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The lumbar dorsal rami of the wild pig: the intermediate branch

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Abstract: This study has documented the intermediate branch of the dorsal rami of the spinal nerves in the lumbar region of 4 adult wild pigs. The lumbar spinal nerves at the L1–L4 levels left the vertebral canal through the intervertebral foramen. Upon the dissection of the 32 dorsal rami at these levels, 24 were displayed to construct 3 discrete branches while the remaining 8 were observed to form 2 typical branches. The dorsal rami were remarkably short, giving their branches in a fan-like spreading fashion. The lateral branches sent 2 to 3 smaller subbranches to the iliocostalis lumborum muscle, then became the cutaneous nerve. The medial branch innervated the medial component of the intertransversal and the multifidus muscles. The intermediate branch directed into the longissimus lumborum muscle, ramifying there and sending no cutaneous branches to the skin area. Four out of 8 dorsal rami dissected at L5 sent off the intermediate branch with roughly similar patterns and distributions to those seen at L1–L4. The dorsal branches at L6 were relatively longer, advanced dorsally, giving a constant branch, presumably the intermediate branch, to the caudal edge of the longissimus lumborum muscle. It then coursed upward through the subcutaneous fascia as the cutaneous nerve.

Key words: Wild pig, lumbar dorsal rami, intermediate branch

1. Introduction

Ramifications of the dorsal branches of the spinal nerves (RDNSs) in both humans and other mammals are amply described in standard textbooks, focusing particularly on the case of the thoracolumbar region since the surgery there requires more detailed knowledge of the neuroanatomy, e.g., ramifications of the lumbar spinal nerves. This is predominantly essential in an attempt to facilitate the design and interpretation of research relevant to the understanding of back pain, thus helping to relieve backache sufferings in afflicted individuals (1).

The 2 ramifications of the dorsal branch of the spinal nerve, the lateral and medial branches, are generally displayed in the literature; however, some studies have reported the presence of another discrete branch, an intermediate branch, in humans (1–4) and animals (5–8). Even though these reports on the intermediate branches of the lumbosacral dorsal rami date back to 1970s, it has not obtained enough clinical attention, probably due to not revealing a detailed course and the further branching of the ramifications in the literature.

Nowadays, the intermediate branch of the dorsal rami has been shown through applying the ventral approach for visualization of RDNSs, instead of dissecting them from the back of the body (the dorsal approach), in humans (4) and other animals including dolphins (8). These studies have reported that the intermediate branch contributes mostly to the innervations of the longissimus muscle, partly the iliocostalis muscle, and relevant skin.

Branch distribution of the RDNS in various animals has been generally superficial and limited other than those descriptions found in classical textbooks. This research, therefore, has been undertaken to provide a deeper description of the ramifications of the RDNS, thus proving the presence of the intermediate branch in wild pigs, which has been rarely studied anatomically as compared to the domestic pig commonly used as a model in the relevant scientific research.

2. Materials and methods

Four already dead adult wild pigs (*Sus scrofa*), which had been hunted by villagers, were fixed through embalming with 10% formaldehyde and studied by gross dissection. Demographic data of the cadavers are given in the Table.

The trunks of the cadavers were firstly divided longitudinally into 2 equal components at the medial plane. The ventral approach was chosen to dissect and reveal a detailed image of the total nerve layout at gross level, just as suggested by the literature (4,8). Having removed the vertebral bodies by sawing of the pedicles of the related

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Table. Demographic data of the cadavers.

Sample no.	Weight (kg)	Sex	Age
1	125	M	≥3
2	110	F	≥3
3	65	F	≥3
4	120	M	≥3

side, the iliopsoas muscle, transverse process, spinal cord together with the meninges, and dorsal roots with the spinal ganglion and ventral roots were displayed. The dorsal and ventral rami were then traced down to their ramification levels. The dorsal rami were subsequently dissected further and the medial, intermediate, and lateral branches were traced systematically through the innervation regions to display the organization of the subbranches as they spread into the related regions.

The 2012 edition of *Nomina Anatomica Veterinary* (9) was applied for anatomical nomenclature.

