The Ultrasound-Guided Transversus Abdominis Plane Block for Anterior Iliac Crest Bone Graft Postoperative Pain Relief

A Prospective Descriptive Study

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Background: Acute postoperative pain and nerve injuries frequently lead to neuropathic chronic pain after anterior iliac crest (AIC) bone graft. This prospective study evaluated postoperative pain relief after preoperative ultrasound-guided transversus abdominis plane (TAP) block for orthopedic surgery with an AIC bone harvest and the prevalence of pain chronicization at 18 months after surgery.

Methods: Thirty-three consecutive patients scheduled for major orthopedic surgery with an AIC harvest for autologous bone graft were studied. Preoperative TAP blocks were performed under in-plane needle ultrasound guidance, anterior to the midaxillary line (15 mL ropivacaine 0.33%). The extent of sensory blockade was evaluated at 20 mins with cold and light-touch tests. Pain at the iliac crest graft site was assessed at rest by visual analog scale (VAS) scores in the postanesthetic care unit, and at 1, 6, 12, 24, and 48 hrs after surgery. Time for first request of morphine and total morphine consumption were recorded. Eighteen months after surgery, each patient was interviewed by phone about the importance and localization of pain chronicization.

Results: Median VAS score was 0 (range, 0–7) at all periods of assessment. At 20 mins, 62.5% of the patients reported complete anesthesia, and 34% hypoesthesia. The sensory blockade extent ranged from T9 (T7–T11) to L1 (T11-L2) in median (range) values. At 18 months, 80% of patients did not complain about pain or discomfort at the iliac crest site; 20% reported pain chronicization at the iliac crest site (VAS scores 2–4). Five patients (26%) complained about numbness at the iliac crest area.

Conclusions: Ultrasound-guided TAP block is an appropriate technique for postoperative analgesia after AIC bone harvest in orthopedic surgery.

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Anterior iliac crest (AIC) bone grafting is frequently used for reconstructive procedures in orthopedic, spinal, or maxillofacial surgery.[1] A high level of acute postoperative pain is the main adverse effect related to that procedure.[2–4] Patients often complain that pain from the iliac harvest is worse than postoperative pain at the main surgical site.[5] Furthermore, the prevalence of nerve injury (ie, ilioinguinal nerve, lateral cutaneous nerve of the thigh, and branches from the subcostal nerves and iliohypogastric nerve) can reach 10%.[6] Acute postoperative pain and nerve lesions can lead to neuropathic chronic pain, with an incidence ranging from 10% to 34%.[2,4,5,7] Consequently, optimization of postoperative analgesia is necessary for these patients. Studies on direct infiltration of the iliac crest by the surgeon or placement of a catheter for continuous local anesthetic (LA) infiltration report controversial results.[3,8–10]

The AIC and its overlying skin are innervated by ventral rami from intercostal nerves T11 and T12 and by the iliohypogastric nerve (L1, L2) (Fig. 1). The nerves run in the plane between the transversus abdominis and internal oblique muscles of the abdominal wall. The transversus abdominis plane (TAP) block[11,12] permits a sensory block of the lower 6 thoracic and L1 ventral rami. Imaging studies on cadavers and volunteers have demonstrated the spread of solution in a plane between both muscles, with a subsequent sensory blockade from T8 to L1.[13] Therefore, TAP block may provide efficient postoperative analgesia for AIC bone harvest. Concerns about possible unintentional peritoneal or liver puncture using the classic double-pop TAP block approach led anesthetists to adopt ultrasound guidance to perform the block.[14–17] Therefore, we prospectively evaluated AIC bone harvest postoperative pain relief after ultrasound-guided TAP blocks in patients scheduled for orthopedic surgery. The secondary end point was to evaluate AIC pain chronicization at 18 months after surgery.

