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The analgesic efficacy of the transversalis fascia plane block in iliac crest bone graft harvesting: a randomized controlled trial

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Background: Iliac crest bone graft (ICBG) harvesting is associated with significant perioperative pain and opioid consumption. This randomized controlled trial sought to determine if the transversalis fascia plane (TFP) block provides effective analgesia for anterior ICBG harvesting.

Methods: Fifty patients undergoing wrist fusion surgery with anterior ICBG harvesting were randomized to receive a TFP block with either 20 ml of 0.5% ropivacaine or 5% dextrose. Patients additionally received a brachial plexus block for primary surgical-site anesthesia and either a general or spinal anesthetic depending on patient preference. Primary outcomes of interest were perioperative opioid consumption (measured as intravenous morphine equivalents [IME]), pain intensity at the ICBG harvest site for up to 48 h postoperatively, and the incidence of persistent postoperative pain at 6 and 12 months after surgery.

Results: The TFP group used less opioid in the post-anesthetic care unit (PACU) (median 0 vs. 2.5 mg IME, P = 0.01) and in the first 8 h following PACU discharge (median 2.5 vs. 13.0 mg IME, P = 0.02). The patients who received a TFP block also had lower pain scores in PACU (median 0 vs. 4.0 out of 10, P < 0.001). Although opioid consumption and pain scores were lower in the TFP group at later timepoints, this difference was not statistically significant. Persistent pain at the ICBG site was reported in only 4.3% and 6.5% of all patients at 6 and 12 months, respectively.

Conclusions: The TFP block provides effective early analgesia for anterior ICBG harvesting. The incidence of persistent postoperative pain was low.

Keywords: Anesthesia; Conduction; Fascia; Local anesthesia; Nerve block.

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Introduction

Anterior iliac crest bone graft (ICBG) harvesting is associated with significant postoperative pain and over 25% of patients report that the ICBG pain is worse than the primary surgical site [1,2].

Systemic opioids and surgical infiltration of local anesthesia have typically been used to provide analgesia for anterior ICBG; however, the effective duration of local anesthetic infiltration is short-lived (approximately 4 h) [3,4]. Surgical placement of a wound catheter for continuous infusion or intermittent boluses of local anesthesia has also been described but there are conflicting reports of efficacy [1,5–7].

The transversalis fascia plane (TFP) block is an ultrasound-guided regional anesthetic technique that targets the T12 and L1 spinal nerves by injecting local anesthesia between the posterior aponeurotic extension of the transversus abdominis muscle and the deep investing transversalis fascia [8]. The use of this block has been described in a variety of clinical situations including anterior ICBG, inguinal herniorrhaphy, chronic post-herniorraphy inguinal pain, and cesarean section [9–13].

We conducted a randomized controlled trial to evaluate the efficacy of the TFP block in managing pain from the anterior ICBG site. This was done by assessing pain scores at the iliac crest and perioperative opioid consumption for patients undergoing elective forearm or wrist surgery requiring an ICBG. Patients were followed up postoperatively for 12 months to examine the incidence and severity of chronic pain at the iliac crest.

Materials and Methods

This double-blinded, randomized controlled trial was approved by the Research Ethics Board at University Hospital Network, Toronto, and prospectively registered at ClinicalTrials.org (NCT01133730).

Patients were identified from the surgical booking schedule. The inclusion criteria were elective upper limb surgery requiring ICBG, American Society of Anesthesiologists physical status I–III, 18–85 years old, and a weight greater than 50 kg. Patients were excluded if they had a contraindication to regional anesthesia, were pregnant, had a history of long-term opioid use or a chronic pain disorder, had a history of drug or alcohol abuse, had significant psychiatric illness, had a history of severe pelvic or hip pain, or if they had an allergy to the study medications. Written informed consent was obtained prior to study inclusion.

