AUTONOMIC ACCESSORY GANGLIA IN NERVES REACHING ORGANS OF THE UROGENITAL SYSTEM IN THE EWE

ZBIGNIEW BORATYŃSKI, AGNIESZKA PEDRYCZ1
AND IZABELA KRAKOWSKA

Department of Animal Anatomy and Histology,
Agricultural University, 20-934 Lublin, Poland
e-mail:zbyszek.boratynski@ar.lublin.pl

1Department of Histology and Embryology with Laboratory of Experimental Cytology,
Medical University of Lublin, 20-080 Lublin, Poland

Received for publication February 02, 2006.

Abstract

In sheep, nerve cell concentrations were found in nerves reaching organs of the urogenital system, which were called autonomic accessory ganglia (AAG) due to the region they occurred. Location of AAG in the studied nerves and their branches is changeable and their shape and size depend on the amount of ganglion cells from which AAG are made. The structure of AAG was described, as well as the appearance of nerve cells being part of it. Moreover, it was found that most of AAG in the studied nerves or their branches could only be confirmed by microscopic examination. The results were compared with those obtained in earlier studies of other authors and probable functions and role of AAG in the autonomic peripheral nervous system were discussed.

Key words: ewe, autonomic ganglia, autonomic nerves, urogenital organs.

A conclusion can be drawn from earlier experimental studies that the system of peripheral autonomic ganglia is not only the area of passing or switching (synapting) from the preganglionic nerve fibres coming from the central nervous system, but also the main outlet of nerve fibres supplying the internal organs (9, 10-13, 30). It was also found that nerve fibres came from different outlets supplying the internal organs or their parts, which is an example of complex connections between the autonomic peripheral nervous system and these organs. Moreover, autonomic peripheral ganglia play a certain role in the pathogenesis of some nosologic units, such as achalasia (19) or megacolon (29).

On the basis of literature review it is implicit that in the complex of the autonomic peripheral ganglia innervating the internal organs, apart from the main ganglia of the abdominal and pelvic cavities, and the ganglia found in the nerves joining the main autonomic peripheral ganglia with the walls of individual internal organs (1, 9-11, 13, 32), these ganglia are of interest because of their probable functions and significance in the peripheral autonomic nervous system. The mentioned ganglia were termed by some authors the accessory ganglia and by others the intermediate ganglia. Up to the present, no paper has been encountered which would deal with the problem of autonomic accessory ganglia (AAG) in an overall way. There is a lack of exact data about their location and functions both in the humans and domestic animals. The purpose of these studies is to determine the location and morphology of the AAG in the nerves reaching the urogenital organs in the sheep.

Material and Methods

Six sexually mature ewes at the age of 3-5 years were used in the studies. After slaughter the following material was taken for the examination of individual trunks and nerve branches:

1. Nerves running from the coeliac ganglion and plexus to the hilus of the kidney;
2. Nerves running from the intermesenteric plexus to the hilus of the kidney;
3. Nerves branching out of the sympathetic trunk to the hilus of the kidney;
4. Nerve branches from the sympathetic trunk to the caudal mesenteric ganglion and hypogastric plexus;
5. Nerve branches from the caudal mesenteric ganglion to the ovarian plexus;
6. Hypogastric nerves and their main branches in the hypogastric plexus;
7. Pelvic nerves and their main branches in the pelvic plexus.

The material was fixed in the 4% solution of neutral formalin, dehydrated in ethyl alcohol, and embedded in paraffin. Paraffin blocks were cut into 15\(\mu\)m sections and stained with methylene blue according to the Nissl, Klüver-Barrera and Alzheimer-Mann methods.

**Results**

It was found that in the course of nerves and their branches running to the urogenital organs of sheep there were concentrations of nerve cells forming ganglia which, due to the area of their occurrence and to differentiate them from the main autonomic ganglia of the abdominal and pelvic cavities, were termed the AAG.

There were concentrations of ganglion cells in the course of nerve branches reaching the hilus of the kidneys from the coeliac ganglion and plexus. In the longitudinal sections the nerve cells were situated one after another, as usual, parallel to the course of nerve fibres. The ganglion cells, arranged in such a way, occurred either in the marginal part of the nerve fibre bundle or inside it. The number of nerve cells forming AAG in these branches was various, from several to several hundred. Also the number of ganglion cells occurring in the studied ganglia affected their shape. When the cells were few, they were usually situated one after another and the distance between them was small. When the cells were numerous they were close one to another and whole ganglion had a shape of elongated spindle. Nerves running from the intermesenteric plexus to the hilus of the kidney did not always occur. They were found in 5 sheep. In these nerves ganglion cells were also found to exist. The way the ganglia were arranged in individual nerves was fairly characteristic. In each of them one to three small ganglia were observed and in their transverse sections from several to several dozen nerve cells were visible (Fig.1).

