Ultrasound-guided continuous fascia iliaca compartment block for pre-operative pain control in very elderly patients with hip fracture: A randomized controlled trial

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Abstract. The present study presented the results of a prospective, randomized controlled trial. The present study enrolled 98 very elderly patients with hip fractures, complicated with at least one cardiovascular, neurological or pulmonary disease, of whom 10 patients were excluded. A total of 88 patients were randomly assigned into 2 groups: i) The control group, receiving traditional analgesia including 50 mg Tramadol and 500 mg paracetamol orally three times a day from admission to surgery; and ii) the study group, receiving ultrasound-guided continuous fascia iliaca compartment block (CFICB), a single 50 ml 0.4% ropivacaine injection with continuous infusion of 0.2% ropivacaine at a dose of 5 ml/h from admission to surgery. The primary outcome measure of pain relief or pain intensity was assessed preoperatively and up to 48 h postoperatively using a visual analog scale (VAS). The results of the present study indicated that in the preoperative period, in the morning of the day of surgery, the VAS pain at rest scores were lower in the study group compared with the control group (P=0.023). The VAS passive movement scores of the study group were also significantly lower compared with the control group 1 h following analgesia at the time of admission (P<0.05) and in the morning of the day of surgery (P<0.05). Scores for patients' satisfaction with the analgesic regimen in the preoperative period were greater in the study group compared with the control group (P<0.001). There was no difference in analgesia-associated side effects between groups. Duration of hospital stay of patients in the control group was significantly longer compared with the study group (P=0.001). Patients in the study group were less likely to have increased complications compared with patients in the control group over the N2-N4 period (from preoperative period to after surgery; P=0.016). The present study concluded that ultrasound guided CFICB was an effective method of providing analgesia for very elderly (≥80 years old) with hip fracture.

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Introduction

The number of elderly patients undergoing surgery due to hip fracture is increasing both in China and around the world (1). It is predicted that by 2050, 6.3 million new cases of hip fracture will be diagnosed each year (2). Hip fracture is common in the elderly, and is associated with significant morbidity and mortality (3). The mortality during hospital stay is 2.3-13.9%, 6-month mortality ranges from 12-23%, and 1-year mortality is ~37.1% for men and ~26.4% for women (4). The main reported causes of mortality following hip fracture are cardiovascular, neurological and pulmonary (5). Numerous guidelines and researches recommend that patients with hip fracture should undergo surgery within 24-48 h and early surgical treatment can relieve pain, and reduce the incidence of postoperative complications and mortality (6-9). Despite remarkable benefits of early surgery following hip fracture on outcomes and elderly patients exhibit numerous complications. The most common coexisting diseases include cardiovascular disease (35%), respiratory disease (14%) and cerebrovascular disease (13%), and ~70% of patients are classified as American Society of Anesthesiologists (ASA) stage III or IV (10) in poor health and time to surgery is prolonged due to direct oral anticoagulants and other factors, including waiting for routine medical clearance and unavailability of the operating suite or surgeon (11,12). In China, very elderly are frequently defined as ≥80 years old patients, and it has been estimated that the lifetime risk for an 80-year-old man or woman to sustain a hip fracture is 9 and 19%, respectively (13). A survey has indicated that very elderly patients with hip fracture in Xuanwu Hospital, Capital Medical University (Beijing, China) account for 35% of all very elderly patients, which is significantly increased compared with the numbers reported in Sweden (the percentage of very elderly patients with hip fracture in Sweden accounts for 9% for men and 19% for women of very elderly patients) (13). High morbidity and mortality are expected due to the advanced age and comorbidities of these patients (14). Preoperative management serves an important role in decreasing the morbidity and mortality of patients. Multiple interventions have been employed to minimize complications and duration of hospitalization including preoperative analgesia (9,15). Severe pain is frequently observed in