Study participants were brought to a dedicated block room where intravenous access was obtained and routine monitors (electrocardiogram, non-invasive blood pressure, and pulse oximetry) were applied. Patients received 1–2 mg intravenous (IV) midazolam prior to the performance of an ultrasound-guided brachial plexus block. The choice of the block for the primary operative site was left to the discretion of the attending block room anesthesiologist. All brachial plexus blocks were performed with 30–40 ml of a 1 : 1 mixture of 2% lidocaine and 0.5% bupivacaine with 5 μg/ml epinephrine.

Patients were randomized to receive an ultrasound guided TFP block with either 20 ml 0.5% ropivacaine with 5 μg/ml epinephrine or a placebo injection with 20 ml 5% dextrose solution. Randomization was performed by a research assistant not otherwise involved in the study, utilizing a computer-generated block randomization schedule. The outcome of randomization was communicated to an anesthesia assistant who prepared the study medication in an unlabeled syringe and assisted with the performance of the block, but thereafter had no further part in the study. The patient, anesthesiologist performing the block, surgeon, anesthesiologist responsible for intraoperative care, and the personnel responsible for data collection were blinded to study group allocation.

The TFP injections were performed in the lateral position as previously described [9,14] using either a linear-array high frequency (7–12 MHz) ultrasound probe or a curved-array low-frequency (2–5 MHz) probe in patients with truncal obesity. All TFP injections were performed by an anesthesiologist who had performed at least 10 successful TFP blocks. A 22-gauge, 80 mm block needle was inserted and advanced until the tip was seen to lie just deep to the transversalis fascia (Fig. 1). A 1 ml test injection was performed to ensure correct needle placement before the remainder of the study solution was injected.

Patients then received either general anesthesia (GA) or spinal anesthesia and conscious sedation. This was decided based on patient preference and at the discretion of the attending anesthesiologist. The spinal anesthesia group received 3 ml of intrathecal 2% mepivacaine and intraoperative sedation with an IV propofol infusion at 25–75 μg/kg/min and IV boluses of midazolam 0.5–1.0 mg or fentanyl 25–50 μg as required. In the general anesthesia group, airway management was with either endotracheal intubation or laryngeal mask airway insertion and anesthesia was maintained with sevoflurane or desflurane at a minimum alveolar concentration of 0.8–1.4. IV boluses of fentanyl 25–50 μg were administered for analgesia at the discretion of the attending anesthesiologist.

Postoperatively, patients were transferred to the post-anesthetic care unit (PACU) where the pain scores at the site of the ICBG harvest site were documented using an 11-point numerical rating score (NRS, 0–10) and additional analgesia was administered as required by the PACU nursing staff. In accordance with the usual practice at our institution, IV fentanyl was initially administered, followed by IV morphine or hydromorphone, and oral oxycodone as necessary. A blinded research assistant assessed the extent of sensory loss to pinprick over the anterior

abdomen in the PACU. Patients were discharged from the PACU once the routine criteria were met and received 1 g oral acetaminophen every 6 h, unless contraindicated. Those admitted to the hospital overnight were prescribed IV patient-controlled analgesia (morphine 1–2 mg or hydromorphone 0.2–0.4 mg every 5 min as required, lockout interval 5 min, no basal infusion) to manage pain from the ICBG harvest site as well as the expected pain from the wrist once the effect of the brachial plexus block had worn off. Upon discharge from the hospital, all patients were instructed to take oral oxycodone 5–10 mg or hydromorphone 2–4 mg every 3–4 h as required.

Once discharged from the PACU, each patient was asked to complete a diary to record the NRS pain scores at the ICBG harvest site and opioid consumption every 4 h for 48 h. We also recorded the block duration, defined as the time from the completion of the block performance to the time of onset of increased pain at the ICBG harvest site.

Patients were asked to note the frequency of opioid-related adverse events during the first 48 h postoperatively on a 5-point scale (0 = never, 1 = rarely, 2 = occasionally, 3 = frequently, and 4 = almost constantly).

This information was gathered by a blinded research assistant. A telephone follow-up was also performed at 6 and 12 months postoperatively to assess the incidence of chronic pain at the ICBG harvest site using the Short Form McGill pain questionnaire [15] and the impact of pain on the quality of life using the SF-36v2^{TM} Health Survey [16].

