major et minor et imus and the L_1 and L_2 branches of the nervi splanchnici lumbales.

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