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

Bilge OLGUN KELEŞ (bilge.olgun@hotmail.com)
Giresun University Faculty of Medicine

Necati SALMAN
University of Health Sciences Türkiye

Elvan TEKİR YILMAZ
Giresun University Faculty of Medicine

Habip Resul BİRİNCİ
Giresun University Faculty of Medicine

Alparslan APAN
Giresun University Faculty of Medicine

Selami İNCE
Beytepe Murat Erdi Eker State Hospital

Ali Faruk ÖZYAŞAR
Karadeniz Technical University Faculty of Medicine

Aysun UZ
Ankara University Faculty of Medicine

Research Article

Keywords: Erector spinae plane block, sacral erector spinae plane block, cadaveric study, radiologic study

Posted Date: April 19th, 2023

DOI: https://doi.org/10.21203/rs.3.rs-2824484/v1

License: ☕️ This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License
Abstract

Backgrounds:

Erector spinae plane block (ESPB) has become very popular for post-operative and chronic pain management. It is aimed to observe the contrast agent distributions of three different methods anatomically and radiologically in ultrasound-guided sacral ESPB interventions.

Materials and Methods:

Six cadavers were enrolled and they were grouped into three groups; median, intermediate, and lateral approaches. An ultrasound-guided ESPB was performed with a mixture of radio-opaque and dye. After 30 minutes, the distribution of the solution was observed in the cadavers by computed tomography (CT) examination. Totally after 60 minutes of intervention, the median and intermediate groups of cadavers were dissected in order to observe the dye spread in the median group and the intermediate group. The lateral group dissection wasn’t performed according to radiologic findings.

Results:

CT images presented a pooling of the radio-opaque at subcutaneous tissue in the median group, at erector spinae in the intermediate group, and at gluteus maximus in the lateral group of cadavers. In addition to compartment spreads, images presented anterior transition of the contrast agent at only median group cadavers. Dissection findings presented pooling of the methylene blue at subcutaneous tissue between S1 and S5 horizontal planes at the median group. The red acrylic paint spread was detected between L2-S3 levels in the erector spinae muscle group.

Conclusion:

Radiocontrast dye was detected at superficial, erector spinae, and gluteus maximus compartments respectively at median, intermediate, and lateral cadaver groups both radiological and anatomically. Anterior transition of the radiocontrast was detected in only the median cadaver group.

Introduction

Postoperative pain is a common outstanding problem that is desired to be resolved without complication. The sacral 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]. Since this work, many studies appeared subjecting thoracic and lumbar surgical areas [2]. The erector spinae is a group of muscles located longitudinally on both sides of the spinous processes between the sacrum and the skull base. The ESPB is applied to the erector spinae between the transverse process and
the spinous processes. The presence of spinous processes and interspinous ligaments in the thoracic and lumbar regions prevents the bilateral spread of the anesthetic agent [3].

Recently, various applications to the sacral region in pediatric and adult cases have been named sacral ESPBs. 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 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]. Kaya et al. reported the successful use of bi-level, bilateral sacral ESPB for the main anesthetic method in two ambulatory anorectal surgery. They performed the block from the intermediate crest, between the S2 and S4 levels. After 30 minutes, the sensorial blockade occurred and the surgery was finished without any need for extra analgesia [6]. Öksüz et al. provided adequate analgesia by performing the median block from the median sacral crest on a pediatric patient who underwent anorectal surgery [7]. Piraccini et al. reported the successful implementation of ESPB performed unilaterally from the intermediate sacral crest on an adult patient with left L5 radicular pain [8]. In a case series, the block was performed by placing the needle on the intermediate crest and using 15 mL anesthetic solution on each side by Roy et al [9]. Kukreja et al. have implemented this block at two levels, from the median sacral crest, in gender assessment surgery [10]. Mistry et al reported a case of ultrasound-guided sacral multifidus plane block for spine surgery, they performed a block bilaterally between the median and intermediate crests at S2 level [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 as a result of the median, intermediate and lateral approaches of the ESPB at the lumbar and sacral regions. 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 cadaveric study was performed, and ethical approval was obtained at the faculty of medicine (2022/229). 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. Six embalmed cadavers, including two females and four 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 randomly divided into three groups containing two cadavers. These groups were randomized to perform median, intermediate, and lateral sacral blocks.
In the median approach, the median crest was defined by placing the linear probe (12–18 mHz) of the ultrasound device (ESAOTE MyLab Gold 30 Genoa, Italy) on the midline of the sacrum in the prone position. A total of 30 mL of solution consisting of 2 mL of methylene blue, 15 ml contrast solution (Iohexol, Kopaq 350 mg/1 ml, Koçsel, İstanbul), and 13 mL of saline was injected slowly between the median sacral crest and erector spinae at the 2nd sacral level with a 50 mm echogenic needle directing from cranial to caudal at about 30º angle with skin (Stimuplex Ultra360 B.Braun, Melsungen, Germany) (Fig. 1-A). In the intermediate approach, the second sacral crest was observed on the screen, and the probe was positioned perpendicular to the midline. Then the ultrasound probe switched through lateral and positioned on the intermediate crest. The needle was advanced from caudal to cranial at the same angle to reach 2nd sacral level 30 ml red colored solution was prepared with 2 mL of red acrylic paint, 15 ml radiocontrast solution (Iohexol, Kopaq 350 mg/1 ml, Koçsel, İstanbul), and 13 mL of saline. The total volume of the solution was divided equally (15 mL) parts. Each part of the red radiocontrast solution was injected into the area between the median and intermediate crest at the right and the same procedure was applied to the left intermediate regions, respectively (Fig. 1-B). In the lateral approach, the sacral intermediate crest was found by ultrasound. The ultrasound probe switched to the lateral on the intermediate crest. The needle was advanced from cranial to caudal at the same angle to reach the 2nd sacral level. 15 ml of the solution was injected at the right and the same procedure was applied to the left (Fig. 1-C).