The primary outcome was total opioid consumption in the first 24 h; for ease of comparison all opioids administered were converted to milligram IV morphine equivalents (mg IME).

We assumed that the 24-h opioid consumption in this cohort of patients would be approximately 45 mg IME based on a pre-

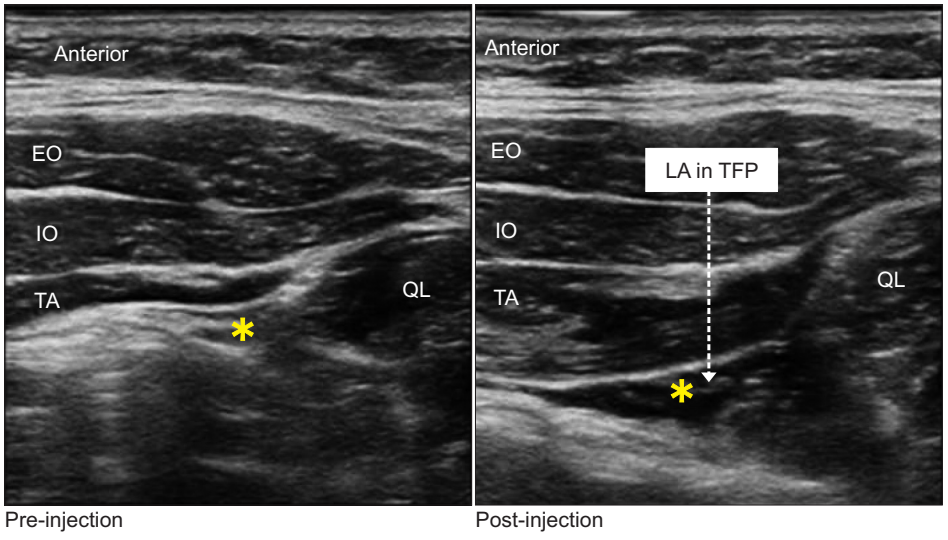

Fig. 1. Pre-injection and post-injection sonograms of the TFP block. The local anesthetic (*) can be seen deep to the TA muscle and pushing the perinephric fat downwards. TFP: transversalis fascia plane, TA: transversus abdominis, EO: external oblique, IO: internal oblique, QL: quadratus lumborum, and LA: local anesthetic. Reproduced with permission from Ultrasound for Regional Anesthesia (USRA; Available from http://www.usra.ca).

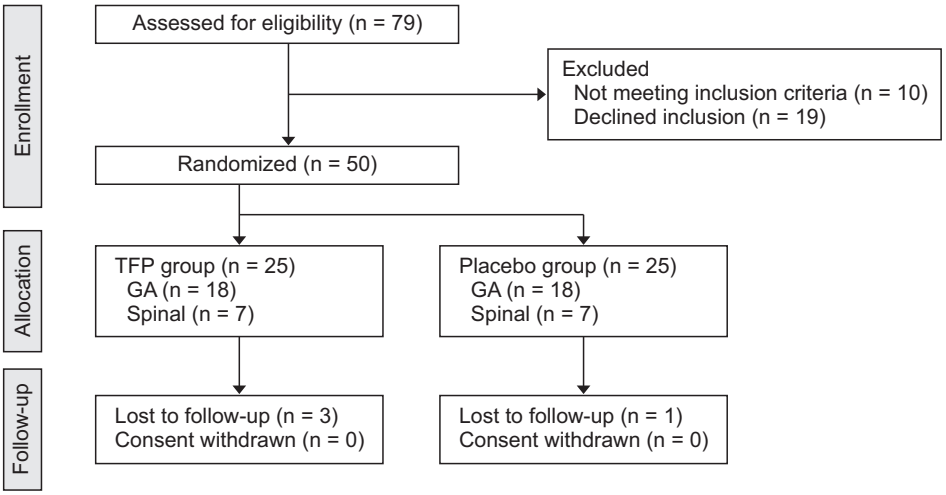

Fig. 2. Flow chart outlining patient inclusion. GA: general anesthesia.

vious retrospective pilot study at our institution [9]. Assuming a power of 80% and an alpha level of 0.05, with a standard deviation of 20 mg IME, the study sample size was set at 28 patients per group. Statistical analysis was performed using SPSS 17.0 (SPSS Inc., USA). Continuous data were tested for normality using the Shapiro-Wilk W statistic; parametric data are reported as mean ± standard deviation and were analyzed using the Student's *t*-test; non-parametric data is reported as median (interquartile range) and were analyzed using the Mann-Whitney *U* test. A P value of 0.05 was chosen as the significance level.

