Accepted: 24 July 2017

DOI: 10.1111/pan.13227

RESEARCH REPORT

WILEY Pediatric Anesthesia

Technical success of the ultrasound-guided supra-inguinal fascia iliaca compartment block in older children and adolescents for hip arthroscopy

Elizabeth Eastburn | Maria A. Hernandez | Karen Boretsky

Department of Anesthesia Perioperative & Pain Medicine, Boston Children's Hospital-Harvard Medical School, Boston, MA, USA

Correspondence
Elizabeth Eastburn, D.O. Department of Anesthesia, Perioperative & Pain Medicine. Boston Children's Hospital-Harvard Medical School, Boston, MA, USA.
Email: elizabeth.eastburn@childrens.harvard.edu

Section Editor: Adrian Bosenberg

Summary

Background: Hip arthroscopic surgery is performed on older pediatric patients. Fascia iliaca compartment block has proven efficacy in providing analgesia following hip surgery and can be performed with target location of local anesthetic below or above the inguinal ligament. The reported success of ultrasound-guided infra-inguinal fascia iliaca compartment block is lower when compared to traditional landmark technique, while the reliability of supra-inguinal fascia iliaca compartment block is unreported.

Aim: The primary aim was to report the results in obtaining sensory changes in the distribution of the femoral and lateral femoral cutaneous nerves following supra-inguinal fascia iliaca compartment block in patients undergoing arthroscopic hip surgery. Secondary outcomes are the ability to find echogenic landmarks and to report pain scores and opioid consumption.

Methods: We reviewed the electronic medical record and regional anesthesia database of patients receiving ultrasound-guided fascia iliaca compartment block for arthroscopic hip surgery. Sensory changes to the femoral and lateral femoral cutaneous nerves were determined. Identification of echogenic landmarks was quantified. Pain scores and opioid consumption were determined.

Results: Seventeen patients of mean age 15.4 years old (SD 1.3; range 13-17 years) were included. Sensory changes to both the femoral and lateral femoral cutaneous nerves occurred in 94% of patients (95% CI: 82%-100%). The average volume of ropivacaine 0.2% was 0.53 mL/Kg (SD 0.11 mL/Kg). Echogenic landmarks were identified in all patients. Pain scores and opioid consumption were generally low.

Conclusion: A supra-inguinal location for the deposition of local anesthetic when performing fascia iliaca nerve block for hip surgery is reliable in anesthetizing the femoral and lateral femoral cutaneous nerves and should encourage investigation into the clinical efficacy.

KEYWORDS
acute pain, child, local anesthetics, orthopedics, regional ultrasound

1 | INTRODUCTION

Hip arthroscopy, frequently performed in older pediatric patients, is often associated with severe pain.[1] This pain arises from the insertion site of surgical trochars in the distribution of the lateral femoral cutaneous nerve (LFCN) and the subsequent hip joint pain originating from sensory components of the femoral (FN), obturator (ON), and sciatic nerves with the most significant contribution being

the FN.[2] The fascia iliaca compartment block (FICB) anesthetizes variable combinations of the FN, LFCN, and ON, and is effective for many painful hip surgeries making it potentially useful for analgesia following hip arthroscopy.[3,4]

While the use of ultrasound guidance for nerve localization has decreased the failure rate of many regional anesthetic techniques in both adults and children,[5,6] published studies of ultrasound-guided FICB show mostly variable success when compared to traditional surface landmark techniques.[7-9] This may be related to the site of local anesthetic deposition relative to the inguinal ligament. The LFCN and FN predictably travel under the fascia iliaca until just above or at the inguinal ligament (Figure 1). At and below the inguinal ligament, the LFCN has a variable course such that 1 or more branches may travel superficial to, through, or deep to the inguinal ligament.[10] Supra-inguinal injection catches nerves in 1 compartment while infra-inguinal injection relies on spread cephalad and under the ligament to anesthetize the LFCN. Landmark technique utilizes a supra-inguinal needle tip location with a wide range of sensory anesthesia from 35% to 88% of adult patients and up to 91% of pediatric patients.[3,4,11,12] Shariat et al. described an ultrasound-guided injection below the inguinal ligament with a success rate of blocking both the FN and LFCN of only 38%.[7] Supra-inguinal approaches have demonstrated reliable spread to the FN and LFCN in cadavers and case reports with only 1 study demonstrating technical success in a large number of adult patients.[9,13,14] Based on anatomical observation that FN and LFCN consistently travel deep to the fascia iliaca and above iliacus muscle in the supra-inguinal area, we have been performing the fascia iliaca block in the supra-inguinal area similar to techniques previously described.[9,13,14]

