Original Article

Factors associated with prolonged duration of ultrasound-guided brachial plexus block for the upper limb fracture surgery: a cross-sectional study

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Background: Previous studies of factors associated with prolonged duration of ultrasound-guided brachial plexus block have included multiple surgical procedures or multiple anesthetic approaches, all of which are important confounders, and there is no study based on a single method of anesthesia exploring the factors affecting the resolution of brachial plexus block during upper limb surgery, especially in Asians. This study aimed to identify the risk factors affecting the prolonged duration of US-guided brachial plexus block in American Society of Anesthesiologists (ASA) I–II grade patients to improve postoperative analgesia.

Methods: This study enrolled patients scheduled to undergo surgery for upper limb fracture in Anting Hospital, Shanghai from May 2021 to September 2021. Inclusion criteria: (I) patients aged 18 years and above; (II) ASA I–II grade patients; (III) success of US-guided brachial plexus block. Based on the median duration of brachial plexus block, patients were divided into a <5-hour group and a ≥5-hour group. The factors were selected base on previous studies conclution and clinical demographic characteristics of patients. Multivariable logistic regression was used to estimate relevant influencing factors.

Results: A total of 129 patients (51.2% males; 51.01±16.54 years old) were analyzed. The duration of brachial plexus block was 2–12 hours, with a median duration of 5.09 hours. Multivariable analysis suggested that age 40–49 years [odds ratio (OR): 4.841; 95% confidence interval (CI): 1.033 to 22.695; P=0.045], 50–59 years (OR: 4.730, 95% CI: 1.149 to 19.474; P=0.031), 60 years (OR: 8.540; 95% CI: 1.605 to 45.449; P=0.012), gender (OR: 3.314; 95% CI: 1.330 to 8.257; P=0.010), alanine aminotransferase (ALT; OR: 5.817, 95% CI: 1.509 to 22.472; P=0.011), and glomerular filtration rate (GFR) <60 (OR: 22.700; 95% CI: 1.994 to 198.386; P=0.012) were the risk factors for the duration of brachial plexus block.

Conclusions: It is advisable to use the lowest effective dose for the shortest possible time when using ropivacaine in upper limb fracture surgery patients with elevated ALT (≥40 U/L) and lower GFR (<60 mL/min) in male patients aged ≥60 years.

Keywords: Duration; brachial plexus block; risk factors; cross-sectional study; ultrasound (US)

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Introduction

Brachial plexus block is a commonly used regional nerve block anesthesia in clinical practice which is mostly used in upper limb surgery. In this method, local anesthetics are injected around the brachial plexus trunk to block nerve conduction in the area innervated by the peripheral plexus, which can effectively relieve surgical pain (1) and provide a better anesthetic effect (2). Multiple approaches, such as axillary brachial plexus block, interscalene brachial plexus block, superior trunk block, infraclavicular brachial plexus block, and supraclavicular brachial plexus block, may be preferred depending on the indications and anatomy of the patient (3). However, a blind puncture may cause blood vessel damage, pneumothorax, and block failure.

Ultrasound (US)-guided plexus blocks have the advantages of a higher success rate, visualized operation, shorter onset time, and lower incidence of puncture complications than the traditional nerve localization methods, such as anatomical positioning of the body surface, parasensory methods, and use of nerve stimulators (4). They have been widely used in clinical multiple injection plexus block anesthesia (5). The US-guided lower brachial plexus block is routinely used with long-acting local anesthetics to maintain long-term postoperative analgesia (1,4). However, the time of plexus block regression after surgery varies among patients, which can result in recurrent pain, causing increased unplanned treatment and decreased patient satisfaction (1,6). Therefore, it is important to identify factors associated with resolution of US-guided lower brachial plexus block for the improvement of postoperative analgesic effects in patients.

The duration of the nerve block refers to the time starting from anesthesia to the recovery of consciousness in terms of normal perception, exercise ability, and absence of numbness to the level of the state before operation (7). The available literature offers difference evidence in terms of factors that may influence block duration (7-10). Prospective study has reported a large inter individual variation in time of axillary plexus block offset using ropivacaine 0.75%. The lack of association between offset time and both demographic and block performance factors (8). It also has been reported that age might be a potential risk factor that affects the resolution of ropivacaine brachial plexus block during the upper limb surgery (7,11). The dose and concentration of anesthesia also affect the time taken for a plexus block to subside (12,13). However, a study based on European and American populations reported that the demographics [gender, age, weight, and body mass index (BMI)] and the American Society of Anesthesiologists (ASA) classification are not associated with the intraoperative or postoperative resolution of brachial plexus block performed with multiple anesthesia methods (including US guidance) (7). Previous studies have included multiple surgical procedures or multiple anesthesia methods, all of which are important confounding factors. In addition, previous studies on brachial plexus block resolution have been based primarily on European and American populations. Currently, there is no study based on a single method of anesthesia exploring the factors affecting the resolution of brachial plexus block during upper limb surgery. Therefore, in the present study, we analyzed the factors that affect the duration of US-guided brachial plexus block during upper limb fracture surgery. We present the following article in accordance with the STROBE reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6365/rc).

