Comparison of Median and Intermediate Approach in the Ultrasound-Guided Sacral Erector Spinae Plane Block: A Cadaveric and Radiologic Study

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Abstract

Backgrounds:

Erector spinae plane block (ESPB) has become very popular for post-operative and chronic pain management. ESPB applications sacral area procedures have been named ‘sacral ESPB’. This study is aimed to conduct a cadaveric study to determine how local anesthesia was distributed at median and intermediate approaches of the sacral region ESPB procedures.

Materials and Methods:

Four cadavers were grouped into two groups; median and intermediate approaches. An ultrasound-guided ESPB was performed with a mixture of radiocontrast and dye. After the distribution of the solution was observed by computed tomography, cadavers were dissected in order to observe the dye spread in the groups.

Results:

CT Images of the median group demonstrated subcutaneous pooling of contrast agents between S1 and S5 horizontal planes. Contrast agent passing from the sacral foramina to the anterior of the sacrum via spinal nerves was also observed between S2-S5. In the intermediate group contrast distribution was observed along the bilateral erector spinae muscle between L2-S3 horizontal planes, and no anterior transition was detected.

Dissection findings in the median group, methylene blue spread was observed in the subcutaneous tissue area between the S1-S5 horizontal planes. There was no methylene blue solution spread under the superficial fascia or the muscle plane. In the intermediate group, the red-colored radiocontrast solution was detected between the L2-S3 intervertebral levels in the erector spinae muscle group.

Conclusion:

Radiocontrast dye was detected at superficial and erector spinae compartments respectively at median and intermediate cadaver groups both radiological and anatomically. The anterior transition of the radiocontrast was detected in only the median cadaver group.

Clinical Trial: Karadeniz Technical University Ethics Approval No: 2022/229, ClinicalTrials.gov ID: NCT05716061

Introduction

Postoperative pain is a common outstanding problem that is desired to be resolved without complication. The sacral erector spinae plane block (ESPB) is a current pain-blocking technique used for perioperative analgesia and post-operative pain blockade treatment. In comparison with neuraxial
techniques, plane blocks are gaining popularity as they have no serious side effects. One of these recently introduced techniques is ESPB which was first described by Forero in 2016 by applying it to a patient with chronic pain from the thoracic region [1]. The current literature includes many studies subjecting thoracic and lumbar surgical area ESPB procedures [2]. Also, the muscle group is limited on both sides by the transverse process and the spinous process, and the ESPB is applied to an area between the transverse process and the spinous process. The presence of spinous processes and interspinous ligaments in the thoracic and lumbar regions prevents the bilateral spread of the anesthetic agent [3].

ESPB applications are named according to the medulla spinalis application site; as an example, sacral area procedures have been named ‘sacral ESPB’. The bilateral sacral ESPB was first performed on an adult patient for postoperative analgesia who underwent anal fissure surgery by Tulgar et al. in 2019. They described the sacral ESPB technique by placing the needle bilateral on the intermediate crest and reported one case of pilonidal sinus surgery [4]. In the same year, Aksu and Gürkan reported effective postoperative analgesia in a pediatric patient who underwent hypospadias surgery by performing the median sacral ESPB from the median sacral crest [5]. There are successful case reports of both techniques reported in the literature [6-11]

The current literature includes both median and intermediate ESPB implementations. However, there is no anatomical and radiological study in the literature describing the application and the method of the median (midline) and intermediate ESPB practices. The aim of this study is to conduct a cadaveric study to determine how local anesthesia was distributed at median and intermediate approaches of the lumbar and sacral region ESPB procedures. The radiologic images and the dissection finding were compared in order to define the spread limits of the radiocontrast anesthetic solution.

Materials And Methods

A two-phased, radiologic and cadaveric study was performed. Ethical approval was obtained, and the study protocol was registered to the clinical trials database (ClinicalTrials.gov ID NCT05716061). After the implementation of the ESPB, the preliminary phase includes radiologic procedures, and the second phase includes cadaveric dissections. Four embalmed cadavers, including two females and two males (68 to 89 age at death) were enrolled in the study. None of the cadavers had a history of trauma or surgery in the sacral region. The cadavers were divided into two groups containing two cadavers and performed ultrasound (USG) guided ESPB in different two approaches by an experienced anesthesiologist.