METHODS

After ethical committee approval (CPP Sud Méditerannée IV) and written informed consent were obtained, patients scheduled to undergo major orthopedic surgery with an AIC harvest for autologous bone graft were enrolled. Patients who did not cooperate and those who had psychologic disorders or communication difficulties that might interfere with sensory/motor blockade or pain assessments were excluded. Medical exclusion criteria were severe bronchopulmonary disease (only for interscalene block), blood-clotting impairment, known allergy to the trial drugs, abdominal wall infection, morbid obesity (>38 kg/m^2), and cardiac conduction problems (second- or third-degree atrioventricular block). In addition, patients who participated in a therapeutic trial within the previous month and those who were already participating in another study were not included in the current study.

Patients were premedicated with midazolam 10 mg orally, 30 mins before arrival in the operating room. Standard monitoring such as blood pressure cuff, electrocardiography, and oxymetry was applied, and a bolus of 500 mL normal saline was administered before regional anesthesia. The puncture site was

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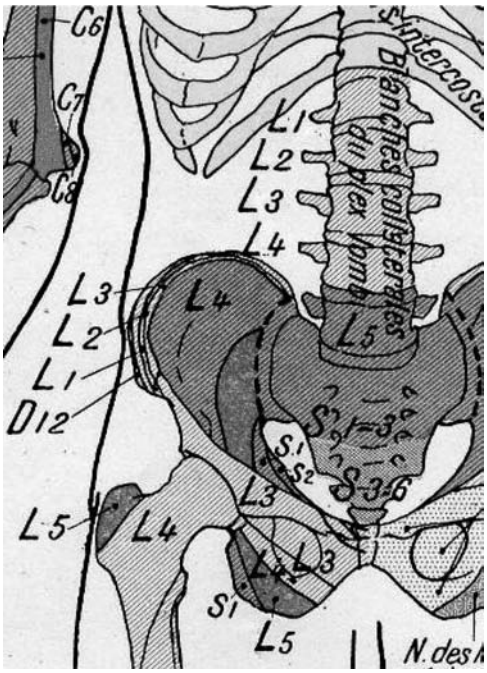

FIGURE 1. Artist's illustration from Jules Déjérine, *Sémiologie des affections du système nerveux* 1914, Paris, Masson, showing metameric levels of the anterior part of the iliac crest bone.

prepared with an alcoholic povidone-iodine solution, and surrounding areas were disinfected. Experienced physicians performed the TAP blocks aseptically in the preanesthesia room, using ultrasound guidance (GE LOGIQ e; GE Healthcare, Buc, France; linear probe, 10 MHz) and with a 50-mm, 22-gauge needle (Nanoline; Pajunk, Geisingen, Germany). The probe was placed cephalad to the iliac crest, transversally, anterior to the midaxillary line as shown in Figure 2. After identification of the different muscle planes and the peritoneum, the puncture was performed in-plane. After needle-tip placement into the fascia between the transversus abdominis and internal oblique muscles, 1 mL of ropivacaine 0.33% was injected to confirm the ideal location of the spread of LA solution. The remaining 14 mL of LA was then injected to reach a total volume of 15 mL of ropivacaine 0.33%. Twenty minutes after injection, an anesthetist blinded to the study evaluated the extent of sensory blockade using the cold sensation and light-touch tests. The classic dermatomes were used: T6, xiphoid process; T10, umbilicus; T12, pubic bone area; and L1, inguinal ligament. Results of the cold and light-touch tests were compared with the contralateral side: 0, no block; 1, hypoesthesia; and 2, anesthesia. Preoperatively, patients received continuous peripheral nerve blocks if indicated for the main surgical procedure: axillary block for metacarpal, wrist, and radial osteosynthesis; interscalene block for humeral osteosynthesis; sciatic block for ankle and metatarsal osteosynthesis and talus surgery; and femoral block for femoral and tibial osteosynthesis and tibial osteotomy. Both these complementary nerve blocks and TAP blocks did not always cover the entire surgical site; moreover, we could not predict the size of the bone graft harvested on the AIC, so all patients received intraoperative general anesthesia with propofol 3 mg/kg and sufentanil 0.2 to 0.3 μg/kg, maintained with 50% nitrous oxide in oxygen and 1.5% end-tidal concentration of desflurane.

