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The Surgical Anatomy of Thoracic Facet Denervation

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Summary

Thoracic percutaneous facet denervation has been employed for the treatment of thoracic zygapophysial joint pain. But the surgical anatomy of this procedure has been assumed to be the same as for lumbar medial branch neurotomy. To establish the anatomical basis for thoracic medial branch neurotomy, an anatomical study was undertaken. Using an X40 dissecting microscope, a total of 84 medial branches from 7 sides of 4 embalmed human adult cadavers were studied.

The medial branches of the thoracic dorsal rami were found to assume a reasonably constant course. Upon leaving the intertransverse space, they typically crossed the superolateral corners of the transverse processes and then passed medially and inferiorly across the posterior surfaces of the transverse processes before ramifying into the multifidus muscles. Exceptions to this pattern occurred at mid-thoracic levels (T5–T8). Although the curved course remained essentially the same, the inflection occurred at a point superior to the superolateral corner of the transverse process.

At no time during the dissection were nerves encountered crossing the junctions between the superior articular processes and transverse processes which have been the target points advocated for thoracic facet denervation. Rather, the results of this study indicate that the superolateral corners of the transverse processes are more accurate target points.

Keywords: Thoracic nerves; dorsal rami; facet denervation; zygapophysial joint.

Introduction

Thoracic percutaneous facet denervation is repeating the history of its progenitor-lumbar facet denervation. First introduced in 1974 by Shealy [12, 13], lumbar facet denervation was designed to relieve low back pain originating from the lumbar zygapophysial (facet) joints by disrupting the nerve supply to these joints. At that time, however, there were no antecedent studies of the anatomy of the target nerves which were the articular branches arising from medial branches of the lumbar dorsal rami. The nerves were presumed to lie at a point to which the thermocouple electrodes were introduced. The appropriate anatomical studies did not appear until five years later when Bogduk and Long [2] showed that the medial branches of the lumbar dorsal rami crossed the root of the transverse process. Distal to this point, articular branches were given off near the caudal and superior poles of the zygapophysial joints. No articular nerves crossed the lateral aspect of the superior articular process as required by Shealy's description of lumbar facet denervation. Consequently, it was not until the 1980s that lumbar facet denervation was performed according to an accurate surgical anatomy.

Recently, Stolker *et al.* [14] have described their clinical experience with thoracic percutaneous facet denervation. They reported the clinical outcomes of their procedure but did not refer to any antecedent anatomical descriptions. The intended targets were the medial branches of the thoracic dorsal rami, and the target points they adopted were said to be analogous to the target points proposed by Bogduk and Long [2] for lumbar facet denervation, i.e., the junction between the superior articular process and the transverse process. However, they provided no data nor any reference to support the notion that the medial branches of the thoracic dorsal rami cross the base of the transverse processes.

Existing textbook descriptions of the thoracic dorsal rami are limited in detail. Textbooks such as Gray's Anatomy [16] focus on the distribution of the lateral branches but provide no details on the course or articular distribution of the medial branches. Hovelacque [4] offers a more detailed description of the thoracic dorsal rami but again, explicit details as to radiological landmarks for the medial branch or its distribution of the zygapophysial joints are not provided. The studies of Lazorthes [6, 7], although addressing the clinical anatomy of the thoracic dorsal rami, do not provide sufficient nor reliable detail as to the exact trajectory of the nerves required for the design of diagnostic blocks or percutaneous surgical procedures based on identifiable radiological landmarks.

In order to prevent thoracic percutaneous facet denervation from falling into disrepute because of an erroneous anatomical basis, we undertook a study to determine the location and course of the medial branches of the thoracic dorsal rami which by analogy to the cervical and lumbar spine are the legitimate targets for thoracic facet denervation. In addition, the origin and course of the articular branches to the thoracic zygapophysial joints were explored.

Methods

Dissection was performed on four embalmed human adult cadavers. Two of the cadavers were male, aged 64 and 88 years, while the other two female cadavers were 39 and 83 years of age.