At the median approach; after the linear probe was covered with a sheath, it was placed longitudinally in the midline at a level of lumber 5 spinous process. The median crest of the sacrum was observed and the probe was slid caudally to visualize the first and second median sacral crest tips and erector spinae muscle. As described by Aksu and Gurkan, a 22G, 50 mm needle (Stimuplex Ultra360 B.Braun, Melsungen, Germany) was inserted with the in-plane technique in the craniocaudal direction until the tip
of the needle touched the second sacral crest (5). After negative aspiration, 2 ml saline was injected and the localization of the needle tip was confirmed with USG. Finally, 40 ml of solution was injected between the sacral crest and the erector spinae muscle for the block (Fig 1-A). The solution was prepared with 4 ml methylene blue, 20 ml contrast solution (Iohexol, Kopaq 350 mg/1 ml, Koçsel, İstanbul), and 16 mL of saline.

At the intermediate approach; as described by Tulgar, after the linear probe was covered with a sheath, the USG probe was placed longitudinally at the same location over the middle of the sacrum, and second median crest was observed. Then the probe was moved laterally 1.5-2 cm to the left and placed over the second intermediate crest of the sacrum. A 22G, 50 mm needle was inserted in-plane technique with a cauda-cranial direction. Following negative aspiration, 2 ml saline and 20 ml volume of the red-colored solution were injected into the area between the median and intermediate crests under the multifidus muscle, respectively (4) (Fig 1-B). The same block was applied to the right side. The red solution was prepared with 2 ml of red acrylic paint, 10 ml of radiocontrast solution, and 8 mL of saline.

Cadavers were transferred within 30 min to the Department of Radiology for computed tomography (CT) workups. Scans were obtained with scout view 512 mm, images were obtained with a rotation time of 0.8 sec, size collimation of 0.6 mm, 120 kv, and the effective current was 120-480 mA (GE Revolution EVO systems, Chicago, IL, USA). Axial, coronal, and sagittal reconstructions were performed with 1.25 mm sections for evaluating the spread of contrast material. Reconstruction from sections was performed to determine the distribution of the radiocontrast solution. The duration of radiological study was completed within 30 minutes and was brought back to the Department of Anatomy.

After the radiologic imaging procedure, the cadavers were transferred to the Anatomy laboratory within 30 minutes. After radiologic imaging, the cadavers were dissected by experienced anatomists in order to examine the degree of solution spread through the tissue planes. For the median group; a superficial subcutaneous area was dissected between the horizontal L5 and the horizontal S5 planes from the medial to lateral side according to radiologic findings. The spreading of the methylene blue solution was observed. For the intermediate group, primarily the subcutaneous area was dissected between the L2 and the S2 horizontal planes in the same manner with the midline dissections. The red acrylic paint spread on the dorsal surface of the erector spinae was examined. Finally, the erector spinae muscle group intersected through the deep part of the muscle between the L2 and S3 intermediate horizontal planes.

Results

The radiologic results of the study were examined by an experienced radiologist. Computed tomography images were examined between the horizontal L1 level and the tip of the coccyx. Images of the first cadaver group (median group) demonstrated subcutaneous pooling of contrast agents between S1 and S5 horizontal planes. Contrast agent passing from the sacral foramina to the anterior of the sacrum via spinal nerves was also observed between S2 and S5. [Figure 2-A-B-C]. In the second group (intermediate
group) contrast distribution was observed along the bilateral erector spinae muscle between L2 and S3 horizontal planes, and no anterior transition was detected. [Figure 3-A-B-C].

Anatomic dissections were performed from superficial to deep tissue planes for all groups. In the median group, methylene blue spread was observed in a horizontal 15 x vertical 18.5 cm subcutaneous tissue area between the S1 and the S5 horizontal planes [Figure 4-A]. There was no methylene blue solution spread under the superficial fascia or the muscle plane. In the intermediate group, the skin was elevated like the median injection group's cadavers. However, a red radiocontrast solution spread was not observed at the loose areolar tissue plane between the skin and the erector spinae. After the removal of loose areolar tissue, the deep fascia over the erector spinae was dissected. Then the muscle was deeply cut vertically in order to observe the red-colored radiocontrast solution spread. The red-colored radiocontrast solution was detected cranially in the muscle at L2-L3 intervertebral levels but not over the horizontal L2 vertebra level [Figure 4-B]. At the caudal part, the red-colored radiocontrast solution was detected in the muscle at S2-S3 intervertebral levels but was not detected under the horizontal S3 vertebra level. At both levels, the solution spread was limited with the deep fascia enclosing the front side of the erector spinae. Consequently, anatomic dissection findings were mostly in accordance with the radiologic findings [Table 1].