Results

The recruitment was hindered by a change in the clinical workload of the surgeon involved and thus it was decided to stop the study earlier than anticipated. Seventy-nine patients were screened for enrolment in the study, of which a total of 50 patients were recruited and randomized to receive either a TFP block or a placebo injection (Fig. 2). Thirty-six patients received general anesthesia and 14 received spinal anesthesia, with equal numbers of patients in each group receiving a TFP block or a placebo injection. There were no significant differences in patient demographics between the groups (Table 1). The average TFP block performance time was 5.84 ± 2.79 min and patients reported an NRS pain score of 2 [1–2] associated with the block. There were no complications related to the block performance in any of the patients.

Opioid consumption was significantly lower in the TFP group compared to the placebo group during their PACU stay (0 [0–2.5] vs. 2.5 [0–7.5] mg IME, P = 0.01), during the overall perioperative period (10.0 [5.0–12.5] vs. 16.5 [10.0–25.0] mg IME, P = 0.01), and for the first 8 h after PACU discharge (2.5 [0.4–13.5] vs. 13.0 [3.5–24.6] mg IME, P = 0.02) (Table 2). At all other time points examined, the reduction in opioid consumption seen in the TFP group did not achieve statistical significance (Table 2). The frequency of opioid-related side effects is shown in Table 3.

Pain scores at the ICBG site were significantly lower in the TFP group on admission to the PACU (0 [0–2.0] vs. 4.0 [0.5–7.0], P < 0.001) and on the PACU discharge (0 [0–2.0] vs. 2.5 [1.0–4.8], P < 0.001) (Table 4). The average pain scores from 0 to 24 h

Table 1. Demographic Information of Study Participants

Demographic		TFP	Placebo	P value
Age (yr)		45.0 (16.3)	48.2 (12.9)	0.5
Sex (n)	M	60.0% (15)	72.0% (18)	0.6
	F	40.0% (10)	28.0% (7)	
BMI (kg/m^2)		26.1 (4.0)	27.2 (5.9)	0.6
Mode of anesthesia % (n)	Spinal	2.1% (7)	28.0% (7)	1.0
	General	72.0% (18)	72.0% (18)	

Values are presented as mean (standard deviation) and percentage (number). BMI: body mass index, TFP: transversalis fascia plane block.

Table 2. Opioid Consumption Measured in Milligram IV Morphine Equivalents (mg IME) at Different Time Periods

Mode of anesthesia	Time period	TFP	Placebo	P value
All patients	Intraoperative	7.5 (5–10)	15 (5–20.0)	0.07
	PACU	0 (0–2.5)	2.5 (0–7.5)	0.01*
	Overall perioperative	10.0 (5.0–12.5)	16.5 (10.0–25.0)	0.01*
	0–8 h	2.5 (0.4–13.5)	13.0 (3.5–24.6)	0.02*
	0–24 h	28.0 (13.5–46.1)	28.0 (13.9–50.5)	0.85
	24–48 h	0 (0–5.0)	0 (0–5.0)	0.79
	48–72 h	0 (0–1.9)	0 (0–0)	0.42
GA patients only	Intraoperative	10.0 (5.0–13.8)	15.0 (10.0–23.1)	0.02*
	PACU	0 (0–2.5)	3.8 (0–10.0)	0.03*
	Overall perioperative	10.0 (6.9–18.1)	17.5 (14.4–29.4)	0.004*
	0–8 h	4.5 (0.8–14.0)	14.0 (5.0–25.3)	0.03*
	0–24 h	25.0 (12.5–43.0)	30.8 (22.9–65.9)	0.25
	24–48 h	0 (0–2.5)	0 (0–8.8)	0.31
	48–72 h	0 (0–3.8)	0 (0–0.6)	0.64
Spinal anesthesia patients only	Intraoperative	5.0 (0–5.0)	5 (0–7.5)	0.79
	PACU	0 (0–0)	0 (0–5.0)	0.17
	Overall perioperative	5.0 (1.0–5.0)	7.5 (2.5–10.0)	0.27
	0–8 h	1.0 (0– 12.0)	3.0 (0–16.0)	0.40
	0–24 h	28.0 (15.7–50.0)	15.0 (6.0–19.0)	0.09
	24–48 h	0 (0–12.5)	0 (0–0)	0.14
	48–72 h	0 (0–0)	0 (0–0)	0.32