the preoperative period. Preoperative analgesia is administered to relieve pain and decrease the systemic stress response (16). Systemic analgesia using opioids and nonsteroidal analgesia may lead to significant adverse effects particularly in elderly patients due to age-associated pharmacokinetic and pharmacodynamic alterations (17). Previous studies have demonstrated the advantages of epidural analgesia by comparing epidural analgesia with conventional drug analgesia in elderly patients with hip fractures (18,19). The results of these studies indicated that epidural analgesia can reduce the incidence of preoperative cardiovascular events, however, epidural block has an impact on circulation, and patients with hip fracture receive anticoagulant therapy immediately following admission, which may lead to epidural hematoma and other severe consequences (18,19). Peripheral nerve blockade is a potential substitute for epidural analgesia (20), which requires further study. Due to the advantages of fascia iliaca compartment block, its application in analgesia prior to hip fracture surgery is increasing, but a number of studies have investigated the effect of single fascia iliaca compartment block (21,22). Very elderly patients mostly exhibit one or more comorbidities and, therefore, the preoperative waiting time may be prolonged. In these cases continuous fascia iliaca compartment block (CFICB) may be more advantageous and two studies have indicated that CFICB is effective in hip fracture analgesia (23,24). However, whether ultrasound-guided CFICB is more advantageous compared with traditional analgesic drugs and whether it helps to reduce the incidence of perioperative complications in very elderly patients complicated with cardiovascular, neurological or pulmonary disease have not yet been reported. It is hypothesized that fascia iliaca blocks by means of continuous catheters may greatly reduce the morbidity in patients with hip fracture for the evaluation of the influence and prevalence of resultant side effects from opiate medications. It is therefore of interest to evaluate the effectiveness of preoperative analgesia provided by CFICB or systemic analgesia in very elderly patients with hip fracture. The aim of the present study was to investigate the effect of ultrasound-guided CFICB in very elderly patients with hip fracture complicated with cardiovascular, neurological or pulmonary disease in the preoperative waiting period.

Patients and methods

Patients. The present study was prospective, randomized and controlled, and had been registered at www.chictr.org.cn (registration number: ChiCTR-IPR-15007283). This study was approved by the Ethics Committee of Xuanwu Hospital of Capital Medical University and all patients had signed informed consent. Elderly patients admitted to Xuanwu Hospital, Capital Medical University (Beijing, China) due to hip fracture from October 2015 to December 2016 were included in the present study (Fig. 1). The following inclusion criteria were used in the present study: i) Diagnosis of hip fracture (femoral neck or intertrochanteric fractures) by X-ray at admission; ii) age ≥80 years; iii) complication with at least one kind of cardiovascular, neurological or pulmonary disease; iv) ASA classification III or IV; and iv) being male or female. Exclusion criteria were: i) Presence of more than one fracture; ii) allergy to amides, paracetamol and tramadol; iii) infection at fascia iliaca compartment puncture site; iv) peripheral neuropathy; v) contraindication of intraspinal block; vi) renal insufficiency and dementia; vii) preoperative waiting time ≥5 days; and vii) refusing to participate in this study.

Treatment groups and the protocol. Patients meeting the inclusion criteria were randomly assigned into two groups, the control group and the study group, by a computer-generated random number table method (MATLAB 2014a; MathWorks, Natick, MA, USA) with randomized group information sealed in an opaque envelope, the envelopes were numbered and used sequentially. All patients were assessed cognitive function with the Mini-Mental State Examination at admission. The control group received traditional analgesia including 50 mg Tramadol (batch no. 10087215; Mundipharma International, Ltd., Cambridge, UK) and 500 mg paracetamol (batch no. 140616620; Johnson & Johnson, New Brunswick, NJ, USA) orally three times a day from admission to surgery. The patients in the control group were not subjected to CFICB and were administrated with saline. In the study group, after the patients were diagnosed with hip fracture by X-ray at admission, the fracture side received ultrasound-guided CFICB following establishment of the upper limb venous pathway. The CFICB operation was performed as follows: Patients were in supine position and the puncture site was selected at 1 cm to the junction point at 1/3 of the connection of anterior superior spine and pubic tubercle. A M-Turbo ultrasound apparatus (Sonosite, Inc., Bothell, WA, USA) high-frequency probe was placed in parallel to the inguinal fold to distinguish the femoral fascia and fascia iliaca, the needle was inserted with out-of-plane technique at an angle of 45˚ and the tip of the needle was pointed to the head. Once needle-tip placement under the fascia iliaca by hydrolocation was confirmed, the probe was rotated 90˚ into a longitudinal parasagittal orientation to visualize the needle tip in-plane and to track cephalad spread of the injectate under fascia iliaca. A total of 50 ml 0.4% ropivacaine (batch no. NAKR; AstraZeneca, Cambridge, UK) was injected and formed a fluid-filled space beneath the fascia. Subsequently, the catheter was inserted with the puncture needle and the tip of the catheter was 5-10 cm beyond the tip of the needle. Following confirmation of the correct location of the catheter, the catheter was fixed tightly and connected to the electronic analgesic pump to continuously infuse 0.2% ropivacaine at a rate of 5 ml/h until the day of surgery. The local anesthetic moved cephalad and reached the nerves of the lumbar plexus, including the femoral, lateral cutaneous and obturator. If the analgesic effect was inadequate (VAS score >30 mm), 5 ml of 0.2% ropivacaine would be added into the fascia iliaca compartment. In the morning of the day of surgery, the catheter was removed from the fascia iliaca compartment. Ultrasound-guided CFICB was performed by an anesthesiologist with experience in ultrasound-guided nerve block.