Upon removal of the skin, deep fascia and superficial muscles of the back, the lateral branches of the thoracic dorsal rami were first identified. At lower thoracic levels, these nerves generally have a cutaneous distribution and were, therefore, easily identified. At upper thoracic levels the lateral branches only have a muscular distribution. Consequently, it was first necessary to resect the surrounding muscles which these nerves supplied. Having identified the lateral branches, they were then traced proximally towards the intertransverse space as a guide to the expected origin of the medial branches. At the same time, muscles were resected working from lateral to medial until the medial branches were encountered. The muscles were resected fascicle by fascicle so as to preserve any nerves that might course through them. Once identified, the medial branches were traced proximally into the intertransverse space as far as their origin from the dorsal rami which in turn were traced back to the spinal nerves. As well, the medial branch was traced distally into the muscles it supplied and to the point where it became cutaneous at levels where cutaneous branches arose. Throughout, the medial branches were dissected using a X40 dissecting microscope. A total of 84 medial branches from 7 sides of the 4 cadavers were successfully dissected.

During the later stages of the dissection, a careful search was made for articular branches, in the region ventrolateral to each thoracic zygapophysial joint between the joint and the dorsal ramus, in the region caudal to each zygapophysial joint, and in the region above each joint.

Results

The course of the medial branches of the thoracic dorsal rami was essentially, systematically similar at all segmental levels, although certain topographic differences occurred at specific levels. Typically, the medial branch arose from the dorsal ramus within 5 mm of the lateral margin of the intervertebral foramen. From its origin, the medial branch first passed dorsally, inferiorly but largely laterally within the

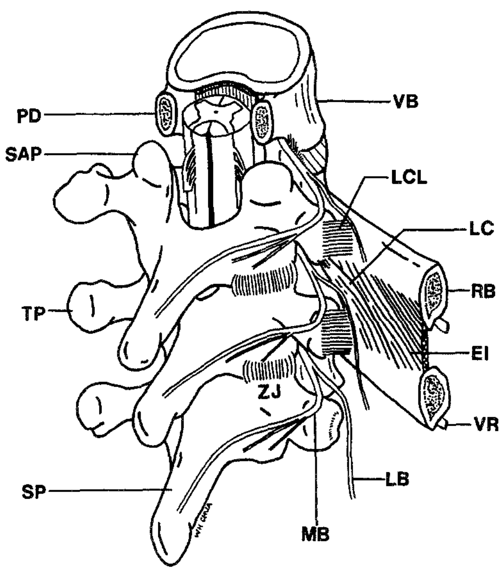

Fig. 1. A sketch of the archetypical course and relations of the thoracic dorsal rami viewed from a right superior aspect. *SP* spinous process; *TP* transverse process, *SAP* superior articular process, *PD* pedicle, *ZJ* zygapophysial joint, *MB* medial branch, *LB* lateral branch, *VR* ventral ramus, *EI* external intercostal, *RB* rib, *LC* levator costae, *LCL* lateral costotransverse ligament, *VB* vertebral body

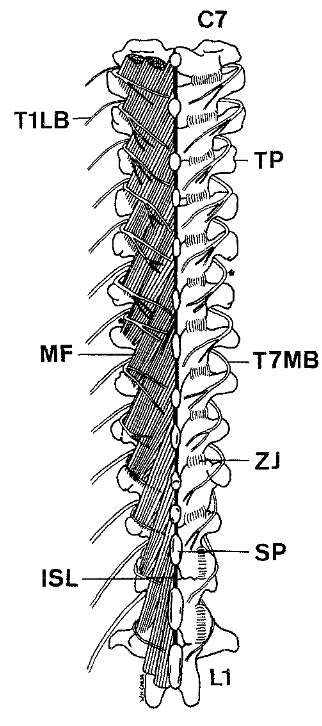

Fig. 2. A sketch of the medial branches of the thoracic dorsal rami viewed from behind. On the right side, the multifidus and lateral branches are not shown. *TP* transverse process, *MB* medial branch, *ZJ* zygapophysial joint, *SP* spinous process, *LB* lateral branch, *MF* multifidus, *ISL* interspinous ligament, *C* cervical vetebra, *L* lumbar vertebra, * atypical medial branch