**Discussion**

Current literature includes radiologic, anatomic, or clinical studies about ESPB interventions. Our study made comparisons between the anatomic and radiologic findings of the ESPB procedures’ radiocontrast dye solution spread patterns. The radiocontrast dye solution given over the median crest did not show any muscle involvement and was spread to the subcutaneous tissue in the sacral area, as observed in anatomical sections. Nanda et al. performed an anatomic study from the median crest located ESPB, and they didn’t show any dye spread into deep tissue compartments including any sacral foramina and nerve too. However, in our studies’ radiologic findings contrast agent passing from the sacral foramen to the anterior of the sacrum via spinal nerves was also observed between S2 and S5. The fact that radiological imaging and anatomical dissection were performed at different times, and the different densities of the substances in the applied mixture may be the reason why the results were not compatible. We assess that the radiocontrast substance may have spread through the superficial tissue, reached the foramen, and passed from there to the anterior of the sacrum via the sacral nerves. It is very important to observe this spread radiologically and we can explain the studies that provided effective analgesia with the median ESPB. In a clinical investigation, Kukreja et al. provided postoperative analgesia with the median approach in the gender reassignment operation, by administering 20 cc of local anesthetic at the S2 and S4 levels [10]. Aksu et al and Öksüz et al., reported similar studies performing the same approach. They performed a median ESPB from the fourth median crest, and they reported successful postoperative analgesia in anorectal and urogenital pediatric surgery [5,7]. We consider that our radiologic findings, the radiocontrast transmission to the pelvic cavity, can explain the successful analgesia effect over the pudendal and obturator nerves’ sensation area.
In the intermediate approach, the solution was applied bilaterally into the erector spinae muscle, approximately 1-2 cm lateral to the median crest at the sacral S2 level. It showed a longitudinal distribution from the S3 to the L2 level horizontally. Similar to our study in previous thoracic and lumbar ESPB anatomical and computed tomography studies, the longitudinal spread of the given dye was shown but no anterior transition was demonstrated. [3,13,14]. Theoretically, the dorsal rami of spinal nerves located in the erector spinae muscle compartment at all levels were involved due to vertical spread. However, the analgesic efficacy in clinical studies cannot be explained only by the involvement of the dorsal rami. Anterior transition or ventral ramus involvement are also required. In a magnetic resonance imaging (MRI) and anatomical study, Adhikary et al. assessed the cadavers with MRI after ESPB block from T5. There was visible injectate distribution to the neural foramen and epidural space. They confirmed the anterior spread of local anesthetic [15]. Bonvici reported an intermediate ESPB intervention from T5. In microscopical examinations, dye diffusion ventrally to the intercostal spaces by following the blood vessels coupled to the nerve passing through the costotransverse foramen was detected in this study [16]. In these two studies, the anterior transition was shown in the thoracic region in different ways apart from our study. The erector spinae muscle group in the thoracic region is thinner than the sacral region. As it goes down, the erector spinae muscle group thickens, which makes the anterior transition more difficult at the sacral segment of the medulla spinalis. We assess that the difference in the transition of the contrast solution between the sacral region and the thoracic region is due to muscle thickness, and this may explain the difference in results between our study and these studies. The difference detected between studies shows that comparisons should be made by taking into account the medulla spinalis segments applied together with the method in further ESPB studies.