According to the type of fracture, the patients were treated with proximal femoral nail antirotation, hemiarthroplasty, cannulated screws or total hip replacement. Subcutaneous injection of enoxaparin sodium (40 mg/day; batch no. 4sj11; Sanofi S.A., Paris, France) was given to all patients preventively after admission, which was discontinued 12 h prior to surgery and continued on the first day after surgery. All patients received combined subarachnoid and epidural anesthesia in L2-3 or L3-4 interspace and subarachnoid injection

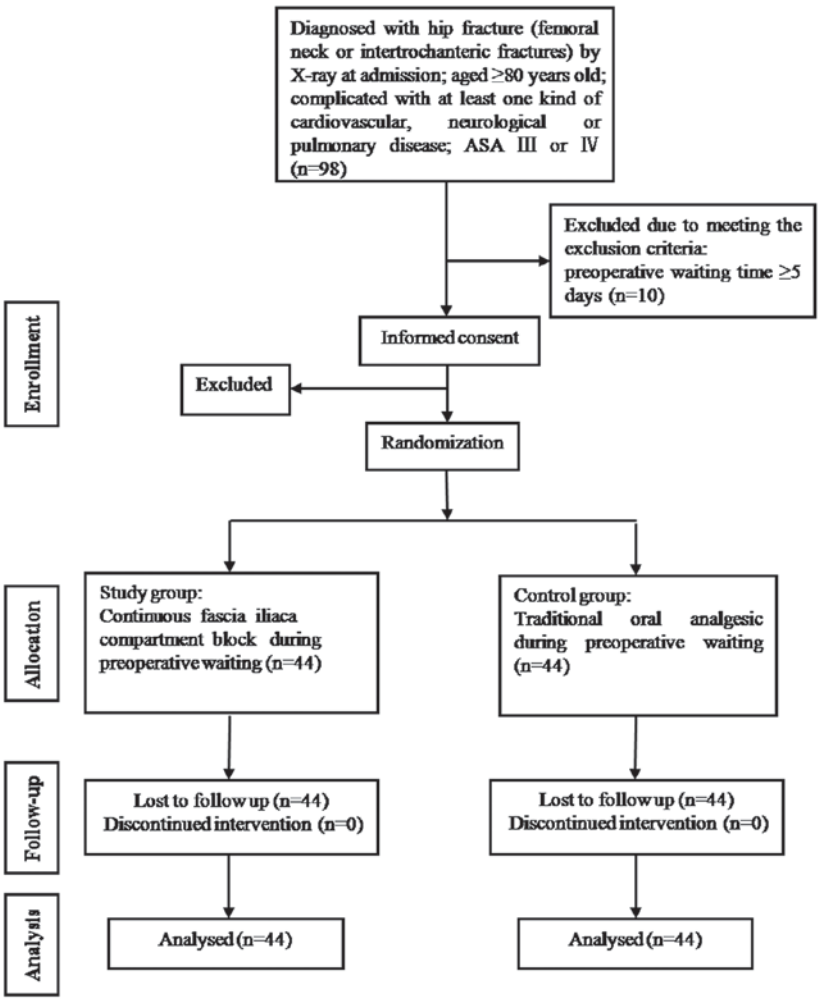

Figure 1. Consolidated standards of reporting trials flowchart of subject enrollment.