Cadavers were transferred within 30 min to the department of radiology for 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 radio-opaque solution. The duration of the 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 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 was intersected through the deep part of the muscle between the L2 and S3 intermediate horizontal planes. The lateral group dissection wasn’t performed according to radiologic findings.

Results
The radiologic results of the study were examined by a 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 in S2 and distal. 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. In the third group (lateral group) it was determined that the contrast agent spread cephalocaudally along the bilateral gluteus maximus muscle. A contrast agent spread to the anterior of the sacrum was not observed [Figure 2-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 3-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 3-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].

<table>
<thead>
<tr>
<th>Anatomical Dissection Findings</th>
<th>Radiologic Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Median Approach</strong></td>
<td>The subcutaneous spread was between S1 and S5 horizontal planes. The muscular spread was not detected.</td>
</tr>
<tr>
<td><strong>Intermediate Approach</strong></td>
<td>The subcutaneous spread was not detected. Erector spinae spread was between L2 and S3 intervertebral horizontal planes.</td>
</tr>
<tr>
<td><strong>Lateral Approach</strong></td>
<td>None</td>
</tr>
</tbody>
</table>

**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’ radio-opaque dye solution spread patterns. The radio-opaque dye solution given to the median crest did not show any muscle involvement, spreading only 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 in S2 and distal. 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 think that the radio-opaque substance may have leaked between the muscles, 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 midline 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 gave the drug from the 4.th median crest, and they reported successful postoperative analgesia in anorectal and urogenital pediatric surgery [5, 7]. We consider that our radiologic findings, the radio-opaque 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 CT studies, longitudinal spread of the given dye was shown, but no anterior transition was demonstrated. [3, 13, 14]. The dorsal ramus of spinal nerves 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 ramus. Anterior transition and 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 foramens 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, anterior transition was shown in the thoracic region indifferent ways apart from our study. 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 and the results of this study 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 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 presented with our study.

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]. 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 this study. We assess that combined investigations including radiologic, anatomic dissection, and clinical surveys should add valuable contributions to ESPB interventions. On radiological images of the lateral technique, it was obtained that it only flowed through the gluteus maximus. For this reason, it was decided not to perform the cadaveric dissection on the lateral technique ESPB cadaver group.

The major limitation of this study was the implementation of the ESPB on embalmed cadavers. It is difficult to obtain fresh cadavers due to legal, familial, and religious reasons in our country. However, 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 radio-opaque dye solutions given by median, intermediate, and lateral crests showed very different characteristics. The distribution of local anesthetic agent may differ in living bodies due to the density difference of solutions without radio-opaque 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 study showed anterior transition of the dye only in the median approach. Craniocaudal spread was observed in the intermediate approach and anterior transition was not observed. To determine the effectiveness of ESPB interventions, it is necessary to demonstrate the anterior rami transition and we think that more anatomical and clinical studies should be done for this.
Declarations

Ethical Approval

Ethical approval for this study was obtained from the ethics committee of Karadeniz Technical University, No: 2022/229. The study protocol was registered to the clinical trials database (ClinicalTrials.gov ID NCT05716061).

Conflict of interest

All authors declare that they have no conflict of interest.

Authors' contributions

All authors reviewed the manuscript. B.K. and N.S. wrote and edited the main manuscript text; H.B. and A.O. collected the data. B.K., N.S., E.Y. and S.I., interpreted the results; A.A., and A.U. made a critical revision of manuscript

Funding

Not applicable

Availability of data and materials

Not applicable

References


Figure 1

USG guided sacral ESPB approaches

USG images present the location of the sacral crests and the needle trajectory.
Figure 2

CT Scan Images

Median Approach A: Axial B: Coronal C: Reconstruction,

Intermediate Approach D: Axial E: Coronal F: Reconstruction,
Figure 3

Anatomic results

A Methylene blue solution spreads into the subcutaneous compartment.

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