3. Results

After dividing vertebral column longitudinally at the media plane (Figure 1) and dissecting the surrounding tissue, the spinal cord together with the meninges and dorsal roots with the spinal ganglion (Figures 2–4), and ventral roots, were observed. The lumbar spinal nerves left the vertebral canal through the intervertebral foramen. They sent off the dorsal (Figures 3 and 4) and ventral (Figures 2–4) rami at the L1–L4 levels right after leaving the intervertebral foramen, while at the L5 and L6 levels coursing caudally for some distance due naturally to the ascensus medullae spinalis. The dorsal rami at the L1–L4 levels arose from the spinal nerves as they passed caudally to the caudal

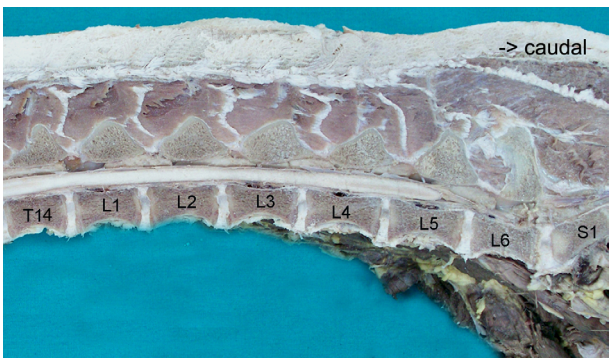

Figure 1. Medial view of the dorsal lumbar region of the wild pig. The segments are indicated with Arabic numerals. The trunk divided longitudinally into 2 equal components at the medial plane, displaying the spinal cord and bony and musculature peculiarities.

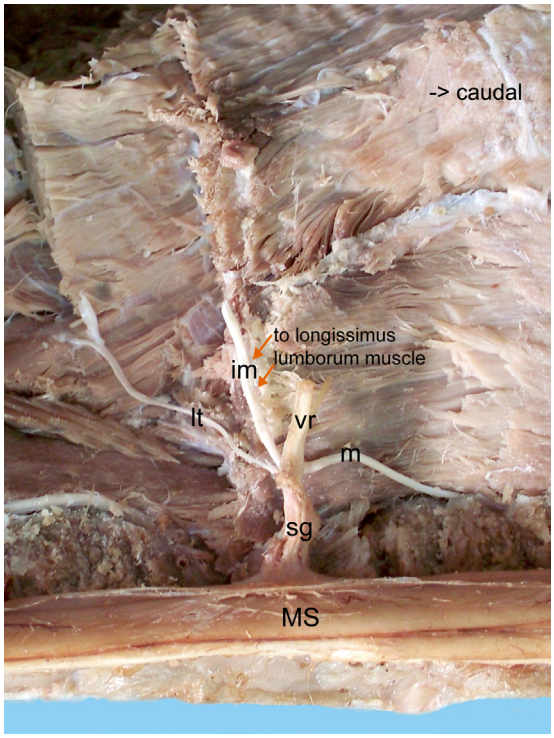

Figure 2. An example of the medial view of the branch distribution of the RDNS at L1–L5. Abbreviations: MS- spinal cord, sg- spinal ganglion, vr- ventral ramus, m- medial branch, im- intermediate branch, lt- lateral branch.

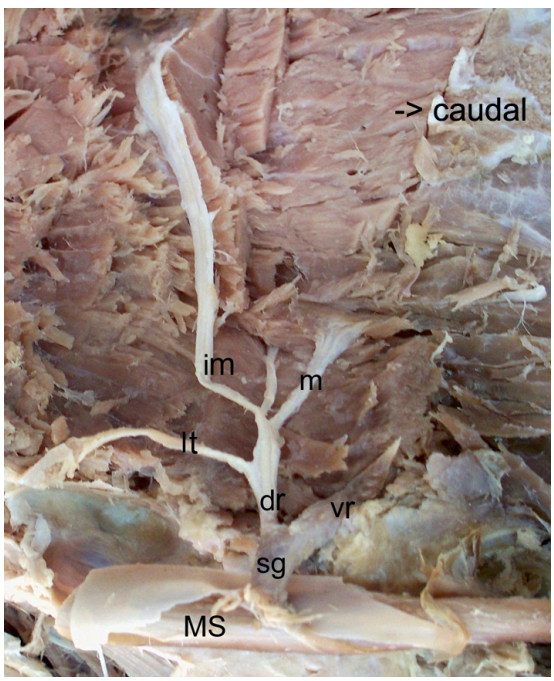

Figure 3. Another example of the medial view of the branch distribution of the RDNS at L1–L5. Abbreviations: MS- spinal cord, sg- spinal ganglion, vr- ventral ramus, dr- dorsal ramus (RDNS), m- medial branch, im- intermediate branch, lt- lateral branch.