of 0.5% bupivacaine (batch no. 73141014; Shanghai Harvest Pharmaceutical Co., Ltd, Shanghai, China) 1.0-1.5 ml for 35-40 sec. After the injection, a 3 cm catheter was placed into the epidural cavity, 2% lidocaine (batch no. 20150401; Beijing Yimin Pharmaceutical Co., Ltd, Beijing, China) was administered through the epidural catheter in doses of 3 ml as needed, and the level of anesthesia was maintained at ~T_{10}. After surgery, all patients entered the post anesthesia care unit for at least 1 h and then were transferred to the wards. All patients received patient-controlled intravenous analgesia within 48 h after surgery, and the analgesic regimen was 1.5 μg/kg sufentanil (batch no. 1150309; Yichang Humanwell Pharmaceutical Co., Ltd, Yichang, China) and 8 mg ondansetron hydrochloride (batch no. 140202A02; Ningbo Tenet Pharmaceutical Co., Ltd, Zhenhai, China), diluted with normal saline to 100 ml, at a background dose of 1-2 ml/h and a single added dose of 1 ml, with a lockout interval of 10 min. From day 3 to discharge, the patients received oral analgesic drugs.

Primary outcome measure. The present study used VAS scores (0-100, with 0 indicating no pain and 100 indicating the worst imaginable pain) to evaluate the analgesic effect and recorded VAS scores at rest (lying flat) and on movement (movement-associated pain was elicited by passively elevating the fractured leg to 15˚) prior to administration of analgesia (t0), 1 h after administration of analgesia (t1), in the morning of the day of surgery (before surgery; t2), in the morning of the day after surgery (t3) and in the second morning after the day of surgery (t4). The patients used VAS (0-100) to evaluate the satisfaction with the analgesic regimen in the preoperative waiting period.

Secondary outcome measures. The present study recorded the number of patients developing analgesia-induced complications, including nausea, vomiting, respiratory depression (respiratory rate of <10/min) and excessive sedation (Ramsay score ≥3 points, where score 1 point indicated not quiet, agitated patients; 2 points: Quiet and cooperative patients; 3 points: Drowsy and obeying directive; 4 points: Drowsy and responding to tactile stimulation; 5 points: Lethargic and only responding to strong stimulation; 6 points: In deep sleep, no response to calling). The number of patients needing additional rescue analgesia and CFICB complications were also recorded, including local anesthetic toxicity, puncture site infection and hematoma. Nausea and/or vomiting were treated using intravenous administration of ondansetron. Respiratory depression was treated by close surveillance together with naloxone and oxygen.

Other outcome measures. Incidence of cardiovascular, pulmonary and cerebral complications during hospital stay was

also recorded. Cardiovascular complications included acute myocardial infarction, angina pectoris, new arrhythmia (atrial fibrillation, ventricular premature beats and tachycardia), acute heart failure, cardiac arrest and deep venous thrombosis of lower extremities. Diagnosis of myocardial infarction was reached if: i) CK-MB isoenzyme or troponin-I concentrations were above the laboratory myocardial infarction threshold (CK-MB, >4.99 ng/ml; cTNI, >0.02 ng/ml); and ii) either new Q waves (≥0.03 s) or persistent alterations (4 days) were identified in the ST-T segment. Unstable angina was defined as severe precordial chest pain with a duration of ≥30 min and unresponsive to standard therapy, associated with ST-segment or T-wave alterations without Q waves or cardiac enzyme abnormalities. Congestive heart failure was defined using clinical (shortness of breath, rales, jugular venous distention, peripheral edema and third heart sound) and radiological (cardiomegaly, interstitial edema, alveolar edema) signs and required modified medication involving minimum treatment with diuretic drugs. New arrhythmia was confirmed by 12-lead electrocardiogram. Pulmonary complications included pulmonary infection, pulmonary embolism and respiratory failure, and cerebral complications included new cerebral infarction and delirium. The above complications were diagnosed by clinical symptoms associated with relevant auxiliary examinations. The incidence of cardiovascular, pulmonary and cerebral complications was recorded in three periods: The preoperative waiting period, surgery and form the end of surgery to discharge. Four different periods, including hospital admission, preoperative period, surgery and following surgery, were denoted as N1, N2, N3 and N4, respectively. In addition, the preoperative waiting time, length of stay, hospital costs and mortality during hospitalization were recorded.

Analgesic effects, analgesia-induced complications and CFICB-associated complications were evaluated and recorded by the acute pain service. Patients' general characteristics, including gender, age, weight, height, ASA grade and type of surgery; perioperative complications; preoperative waiting time; length of stay; hospital costs and other data were collected by another anesthesiologist in a blinded manner.