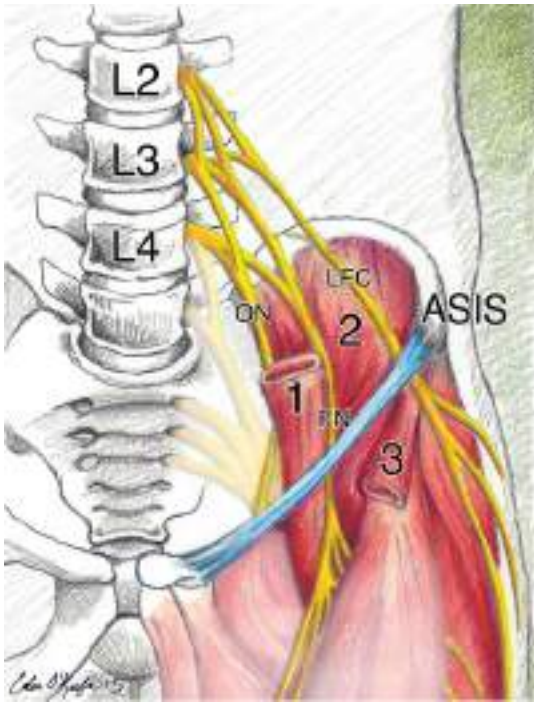

FIGURE 1 Cartoon of the course of the obturator (ON), lateral femoral cutaneous (LFCN), and femoral nerve (FN) in the pelvis and under the inguinal ligament. The illustration pictured above is original work of Colin O'Keefe. Dr. Boretsky holds the right to publish this image

What is already known

- Landmark-based fascia iliaca block has proven efficacy for pain management for hip surgeries
- The technical success of ultrasound-guided infra-inguinal fascia iliaca is unreliable

What this article adds

- A supra-inguinal ultrasound-guided approach to the fascia iliaca block has a high success rate (0.71-1.0) in anesthetizing the femoral and lateral femoral cutaneous nerves.
- Sonographic landmarks are well-defined and easy to locate

Our primary objective was to report the technical success rate of ultrasound-guided supra-inguinal FICBs in older children; specifically, the incidence of sensory changes of the FN and LFCN when local anesthetic (LA) is deposited between the fascia iliaca (FI) and the iliacus muscle with a supra-inguinal needle tip location. Secondary outcomes were to determine the success in finding echogenic landmarks and to report LA dosing, postoperative pain scores and opioid consumption, and associated complications or safety concerns.

2 | MATERIALS AND METHODS

EQUATOR guidelines were adhered to; Institutional IRB approval was obtained and requirement for informed consent was waived. Patient data from June 2013 through April 2014 in a quality assurance database (implemented to follow newly introduced regional anesthesia techniques) and the electronic medical records were reviewed. Inclusion criteria were ultrasound-guided FICB, age <18, and hip arthroscopy. Exclusion criteria included chronic opioid use, chronic pain, or previous surgery to operative hip.

2.1 | Anesthesia technique

All patients received general anesthesia and received FICB after induction and preincision. Blocks were performed by 1 of 3 pediatric regional fellows under the supervision of 4 pediatric anesthesiologists. Intraoperative analgesic administration was not controlled. All patients were extubated in the operating room.

FIGURE 2 Top: Initial transducer position: longitudinal orientation adjacent to the anterior superior iliac spine. Bottom. Transducer position showing medial movement 2 cm, tilt/toggle 15° to aim back toward the ASIS and 30° medial rotation to the cephalad end of the transducer

2.2 | FICB technique

The FICB was performed using sterile technique with patients supine. A 6-18MZ linear transducer (8870, Analogic Corp, Peabody, MA USA) was placed longitudinal just medial to the ASIS (anterior superior iliac spine). The superior edge of the transducer was rotated 30° toward the umbilicus to approximate a parallel course with the ilium curve and then tilted/toggled laterally (Figure 2). The sonographic anatomy was identified from superficial to deep and consisted of internal oblique muscle, transversus abdominis muscle, FI, iliacus muscle, and the ilium bone (Figure 3). A 100 mm x 21 G or, for catheter placement, a 100 mm x 18 G Tuohy needle (Pajunk Medical Inc., Geisingen, Germany) was introduced at the transducer inferior/caudal edge and advanced in-plane from caudad to cephalad under visualization until the tip was below the FI but above the iliacus muscle. Approximately 0.5 mL/kg of 0.2% ropivacaine (maximum=40 mL) was bolused with aspiration every 3-5 mL. The needle was further advanced into the space created by the separation of the fascia from the muscle. Echogenic landmarks were defined as the FI, iliacus muscle, and ilium (Figure 2).