Values are presented as median (interquartile range). Mann-Whitney *U* tests were performed to assess significance. GA: general anesthesia, PACU: postoperative care unit, TFP: transversalis fascia plane block. *Indicates a statistically significant result with P < 0.05.

and 24 to 48 h following PACU discharge were lower in the TFP group at other time points but this difference did not achieve statistical significance (Table 4).

Upon subgroup analysis, those patients in the TFP group who received GA used significantly less opioid intraoperatively (10.0 [5.0–13.8] vs. 15.0 [10.0–23.1] mg IME, P = 0.02), in the PACU (0 [0–2.5] vs. 3.75 [0–10.0] mg IME, P = 0.03), and overall during the perioperative period (10.0 [6.9–18.1] vs. 17.5 [14.4–29.4] mg IME, P = 0.004) (Table 2). This reduction was also significant during the first 8 h after the PACU discharge (4.5 [0.8–14.0] vs. 14.0 [5.0–25.3] mg IME, P = 0.02) but not at any later time period. Regarding pain scores, the patients in the TFP group who underwent GA had significantly less pain on admission to the PACU (0 [0–2.0] vs. 4.5 [1.8–7.0], P < 0.001) and on discharge from the PACU (0 [0–2.0] vs. 4.0 [1.5–5.5], P < 0.001).

In the subgroup of patients who underwent spinal anesthesia, there was no significant difference between the groups in opioid consumption or pain scores at any time points analyzed (Tables 2 and 4).

We were able to perform postoperative sensory testing in 23 of the 25 patients in the TFP group. All patients had a sensory loss to touch in the L1 dermatome, but no higher in 65% of the patients. In one patient the upper limit of sensory loss reached T6 with the remainder ranging from T7 to T12 (Fig. 3).

Block duration was assessed in 11 of the 25 patients in the TFP group; the remaining patients had either no pain at the ICBG harvest site or were unable to discern if and when there was any increase in pain. The mean block duration recorded was 11.7 ± 4.9 h.

Assessments for persistent postoperative pain were completed for all but three and four patients at 6 months and 12 months, respectively. There was no statistically significant difference in the SF-36 Physical Component Summary or Mental Component Summary scores between the groups at both time periods. At 6 months, one patient in each group reported mild pain during activity at the ICBG harvest site. At 12 months, one patient in the placebo group had mild pain and two patients (one in each group) had moderately severe pain with activity. Due to the small numbers, no further analysis was performed on the chronic pain data.

Table 3. Frequency of Opioid Related Side Effects (%)

Adverse effect	TFP		Placebo		P value
	0–2	3–4	0–2	3–4	
Nausea	84	16	86.4	13.6	0.63
Vomiting	91.7	8.3	100	0	0.003*
Constipation	95.8	4.2	95.2	4.8	0.84
Dysuria	87.5	12.5	95.7	4.3	0.04*
Concentration	80	20	86.4	13.6	0.23
Drowsiness	68	32	69.6	30.4	0.80
Dizziness	92	8	86.4	13.6	0.20
Fatigue	64	36	56.5	43.5	028
Confusion	96	4	95.5	4.5	0.86
Itchiness	84	16	90.9	9.1	0.14
Dry mouth	64	36	60.9	39.1	0.65
Headache	92	8	95.5	4.5	0.31

Frequency of side effects were reported by patients on a 5-point scale (0 = never, 1 = rarely, 2 = occasionally, 3 = frequently and 4 = almost constantly). TFP: transversalis fascia plane block. *Indicates a statistically significant result with P < 0.05.