Statistical analysis. All the analyses were performed using SPSS software (version 18.0; SPSS, Inc., Chicago, IL, USA). The sample size was estimated based on two-way repeated measures analysis of variance comparison of the VAS scores between groups. VAS scores were measured at five different time points outlined above for each patient. A total of 40 patients in each group were required to complete the study and the assumptions of 5% type I error rate, 80% power and 0.45 effect size were considered. Based on the assumption of a dropout rate of ~10%, 44 patients would be required to be enrolled in each group. A total of 88 patients were included in the statistical analysis, 44 cases were included in the control group and 44 cases in the study group.

Data are presented as mean ± standard deviation for continuous variables and as frequency (%) for categorical variables. For continuous variables, the normal distribution assumption was assessed. Equal variance assumption was also assessed. The differences of these characteristics between the control group and study group were performed using independent two-sample t-tests. Categorical variables were summarized using frequency and percentage and compared using Chi-square test. Intergroup differences in VAS scores were assessed by two-way repeated measures analysis of variance with Bonferroni post hoc test. $P<0.05$ was considered to indicate a statistically significant difference.

Results

Demographic data. From October 2015 to December 2016, a total of 88 patients were included in the statistical analysis, 44 cases were included in the control group and 44 cases in the study group. General patients' characteristic and surgical characteristics were summarized in Table I. No significant differences were identified between the two groups, including age, height, weight and ASA classification (Table I). The duration of hospital stay of the control group was significantly longer compared with the study group.

Pain assessment. Although the differences were small, VAS pain scores at rest of the study group were lower compared with the control group ($P=0.023$) at the time point t2. There were no significant differences in the VAS pain scores at rest between the groups at the other time points ($P=0.178$ at t0; $P=0.260$ at t1; $P=0.240$ at t3; $P=0.103$ at t4; Fig. 2; Data are presented as the mean ± standard deviation).

VAS pain scores at passive movement of the study group were significantly lower compared with the control group at the time point t1 ($P<0.05$) and t2 ($P<0.05$). There were no significant differences in VAS pain scores at passive movement between the groups at the other time points ($P=0.931$ at t0; $P=0.762$ at t3; and $P=0.139$ at t4; Fig. 3; Data are presented as mean ± standard deviation).

Scores for patients' satisfaction with the analgesic regimen in the preoperative period were increased in the study group compared with the control group (45.68±11.29 in the control group vs. 74.77± 9.52 in the study group; $P<0.001$; Table II).

Intergroup differences in VAS scores were assessed by two-way repeated measures analysis of variance with Bonferroni post hoc test. For VAS pain scores at rest, there were no significant differences between the groups ($P=0.472$). Significant time effect ($P<0.001$) and significant interaction effect between time and group ($P=0.034$) were identified; a significant difference of VAS at rest between groups at time point t2 and no significant difference at other time points were observed. For VAS pain scores at passive movement, there were significant differences between groups ($P<0.001$), significant time effect ($P<0.001$) and significant interaction effect between time and group ($P<0.001$); a significant difference of VAS at passive movement between groups at t1 and t2 and no significant difference at other time points were suggested.

Side effects. The incidence of nausea and vomiting were similar between the control group and the study group in the preoperative period ($P=0.195$ and $P=1$; respectively; Table II). All patients in the present study did not demonstrate symptoms of respiratory depression and excessive sedation in the preoperative waiting period. The study group did not develop CFICB complications (local anesthetic toxicity, puncture site infection and hematoma in preoperative waiting period; data not shown).

Table I. Characteristics of patients.