2.3 | Postoperative technique

Upon arrival in the PACU and at subsequent intervals, patients self-reported pain scores (0-10 numeric score). PACU nurses recorded results in the EMR. Postoperative rescue analgesics were not standardized and administered by the PACU nurse to treat patients reporting a pain score of ≥4.

2.4 | Regional anesthesia success

Prior to discharge from the PACU, when patients were alert and cooperative, the presence or absence and distribution of sensory changes were determined and entered into a regional anesthesia database by a pediatric anesthesia fellow, a pediatric regional anesthesia fellow, or the attending regional anesthesiologist. Sensory changes were defined as alterations to perception of touch (smooth edge of a tongue depressor) or loss of cold discrimination (ice in a glove) consistent with known dermatome patterns and recorded as dichotomous (present/absent) data. For analysis, the median pain scores were grouped according to severity of pain defined as: mild pain = NRS 0-3, moderate pain = NRS 4-6, and severe pain = NRS >7. For patients admitted overnight, rescue analgesics were administered by the nurse for pain scores of ≥4.

2.5 | Statistical analysis

Continuous variables are presented as mean or median (SD, range, interquartile range); discrete data as n% (95% confidence intervals). Findings are descriptive; no inferential comparisons were made.

3 | RESULTS

During the study period, 89 FICBs were performed with 35 patients meeting inclusion criteria. Complete records were available on 17 patients.

Mean age was 15.4 years (SD 1.3; range 13-17 years). Mean weight was 65.8 kg (SD 17.3; range 45-115 Kg). Acoustic landmarks could be identified in all patients.

Sensory changes in both anterior (FN) and lateral surfaces of the thigh (LFCN) occurred in 16/17 patients (95% CI: 82%-100%).

Ropivacaine 0.2% dose: 0.53 mL/kg (SD 0.06 mL/Kg; range 0.33-0.60 mL/Kg) and 1.06 mg/kg (SD 0.21 mg/Kg; range 0.67-1.2 mg/Kg) was used.

Opioids were converted to morphine equivalents. The average opioid consumption in the operating room and PACU was 0.18 mg/kg and 0.06 mg/kg, respectively. Sixteen patients received intraoperative or PACU acetaminophen and 12/17 received ketorolac. For the 12 admitted patients, the average postoperative opioid consumption from 0 to 12 hours and from 12 to 24 hours was 0.04 mg/kg (SD 0.13) and 0.11 mg/kg (SD 0.08), respectively. Eleven inpatients received acetaminophen and 10/12 received nonsteroid anti-inflammatory drugs (NSAIDs). Pain scores were recorded in PACU: mild

