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ORIGINAL RESEARCH

Procedure-Specific Complications Associated with Ultrasound-Guided Erector Spinae Plane Block for Lumbar Spine Surgery: A Retrospective Analysis of 342 Consecutive Cases

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Purpose: Presumed benefits of erector spinae plane blocks (ESPB) include an enhanced safety profile and few complications. There are few large series, which report the incidence of complications associated with ESPB on a procedure-specific basis. The objective of this retrospective cohort study was to estimate the incidence of complications of ESPB in a large series of patients undergoing lumbar spine surgery.

Patients and Methods: We included 342 consecutive patients who underwent any primary lumbar spine surgery via posterior approach (November 2018–July 2020). All patients received bilateral ultrasound-guided ESPB. The primary study outcome was the incidence of any perioperative complication, defined a priori as sensory, motor, hematologic, hemodynamic or respiratory complication consistent with plausible contribution from the ESPB. Secondary outcomes included the incidence of numeric rating scale (NRS) pain scores ≥7 in the post anesthesia care unit (PACU) and risk factors associated with NRS ≥7 (age, sex, ASA class, BMI, opioid tolerance, surgical type, and duration).

Results: We did not identify any pre-specified complications associated with ESPB. There was one unilateral pneumothorax, in one patient, deemed unlikely to have been related to ESPB. NRS ≥7 was found in 17/342 patients (5%) and was independent of any background differences or risk factors assessed.

Conclusion: Ultrasound guided ESPB for lumbar spine surgery was associated with zero complications, no interference with intraoperative neuromonitoring or the early postoperative neurological examination, and low incidence of poorly controlled pain in the PACU. These results help to establish procedure-specific risks and benefits of ESPB for spine surgery.

Keywords: erector spinae plane block, complications, block failure, pneumothorax, spine surgery, local anesthetic systemic toxicity

Introduction

Ultrasound-guided erector spinae plane block (ESPB) is an inter-fascial plane block first described in 2016 for the treatment of thoracic neuropathic pain.[1] Since the initial description, ESPB has been applied to multiple surgical procedures and consistent benefits for pain and opioid-related outcomes have been demonstrated. Case reports have described complications in patients undergoing ESPB, including motor block and local anesthetic systemic toxicity (LAST).[2–4] In contrast, a recent systematic review of outcomes after thoracic ESPBs included 1904 blocks but identified zero complications.[5] Thus, estimates of the true incidence of site and procedure-specific complications are needed.

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Bilateral ESPB has emerged as a useful tool to improve care and outcomes after spine surgery.[6–9] To date, no large series have comprehensively described complications of ESPBs in patients undergoing spine surgery. Prospective studies have included complications as secondary outcomes, but consistently report zero incidence. However, if complications are rare, these trials may be underpowered to detect the true incidence.

General complications of ESPBs to be considered prior to block performance are shared between spine and other surgery subtypes, including vascular injury, pneumothorax, LAST and failed block. However, several procedure-specific complications are unique to spine surgery and may influence the decision to perform ESPB or preclude performance altogether. Chief among these is the potential for interference with intraoperative neuromonitoring and/or the early postoperative motor examination. Additionally, the consequences of local infection or hematoma associated with performing ESPBs in or directly adjacent to the surgical field may be especially grave in spine surgery cohorts. Assessments of these general and specific complications are required to determine the overall risk and benefit of applying ESPBs to spine surgery.

Accordingly, the aim of the present study was to estimate the incidence of any complication associated with bilateral ESPB in a large series of adult patients undergoing lumbar spine surgery. We considered any sensory, motor, hematologic, hemodynamic or respiratory adverse event consistent with plausible contribution from the ESPB to be a complication. Additionally, we estimated the incidence of poorly controlled pain in the post anesthesia care unit (PACU) as a surrogate of ESPB benefit, and explored independent risk factors associated with poorly controlled PACU pain.

Patients and Methods

Design

A retrospective cohort study of 342 patients who underwent primary lumbar spine surgical procedures between November 2018 and July 2020 at an orthopedic specialty hospital in New York City. The study was conducted in accordance with the ethical principles of the Helsinki declaration and approved by the institutional review board of Hospital for Special Surgery (HSS-IRB #2020-1877). As a retrospectively designed study, written informed consent was waived.

Patients over age 21 presenting for any primary lumbar spine surgery via posterior approach who received bilateral ultrasound-guided ESPB were included in the analysis. Lumbar spine surgery was considered to be any procedure on any level/number of levels between T12-S1 and included open and minimally invasive surgical techniques. Patients presenting for revision surgery were excluded from analysis, as were patients who received unilateral ESPB or other peripheral/fascial plane block, and/or combined anterior-posterior or stand-alone lateral-posterior procedures.