Characteristics	Control group (n=44)	Study group (n=44)	P-value
Waiting time before surgery (days)	3.34±0.89	3.27±0.82	0.709
Hospital stay (days)	13.55±6.03	9.98±2.46	0.001
Hospital expenses (¥RMB)	65,786.82±19,741.77	61,425.02±13,159.95	0.226
Male (n, %)	14 (31.8%)	16 (36.4%)	0.653
Age (years)	83.73±3.40	84.05±5.04	0.730
Weight (kg)	60.18±10.83	58.70±12.35	0.552
Height (cm)	159.93±7.12	163.20±9.38	0.069
ASA stage (n)			0.676
III	40	42	
IV	4	2	
Type of surgery (n)			0.752
Hemiarthroplasty	9	6	
Proximal femoral nail antirotation	33	34	
Cannulated screws	1	2	
Total hip replacement	1	2	
Anesthesia method (n)			1.000
Combined spinal-epidural anesthesia	44	44	
Duration of anesthesia (min)	168.73±47.13	158.48±36.71	0.258
Duration of operation (min)	95.07±42.53	82.25±32.79	0.117
Total liquid intake (ml)	985.23±156.48	965.91±158.40	0.566
Crystalloid solution volume (ml)	628.41±238.06	613.64±206.40	0.757
Colloidal solution volume (ml)	279.55±241.68	304.55±263.21	0.644
Bleeding (ml)	180.68±89.76	168.18±111.13	0.563
Urine volume (ml)	411.59±179.29	373.86±199.27	0.353
Intraoperative blood infusion (n, %)	9 (20.5%)	9 (20.5%)	1.000
MMSE	20.95±1.57	21.18±1.77	0.526

Values are presented as the mean ± standard deviation or number (proportion). ASA, American Society of Anesthesiologists; MMSE, mini-mental state examination.

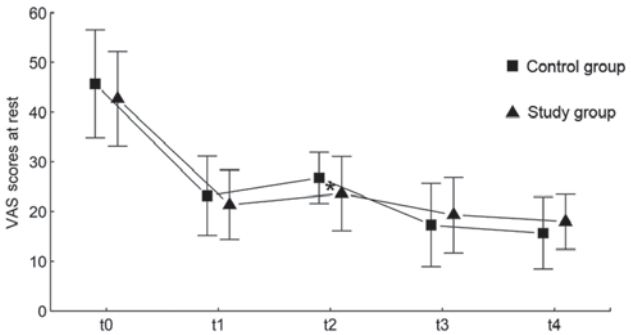

Figure 2. VAS pain scores at rest. VAS, visual analog scale; t0, VAS score prior to analgesia at basic rest; t1, VAS score 1 h after analgesia; t2, VAS score in the morning of the day of surgery; t3, VAS score in the first day after surgery; t4, VAS score in the second day after surgery. *P<0.05 vs. the control group.

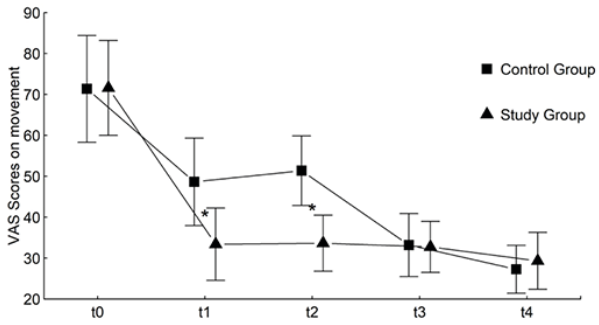

Figure 3. VAS pain scores at passive movement. t0, VAS score prior to analgesiaat basic rest; t1, VAS score 1 h after analgesia; t2, VAS score in the morning of the day of surgery; t3, VAS score in the first day after surgery; t4, VAS score in the second day after surgery. *P<0.05 vs. the control group.

Number of complications. The number of complications was calculated at four different periods, including hospital admission, preoperative period, surgery and following surgery, and were denoted as N1, N2, N3 and N4, respectively (Fig. 4). The alterations in the number of complications between two different time points were analyzed, as shown in Table III. Patients in the study group were less likely to have increased complications compared with patients in the control group over the N2-N4 period (from preoperative period to after surgery; P=0.016; Table III).

Table II. Analgesia satisfaction scores and analgesia-associated side effects.

Parameters	Control group (n=44)	Study group (n=44)	P-value
Satisfaction with the analgesic regimen in the preoperative period	45.68±11.29	74.77±9.52	<0.001
Nausea (n, %)	12 (27.3%)	7 (15.9%)	0.195
Vomiting (n, %)	5 (11.4%)	4 (9.1%)	1.000

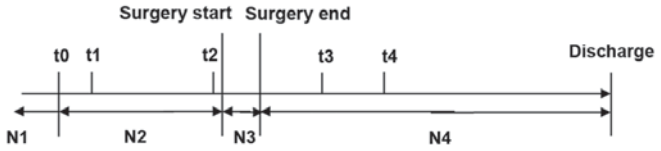

Figure 4. Analgesic effect observation time points (t0-4) and complications observation time periods (N1-4).