Nerve branches running from the sympathetic trunk to the hilus of the kidneys most often came from the ganglia located on the level of the first and second lumbar vertebrae (L1 and L2). The picture of AAG in these nerve branches was basically the same as the picture of the ganglia described in previous nerves. The location of AAG in the mentioned branches was changeable. Part of them occurred not far from the sympathetic trunk, others were found in the medial part of nerve branches, and in the remaining cases they were localized close to the kidneys.

The nerves connecting the sympathetic trunk with the caudal mesenteric ganglion came from the ganglia of the sympathetic trunk on the level of the 4th lumbar neuroner. In two sheep the nerve coming from ganglion L3 was connected with the nerve coming from ganglion L4 of the sympathetic trunk before reaching the caudal mesenteric ganglion. In one sheep the nerve coming from ganglion L1 of the sympathetic trunk ran directly to the area of the ovarian artery and further on to the ovarian plexus. AAG occurred often in the mentioned nerves (Fig. 2).

A great many nerve cells grouped in ganglia of different sizes were particularly observed in the nerves coming from ganglion L4 of the sympathetic trunk. In the nerve branch coming directly from ganglion L1 of the sympathetic trunk to the ovarian plexus, a ganglion was found which was 1.5 mm long and was situated only in one of the nerve fibre bundles forming the mentioned branch. In the area of the ovarian plexus, sometimes little small ganglia were observed which had from 10 to 30 nerve cells and were situated at the external area of small blood vessels. Hypogastric nerves, coming from the caudal mesenteric ganglion did not occur as individual nerve trunks but as 3 - 5 nerve branches which after a short course passed into the hypogastric plexus. Sometimes, one or two of these branches ran through the hypogastric plexus and were divided into thin branches in the area of the final part of the ureters or in a short distance from the urinary bladder. In all the animals small ganglia were found in the hypogastric nerves. The shape of AAG in the longitudinal sections was usually spindle-like, but in the transverse sections the cells forming the ganglia were scattered all over the sections area of one bundle of nerve fibres. Moreover, almost all along the hypogastric nerves individual ganglion cells were encountered. They were situated most often in central part of the bundle of nerve fibres (Figs 3, 4, 5).

Pelvic nerves occurred as individual fairly thin nerve trunks coming from the ventral roots of the sacral nerves at the level of S2 to S5. After a short course as separate nerves, they reached the pelvic plexus and just there were divided into a number of nerve branches. In the course of pelvic nerves, the beginning from to the area of their division, no ganglion cells were observed, but their presence was found in the course of the main nerve branches being part of the hypogastric and pelvic plexuses. In the nerve branches of both plexuses the AAG occurred as concentrations of several to several hundred ganglion cells, or these cells occurred individually in the course of nerve fibres (Figs 6, 7). The size and shape of AAG depended on the number of the ganglionic neurons being part of them. Small ganglia containing from several to several dozen cells arranged one after another along the course of nerve fibres were separated from the fibres with a thin layer of glial cells which were knitted closely together. Larger AAG were usually of elongated spindle shape and sometimes they were oval. These ganglia, occurring both in individual nerves and nerve plexuses were surrounded with a thin, connective tissue capsule. Lack of the ganglion capsule was found only in the areas of the inlet and outlet of the nerve fibres. It was also found that not all the nerve fibres being part of the ganglia spread in them and ended their course there.
Fig. 1. Autonomic accessory ganglion (AAG) in the nerve branch connecting the coeliac ganglion with the hilus of the left kidney. Stained with methylene blue (according to Nissl’s method). About 70x.

Fig. 2. Autonomic accessory ganglion in the nerve connecting the sympathetic trunk with the caudal mesenteric ganglion. Stained with methylene blue (according to Nissl’s method). About 70x.

Fig. 3. Transverse section of the nerve branch connecting sympathetic trunk with ovarian plexus. AAG is visible in one of the nerve bundles. Stained according to Klüver-Barrera’s method. About 80x.

Fig. 4. Small AAG (white arrow) situated in the area of the ovarian plexus in the direct vicinity of the blood vessel (black arrows). Stained according to Klüver-Barrera’s method. About 80x.

Fig. 5. Ganglion cells in the hypogastric nerve. Stained with methylene blue (according to Nissl’s method). About 70x.

Figs 6, 7. Individual ganglionic neuron (6) and small AAG (7) in the nerve branches of the pelvic plexus. Stained according to Klüver-Barrera’s method. About 70x.
Part of the fibres, after entering the ganglion, came towards the internal area of the ganglion capsule, and then they left the ganglion running further in the peripheral direction (Fig. 8). Bundles of nerve fibres inside the ganglia were also observed in the transverse sections and nerve fibres of different diameter were found to be part of them (Fig. 9).