Anesthetic and Surgical Care

Patients were cared for under the relevant standardized procedure-specific care pathway.[10,11] In brief, all patients received general anesthesia with endotracheal intubation and a total-intravenous anesthetic-based regimen (choices include propofol, dexmedetomidine and ketamine, but exclude iv lidocaine when other peripheral/fascial plane blocks are performed). Standardized, multimodal analgesia including acetaminophen, ketorolac and oral opioids (titrated to pain scores) were provided. Patients were prescribed hydromorphone IV patient-controlled analgesia (PCA) for postoperative care on an as-needed basis.

Erector Spinae Plane Blocks

Bilateral ultrasound-guided ESPBs were performed with the patient in prone position after induction of general anesthesia, prior to surgical incision. Blocks were performed by experienced attending anesthesiologists, all of whom were fellowship-trained in regional anesthesia and were members of a dedicated spine-anesthesia service. A C60 curved array ultrasound probe (FUJIFILM Sonosite, Inc., WA, USA) was placed in parasagittal orientation in the midline to identify the spinous processes. The probe was translated laterally until the tips of the transverse processes were viewed. A 20-Ga 4-inch Ultraplex needle (B. Braun Medical Inc., PA, USA) was placed in-plane and advanced in a cranial-to-caudal direction until the tip was under the

erector spinae plane. Depending on patient body mass index (BMI), between 20 and 30 mL 0.25–0.375% bupivacaine was injected bilaterally at the tips of the transverse process/under visual guidance.

Data Collection

Basic demographics and patient factors were collected retrospectively by review of the electronic medical record (EMR). Complications were assessed via EMR review and search of an institutional quality assurance (QA) database.

Variables of interest included sex, age, BMI, race, American Society of Anesthesiologists (ASA) classification, smoking status, history of psychiatric illness (anxiety, depression), opioid tolerance (defined as opioid use on most days for >3 months).[12] Perioperative factors of interest were the procedure performed, indication for surgery, and duration of the procedure.

Outcomes

The primary study outcome was the incidence of complications, defined a priori as any sensory, motor, hematologic, hemodynamic or respiratory complication consistent with plausible contribution from the ESPB. To determine if a complication had occurred, the EMR and QA databases were searched for any description of any complication in the notes. Orders for thoracic imaging/chest X-ray or placement of chest tube were additionally used to screen for incidence of pneumothorax. Administration of lipid emulsion therapy was used to estimate the occurrence of LAST. An internal billing database was additionally searched using ICD10 codes J93.9 (pneumothorax) and T41.3X5A (adverse effect of local anesthetics). Need for re-operation/evacuation of hematoma on the index admission was considered a possible ESPB complication. Interference with intraoperative neuromonitoring was considered significant if a wake-up test was performed. Documented unexplained/unexpected motor weakness, numbness or sensory deficits were considered surrogates for potential interference with the postoperative neurological examination.

The secondary outcomes were the number of patients with initial pain numeric rating scale (NRS) scores ≥7 in the PACU and risk factors associated with NRS ≥7. The risk factors assessed for were age, sex, ASA class, BMI, opioid tolerance, psychiatric co-morbidity, surgical type, and duration.

Statistical Analysis

Shapiro–Wilk testing was applied to check the normality of data. Continuous variables were summarized with median and interquartile range (IQR). Discrete variables were expressed as counts and percentages. Univariable analysis was performed to identify independent risk factors associated with failed block (age, sex, ASA class, BMI, opioid-tolerant status, psychiatric co-morbidity, surgical type and duration). Mann–Whitney *U*-test was applied for continuous variables, and Fisher's exact test was used for discrete variables. Statistical significance was defined as p-value <0.05.

Results

We identified 342 patients for inclusion in the analysis. Demographic, surgical, and perioperative variables are summarized in Table 1. The median age was 66 (IQR 56, 74) years, and 43% of the patients were female. The majority (n=280, 82%) were of white ethnicity and 81% of the cohort was ASA Class II (n=276). The most common indication for surgery was lumbar spinal stenosis (n=300, 88%), and over half of the cohort had an additional diagnosis of spondylolisthesis (n=177, 52%). Sixty percent of the cohort underwent instrumented fusion of 1 (n=137, 40%), 2 (n=62, 18%) or ≥3 (n=7, 2%) lumbar levels. The remaining 40% of the cohort underwent decompression of 1 (n=16, 5%) or 2 (n=105, 31%) lumbar levels, or microdiscectomy (n=15, 4%).