Patient mortality. A total of 3 patients succumbed to mortality in postoperative hospitalization. A total of 2 cases (4.5%) succumbed to mortality in the control group, including 1 mortality due to respiratory failure and 1 mortality due to acute myocardial infarction and heart failure. A patient (2.3%) in the study group succumbed to sudden cardiac mortality associated with malignant arrhythmia.

Discussion

Patients with hip fracture are often in considerable pain and, if untreated, may develop various complications that delay operative intervention and prolong hospitalization (25). Pain management is believed to be critical in both the pre- and post-operative periods for patients with geriatric hip fractures (26-28). For most fractures, administration of systemic analgesics including opioids, paracetamol and non-steroidal anti-inflammatory drugs is preferred for pain management. Despite the relative safety of paracetamol, both opioids and nonsteroidal analgesia can induce significant adverse effects especially in the elderly population (17,29). According to the guidelines from the National Institute for Health and Clinical Excellence, neural blockade by trained personnel is recommended for a reasonable opioid dosage (30).

The present study demonstrated that pain relief was superior in the study group (patients aged ≥80 years old, complicated with at least one type of cardiovascular, neurological or pulmonary disease), compared with the control group, during the preoperative period. In addition, CFICB was associated with greater patient satisfaction, which was consistent with the results of Candal-Couto *et al* (23) and Dulaney-Cripe *et al* (24). Diakomi *et al* (31) concluded that performing an FICB prior to positioning for spinal anesthesia provided superior pain management compared with intravenous fentanyl administration facilitated spinal performance. According to Diakomi *et al* (31) and the present study, FICB provided superior analgesia not only prior to positioning for spinal anesthesia but also during the preoperative period. The study group in the present study did not develop CFICB-associated complications. The present results suggested that a fascia iliaca compartment block performed via a catheter provided a significant benefit to very elderly patients with hip fractures. Hip innervation involves the lateral cutaneous nerve of the thigh, the femoral nerve and the obturator nerve (32). Fascia iliaca compartment block utilizes the space under the iliac fascia where the femoral, obturator and lateral cutaneous nerves are located (33). The block acts by suppressing the sensation of pain in the femoral nerve, lateral femoral cutaneous nerve of the thigh and obturator nerve (22). The incidence of nausea and vomiting were similar between the control group and the study group during pre-operative period, which may have been due to the small number of patients enrolled in this study. In other countries, a majority of patients with hip fracture undergo single fascia iliaca compartment block in the emergency room prior to surgery (21,22), while in the present study, continuous block and perineural catheter placement permitted the provision of continuous peripheral nerve block, thereby extending the duration of analgesia.

Szucs *et al* (34) have demonstrated that continuous femoral nerve block provided a more effective perioperative analgesia compared with a standard opiate-based regimen for patients undergoing fixation of fractured neck of femur. Another study

Table III. Number of complications in the four time periods in the control and study groups.

Time period	Control group (n=44)	Study group (n=44)	P-value
N2 vs. N1			1.000
No change	40	41	
Increase	4	3	
N3 vs. N1			1.000
No change	40	40	
Increase	4	4	
N4 vs. N1			0.059
No change	32	39	
Increase	12	5	
N3 vs. N2			0.306
Decrease	2	0	
No change	41	43	
Increase	1	1	
N4 vs. N2			0.016
Decrease	2	0	
No change	33	42	
Increase	9	2	

N1, hospital admission; N2, preoperative period; N3, during surgery; N4, after surgery.

suggested that both ultrasound-guided continuous femoral nerve block and fascia iliaca compartment block with a novel cannula-over-needle provide effective anesthesia and postoperative analgesia for elderly patients with hip replacement (35). It has been reported that 3-in-1 femoral nerve block is also effective in hip fracture analgesia (20,36). Femoral nerve block is recognized as an effective method; however, it is controversial due to its potential for nerve injury and femoral nerve block can cause quadriceps weakness (37). The FICB technique is somehow favorable compared with the femoral nerve block technique, as it is not necessary to use a neurostimulator during the procedure (38). The site of injection with the FICB is distant from any nerves or blood vessels, where intravascular or intraneural injection is contraindicated in principle (39). The fascia iliaca compartment block is more effective compared with the 3-in-1 block in producing simultaneous blockade of the lateral femoral cutaneous nerve of the thigh and femoral nerves in adults (40). The three nerves, including femoral nerve, lateral femoral cutaneous nerve of the thigh and obturator nerve, were more successfully blocked by FICB (>90%) compared with the 3-in-1 block (20%) (33). In addition, performing the fascia iliaca compartment block is easier to teach and learn compared with the 3-in-1 block, and more convenient and cost-effective (41). Therefore, the continuous FICB was selected in the present study.