After surgery, patients were admitted to the recovery room after a wound dressing and an arm or leg splint had been applied. They received a multimodal analgesia regimen in the postoperative period with 1 g of paracetamol intravenously administered (IV) at the end of surgery and every 6 hrs thereafter, IV ketoprofene 100 mg twice a day for 48 hrs, and IV patient-controlled anesthesia morphine as rescue analgesia (bolus 1 mg, without basal flow, and 8-min lockout time) for 48 hrs. The level of pain at the iliac crest graft site was assessed at rest by visual analog scale (VAS) scores in the postanesthetic care unit (PACU) and then at 1, 6, 12, 24, and 48 hrs after surgery. Patients were instructed on how to differentiate pain from the main surgical site and pain from the iliac crest site. Time for first request of morphine was noted; morphine titration in the recovery room and use of morphine patient-controlled anesthesia as rescue analgesia at 24 and 48 hrs were noted. After 48 hrs, the injection site of the TAP block was inspected to detect any adverse effects such as hematoma or infection.

Eighteen months after surgery, every patient was questioned by phone about the importance and localization of pain and asked the following questions: "Do you still feel any pain or discomfort at the iliac crest area? Do you have abnormal sensation or numbness on the iliac crest area? Do you feel any discomfort with clothes?" The level of pain was assessed by numeric scale from 0 to 10.

Statistics

Continuous data are expressed as mean (SD) or median (range) for non-Gaussian variables. Categorical data are expressed as frequencies (%). Pain scores are presented as median; 10th, 25th, 75th, and 90th percentiles; and maximum values (>90th percentile).

RESULTS

Thirty-three consecutive patients, American Society of Anesthesiologists physical status 1 to 3, were included in the trial: 20 males and 13 females, aged from 16 to 77 years (mean age, 38.5 years). One patient was removed from the study for incomplete data. Patient characteristics and types of surgery are summarized in Table 1. The quality of acute postoperative pain relief is reported in Figure 3. The median value of VAS scores was 0 at all periods of assessment. Maximum values (>90th percentile) ranged from 2 to 8. The 75th percentile VAS scores were always

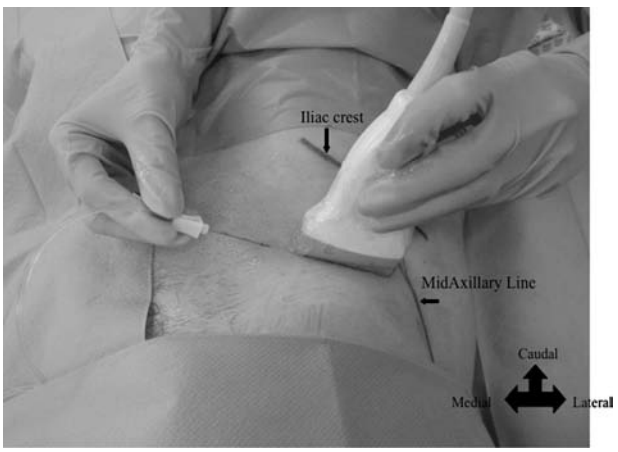

FIGURE 2. In-plane TAP block puncture under ultrasound guidance. The probe is placed cephalic to the iliac crest, transversally in the midaxillary line. The puncture is realized with a 50-mm, 22-gauge needle (Nanoline; Pajunk) in the plane of the probe.