Primary Outcome

We did not find any sensory, motor, hematologic or hemodynamic complications associated with ESPB. No patients required intraoperative wake-up test or administration of lipid emulsion therapy. No patients were evaluated for concerning postoperative neurological findings. We identified one unilateral pneumothorax, in one patient. This case was identified in both the QA and billing databases. The patient underwent 1-level fusion at L4-L5 and bilateral ESPBs were performed at T12. Neither concern for potential nor actual pleural trauma were documented in the block note in the

Table 1 Patient Demographics and Comparisons Between Opioid-Tolerant and -Naïve Patients Receiving ESPB for Lumbar Spine Surgery

Variable		Opioid Naive	Opioid Tolerant	*p*-value
Number of participants (N=342)		294	48	**<0.0001**
Age	Median (IQR)	66 (58, 74)	65 (56, 72)	0.145
Sex, n (%)	Female	128 (43)	18 (38)	
	Male	166 (57)	30 (62)	0.529
Race, n (%)	White	243 (83)	37 (77)	
	Black or African American	21 (7)	4 (8)	
	Others/unknown	30 (10)	7 (15)	0.514
BMI (kg/m^2)	Median (IQR)	29 (25, 32)	31 (27, 34)	0.061
Current smoking	n (%)	22 (8)	5 (10)	0.623
Comorbidities, n (%)	Anxiety	32 (11)	15 (31)	**<0.0005**
	Depression	29 (10)	9 (19)	0.082
Diagnosis, n (%)	Stenosis	256 (87)	44 (92)	0.480
	Scoliosis	28 (10)	5 (10)	0.794
	HNP	50 (17)	9 (19)	0.837
	DDD	107 (37)	23 (48)	0.149
	Spondylolisthesis	156 (53)	21 (44)	0.276
ASA class, n (%)	I	22 (7)	2 (4)	
	II	238 (81)	38 (79)	0.607
	III	34 (12)	8 (17)	
Surgery, n (%)	1-level fusion	120 (41)	17 (35)	
	2-level fusion	52 (18)	10 (21)	
	≥3-level fusion	7 (2)	–	
	1-level decompression	12 (4)	4 (8)	0.868
	2-level decompression	92 (31)	13 (27)	
	Microdiscectomy	11 (4)	4 (8)	
Duration of surgery (min)	Median (IQR)	137 (97, 199)	123 (93, 170)	0.195

Note: Bold font indicates significance at p<0.05.
Abbreviations: ESPB, erector spinae plane block; IQR, interquartile range; BMI, body mass index; ASA, American Society of Anesthesiologists.

electronic medical record. A small, left-sided pneumothorax was identified in the PACU by chest radiography after the patient complained of dyspnea. Past medical history was significant for persistent, moderate asthma, which was considered well controlled on medical therapy. The patient was managed with supplemental oxygen (2L by nasal cannula) and did not require chest tube thoracostomy. Serial chest radiographs indicated resolution of the pneumothorax over the subsequent 3 days.

Secondary Outcomes

NRS ≥ 7 was found in 17/342 patients (5%) and was independent of any background differences or risk factors assessed (Table 2). Of the 17 patients with poorly controlled pain, 13/294 patients were opioid naïve (4%) and 4/48 were opioid tolerant (8%). Opioid status was not a significant factor contributing to NRS ≥ 7 (p=0.275).

Discussion

We estimated the incidence of pre-specified complications and the incidence of poorly controlled early postoperative pain associated with ESPB in 342 consecutive patients undergoing lumbar spine surgery. The sole major complication was pneumothorax in one patient. The incidence of poorly controlled pain was estimated at 5%. We did not identify any occurrences of LAST or motor weakness or any interference with intraoperative neuromonitoring or the early post-operative examination associated with ESPB. These results suggest the relative safety and suitability of ESPB for patients undergoing lumbar spine surgery.

Table 2 Univariable Comparisons Between Patients with and without Failed ESPB

Failed ESPB Variable	No (n=325)	Yes (n=17)	*p*-value
Age (years)			0.297
Median (IQR)	67 (58, 74)	63 (55, 71)	
Sex (n)			0.0778
Male	190	6	
Female	135	11	
ASA Class			>0.99
I	23	1	
II	262	14	
III	40	2	
BMI (kg/m^2)			0.575
Median (IQR)	29 (25, 35)	30 (25, 37)	
Opioid-tolerant			0.275
No	281	44	
Yes	13	4	
Anxiety			0.789
No	281	14	
Yes	44	3	
Surgery			0.868
1-level decompression	14	2	
1-level fusion	132	5	
2-level decompression	101	4	
2-level fusion	57	5	
3+ level fusion	7	–	
Microdiscectomy	14	1	
Duration of surgery (min)			0.756
Median (IQR)	130 (96, 202)	129 (39, 269)	

Abbreviations: ESPB, erector spinae plane block; IQR, interquartile range; BMI, body mass index; ASA, American Society of Anesthesiologists.