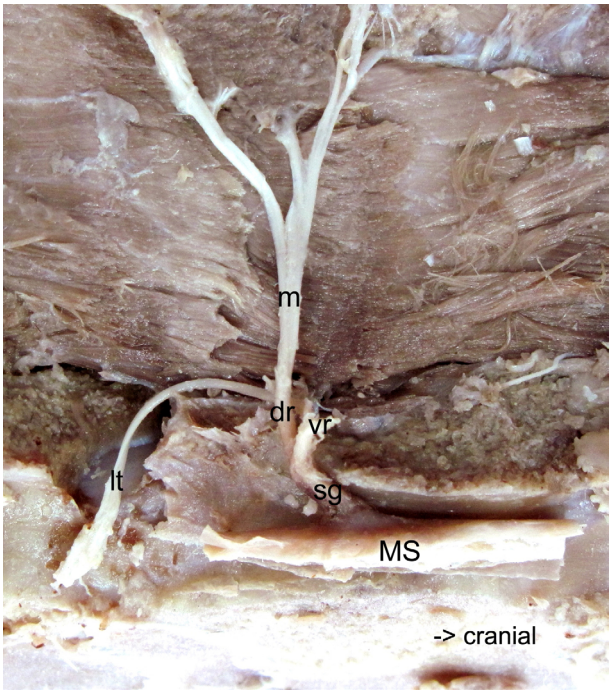

Figure 4. Medial views of the 2 typical branch distributions of the RDNS, as the lateral and medial branches, at L1–L5. Abbreviations: MS- spinal cord, sg- spinal ganglion, vr- ventral ramus, dr- dorsal ramus (RDNS), m- medial branch, lt- lateral branch.

articular processes. They were remarkably short, passed dorsally, and pierced the intertransverse ligament, giving their branches in the dorsal, lateral, and medial directions in a fan-like spreading fashion. Since the morphology of the branches of the dorsal rami at the L1–L4, L5, and L6 differed significantly, the results at these 3 levels were described individually.

3.1. Dorsal rami L1–L4 (Figures 2–4)

Upon the dissection of the 32 dorsal rami at these levels in 4 cadavers, 24 were displayed to construct 3 discrete branches: the lateral (Figures 2–4), the intermediate (Figures 2 and 3), and the medial (Figures 2–4) branches of the dorsal rami. The remaining 8 were observed to form 2 typical branches as the lateral (Figure 4) and medial (Figure 4) branches of the dorsal rami.

Lateral branch (Figures 2–4): This branch arose from the dorsal ramus as it penetrated the intertransverse ligament, emerging from the ligament lateral to the caudal edge of the caudal articular process. The branch then coursed caudally, lateral to the pedicle, and dorsally through the iliocostalis lumborum muscle. It supplied 2 to 3 smaller subbranches to this muscle and became the cutaneous nerve (cn in Figure 5).

The cutaneous nerve ascended dorsally, piercing the iliocostalis lumborum muscle and thoracolumbar fascia.

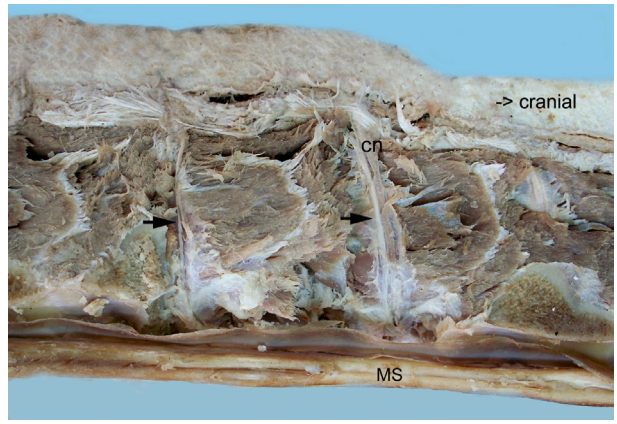

Figure 5. Medial view of the cutaneous nerve, continuation of the lateral branch of the RDNS at L1–L5. Abbreviations: MS- spinal cord, cn- the cutaneous nerve, the continuation of the lateral branch.

The main trunk of the nerve then passed the very thick subcutaneous fat, terminating in the subcutaneous tissue and skin.

