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Anatomical study of the paraspinal approach to the lumbar spine

Received: 14 April 2004
Revised: 28 June 2004
Accepted: 18 August 2004
Published online: 19 November 2004
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Abstract The original description of the paraspinal posterior approach to the lumbar spine was for spinal fusion, especially regarding lumbo-sacral spondylolisthesis treatment. In spite of the technical details described by Wiltse, exact location of the area where the sacrospinalis muscle has to be split remains somewhat unclear. The goal of this study was to provide topographic landmarks to facilitate this surgical approach. Thirty cadavers were dissected in order to precisely describe the anatomy of the trans-muscular paraspinal approach. The level of the natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis muscle was noted and measurements were done between this level and the midline at the level of the spinous process of L4. A natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis muscle was present in all cases. There was a fibrous separation between the two muscular parts in 55 out of 60 cases. The mean distance between the level of the cleavage plane and the midline was 4 cm (2.4–5.5 cm). In all cases, small arteries and veins were present, precisely at the level of the cleavage plane. We found it possible to easily localize the anatomical cleavage

plane between the multifidus part and the longissimus part of the sacrospinalis muscle. First the superficial muscular fascia is opened near the midline, exposing the posterior aspect of the sacrospinalis muscle. Then, the location of the muscular cleft can be found by identifying the perforating vessels leaving the anatomical inter-muscular space.

Keywords Paraspinal approach · Lumbar spine · Lumbosacral spondylolisthesis · Sacrospinalis muscle · Minimally invasive approach

Introduction

The paraspinal approach to the lumbar spine was first described by Watkins in 1959 [3]. It goes between the lateral border of the sacrospinalis muscles and the quadratus lumborum muscle. Wiltse described a modified trans-muscular paraspinal approach [6, 8, 9] consisting of a longitudinal separation of the sacrospinalis muscle between its multifidus and longissimus parts (Fig. 1). The original description was for spinal fusion, especially regarding lumbosacral spondylolisthesis treatment [5]. Through this approach, a one-level or a multilevel fusion can be performed; leaving the supraspinous and interspinous ligaments intact. Its uses for removing a far-lateral disc herniation [7], decompressing a far-out syndrome [10], and inserting pedicle screws, as well as for spinal canal decompression have been well-described [8]. In spite of the technical details described by Wiltse, exact location of the area where the sacrospinalis muscle has to be split remains somewhat unclear. The goal of this study was to precisely describe the anatomy of this trans-muscular paraspinal approach and to provide topographic landmarks to facilitate this approach.

Materials and methods

Thirty cadavers (17 males and 13 females) of undetermined age were dissected by the same author (R.V.). There were 23 cases of embalmed cadavers and seven cases of fresh cadavers. Cadavers were placed in prone position. For each cadaver, the length of the trunk was evaluated by the distance between the spinous process of the seventh cervical vertebra and the posterior superior iliac spine. A midline skin incision was made down to

Fig. 1 The initial description by Wiltse of the paraspinal sacrospinalis-splitting approach to the lumbar spine (1968). Note location of bone grafts after closure of the wound (left)

the level of the muscular fascia. The superficial fascia is in continuity with the fascia of the latissimus dorsi muscle. This fascia was opened just close to the midline and retracted laterally in an anatomical avascular space between the superficial fascia and the muscular aponeurosis of the sacrospinalis muscle. The muscular aponeurosis of the sacrospinalis muscle contains muscular fibers on its cranial superficial part and only fibrous tissues on its caudal superficial part. The limit between muscular and fibrous tissues was noted by the use of two measurements. The “d1” distance was measured between the caudal muscular limit and the superior posterior iliac spine. The “d2” distance measured between the caudal muscular limit and the midline. The d1 and the d2 distances were orthogonal (Fig. 2). The level of the natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis muscle was noted and measurements were done between this level and the midline at the level of the spinous process of L4 (d3 distance) (Fig. 3). The approach was then completed through the sacrospinalis muscle to expose cranially the transverse process of L3 and caudally the articular process of S1 (Fig. 4). The same procedure was performed on both sides. All measurements were collected in a computerized database. Because of the small number of cases, statistical analyses were carried out using non-parametric tests.