Ultrasound-guided ESPB has been proposed to represent a safety advantage over other truncal blocks and epidural analgesia.[13] Compared to these techniques, ESPB is regarded as technically simple, easy to learn, and is performed at a location, which is relatively remote from vulnerable anatomic structures. It follows that ESPB should be associated with low incidence of important complications: primarily lung, nerve, neuraxial and vascular injury. Consistent with this, a systematic review of outcomes after thoracic ESPBs included 1904 blocks but identified zero complications.[6] Likewise, pro- and retrospective studies evaluating the clinical effectiveness of ESPB in lumbar spine surgery consistently report zero incidence of major complications.[6–9] However, case reports suggest complications do occur after ESPB, including motor weakness, and LAST.[2–5] Thus, the true incidence of these complications has not yet been established.

We identified one pneumothorax in our cohort. The frequency of pneumothorax after ESPB is presumed to be lower compared to other truncal blocks, including paravertebral blocks, given the distance between pleura, lung and needle tip when the block is properly performed.[13–15] Similar to paravertebral block, even in experienced hands, pneumothorax after ultrasound guided ESPB may result after error in calculating the depth of anatomic structures, or loss of hand-eye coordination.[16] Although we are unable to definitively determine whether the pneumothorax was the result of trauma from the ESPB and/or surgery or due to other factors, ultrasound-guided ESPB at T12 in experienced hands may not be the most likely explanation. Other unidentified factors may have contributed to the pneumothorax, including the presence of underlying bullous lung disease in this patient with obstructive lung disease and/or a contribution of positive pressure ventilation to barotrauma during spine surgery.[17]

To our knowledge, the incidence of poorly controlled early postoperative pain has not been estimated in patients undergoing lumbar spine surgery. Several factors have been identified as risk factors for failed peripheral nerve blocks, including obesity, higher ASA class, male sex and experience level of the anesthesiologist.[18–21] In contrast, we did not identify any significant individual risk factors for poorly controlled pain, although our sample available for analysis was small. Our definition of 'poorly controlled pain' was based on NRS pain scores in the PACU. Pain-based qualitative assessment of block function has been used to capture ESPB success or failure in at least one prior report.[16] In this study, the incidence of failed ESPB in combined surgical subtypes (that did not include spine surgery) approached 6.5%. Interestingly, the most common definition of block success is the "achievement of a surgical block within a designated period …".[22] In contrast to peripheral nerve blocks, truncal fascial plane blocks lack the motor and sensory changes required to apply this classic definition of block success. Arguably, newer methods to assess block success need to be developed and applied to the novel fascial plane blocks in order to advance the evaluation of their efficacy and risk: benefit profile.

In our study, the approach and spinal level at which the ESPBs were performed was at the discretion of the performing provider. There is no consensus regarding the optimal location for ESPB performance for lumbar spine surgery. Early reports of successful analgesia after lumbar surgery described low thoracic catheters or single-shot ESPBs.[6,23] More recently, the appropriateness of fixed thoracic-level ESPBs for lumbar surgery has been questioned.[24] Specifically, a radiological study of the spread of local anesthetic after injection at T12 suggests a distal distribution only as far as L2. We did not formally analyze needle-tip position in the current study, and this may have influenced efficacy and subsequent pain scores.

Strengths and Limitations

The main strengths of this study are the large sample size and comprehensive approach to identifying complications associated with ESPB and block failure. However, our study has several limitations. First, as a retrospective chart-based analysis, complications may have occurred that were not properly recorded or identified in the electronic records. For example, all ESPBs were performed after induction of general anesthesia, so some neurological sequelae of LAST may have been masked. Consistent with this, the incidence of LAST in a series of mixed surgical patients receiving ESPB was 1.6%, but none were major complications requiring administration of lipid emulsion therapy (eg, seizure or cardiovascular collapse).[16] We attempted to control recording bias by searching multiple institutional sources for the defined complications, including the patient electronic medical record, as well as QA and billing databases. We identified the patient with pneumothorax in both the QA and billing datasets, suggesting this method was a reasonable approach to finding major complications. Second, in addition to the caveats related to assessing ESPB efficacy discussed above, we relied on NRS pain scores to be accurately reported, recorded, and to reflect the overall pain state of the patients. This may not be the most appropriate way to judge block performance and could have led to over- or underestimation of the true incidence of poorly controlled PACU pain. Third, we conducted this study in adult spine surgery patients at a specialty orthopedic surgery hospital, which benefits from developed regional anesthesia services and expertise. This increases the applicability of our results to this population and practice setting, but limits generalizability.

Conclusion

In this series of 342 consecutive patients undergoing lumbar spine surgery, ultrasound-guided ESPB was associated with no complications, no interference with intraoperative neuromonitoring or the postoperative examination and low incidence of poorly controlled early postoperative pain. Given that the true incidence of major complications after ESPB is likely to be low, more large studies which similarly report complications and efficacy are required before concluding safety benefits of ESPB compared to other regional techniques.

Disclosure

All authors report no conflicts of interest in this work.

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