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Erector spinae plane blocks for analgesia after percutaneous nephrolithotomy

A pathway to reduce opioids

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ABSTRACT

INTRODUCTION: Despite its minimally invasive nature, percutaneous nephrolithotomy (PCNL) may be associated with significant pain. Challenges in pain control may prevent timely discharge (and expose patients to adverse effects of opioid use). We sought to evaluate whether our patients who underwent erector spinae plane (ESP) regional blocks experienced improved postoperative pain control and decreased opioid use after PCNL (compared with those who did not receive blocks).

METHODS: We retrospectively reviewed consecutive PCNL cases on patients admitted for greater than 24 hours without pre-existing opioid regimens for chronic pain. Cases were completed by a single high-volume surgeon. Patients who accepted an ESP block were compared to those who did not receive a block. Patients received either a single injection or a disposable pump delivering intermittent boluses of ropivacaine 0.2%. Demographic and perioperative data were analyzed. The primary outcomes were opioid use measured in morphine milligram equivalent (MME) and patient-reported pain scores during the first 24 hours of hospitalization.

RESULTS: From March 2019 to August 2021, 44 patients were identified who met criteria — 28 of whom received an ESP block (including 14 continuous blocks). The patients who received blocks had significantly decreased opioid use (18.3 vs. 81.3 MME, p=0.004) and a longer mean time to first non-zero pain score (p=0.004). Continuous blocks had similar opioid use to single shot blocks (21.0 vs. 15.6 MME, p=0.952).

CONCLUSIONS: ESP regional blocks appear to offer an effective adjunct method for pain control after PCNL and may reduce post-PCNL opioid use while maintaining adequate patient analgesia.

INTRODUCTION

Percutaneous nephrolithotomy (PCNL) remains the standard of care for surgical treatment of large kidney stones.[1] Despite the effectiveness and minimally invasive approach of PCNL, postoperative pain may be a barrier to early discharge.[2] Furthermore, even short-term therapeutic opioid use may result in long-term adverse events.[3,4] Historically, non-steroidal anti-inflammatory drugs (NSAIDs) and opioids have been the primary tools to address post-PCNL analgesia. NSAIDs, however, may often not be safe due to their nephrotoxic effects, and opioids continue to become more scrutinized for side effects, such as increasing the risk of respiratory depression, constipation, and abuse/misuse.[4,5] Although some pain originates at the incision site, a significant contribution to post-PCNL pain can be attributed to the dilatation of the renal capsule and parenchymal tract.[6]

The visceral pain from a PCNL is carried from the T10-L1 thoracolumbar nerves, which allows the opportunity to use peripheral nerve blocks as a possible adjunct method for pain relief.[7] Many different types of regional nerve block have been described for postoperative pain relief, including paravertebral blocks, intercostal nerve blocks, and erector spinae plane (ESP) blocks.[8] Described in 2016 for its use in thoracic neuropathic pain, the ESP block works by inhibiting both the dorsal and ventral rami of the thoracic spi-

KEY MESSAGES

- Erector spinae plane blocks appear associated with reduced post-PCNL pain.
- Patients receiving erector spinae plane blocks may require less opiate-based pain control postoperatively.
- Erector spinae plane blocks may be delivered via a single shot or continuous catheter infusion.

nal cord.[9] An ESP regional block is administered by either a single shot injection (SS) of anesthetic or a catheter for continuous infusion. The ESP block has since been described in a few case reports and prospective studies for its beneficial use in urologic surgeries, including PCNL.[8-12]

The primary objective of our study was to investigate the effects of ESP blocks, both SS and continuous infusion, on reducing postoperative pain and opioid use. We hypothesized that the use of the ESP block as an adjunct with general anesthesia would result in lower opioid intake during the first 24 hours after PCNL surgery. Our secondary objective was to investigate whether a difference exists in efficacy between SS and catheter ESP blocks.

METHODS

We performed a retrospective, case-controlled cohort study, which was approved by the institutional review board of the University of California, San Diego (#800869). The electronic health records of 160 patients who received a PCNL from a single high-volume surgeon between March 2019 and August 2021 were reviewed retrospectively. Patients were excluded if they had a history of chronic pain disorder, existing opioid regimen, hospital stay less than 24 hours, or multiple procedures during the same hospital stay (either preceding the PCNL or occurring within 24 hours after the PCNL). Patients were also excluded if they had a comorbidity that resulted in moderate to severe functional limitation.