Intermediate branch (Figures 2 and 3): This branch originated from the dorsal ramus in the intertransverse ligament, advancing in between the lateral and medial branches directly into the longissimus lumborum muscle. The origins of this branch and the lateral one were enclosed in a common sheet of fascia for some distance, distinguishable at the gross anatomical level. It ramified in the longissimus lumborum muscle, sending no cutaneous branches to the related skin area.

Medial branch (Figures 2 and 4): This branch left the dorsal ramus in the intertransverse ligament, initially coursing cranioventrally. It emerged from the intertransverse ligament at the level of the caudal aspect of the cranial articular process. It then turned dorsally, running at the lateral edge of the vertebra, reaching the dorsal surface. During this course, it sent smaller subbranches to the relevant joint and region and the medial intertransversal branch to the medial component of the intertransversal muscle. After sending several branches, it finally terminated within the multifidus muscle.

3.2. Dorsal ramus L5

The spinal nerves at L5 descended caudally for some distance and left the vertebral canal, leaving through the intervertebral foramen. They gave considerably thick ventral branches and relatively thinner dorsal branches. The dorsal branches were relatively longer and passed dorsally and pierced the intertransverse ligament, sending their branches in the dorsal, lateral, and medial directions in a fan-like spreading fashion. Four out of 8 dorsal rami dissected at this level in 4 specimens were found to send off the intermediate branches, along with the lateral and medial branches.

3.3. Dorsal ramus L6 (Figure 6)

The spinal nerves at L6 left the vertebral canal through the intervertebral foramen after coursing caudally for some distance. The dorsal branches were relatively longer and passed caudally and dorsally after piercing the intertransverse ligament. In 8 dorsal rami dissected, the dorsal branch advanced dorsally by hooking over the ala of the sacrum, sending smaller subbranches to the relevant muscle components. As it hooked over the ala, it gave a constant branch, presumably the intermediate branch, to the caudal edge of the longissimus lumborum muscle. It then continued as the cutaneous nerve (cn in Figure 6) and coursed upward through the subcutaneous fascia, terminating there. No such branch correspondence with the medial one was observed at this level.

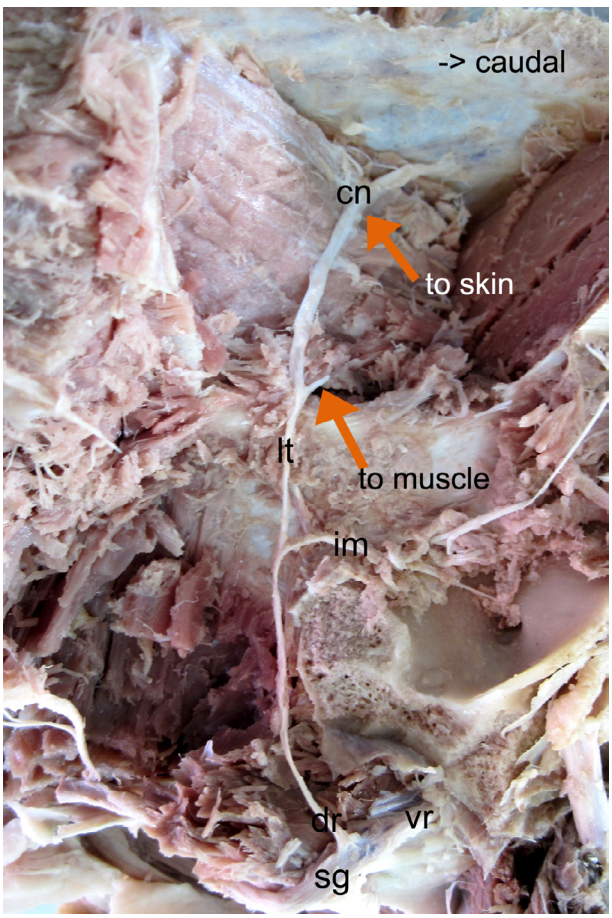

Figure 6. Medial view of the cutaneous nerve, continuation of the lateral branch of the RDNS at L6. Abbreviations: sg- spinal ganglion, vr- ventral ramus, dr- dorsal ramus (RDNS), im- intermediate branch, lt- lateral branch, cn- the cutaneous nerve, the continuation of the lateral branch.