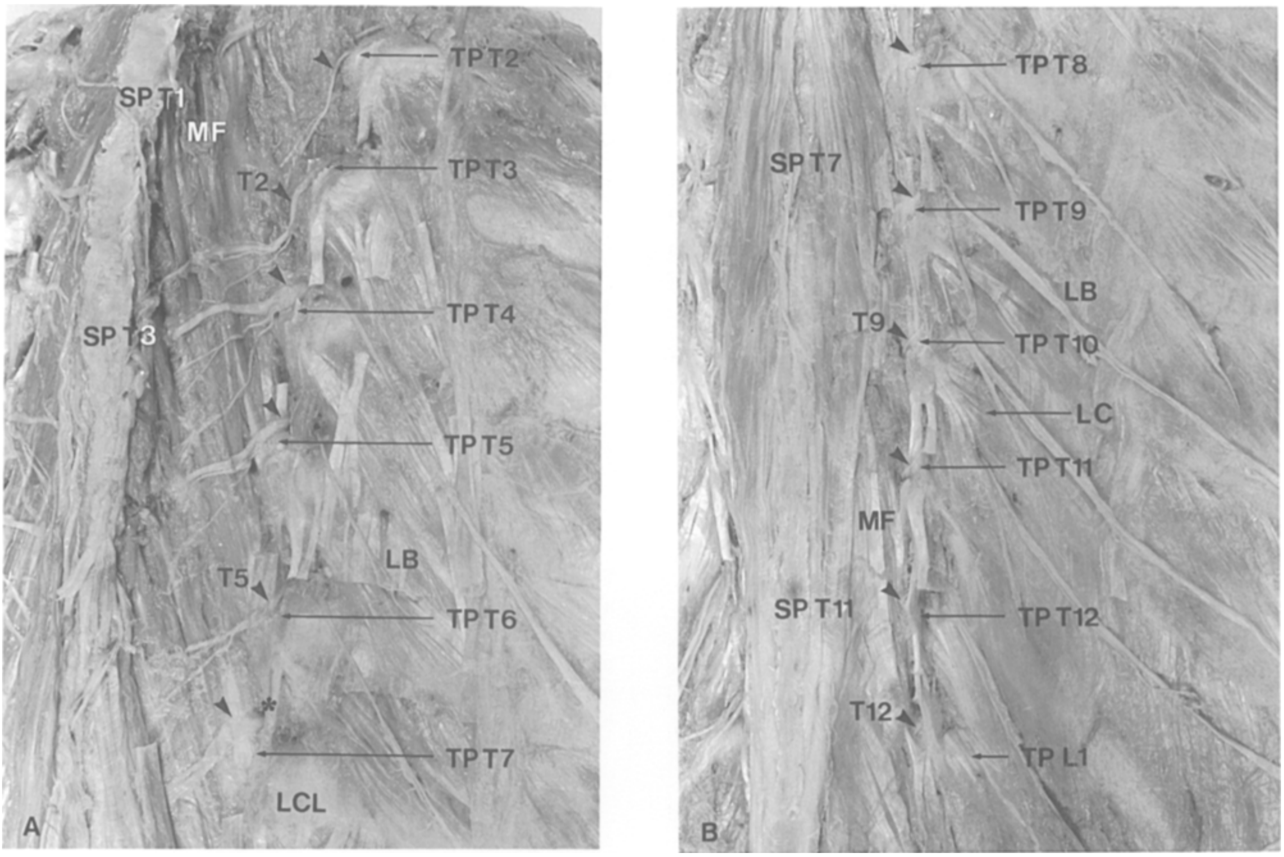

Fig. 3. Photographs of a dissection of the branches of the right thoracic dorsal rami viewed from behind. (A) Upper 6 thoracic levels: (B) lower 6 thoracic levels. The medial branches are indicated by black arrowheads. *LB* lateral branch, *SP* spinous process, *TP* transverse process, *MF* multifidus, *LCL* lateral costotransverse ligament, *LC* levator costae, * atypical medial branch