Fig. 2 The d1 and d2 distance allow locating the limit between the muscular part and the fascial part of the superficial aspect of the sacrospinalis muscle (SSm) (SPIS superior and posterior iliac spine)

Fig. 3 The $d3$ distance is measured between the muscular cleft between the multifidus and the longissimus parts of the sacrospinalis muscle and the midline at the level of the spinous process of L4

Fig. 4 Exposition of the *left* L4 and L5 transverse processes through the paraspinous sacrospinalis-splitting approach. Note the emergence of the posterior ramus of the L3 nerve at the *cranial* part of the surgical approach (*arrow*)

Results

The mean distance between the spinous process of the seventh cervical vertebra and the posterior superior iliac spine was 47.58 cm (40–55 cm). This value was significantly higher in men than in women ($p=0.003$, Wilcoxon's test). In all cases, there was an anatomical avascular space between the superficial muscular fascia and the muscular aponeurosis of the sacrospinalis muscle. The limit between muscular and aponeurotic parts of the sacrospinalis muscle was easily identified in 57 cases out of 60. In three cases (both sides of the same cadaver and one unilateral side), muscular fibers of the sacrospinalis muscle were attached down onto the sacrum. The mean distance between the superior posterior iliac spine and the limit between muscular and aponeurotic parts of the sacrospinalis muscle ($d1$ distance) was 5.05 cm, from 0 cm (in the three cases mentioned above) and 8 cm. The mean distance from the limit between the muscular and aponeurotic parts of the sacrospinalis

muscle to the midline was 4.66 cm (2.5–6 cm). There was a positive correlation between these two distances ($p=0.003$ Kendall's test): the closer the musculo-aponeurotic limit was to the sacrum, the closer it was to the midline. A natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis muscle was present in all cases. There was a fibrous separation between the two muscular parts in 55 out of 60 cases (Fig. 5). The fibrous separation was easily identified at the caudal part of the muscular cleft but disappeared gradually above the level of the L4 transverse process. In five cases (four cases were both sides of two cadavers and one a unilateral case), there was no well-defined fibrous partition inside the sacrospinalis muscle. Nevertheless, a natural cleavage plane was noted, as for the other cases. The mean distance between the level of the cleavage plane and the midline was 4 cm (2.4–5.5). In all cases, small arteries and veins were present, precisely at the level of the cleavage plane, arising from this anatomical inter-muscular space and remaining on the surface of the sacrospinalis muscle

Fig. 5 A natural cleavage plane between the multifidus and the longissimus part of the sacrospinalis muscle and a fibrous partition between the two muscular parts is well-visualized on this axial spin-echo T1-weighted magnetic resonance image at L4/L5 level (arrows)

(Fig. 6). In four cadavers, we identified, on both sides, the emergence of a large posterior ramus of the L3 nerve. It was possible to retract and preserve the nerve cranially and laterally, in order to expose the articular and transverse processes from L3 to S1. The main topographic data are reported in Table 1.

Discussion

We found it possible to easily localize the anatomical cleavage plane between the multifidus part and the longissimus part of the sacrospinalis muscle. First the superficial muscular fascia is opened near the midline, which exposes the posterior aspect of the sacrospinalis muscle. Then, the location of the muscular cleft can be found by identifying the perforating vessels leaving the anatomical inter-muscular space. During this anatomical study, we noted no morphometric differences between fresh and embalmed cadavers.