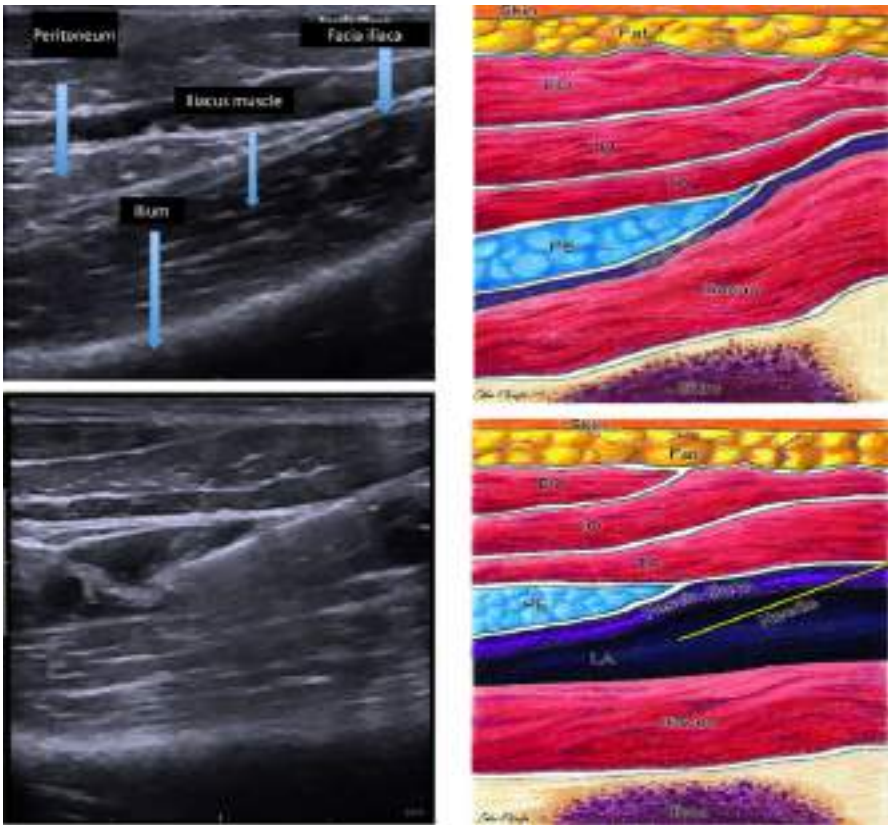

FIGURE 3 Top: Longitudinal US scan showing the fascia iliaca overlying the thick, striated iliacus muscle. Note the peritoneum in close proximity to the fascia iliaca. Bottom: Longitudinal US scan of the fascia iliaca showing the LA accumulation between the fascia iliaca and the iliacus muscle. EO=external oblique muscle, IO=internal oblique muscle, TA=transversus abdominis muscle, PE=peritoneum, Iliacus=iliacus muscle

9/17, moderate 7/17, and severe 1/17; and 0-24 hours postoperatively: (n=12 patients); low 9/12, moderate 3/12 and severe 0/12.

No cardiac or CNS evidence of local anesthetic systemic toxicity, or prolonged sensory or motor deficits or other complications was observed.

4 | DISCUSSION

The technical success rate of ultrasound-guided supra-inguinal FICB in older children was high (95% CI: 82%-100%) with localizing landmarks identified in all patients. Patients reported relative comfort, opioid consumption was modest, and no complications were reported.

The results of this pediatric study are comparable to the adult study reported by Desmet et al.[10] showing the supra-inguinal technique being more reliable compared to previous reports of ultrasound-guided infra-inguinal and landmark-based techniques in patients.[7-9,12,14] While the FI can be located at several sites relative to the inguinal ligament, it is important to inject superior/cephalad to the inguinal ligament where the sensory nerves are located in the same fascial plane. The infra-inguinal location described by Shariat[7] relies on cephalad spread under the inguinal ligament or movement of the LA across a fascial barrier (Figure 1). Miller[13] reported a similar successful technique in 2 pediatric patients but describes an intramuscular (iliacus) location for LA administration. We observed better spread when LA was injected between the muscle and FI. We had 1 patient (BMI=35) with no sensory changes who accounted for our 1 failure and pain score >7. The characteristic ultrasound images produced by the ilium, iliacus muscle, and FI provided reproducible ultrasound landmarks in all patients. While we find imaging easy for trainees, the steep transducer angle on skin and subsequent difficulty visualizing a needle in oblique orientation makes the FICB moderately difficult.

The low opioid consumption and pain scores in the PACU and subsequent 24-h pain score indicated relative patient comfort. We were unable to establish a historical cohort for due to lack of data of sufficient integrity to allow a valid comparison. Aside from 1 patient with block failure, pain scores were ≤6. Patients had modest opioid consumption. The effects of adjuvant analgesics on results are unclear but regional anesthesia is best employed within a multimodal plan. For efficacy studies, it is important to establish the sensory coverage of a new technique prior to subjecting patients, especially pediatric patients, to randomization and blinding. The Shariat technique with 38% coverage of the targeted sensory nerves was little better than placebo and the lack of efficacy in pain relief could have been predicted with prior sensory coverage determination.

Of concern, the peritoneum was consistently observed in all imaging. Transducer caudad movement eliminated peritoneum from needle paths but on 1 occasion, an observed fecalith necessitated changing needle direction. Ultrasound imaging of adjacent structures may prove helpful in decreasing errant needle location and may be especially important in smaller patients. We report no associated complications but our study was under-powered to determine complications.

We used an average volume of 0.53 mL/kg (1.06 mg/kg) but detected a large range. Our results are consistent with previous

reports of 20-40 mL in adults and 0.43-0.80 mL/kg in pediatric patients.[7-9,12,14,15] The large contact surface area with well-vascularized muscle makes absorption of LA from FICBs rapid. Acceptable plasma levels are documented with ≤2.60 mg/kg.[9,15,16] Our patients received a maximum of 1.20 mg/kg of ropivacaine with potential safety implications with lower dosing.[6]

Our report has the limitations of retrospective reports lacking control groups. It is not the intent of this study to argue clinical efficacy, but rather, we report pain scores and opioid consumption to document lack of suffering, provision of additional analgesics, and to provide data for powering future studies. Patient ages and emotional states precluded establishing a single measure of sensory changes. Some patients had difficulty understanding that an object could be both warm and cold (ice in glove) and we allowed both loss of cold discrimination and light touch discrimination for reporting. We could not determine the incidence of blockade of the ON as hip adductor testing was prohibitively difficult due to postoperative bandaging. We were unable to determine the relative contributions of the different nerves to FICB analgesia.