A total of 44 patients were identified that met inclusion criteria. These patients were divided into two cohorts; one group received subcutaneous infiltration of bupivacaine at the incision site (non-block) (n=16), and the other cohort received an ESP block (SS or catheter) prior to surgery (n=28). Demographic and perioperative data was compared between the two groups, as well as post-procedural opioid intake for the first 24 hours. Post-PCNL opioid medications were offered to patients for persistent intolerable pain despite acetaminophen and NSAIDs (and offers of non-pharmaceutical interventions, such as body repositioning and heating packs). Opioid use was standardized in morphine milligram equivalents (MME). Time to a non-zero reported pain (visual analog scale, VAS) was analyzed. The ESP block group was further subdivided into a continuous catheter ESP (n=14) group and a SS injection ESP group (SS ESP) (n=14). See Figure 1 for illustration of patient case review.

General anesthesia protocol

Participants from both groups received the same general anesthesia, following the same protocol and technique for all PCNL surgeries conducted at our institution. Non-opioid pharmacologic management includes scheduled (every eight hours) intravenous dosing of

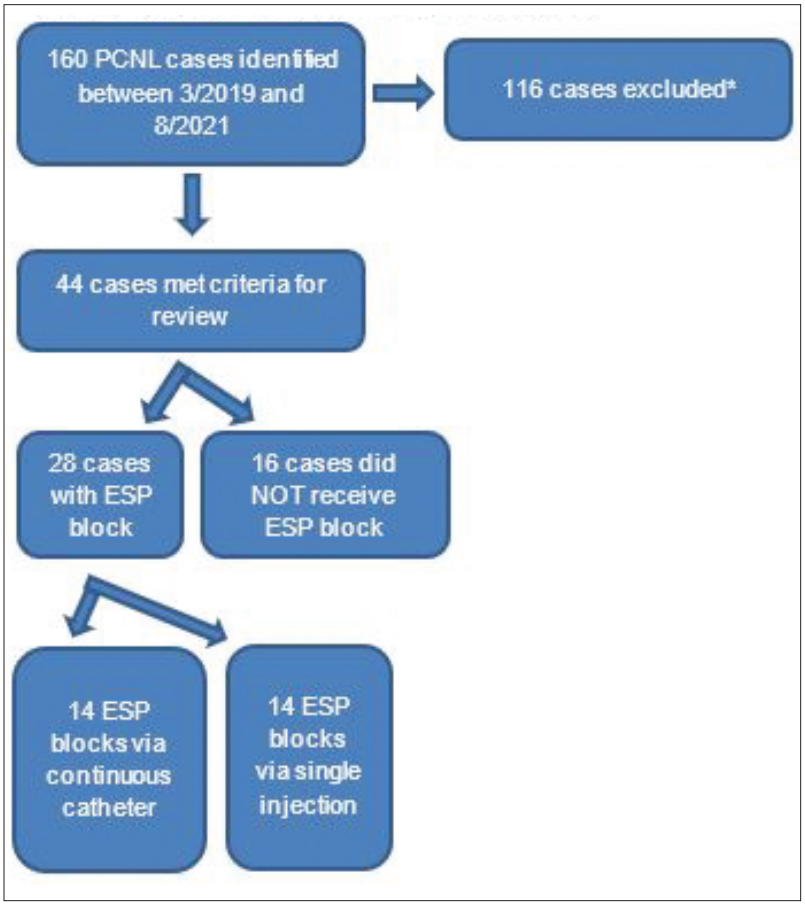

Figure 1. Flow diagram for inclusion/exclusion.

acetaminophen and ketorolac (unless contraindicated due to comorbidities, such as poor renal function).