Nerve cells forming AAG were most often of oval shape, round cells were fewer, but individual neurons localized in the course of nerve fibres had usually the shape of elongated oval. The size of ganglion cells ranged from 20 to 50 µm. In the ganglion cells there was a round cell nucleus visible with nucleolus in the central position, and in neuroplasma granular tigroid was found (Fig. 10). Fairly often the cells were observed whose nucleus had two nucleoli (Fig. 10). There were three nucleoli in the area of pelvic plexus in the cell nucleus of some ganglionic neurons (Fig. 11). Such nerve cells were noticed very rarely, however.

Observations made in all the sheep allowed, to state that there are no basic differences in the distribution and size of AAG in the nerves reaching the urogenital organs within the whole group studied.

Discussion

The results presented above make it possible to state, that in the course of nerve fibres running to the urogenital organs in the ewe, besides the main autonomic ganglions of the abdominal and pelvic cavities, also numerous AAG are engaged, which are localized in the nerves and their branches reaching the mentioned organs.

Presence of the AAG was found in the course of nerves running both from the sympathetic trunk and from the coeliac ganglion and plexus, and from intermesenteric plexus to the hilus of the kidneys. The results are in agreement with the earlier studies carried...
out in the man, ape, cat, and dog (20, 27, 28, 31), which confirm the presence of small autonomic ganglia in the mentioned nerves. The present studies also confirm other investigations (20, 27, 28) which say that AAG are possible to be detected only with the help of microscopic examinations. The contradictory observations were made by Grottel (16) who while describing innervation of the adrenal gland in the cat, dog, and rabbit, often encountered ganglia macroscopically visible, located in the course of nerve branches running from ganglia L1, and L2 of the sympathetic trunk and reaching the renal plexus. In the examined sheep, in the remaining visceral nerves running from the posterior part of the lumbar sympathetic trunk mainly to the caudal mesenteric ganglion, also the presence of AAG of different sizes was found. Similar ganglia were found in the nerve branches in sheep (9, 10, 11) and in the cow (12, 13). Similar results were obtained in the man, ape, sheep, cat, and dog (24, 31, 34). According to these studies, it is possible that the nerve cells of AAG localized in the mentioned nerve branches are the source of postganglionic fibres for the autonomic nerve structures (ganglia and plexuses), with which the branches are connected. Presence of ganglionic neurons was found in the hypogastric nerves. The ganglia and individual nerve cells in these nerves were also observed by other authors (4, 26). AAG present in the hypogastric nerves should be included in all the nerve cells occurring in the hypogastric plexus.

Recently, more attention is paid to the integration of sympathetic and parasympathetic innervation at the level of the peripheral ganglia in relation to some internal organs (8). Elbadawi and Schenk (5, 6) brought anatomical evidence proving the existence of such an integration. These authors showed that in the vicinity of some organs or their walls the so-called mixed ganglia occurred, in which adrenergic and cholinergic neurons occurred one beside another, and also, they observed the occurrence of individual nervous cells of both kinds outside the ganglia – in the bundles of nerve fibres. Moreover, they found the presence of adrenergic structures around the cholinergic neurons. In the small autonomic ganglia belonging to the hypogastric plexus situated near the urinary bladder – sympathetic postganglionic synapses occur modulating the activity of “short adrenergic neurons” which act on the cells of smooth muscles of the urinary bladder (7). Also the ureters are innervated by the hypogastric plexus. Ogata et al. (23) found numerous little autonomic ganglia in the vicinity of the 2/3 anterior part of the ureters, which probably are responsible for the “peristalsis” of the ureters. Despite numerous studies, the integration of the autonomic innervation at the level of peripheral AAG is poorly known.

Some authors (19, 29) point to a direct connection of AAG and ganglia in the intramural plexuses with the organs innervated by them. They found degenerative lesions in the ganglion cells of the intramural plexuses in the case of achalasia of the cardia (19) and in the AAG neurons localized in the nerve branches from the lumbar part of the sympathetic trunk to the caudal mesenteric ganglion in the case of megacolon (29).

The structure of AAG does not differ basically from the descriptions presented by other authors (25). In all the sheep the occurrence of ganglionic neurons of two nuleoli was noticed fairly often. Similar ganglionic neurons were observed by others (3, 24). Intermediate ganglia, described by many authors should also be mentioned (2, 17, 27, 33). They occur in the white and gray communicating branches. Gruss (17) thought that these ganglia could be the remnants of the secondary sympathetic trunk, Alexander et al. (2) and Wrete (33) presented opinion, that these ganglia originated from the neuroblasts which, in the embryonal growth, did not manage to reach the basic ganglion of the sympathetic trunk. Both authors seem to believe that intermediate ganglia passing the postganglionic sympathetic fibres to the spinal nerve omitting the sympathetic trunk cause lack of efficiency of sympathectomy fibres used experimentally and sometimes in clinical conditions as well.

References

188

centres of the mammary gland in the cow. Ann Univ Mariae Curie-Skłodowska (Vet) 1979, 34, 47-60.