intertransverse space, posterior to the superior costotransverse ligament (Fig. 1). Along this course, the nerve was embedded in areolar tissue and accompanied by arteries and veins. Opposite the tip of the transverse process, the medial branch curved dorsally through the intertransverse space, aiming for the superolateral corner of the transverse process. It then entered the posterior compartment of the back by crossing this corner and then running caudally along the posterior surface of the tip of the transverse process, lying in the cleavage plane between the origin of multifidus medially and that of semispinalis laterally (Figs. 2 and 3). Thereafter, covered by the fibres of the semispinalis, it curved inferiorly and medially over the dorsal aspect of the fascicles of multifidus to which it provided numerous filaments. At upper thoracic levels, one filament continued over the dorsal surface of the multifidus towards the mid-line where it then penetrated the fascicles of spinalis thoracis, splenius cervicis, rhomboids and trapezius to become cutaneous. At lower levels, this filament was not represented and only terminal filaments to the multifidus occurred.

The archetypical course of the medial branches was consistently exhibited by the nerves at the upper thoracic levels (T1–T4) and lower levels (T9–T10). The course of the T11 and T12 medial branches differed because of the different osseous anatomy. The T12 transverse process was much shorter than typical transverse processes. Consequently, the T11 medial branch ran across the lateral surface of the root of the superior articular process of T12 (Figs. 2 and 3). The T12 medial branch assumed a course analogous to that of the lumbar medial branches, crossing the junction of the superior articular process and the base of the transverse process (Figs. 2 and 3).

At mid-thoracic levels (T5–T8), the medial branch did not always assume contact with the transverse process. The nerve sometimes appeared to be suspended in the intertransverse space as it passed dorsally. It assumed a course parallel to those at typical levels but was displaced somewhat superiorly. Instead of crossing the superolateral corner of the transverse process, the nerve entered the posterior compartment of the back by passing dorsally through the middle of the intertransverse space, medial to the intertransverse muscle, and wrapping medially around the fascicles of multifidus above the level of the transverse process (Figs. 2 and 3). It then curved medially and only slightly inferiorly so that it remained separated from the transverse process by the fascicles of the multifidus.

Two types of articular branches arose from the medial branches. Ascending branches arose from the medial branch as it passed caudal to the zygapophysial joint. These branches were short and they ramified in the inferior aspect of the zygapophysial joint capsule. A slender descending articular branch arose from the medial branch as it crossed the superolateral corner of the transverse process. It followed a sinuous course between the fascicles of multifidus to reach the superior aspect of the capsule of the zygapophysial joint below.

Discussion

Although a small number of cadavers were used in the present study, a large number of nerves (n = 84) was nonetheless studied. No substantial variations were encountered except for those at specific segmental levels. Consequently, we submit that the present study reliably establishes the anatomy of the medial branches of the thoracic dorsal rami.

The course and distribution of the lateral branches were not addressed in this study because these have been addressed in previous studies. Descriptions of their deep course can be found in textbooks [4, 9, 11, 16] while their distribution to the skin has been described in dissections studies of adult cadavers [5, 8] and human fetal material [10].

The observation of the present study are concordant with the descriptions of Hovelacque [4] but amplify the detail sufficient for clinical purposes. The key feature of the thoracic medial branches is that by and large, they cross the superolateral corner of the subjacent transverse process. However, at mid-thoracic levels, the nerve may be displaced cephalad and therefore does not assume this relationship while at lower thoracic levels, the nerve assumes an osseous relationship analogous to that of the medial branches of the lumbar dorsal rami.