In summary, the supra-inguinal ultrasound-guided FICB has a high technical success rate (95% CI 82%-100%) in older children using readily identified landmarks. Doses from 0.35 to 0.60 mL/kg-produced successful block with modest opioid consumption and pain scores indicate relative patient comfort. The results should encourage further studies into clinical efficacy.

DISCLOSURES

IRB approval from the institution was obtained.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ORCID

Maria A. Hernandez http://orcid.org/0000-0001-8028-0433

REFERENCES

1. Lee EM, Murphy KP, Ben-David B. Postoperative analgesia for hip arthroscopy: combined L1 and L2 paravertebral blocks. *J Clin Anesth*. 2008;20:462-465.
2. Birnbaum K, Prescher A, Hessler S, Heller KD. The sensory innervation of the hip joint—an anatomical study. *Surg Radiol Anat*. 1997;19:371-375.
3. Foss NB, Kristensen BB, Bundgaard M, et al. Fascia iliaca compartment blockade for acute pain control in hip fracture patients: a randomized, placebo-controlled trial. *Anesthesiology*. 2007;106:773-778.
4. Stevens M, Harrison G, McGrail M. A modified fascia iliaca compartment block has significant morphine-sparing effect after total hip arthroplasty. *Anaesth Intensive Care*. 2007;35:949-952.7.
5. Neal JM, Brull R, Chan VWS, et al. The ASRA evidence-based medicine assessment of ultrasound-guided regional anesthesia and pain medicine: executive summary. *Reg Anesth Pain Med*. 2010;35:S1-S9.
6. Oberndorfer U, Marhofer P, Bosenberg A, et al. Ultrasonographic guidance for sciatic and femoral nerve blocks in children. *Br J Anaesth*. 2007;98:797-80.
7. Shariat AN, Hadzic A, Xu D, et al. Fascia Iliaca block for analgesia after hip arthroplasty: a randomized double-blind, placebo-controlled trial. *Reg Anesth Pain Med*. 2013;38:201-205.
8. Dolan J, Williams A, Murney E, Smith M, Kenny GNC. Ultrasound Guided Fascia Iliaca Block: a Comparison With the Loss of Resistance Technique. *Reg Anesth Pain Med*. 2008;33:526-531.
9. Desmet M, Vermeylen K, Van HI, et al. A Longitudinal Supra-Inguinal Fascia Iliaca Compartment Block Reduces Morphine Consumption After Total Hip Arthroplasty. *Reg Anesth Pain Med*. 2017;42:327-333.
10. Tomaszewski K, Popieluszko P, Henry B, et al. The surgical anatomy of the lateral femoral cutaneous nerve in the inguinal region: a meta-analysis. *Hernia*. 2016;20:649-657.
11. Dalens B, Vanneuville G, Tanguy A. Comparison of the fascia iliaca compartment block with the 3-in-1 block in children. *Anesth Analg*. 1989;69:705-713.
12. Capdevila X, Biboulet P, Bouregba M, Barthelet Y, Rubenovitch J, d'Athis F. Comparison of the three-in-one and fascia iliaca compartment blocks in adults: clinical and radiographic analysis. *Anesth Analg*. 1998;86:1039-1044.
13. Hebbard P, Ivanusic J, Sha S. Ultrasound-guided supra-inguinal fascia iliaca block: a cadaveric evaluation of a novel approach. *Anaesthesia*. 2011;66:300-305.
14. Miller BR. Ultrasound-guided fascia iliaca compartment block in pediatric patients using a long-axis, in-plane needle technique: a report of three cases. *Pediatr Anesth*. 2011;21:1261-1264.
15. Paut O, Sallabery M, Schreiber-Deturmeny E, Remond C, Bruguerolle B, Camboulives J. Continuous fascia iliaca compartment block in children: a prospective evaluation of plasma bupivacaine concentrations, pain scores, and side effects. *Anesth Analg*. 2001;92:1159-1163.
16. Paut O, Schreiber E, Lacroix F, et al. High plasma ropivacaine concentrations after fascia iliaca compartment block in children. *Br J Anaesth*. 2004;92:416-418.

How to cite this article: Eastburn E, Hernandez MA, Boretsky K. Technical success of the ultrasound-guided supra-inguinal fascia iliaca compartment block in older children and adolescents for hip arthroscopy. *Pediatr Anesth*. 2017;27:1120–1124. https://doi.org/10.1111/pan.13227