The sensorial innervation of the hip is provided by the nerves in the lumbar plexus and sacral plexus (42). Although whether lumbar or sacral plexus have a primary effect on sensorial innervation of the hip remains unknown, according some previous studies (39,40) and the present study, the lumbar plexus block can provide effective analgesia. In addition, the two groups of patients included in the present study did not undergo FICB after surgery, as neural blockade could intervene with postoperative mobilization in those patients.

There are numerous ways to perform the FICB, including the loss of resistance ('2-pop technique') (21), ultrasound guided blocks (43) or the nerve stimulators for femoral nerve localization (44). Nerve stimulator-based femoral nerve block is characterized by stimulation of the leg muscles, which may cause discomfort to the patient and compromise the fracture alignment (45). Ultrasound guidance does not require a nerve stimulator, facilitates the FICB technique and reduces the risk of block failure or nerve injury (43,46).

The results of the present study indicated that the length of stay was shorter and costs of hospitalization were slightly lower in the study group compared with the control group. After hip fracture, pain is an important determinant of function, which therefore determines length of stay and clinical outcome, defined by complication and mortality rates (47). Adequate analgesia allows for increased mobility of patients and reduced duration of hospitalization (24,28). A shorter stay is beneficial to patients in terms of reduced risk of hospital-acquired complications and the associated reduction of costs of hospitalization is economically beneficial for the healthcare system (24,48). In addition, in the present study, the duration of hospital stay was shorter in the study group compared with the control group, which may have been associated with the number of patients with increased complications being smaller in the study group compared with the control group.

Patients in the study group were less likely to have increased complications compared with patients in the control group over the N2-N4 period (from preoperative period to after surgery), and the results of the analysis of postoperative morbidity outcomes should be interpreted cautiously, as these factors, including the supplement of oxygen, fluid management and mobilization, were not controlled. However, failure to stabilize the medical conditions prior to surgery poses an increased risk of postoperative cardiac and pulmonary complications, prolonged hospitalization and mortality (49). The present study indicated that ultrasound-guided CFICB induced a satisfactory analgesic effect, which may be associated with decreased incidence of complications in the study group, compared with the control group after surgery.

In addition, mortality during hospital stay was 2/44 (4.5%) in the control group and 1/44 (2.3%) in the study group, which was consistent with earlier studies that reported in-hospital mortality rates of 2.3-13.9% in unselected groups of patients with hip fracture (4).

There are several limitations of the present study and it was mainly limited by its size. Due to a small number of cases, whether ultrasound-guided CFICB can reduce the incidence of postoperative cardiovascular, pulmonary and cerebral complications in very elderly patients with hip fracture requires further confirmation by multicenter and large-sample size studies. Furthermore, the patients were not blind to group allocation due to the ethical considerations. As it was considered ethically unacceptable to insert a placebo fascia iliaca compartment catheter for blinding purposes only, no further damage could be simulated in the control group patients, and, therefore the patients in the control group were not subjected to CFICB and administrated with saline. Furthermore, the present study only recorded patients' mortality during the hospital stay, without a follow up for a longer period.

In conclusion, the present study demonstrated that ultrasound guided continuous fascia iliaca compartment block may provide a superior analgesia for very elderly patients with hip fracture compared with patients receiving systemic analgesia-based regimen during the preoperative period.

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Availability of data and materials

The datasets used and/or analyzed during the present study are available from the corresponding author on reasonable request.

Authors' contributions

YM and TW designed the study. JW performed the collection and entry of the data. JX analyzed the data. YM prepared the

manuscript. FL participated in the collection of the data and a literature analysis. All the authors read and approved the final manuscript.

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Xuanwu Hospital, Capital Medical University (Beijing, China). Signed written informed consents were obtained from the patients.

Patient consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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