Our observations are at variance with the descriptions of Lazorthes [6] who described and illustrated the thoracic medial branches as passing next to the superior articular process. The nerves are not this close to the zygapophysial joint; they swing laterally to circumvent the multifidus which arises from the distal end of the transverse process.

At no time in the present study were nerves encountered crossing the superomedial corner of the transverse process which is the target point for thoracic facet denervation advocated by Stolker *et al.* [14]. This means that the target points do not coincide with the course of the medial branch. Therefore, the procedure that they describe cannot constitute a thoracic medial branch neurotomy. When in contact with the transverse process, the medial branch lies at least 12 mm lateral to the root of the transverse process. However, the maximum size of the lesions created by the thermocouple electrodes used in thoracic facet denervation measures only 1.1 mm in radius [3].

In a more recent publication, Stolker *et al.* [15] referring to Hovelacque and Lazorthes, suggest that fine filaments can be found crossing the inferomedial corner of the intertransverse space in the vicinity of their electrode position. In the present study, these fine filaments could not be verified by microdissection. If they exist, they would require histological confirmation. In the case of tiny, putative articular branches, conclusions based on microdissection alone would be unreliable because it can be difficult to distinguish neural tissue from fine fascial fibres. It is the lack of histological confirmation that precludes us from accepting the description of Lazorthes [6].

Stolker *et al.* [14] adopted the target point at the superomedial corner of transverse process because they perceived this to be analogous with the site at which the medial branch of the lumbar dorsal ramus cross the bone. What they neglected was the homology between the lumbar and thoracic vertebrae. The so-called transverse process of the lumbar vertebra is formed largely by the costal element of the lumbar vertebra. The true transverse process is represented by the mamillary process, the lateral surface of the superior articular process and the transverse process but only as far as the accessory process. That being the case, the lumbar medial branches can be perceived as crossing the transverse element diagonally from its superolateral corner to its inferomedial corner. Thus, when addressing the thoracic medial branches, the course would be expected to run from the superolateral to the inferomedial corner of the transverse element which is the transverse process proper on the thoracic vertebra. This is where the medial branches were encountered in the present study. This homology is further endorsed by the myotendinous relations of the medial branch. At the thoracic levels, the medial branch lies lateral to the multifidus but deep to the tendons of semispinalis. In the lumbar spine, the nerve runs deep to the mamillo-accessory ligament which is homologous to the semispinalis muscle in the thoracic spine [1].

If thoracic percutaneous facet denervation is to be accepted as a legitimate option for the treatment of thoracic zygapophysial joint pain, further validation of data is required. Either the technique of Stolker *et al.* [14] must be verified clinically in the form of a double-blind controlled trial or the procedure needs to be modified so as to be concordant with the surgical anatomy of the thoracic medial branches.

If the medial branches of the thoracic dorsal rami are to be targets for diagnostic blocks or percutaneous facet denervation, the best landmark is at the superolateral corner of the transverse process. Here the nerve lies against bone and for the purposes of diagnostic blocks, could be reached by needles directed towards this site. Radiofrequency electrodes directed to this nerve would first have to contact this superolateral corner and then be passed over the superior edge of the transverse process in order to lie parallel with the medial branch. Target points for the medial branches in mid-thoracic levels are less reliable. Because the nerves enter the posterior compartment suspended in the intertransverse space, they lack an osseous relation. Techniques for reaching these nerves would have to be carefully developed taking into account the different anatomy of these nerves.

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Comment

The authors perform dissections of the posterior spinal regions for embalmed human adult cadavers in order to establish the anatomical course of the medial branches of the thoracic, dorsal rami.

The objectives of the paper are clearly defined and the methodology described. Both photographic illustrations and diagrammatic representations are clear and well labelled, and the authors describe consistent routes for the medial branches of the dorsal rami.

The findings in this paper should be of practical value for planning of thoracic percutaneous facet denervation.

R. O. Weller