Discussion

The results of this study demonstrate that the TFP block is an effective analgesic technique in anterior ICBG harvesting. The TFP block is quick to perform, well tolerated in the minimally-sedated patient, consistently provides unilateral sensory

Table 4. Average Pain Numerical Rating Scores (NRS) at the ICBG Harvest Site

Mode of anesthesia	Time	TFP	Placebo	P value
All patients	PACU admission	0 (0–2.0)	4 (0.5–7.0)	< 0.001*
	PACU discharge	0 (0–2.0)	2.5 (1.0–4.8)	< 0.001*
	0–24 h average	1.5 (0–4.0)	3.0 (1.0–5.0)	0.07
	24–48 h average	1.5 (0.6–3.8)	3.5 (1.0–5.0)	0.24
GA patients only	PACU admission	0 (0–2.0)	4.5 (1.8–7.0)	< 0.001*
	PACU discharge	0 (0–2.0)	4.0 (1.5–5.5)	< 0.001*
	0–24 h average	1.0 (0.3–4.0)	3.0 (1.5–5.0)	0.08
	24–48 h average	1.5 (0.8–3.5)	3 (1.0–5.0)	0.15
Spinal anesthesia patients only	PACU admission	0 (0–0)	0 (0–4.0)	0.53
	PACU discharge	0 (0–2.0)	1.0 (0–2.0)	0.30
	0–24 h average	2.0 (0–4.0)	2.8 (0.8–5.0)	0.51
	24–48 h average	1.0 (0–4.0)	4.0 (1.0–4.0)	0.36

Values are presented as median (interquartile range). The Reduction in pain scores only achieved statistical significance in the post-anesthetic care unit (PACU). Mann-Whitney *U* tests were performed to assess significance. GA: general anesthesia, TFP: transversalis fascia plane block. *Indicates a statistically significant result with P < 0.05.

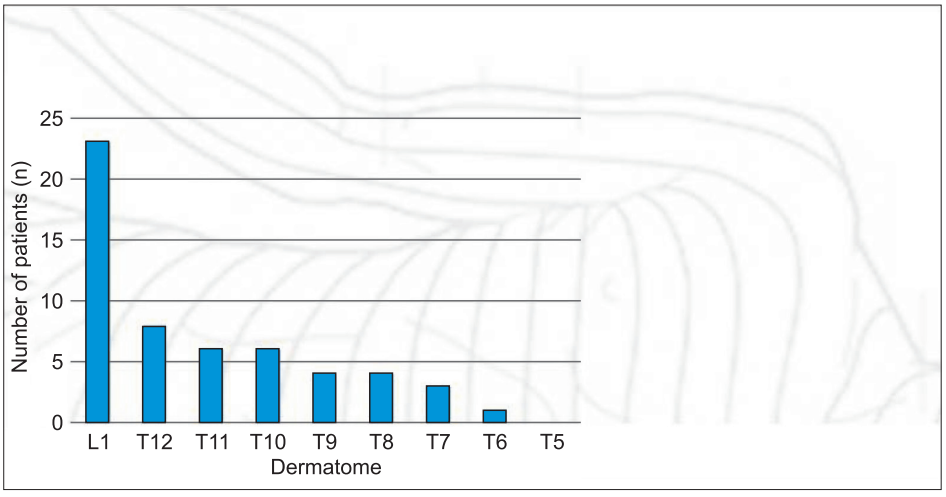

Fig. 3. The numbers of patients with sensory loss to touch at each dermatomal level. All patients had a block at L1; however, the block was limited to this dermatome in the majority (65%). One patient had a block that extended to T6.

blockade of the L1 dermatome, and provides analgesia for almost 12 h on an average.