TABLE 1. Demographic Characteristics and Type of Surgery

Patients Characteristics	
Sex, male/female	20:12
Mean age, mean (SD), y	38.5 (17.7)
Mean height, mean (SD), cm	169.4 (10.8)
Mean weight, mean (SD), kg	75.8 (16.6)
Type of surgery	
Upper limb (n = 16)	Osteosynthesis: metacarpal, n = 4; wrist, n = 3; humeral, n = 6; radial, n = 1; collarbone, n = 2
Lower limb (n = 14)	Osteosynthesis: ankle, n = 1; tibial, n = 5; femoral, n = 3; metatarsal, n = 2
	Tibial osteotomy, n = 1
	Femoral head osteonecrosis, n = 1
	Lesion of the talus, n = 1
Biopsies (n = 2)	Iliac crest biopsies, n = 2

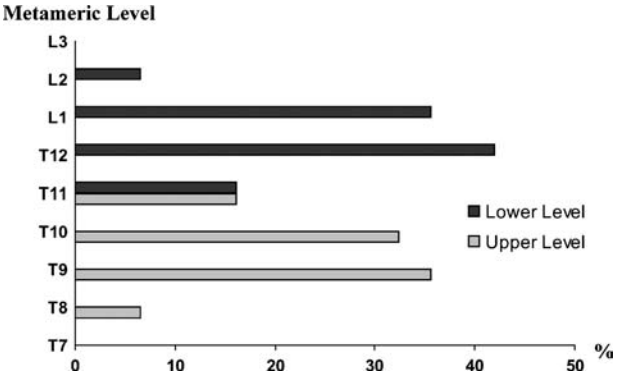

FIGURE 4. Sensory block extent (upper and lower levels) 20 mins after injection of the LA solution. The extent of sensory blockade was evaluated with ether solution (cold sensation) and the light-touch tests. The classic dermatome landmarks were used. One patient still had no sensory blockade 20 mins after TAP block injection.

4 or less. At 24 hrs, 19 patients (59.4%) had no pain (VAS score = 0), and 13 patients (40.6%) reported an acceptable pain (VAS scores from 1 to 5). At 48 hrs, 22 patients (68.7%) had no pain, and 10 patients (31.3%) reported an acceptable pain. At 20 mins, 62.5% of the patients achieved complete anesthesia, and 34% showed hypoesthesia. One patient has no sensory blockade. The extent of sensory blockade ranged from T9 (T7–T11) to L1 (T11-L2) (Fig. 4). The mean number of anesthetized dermatomes was 4 (SD, 1.5). For patients who needed rescue analgesia, the mean time for the first postoperative request of morphine was 297 (SD, 91) mins after TAP block. The median overall postoperative morphine consumptions in 24 and 48 hrs were, respectively, 7 mg (range, 0–47 mg) and 7 mg (range, 0–67 mg). Thirteen patients did not need any morphine titration in PACU, and after 48 hrs, 10 patients did not request any bolus of IV morphine. No complications or adverse effect during or after TAP block was reported. Table 2 reports follow-up phone calls for 19 patients for chronic pain at 18 months after surgery. Eighty percent of these patients did not complain about pain or discomfort at the iliac crest site. Twenty percent reported pain chronicization at the iliac crest site, with pain VAS values ranging from 2 to 4 (mean pain VAS value, 2.73). Among these patients, 2 have had multiple iliac crest harvests.

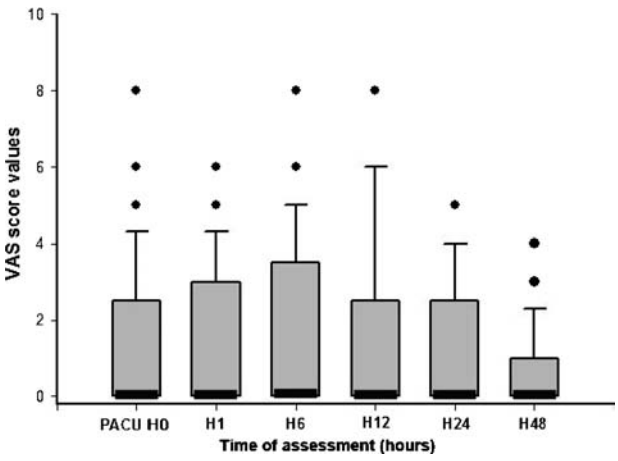

FIGURE 3. Visual analog scale score values in PACU and at 2, 6, 12, and 48 hrs. The box represents the 25th to 75th percentiles; the large dark line is the median. The extended bars represent the 10th to 90th percentiles, and the dark circles represent values outside this range. Medians, 25th percentiles, and 10th percentiles are confounded.