ESP block protocol

After obtaining consent, ESP blocks were administered to patients with no contraindications in the preoperative area by an anesthesiologist trained in regional anesthesia. The block was administered either as a single injection or with placement of a perineural catheter, through which a disposable ambulatory pump delivered intermittent boluses of ropivacaine 0.2% (continuous catheter). The blocks were completed in the preoperative holding area and were allotted 5–10 minutes (for a single shot) or 10–20 minutes (for a catheter placement). The technique for block has been previously described.[13] Briefly, the transverse process of the 10th thoracic vertebra was identified, and after anesthetization of the skin with 1% lidocaine, a 17 Ga needle was advanced under ultrasound guidance to a point just to the depth of the erector spinae muscle and superficial to the 10th transverse process ipsilateral to the surgical side. Local anesthetic was injected and visualized to spread, and for continuous blocks, a 19 G perineural catheter was inserted and secured to the skin. Because the initial block was performed using a long-acting local anesthetic (8–12-hour duration), patients received intermittent boluses of ropivacaine 0.2% (15 mL automatic bolus every two hours, with 5 mL patient-controlled bolus available every 30 minutes) after a six-hour delay postoperatively using an ambulatory electronic pump. The catheter was kept for at least 2–3 days postoperatively and then removed at home by the patients after receiving detailed instructions.

Statistics

Data from the cohorts were compared using independent sample t-test and Chi-squared tests (where applicable). Calculations were made using IBM SPSS Statistics 28.0 (Armonk, NY, U.S.). Where applicable, a p-value of <0.05 was considered significant.

RESULTS

A total of 28 ESP block patients and 16 non-block patients met inclusion criteria. Perioperative variables of the two cohorts were compared (Table 1). There was no significant difference between the two groups in mean age, sex, American Society of Anesthesiology (ASA) physical class, body mass index (BMI), hypertension status, procedure laterality, mean stone size, mean operative time, postoperative stent/nephrostomy tube status, or mean length of hospitalization. There was a

Table 1. Perioperative cohort comparison

	ESP block (n=28)	No block (n=16)	p*
Gender			0.199
Male	25.0% (7/28)	43.7% (7/16)	
Female	75.0% (21/28)	56.3% (9/16)	
Mean age (years), SD	54.4, 11.8	55.9, 17.9	0.071
HTN diagnosis	53.6% (15/28)	56.3% (9/16)	0.864
BMI, SD	30.1, 7.2	31.2, 9.3	0.224
ASA class			0.495
1	1	0	
2	8	5	
3	19	10	
4	0	1	
Mean stone size (mm), SD	28.4, 10.9	27.2, 12.4	0.472
PCNL laterality			0.764
Left	35.7% (10/28)	31.2% (5/16)	
Right	64.3% (18/28)	68.8% (11/16)	
Access location			0.641
Upper	14	6	
Interpolar	7	4	
Lower	7	6	
Sheath size			
% 30 F vs. 1 7F	**96.5**	**81.3**	**<0.001**
Mean operative time† (min), SD	91.6, 25.7	113.2, 32.4	0.385
Mean in OR time¶ (min), SD	139.6, 27.1	160.9, 33.1	0.198
Postop drainage method:			
Ureteral stent	19	11	0.969
Nephrostomy tube	6	3	
Both	3	2	
Mean length of stay (# of midnights), SD	1.79, 2.32	1.94, 2.05	0.777

*Chi squared or independent samples t-test as applicable. †Operation time (from initial instrumentation of patient to placement of final dressing/removal of endoscope). ¶Operation room time (from patient arrival into the operating room to patient exit from operating room). ASA: American Society of Anesthesiology; BMI: body mass index; ESP: erector spinae plane; HTN: hypertension; OR: operating room; PCNL: percutaneous nephrolithotomy; SD: standard deviation.

difference in access sheath size between the groups involving 96.5% use of 30 F access sheaths in the ESP block group vs. 81.3% in the "no block" group. When a 30 F access sheath was not used, a 17 F sheath was employed.

The ESP block group had a statistically significant lower mean MME intake compared to the non-block group during the first 24 hours postop (18.3 vs. 81.3 MME, p=0.004) (Table 2). The ESP block group also had a significantly longer mean time to first non-zero pain score (p=0.004).

Subgroups comprised of the two different block methods (SS and continuous catheter) were also compared. There was no significant difference in postoperative opioid intake between the ESP catheter vs. the ESP single shot (21.0 vs. 15.6 MME, p=0.952) (Table 3). There was also no difference in the mean time to first non-zero pain score (p=0.549); however, the ESP SS group had a significantly shorter mean time to first opioid analgesic administration.