Three different paraspinal approaches to the lumbar spine have been described in the literature. The surgical approach described by Charles Ray [2] and those described by Melvin Watkins [3, 4] are between the sacrospinalis muscle and the quadratus lumborum muscle. The approach described and popularized by Wiltse [6, 8, 9] is much more medial, in the cleft between the mul-

Fig. 6 In all cases, we noted the presence of small arteries and veins, just at the level of the cleavage plane, arising from this anatomical inter-muscular space and remaining on the surface of the sacrospinalis muscle (arrows)

Table 1 Main topographic data from study

	<i>n</i>	Minimum	Maximum	Mean	Standard deviation
Trunk size	30	40	55	47.5833	3.5798
d1 distance	60	0	8	5.055	1.82714
d2 distance	60	2.5	7	4.6583	1.05963
d3 distance	60	2.4	5.5	4.005	0.67533

tifidus and longissimus parts of the sacrospinalis muscle. These three approaches allowed the surgeon to reach the area to be fused or decompressed without cutting many of the supporting structures. In our experience, the paraspinal approach is very useful to obtain solid posterior fusion in children and adolescent high-grade lumbosacral spondylolisthesis [1]. The L5 and S1 transverse and articular processes are reached easily through this approach, which causes less bleeding than the posterior approach to the lateral parts of the vertebrae. The anatomy of the paraspinal approach is somewhat more

complicated than the midline approach, since one does not have the spinous processes exposed, which would give a landmark. Moreover, at that time the exact description of the anatomical cleavage plane between the multifidus part and the longissimus parts of the sacrospinalis muscle was still unknown. For Wiltse, the fascial incision is made 2 cm lateral to the midline, and the finger can be plunged inside the sacrospinalis muscle at any point above the L4 level [8]. The cleavage plane seems to be easier to find caudally, but it is a much more bloody approach. In our study, in 92% of the cases, a fibrous partition was well identified at the caudal part of the muscular cleft (Fig. 7) and disappeared gradually above the level of the L4 transverse process. This anatomical finding may explain a part of Wiltse's observations but we did not find specific vessels explaining increased bleeding.

Regarding the level of fascial incisions we think that it is possible to open the superficial fascia just close to the midline. Thus, it is possible to reach the whole posterior aspect of the sacrospinalis muscle through an anatomic cleavage plane. It is always possible to identify small arteries and muscular veins, just at the level of the muscular cleavage plane, arising from the anatomical inter-muscular space and remaining on the surface of the sacrospinalis muscle (Fig. 8). It gives a good anatomical landmark to open the sacrospinalis fascia (after having staunched the vessels with cautery) and find the cleavage

Fig. 7 The fibrous partition between the two muscular parts is thicker as one approaches down to the sacrum. This can be visualized on this axial spin-echo T1-weighted magnetic resonance image at L5/S1 level (arrows)

Fig. 8 The initial description by Wiltse of the paraspinal sacrospinalis-splitting approach to the lumbar spine (1968). Note the course of the posterior ramus of the lumbar nerve in the anatomic cleavage plane between the longissimus part and the multifidus part of the sacrospinalis muscle. We found, in all cases, small perforating vessels having the same course

plane. Except these perforating arteries, we noted no anatomical landmark allowing to differentiate the muscular cleavage plane. In our cadaveric study, the muscular cleft was 4 cm lateral to the midline but this distance (d3 distance) may be different in patients. In the current study, cadavers were old and amyotrophic and the d3 distance between the midline and the muscular cleft we measured should be different in young and healthy patients, especially teenagers treated for lumbosacral spondylolisthesis.

In all the cases, it was easy to expose the transverse and articular processes from L3 to the sacrum. We found in four cases a large posterior ramus of the L3 nerve which could have been injured during surgical approach. The dissection must be performed carefully at the cranial part of the surgical approach to avoid damaging this sensitive nerve which course is through the muscular cleavage plane.

Our anatomical study confirms the numerous advantages of the paraspinal sacrospinalis-splitting approach. The approach is easy and allows reaching the articular and transverse processes. Through this approach either a one-level or a multilevel fusion can be done, without wide muscular disinsertions and leaving the supraspinous and interspinous ligaments intact.

This study benefited from the financial support of the Société Française de Chirurgie Orthopédique et Traumatologique and the Fondation pour la Recherche Médicale

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