DISCUSSION

This prospective study reports that TAP block is an appropriate technique for postoperative pain relief after autologous bone graft harvest from the AIC. Performed under ultrasound guidance, it is an efficient and simple technique that covers a large unilateral sensory blockade including the AIC bone and overlying skin territory.

In this study, we decided to use TAP blocks under ultrasound guidance to avoid possible puncture of the digestive system or liver.[14–17] The primary landmark used was the midaxillary line, as suggested by Jankovic et al[18] in their study on cadavers. No complications were noted in our patients after the completion of the TAP blocks. Twenty minutes after puncture, only 1 patient had no sensory block. The other patients had an average of four dermatomes blocked with upper and lower levels consistent with those described by McDonnell et al[19] in a study on healthy

TABLE 2. Results of Phone Call Follow-Up for Chronic Pain Parameters at 18 Months After Surgery

	n (%)
Do you feel any pain or discomfort?	
Yes	4 (20)
If you feel any pain, how high is it on a scale between 0 and 10?	
0	15 (78)
1	0
2	2 (10)
3	1 (5)
4	1 (5)
>4	0
Numbness at iliac crest surgical site?	
Yes	5 (26)
Discomfort with clothes?	
Yes	3 (16)

volunteers using the Petit triangle location. This would seem to favor a wide distribution of LA in the abdominal transverse plane as well as a cranial or caudal spread when the injection is performed properly in the abdominal transverse plane.

In the present study, a preoperative TAP block with 15 mL ropivacaine 0.33% led to pain VAS score median values of 0 at any time of the assessment. Several studies, conducted mostly for spinal surgery, helped to quantify acute and chronic pain after iliac crest harvest. Shamsaldin et al[20] reported in 50 patients that mean postoperative pain at rest assessed on day 2 at the iliac crest bone harvest site was greater than 7 in 8% of the patients and between 5 and 7 in 54%. Heary et al[2] noted that 34% of 105 patients complained about moderate to severe pain (pain VAS scores between 1 and 5) and 3% about severe pain (pain VAS score >6). Concerning on-site single-shot or continuous LA surgical infiltration, the results are mixed. Brull et al[21] reported a median postoperative VAS score in PACU of 1.5 after a single injection of 10 mL of bupivacaine 0.25%. In a randomized double-blind trial, Schaan et al[22] obtained a significant decrease in postoperative pain after intraoperative infiltration with ropivacaine 0.75%. We present comparable data in our study. Using a continuous infusion of ropivacaine 0.2% 5 mL/hr or saline at the harvest site in 36 patients, Blumenthal et al[8] reported a significant decrease in pain VAS scores at rest and during mobilization (flexion of the thigh on the thorax) in the ropivacaine group during the first 48 hrs and at 3 months during mobilization (1 vs 5.8). Mean postoperative morphine consumption was 20 mg at 48 hrs in the ropivacaine group. In a randomized trial, Singh et al[10] compared a continuous infusion of bupivacaine 0.5% at 2 mL/hr with an elastomeric pump for 48 hrs versus infusion of saline solution at 2 mL/hr. They noted a decrease in morphine (hydromorphone) consumption in the bupivacaine group at 24 and 48 hrs (5.9 and 7.5 mg), but there was no significant trend for lower VAS scores. Morgan et al[3] found no significant difference between the 2 groups in terms of VAS scores (from H0 to 6 weeks postoperatively) and for morphine consumption (48.9 [SD, 35.76] during the first 24 hrs and 38.9 [SD, 35.86] during the second 24 hrs). In our study, postoperative VAS pain scores were very low and comparable with those obtained in previous studies using continuous LA infusion at the iliac crest site. However, the overall postoperative morphine consumption decreased compared with the earlier trials. This result emphasizes the need for optimal pain management by a single-shot infiltrative block distant from the surgical site. Some concerns about the risk of on-site infiltrative techniques with or without a catheter are reported in the literature. Previous studies reported that AIC site wound infection or dehiscence occurred in 2.4% to 5.6% of patients,[4,23] mainly in patients with comorbidities.[9,23] The TAP block could therefore be an attractive alternative to surgical infiltration.