4. Discussion

This research examined the lumbar dorsal rami of the wild pig by gross dissection, revealing the branch distribution of the RDNSs, particularly the classification of an "intermediate branch" for the first time. The ventral approach was applied for visualization of RDNSs, instead of the dorsal approach, just as suggested by the literature (4,6). This is because finding the origins of the spinal nerves and tracing the spreading of the branches from the ventral side of the vertebral column to the dorsal side was easy at the gross anatomical level.

Ramifications of the dorsal branch of the spinal nerve are amply seen in the literature. The classic view considers these ramifications as the lateral and medial branches. Along with that, though, researchers (1–4) have the tendency of naming another discrete branch, the intermediate branch, in human and animals. There are no new nerves. They change their size along with the segmental change of all vertebral structures. The medial branch innervates the spinal muscles. In humans, small cutaneous branches are described in the median line where the median muscles are few, e.g., the lumbar region seen here, where the medial branch is small in the upper segments (Figure 1) but smaller in the lower (Figure 6). This correspondent to some research in comparative anatomy: the medial branch innervates the medial compartment, or the transversospinal system (7). Such homology is seen in the lateral branch, which basically innervates the lateral compartment, i.e. the iliocostal muscle (1,7). This nerve reaches one segment, which is ordered to metamers, mentioned by Nishi (10). It is exemplified as an "autochton" by Eisler (11). In general, as the literature (10,11) has indicated, we see a more ascending lateral branch cranially (Figure 2) and a more descending branch caudally (Figures 4 and 5).

The literature (1,3,4) has shown that an intermediate branch may consist of a muscular branch to the longissimus and a long branch to the skin. The long skin branch divides the muscles into the lateral compartment (iliocostalis) and an intermedial compartment, which is innerved by the intermedial nerve. The long skin branch reaches far into skin area and perforates from ventral to dorsal skin as the superior cluneal nerves.

This has been the case since the 1970s but it has obviously not acquired the clinical attention it deserves, due partly to not revealing a detailed course and further branching of the ramifications and to the lack of the conduction of similar research in various species. In an attempt to contribute to this topic, the present study examined the possible presence of the intermediate branch of the RDNS in wild pigs and revealed it for the first time.

The branch distribution of the RDNSs at L1–L5 in the wild pig was observed to be similar to those indicated in textbooks and literature reports. On the other hand,

the course of the main stem of the spinal nerves at the L5 segment was different in the vertebral canal. They descended caudally for some distance, leaving it through the intervertebral foramen. Their ventral branches were considerably thicker than dorsal ones, which were relatively longer, though sending their branches in the dorsal, lateral, and medial directions in a fan-like spreading fashion.

The intermediate branch of the RDNSs at L1–L5, when present, directed to the longissimus lumborum muscle, ramifying there. As indicated in the literature on cats (6), no cutaneous branch originating from the intermediate branch was observed at the gross dissection level, innervating the related skin area. It is essential to note here that small cutaneous branches arising from the intermediate branch have been observed eminently to reach the skin, therefore being called the dorsal intermediate branch of the RDNSs (1,4).

The branch distribution of the RDNSs at L6 in the wild pig differed greatly, as compared to that observed at L1–L5. The long lateral branches advanced dorsally by hooking over the ala of the sacrum, sending smaller subbranches to the relevant muscle components. While coursing, they sent an eminent intermediate branch to the caudal edge of the longissimus lumborum muscle and then became the cutaneous nerve through the subcutaneous fascia. The failure to observe a branch correspondence with the medial branch in dissections may be either due to the actual absence of such branch or because of the destroying of such a branch during gross dissection. This is always considered to be the case in gross anatomical observations, as suggested by the literature (6); however, it seems to us that a medial branch is lacking at the L6 segment in the wild pig.

The literature (1,4,12) has indicated that the segmental branches of the RDNS anastomose with each other. It was suggested that this connection may also play a role in the explanation of the thesis of visceral pain, which is, in general, said to be transmitted by the connecting sympathetic chain. No anastomoses were observed among the segmental branches of the RDNSs in the wild pig, which were examined at gross observation level.

Traces of sinuvertebral nerves, if present, were not focused on while dissecting the branch distribution of the RDNSs at macroscopic level. This is because they have been indicated to be of microscopic size in cats (6) and monkeys (13).

Consequently, the branch distribution of the RDNSs in the wild pig was observed in this study, revealing the existence of the constant intermediate branch in the lumbar region for the first time.

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