Pain at the ICBG harvest site was generally of low intensity and, despite a trend towards lower pain scores in the TFP group up to 48 h postoperatively, there was no statistically significant difference between the groups after the PACU discharge. The lack of difference in the pain scores may be attributed to effective systemic analgesia in the group receiving a placebo injection and is reflected in the significantly higher opioid consumption that was observed in these patients during the first 8 h following PACU discharge. Thereafter, there was no significant difference in opioid consumption between the groups. This may be attributed to the offset of the brachial plexus block and the onset of pain at the primary surgical site at the wrist, which would have required opioid analgesia for effective management.

The reported incidence of persistent postoperative pain following ICBG harvesting is variable; in one study, the iliac crest pain was present 2 years after surgery in 21.1% of the patients who had had an ICBG for spine surgery compared to only 6.2% for non-spine surgery [17]. Spine surgery usually involves the harvest of larger segments of the bone as well as the use of a posterior iliac crest site versus an anterior one. The intensity of acute postoperative pain is much greater, which in turn is a significant risk factor for the development of persistent postoperative pain [18]. The low incidence of chronic pain observed in the current study is thus not surprising, but it does prevent us from determining if the TFP block may contribute to a reduction in the incidence of this complication.

One of the major limitations in our study was the fact that some patients in this study received spinal anesthesia and others general anesthesia to provide surgical anesthesia for the ICBG harvest site. Unfortunately, at the time the study was conducted, this was routine institutional practice and the exclusion of either modality would have significantly hampered study recruitment. The use of spinal anesthesia would have masked any intraoperative benefit of the TFP block, and this confounding was further exacerbated by the common practice in our institution to administer incremental doses of fentanyl for conscious sedation during regional anesthesia. Outcome assessment in the PACU was impacted to a lesser extent as patients were discharged only after the sensory level had regressed to the L3 dermatome or lower. We attempted to address these limitations with a subgroup analysis by mode of anesthesia. Results in the general anesthesia subgroup were similar to the overall analysis in that patients who received a TFP block used significantly less opioid at all time points up to 8 h following PACU discharge and had lower pain scores in PACU. In addition, the TFP block also reduced intraoperative opioid consumption in the GA subgroup. In contrast, the reductions in the smaller spinal anesthesia subgroup failed to reach statistical significance at any time point. This however may represent a type 2 error given the small sample size of the subgroup. Another related limitation of our study was the failure to reach the targeted sample size due to difficulties with recruitment. This may have contributed to the lack of a statistically significant difference in the primary outcome of 24-h opioid consumption.

Transversus abdominis plane (TAP) blocks [13,19] and transmuscular quadratus lumborum (TQL) [20] blocks have been used to provide analgesia for ICBG. One concern in using TAP blocks for ICBG is that they may not reliably cover the L1 dermatome [21,22]. A study by Lee et al. [22] showed that an ultrasound-guided posterior TAP block will produce sensory loss in the L1 dermatome less than 50% of the time. The TQL block may be more consistent and a case series of five patients undergoing ICBG by Sondekoppam et al. [20] showed that there was sensory loss in the L1 dermatome in all cases. In the present study, the TFP block provided sensory loss in the L1 dermatome in all patients and, unlike the TQL block, does not require access

to the back or use of a curvilinear probe in the majority of patients.

We did not note any complications of the TFP block or placebo injection in the current study, although the potential safety concerns are similar to that of other abdominal wall blocks, including visceral injury, vascular injury, and local anesthetic systemic toxicity [23]. However, there is one report of quadriceps weakness following a TFP block, which was believed to have been caused by the proximal spread of local anesthetic to the lumbar plexus [24]. Lower limb weakness has also been described following quadratus lumborum [25] and TAP [26,27] blocks, suggesting that vigilance is warranted when mobilizing patients.

In summary, an ultrasound-guided TFP block is a relatively simple regional anesthetic technique that reliably blocks the L1 dermatome and can provide early postoperative analgesia in patients undergoing anterior ICBG harvesting.

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Conflicts of Interest

Dr. Vincent Chan has received honorarium from Aspen Pharma, BBraun, Smiths Medical, and SonoSite.

Author Contributions

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