In healthy volunteers, after completion of TAP block with lidocaine 0.5%, McDonnell et al[19] noted that the sensory block started to decrease at 4 hrs after the puncture. After gadolinium injection in the TAP, the magnetic resonance imaging signal began to decrease at 4 hrs after puncture. In our study, the mean time for the first morphine request was 5 hrs after TAP block performance. Given the results obtained by McDonnell et al,[19] this could match with the end of the sensory blockade. Nevertheless, patients still have a good quality of analgesia up to 48 hrs postoperatively with a single-shot injection.

Pain chronicization is a very relevant problem. In a retrospective analysis, Silber et al[4] studied 134 patients undergoing spinal surgery with iliac crest bone harvest. They noted that 26% of the patients reported pain chronicization, with a mean VAS score of 3.8, and 11.2% were still under analgesic treatment. Kim et al[7] reported 29.1% of noticeable numbness and abnormal sensation at the iliac crest donor site and 5.9% discomfort with clothing at 12 months. In another study,[24] persistent pain at the iliac crest site was noted in 39%, 38%, and 19% of patients at 3 months, 6 months, and 2 years after surgery, respectively. In our study, only 20% reported persistent pain at the iliac crest donor site. At 18 months, we noted almost the same proportion of patients with pain chronicization as in the study of Silber et al,[4] but the median level of pain noted in our patients was lower (2.7 vs 3.8). In the literature, results concerning the incidence of chronic pain and evaluation of morbidity after AIC bone graft vary a lot, depending on study design and population.[7] Twenty-six percent of the patients, interviewed after 18 months, reported numbness at the iliac crest surgical site, and 16% discomfort with clothing. These abnormal sensations related to neuropathic nature of the pain can be due to intraoperative nerve injuries or development of inflammatory mechanisms. It has been shown in a few studies that regional analgesia could prevent or limit the development of inflammatory and neuropathic mechanisms after a limited number of surgical procedures, but whether these techniques can also avoid the occurrence of complications related to direct nerve injury remains understudied. On the other hand, our data do not conclude for an effect on chronic pain as the incidence observed in the present study is in the range of what has been obtained elsewhere and by the fact that the incidence of chronic pain progressively decreases as a function of time. The percentages we reported are in agreement with the data from the literature, but we studied a case series, and we did not have a comparison group. Patients were well informed and educated to differentiate pain from the iliac crest site from pain from the principal surgical site. One possible bias in the comparison of patients' pain could be the size of graft harvested. Our patients benefited from different orthopedic surgeries of lower or upper limbs. Therefore, the size of graft varied depending on the main surgical site. However, according to Schaan et al,[22] there is no correlation between pain scores and the size of graft harvested. We could not evaluate analgesic consumption at 18 months in connection with the iliac crest pain. As patients often underwent multiple surgeries, they were always under analgesic treatments in relation to pain at their main surgical site.

In conclusion, according to the results of this preliminary study, preoperative ultrasound-guided TAP block seems to be a feasible technique for postoperative analgesia after AIC bone graft in orthopedic surgery patients. This block is easy to perform and safe, and a large extent of unilateral sensory blockade is achieved. Future comparative studies are necessary to confirm its efficiency and focus on its effect on long-term and chronic pain complications.

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