Sandeep et al. reported a cadaveric study with the intermediate sacral ESPB intervention. They observed methylene blue above and below the sacral multifidus muscle during dissection. In addition, they found that the sacral foramen and sacral nerves were stained and methylene blue leaked from the dorsal surface of the sacral foramen into the sacral epidural space. They explained the diffusion of methylene blue into the ventral and epidural spaces by injecting a more pressurized volume of solution through the catheter [17]. We assess that the difference between our study results is due to the difference in the methods of both studies. Mistray et al. performed the intermediate approach in the sacral spine surgery and observed selective sensory loss in the L4-S3 dermatomes postoperatively [11]. Piraccini et al. perform the sacral ESPB with an intermediate approach unilaterally, from the S1 level, with a 15 cc drug, and the radicular pain numerical rating scale of the patient was decreased after 20 minutes, and the patient was able to stand up and walk [8]. We assess that these clinical results can be explained by the blockage of intramuscular spinal nerve fibers located in the erector spinae muscle compartment. Another researched item related to ESPB is the effective area of anesthesia. Tulgar reported a bilateral ESPB on the intermediate crest in pilonidal sinus surgery and provided adequate postoperative analgesia [4]. In another clinical study, Kaya et al. performed intermediate ESPB in anorectal surgery and achieved adequate analgesia [6]. As our study presented the intramuscular spread of the solution, we assess that this approach can provide efficient analgesia in surgeries involving the lower lumbar and sacral vertebra, in lumbar pain, and in orthopedic surgical interventions as well.
Tulgar described the intermediate crest approach in his letter and named it as 'sacral erector spinae plane block'. In a letter published in 2020, Hamilton DL stated that the muscle fibers of the erector spinae are more superficial in the sacral region above the multifidus, and therefore the name of this block should be changed to "sacral multifidus block" [18]. According to an anatomical point of view, Piraccini et al. argued for a change in this nomenclature [19]. Although different terminological definitions have been made, we consider that the described clinical procedures are within the definition of ESPB utilized by our study.

Our study is a cadaveric study and was performed with four embalmed cadavers donated to the Anatomy Department. First of all, we present our appreciation to these devoted people for their contribution and we commemorate them with respect. However, the major limitation of this study was the implementation of the ESPB on embalmed cadavers. A cadaveric study enables us to explain the morphometry of the procedure methodology but it is difficult to compare all results with living subjects. Nonetheless, we do not presume this may potentially change our results since it was recently reported that similar distributions were observed in a study performed on both fresh and embalmed cadavers’ ESPB interventions [12]. Our results revealed that the distributions of radiocontrast dye solutions given by median and intermediate crests showed very different characteristics. The distribution of local anesthetic agents may differ in living bodies due to the density difference of solutions without radiocontrast dye ingredients. In addition, intraabdominal pressure changes during breathing, blood circulation, muscle contraction, and body position can change the spread in vivo [16].

In conclusion, this cadaveric and radiologic study showed the pelvic transition of the radiocontrast dye solution only in the median approach. The craniocaudal muscular spread was detected but pelvic compartment transition was not observed in the intermediate sacral ESPB approach. We assess that the methodology of the ESPB procedures should be investigated with further combined studies as there are some controversies between the results of the studies on the same subject.

**Declarations**

**Author's contribution statements**

B Olgun Keleş: Project development, performing the blocks, data collection, manuscript writing, editing

N Salman: Project development, performing the cadaveric dissection, manuscript writing, editing

E Tekir Yılmaz: Data collection and management

H Birinci: Data collection and management

A Apan : Project development, manuscript writing, editing

S İnce: Interpreting radiologic images

AF Özyaşar: Data collection and management
References


Tables

Table 1. Findings of the anatomical dissections and radiologic results of median and intermediate group cadaver dissections.
### Anatomical Dissection Findings

| Median Approach | The subcutaneous spread was between S1 and S5 horizontal planes. The muscular spread was not detected. |
| Intermediate Approach | The subcutaneous spread was not detected. Erector spinae spread was between L2 and S3 intervertebral horizontal planes. |

### Radiologic Findings

| Median Approach | The subcutaneous spread was between S1 and S5 horizontal planes. The anterior transition was detected. |
| Intermediate Approach | Erector spinae spread was between L2 and S3 intervertebral horizontal planes. The anterior transition was not detected. |

## Figures

**A** Median approach

**B** Intermediate approach

### Figure 1

USG images of ESPB median and intermediate approaches.

A- In the median approach; Local anesthetic between the ESM and median crest

B- In the intermediate approach; local anesthetic between median and intermediate crests and under the ESM
Figure 2

Median approach CT scan images in axial (A) coronal (B) sagittal (C) plane showed contrast agent anterior of the sacrum
Figure 3

Axial (A), coronal (B), sagittal (C) plane view of intermediate approach CT scan images showed contrast distribution along the bilateral erector spinae muscle.
Figure 4

Anatomic results

A: Median approach: Methylene blue solution spreads into the subcutaneous compartment between S1-S5.

B: Intermediate approach: Red acrylic paint solution spreads into the erector spinae muscle compartment both at superficial and deep tissue planes at L2.