Table 2. Postoperative pain comparison (ESP block vs. no block)

	ESP block (n=28)	No block (n=16)	p*
Mean MME, SD	98.2, 122.0	167.6, 226.4	0.205
Mean MME excluding fentanyl, SD	18.3, 19.0	81.3, 131.4	0.004
Mean time to first non-zero pain score (min), SD	340.8, 486.6	109.4, 109.2	0.004
Mean time to first opioid analgesic (min), SD	315.3, 403.0	237.8, 312.2	0.264
Mean pain score in first 12 hours, SD	2.42, 2.4	3.32, 2.4	0.868

*Independent samples t-test. ESP: erector spinae plane; MME: morphine milligram equivalent; SD: standard deviation.

Table 3. Postoperative pain comparison (ESP catheter vs. single shot)

	ESP catheter (n=14)	ESP single shot (n=14)	p*
Mean MME, SD	104.5, 140.5	92.7, 108.8	0.384
Mean MME (excluding fentanyl), SD	21.0, 19.6	15.6, 18.6	0.952
Mean time to first non-zero pain score (min), SD	322, 416.4	364.8, 584.7	0.549
Mean time to first opioid analgesic (min), SD	424.3, 503.8	184.5, 184.1	0.007
Mean pain score in first 12 hours, SD	2.65, 2.86	2.12, 1.70	0.014

*Independent samples t-test. ESP: erector spinae plane; MME: morphine milligram equivalent; SD: standard deviation.

DISCUSSION

PCNL is a widely used minimally invasive surgical technique for the removal of kidney stones, though there can be significant postoperative discomfort (likely related in part to dilation of the renal access tract).[6] In a series of 60 patients undergoing planned outpatient PCNL, 12% (n=7) had to be admitted overnight due to postoperative pain and nausea.[14] Regional blocks may allow surgeons to minimize use of more "traditional" modalities of pain control, such as the pharmaceutical approach of opioids, and facilitate sooner discharge from the hospital. A review of over three million cases within the National Anesthesia Clinical Outcomes Registry suggested that while 25.5% of surgical cases may have benefited from a peripheral nerve block, only 3.3% of cases appeared to include a nerve block in the anesthesia strategy.[15] However, the same registry review noted a significant upward progression in the use of peripheral nerve blocks in the years reviewed (2010–2015).[15] The use of ESP blocks was first mentioned by Forero et al for its beneficial use in neuropathic pain management.[9] The block has been successfully used in a multitude of surgical procedures, including thoracotomies, PCNLs, hernia repairs, and lumbar fusions.[12,16] And although a relatively "new" nerve block, the ESP block technique not only appears to be efficacious, but also may be easier to learn than previously described nerve blocks.[17]

ESP blocks have been studied in the literature for PCNL and have been shown to be beneficial. In one randomized controlled trial, Gultekin et al found that patients who received an ESP block before PCNL had significantly lower VAS pain scores compared to patients who only received general anesthesia.[18] For the patients that received an ESP block, the result trends show a longer mean time to first opioid analgesic (315±403 minutes vs. 237±312 minutes) and a lower mean pain score on a scale of 1–10 in the first 12 hours (2.42±2.4 vs. 3.32±2.4), but findings were not significantly different. Prasad et al reported similar results for the VAS scores and time to first rescue analgesia; they and others also found that the ESP block group consumed less tramadol or morphine in the first 24 hours compared to the general anesthesia group (100 mg vs. 350 mg).[19,20] Our results are consistent with these findings; the ESP block group had over a fourfold

reduction in opioid consumption compared to the non-block group (18.3±19.0 MME vs. 81.3±131.4, p=0.004).

Although our findings show the value of an ESP block in reducing opioid requirements, the literature is lacking when it comes to comparing the efficacy of the ESP single-injection block vs. the ESP continuous catheter block in PCNL. We describe a novel technique of pain control via continuous infusion through a nerve catheter by automated pump. Our limited comparison found that there was no significant difference in the mean MME intake between the ESP catheter and SS groups within the first 24 hours (21.0±19.6 MME vs. 15.6±18.6, p=0.952). Similar results have been reported when comparing continuous catheters to single-injection blocks using different block techniques in non-urologic surgeries. In a prospective, randomized, controlled study of 44 patients undergoing total knee arthroplasty, Frassanito et al reported no significant difference in tramadol consumption between the groups who received continuous catheter lumbar plexus and sciatic nerve blocks and those who receive a single-injection block (185±101 vs. 236±155 mg of tramadol, p=0.06).[21]

In another prospective, randomized clinical trial comparing the efficacy of SS vs. continuous catheter interscalene blocks for shoulder arthroplasty, Hasan et al reported no significant difference between the two groups in opioid consumption (MME) on postoperative day zero.[22]

Although we did not see a significant difference in opioid consumption on postoperative day 1 in our study between the catheter groups, this highlights a limitation in our study; given that we only collected opioid intake for 24 hours, we were unable to examine the efficacy of the ESP catheter in providing longer-term pain relief and thus reducing the need for opioids, or even time to return to regular activities, after patients go home following PCNL.

When comparing the ESP catheter to the ESP SS, we found that the catheter group had a significantly longer mean time to first rescue analgesic postop (424.3±503.8 minutes vs. 184.5±184.1 minutes). In a randomized, controlled trial comparing the efficacy of continuous adductor canal blocks vs. SS blocks following total knee arthroplasty, rescue analgesia was required for 10% of the patients in the single injection group vs. 1.59% of the continuous catheter patients.[23] While this study only reports the proportion of patients that required 50 mg of tramadol for rescue analgesia, it highlights the potential of a continuous catheter to provide prolonged pain relief after surgery. The ESP SS group received rescue analgesia at an average time of roughly three hours postop and reported a mean pain score of 2.12±1.7 during the first 12 hours postop, compared to the continuous catheter group, which required a rescue dose at an average time of roughly seven hours postop and reported a mean pain score of 2.65±2.86. In contrast, Salinas et al found that mean VAS scores were significantly lower on the first and second days postop in patients that received a continuous femoral nerve block after total knee arthroplasty vs. those who received a single-injection femoral block.[24] Other studies have also reported similar findings in terms of average pain scores.

Limitations

Several limitations of our study deserve mention. We only evaluated pain scores and opioid requirements for the first 24 hours postoperatively, due in part to the availability of data from the medical record during this time period. We would expect to see a continued reduction in opioid requirements beyond 24 hours in the continuous catheter group. In addition, our study is retrospective in nature, which does not allow us to fully standardize the type and schedule of distribution of rescue analgesia during the postoperative inpatient time.

To reduce possible confounders and effect modifiers (such as chronic pain, chronic opioid use, recovering from multiple procedures, severe functional limitations at baseline, etc.), a significant number of potential subjects were excluded, thus introducing the risk for selection bias. Furthermore, although our comparison groups were generally similar, there was a difference in access sheath size between the two groups. The difference in sheath size, however, included a greater use of smaller (17 F sheaths) in the "no block" group, which would be expected to lower reported pain based on prior studies.[25] Similarly, a trend towards upper pole access in the ESP block group would conceivably be associated with a trend towards increased pain in the ESP block group.

Additionally, our sample size was small, which may have left it underpowered to discern some differences between the SS and continuous block groups.

Finally, as a retrospective review focused on opioid reduction after PCNL, our scope excluded other variables, such as cost. Though specific costs will vary from institution to institution, estimates for a single injection may be around $50 USD and upwards of $800 USD for a continuous catheter (varies on device used).[26] In addition, use of peripheral nerve blocks is associated with a reduction in post-anesthesia care

unit time, which translates into cost savings for the health system.[27]

Despite these limitations, our statistically significant findings serve as a strong "proof-of-concept" for use of these low-risk ESP blocks as an adjunct for pain control for PCNL patients. Prospective, randomized, controlled trials evaluating the impact of ESP blocks on pain reduction, opioid requirement, and quality of life, both as inpatient and outpatients, are warranted and currently underway at our institution.

CONCLUSIONS

ESP regional blocks appear to offer an effective adjunct method for pain control after PCNL, with reductions in postoperative opioid use. Whether continuous infusion blocks lasting several days after surgery offer additional pain control compared to SS ESP regional blocks remains to be seen, but both approaches may be effective in reducing risk of opioid dependence and improved return to normal function.

COMPETING INTERESTS: The authors have no competing personal or financial interests to declare.

This paper has been peer-reviewed.

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