Highlight box

Key findings

- Gender, increased age and ALT, and decreased GFR are risk factors for the duration of brachial plexus block.

What is known and what is new?

- Brachial plexus block is a commonly used regional nerve block anesthesia in clinical practice, mostly used in upper limb surgery.
- In the present study, we analyzed the factors that affect the duration of ultrasound-guided brachial plexus block during upper limb fracture surgery.

What is the implication, and what should change now?

- Our research showed that the duration of brachial plexus block in patients with ALT values greater than 40 U/L was 5.817 times that of the duration in patients with ALT less than 40 U/L, indicating that the brachial plexus block would take longer to subside in patients with abnormal liver function.

Methods

Study design and population

This study enrolled patients who were scheduled to undergo internal fixation surgery for upper limb fractures at the Department of Orthopedics in Anting Hospital of Jiading District, Shanghai, from May 2021 to September 2021. The inclusion criteria were as follows: (I) patients aged 18 years and above; (II) ASA I–II grade patients. The exclusion criteria were as follows: (I) failure of US-guided brachial plexus block; (II) no use of ropivacaine plus lidocaine for brachial plexus block; and (III) patients who were converted to general anesthesia after failed plexus block; (IV) patients with missing data in follow up. This study was conducted in accordance to the Declaration of Helsinki (as revised in 2013). This study was approved by the Ethics Committee of Anting Hospital of Jiading District (RLSC-KY2021-06). All patients provided informed consent.

Data collection

Demographic characteristics, including age, gender, medication history, and laboratory indicators [such as systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting blood glucose (FBG), alanine aminotransferase (ALT), glomerular filtration rate (GFR)] were collected using standardized questionnaires by trained investigators. Hypertension was defined as the presence or history of hypertension, the use of antihypertensive medication, SBP ≥140 mmHg, or DBP ≥90 mmHg. Diabetes mellitus was defined as the presence or history of diabetes mellitus, current treatment with insulin or oral hypoglycemic agents, or an FBG level of ≥126 mg/dL. Elevated ALT was defined to be greater than 40 U/L. A GFR <90 mL/min was considered an impaired renal function.

Brachial plexus block

The brachial plexus block was combined with either interscalene or axillary block by the same anesthesiologist. The interscalene block was performed with the traditional in-plane, single injection cluster approach (14). The axillary approach was performed in the supine position, with the upper arm in 90° abduction and the elbow in flexion on the operating table. The most appropriate in-plane or out-of-plane technique was employed, according to the actual anatomical position of the vessels and nerve structures (15-17). All patients had 30 mL of a mixture of 10 mL of 0.1% ropivacaine (10 mg) and 10 mL of 2% lidocaine (200 mg) and 10 mL 0.9% NaCl injection, making a total of 30 mL, with intermittent aspiration. Blocks were performed using the 22 G 80 mm syringe (Shanghai, China). All patients underwent US-guided with a high-frequency 13-6 MHz linear probe (Ultrasound SonoSite Prosound M-TURBO, Bothell, WA, USA). The imaging of the patient injected with drugs to block the brachial plexus under the guidance of US is shown in *Figure 1*.

Definition of the duration of plexus block

The duration of plexus block was defined as the time taken for the restoration of sensation and movement in the arm of the patient to the preoperative condition (i.e., the condition when normal movement would be possible without numbness in any area, apart from any part immobilized due to the surgical procedure). The patient's duration of plexus block was recorded by the attending nurse.

Statistical analyses

Statistical analysis was performed using SAS software (version 9.3; SAS Institute, Cary, NC, USA). Continuous variables with normal distribution were presented as mean ± standard deviation (SD), and those with nonnormal distribution were presented as medium (range). Patients included in the study were divided into <5-hour group and ≥5-hour group, based on the median duration of brachial plexus block by Raeder *et al.* reported (9). Continuous variables with normal distribution were compared using the independent Student's *t*-test, and continuous variables with nonnormal distribution were compared using the Mann-Whitney U test. Categorical variables were presented as count (percentages) and were analyzed using the chi-squared test. The demographics, laboratory indicators and the American Society of Anesthesiologists (ASA) classification by previous reports (7,11). Multivariable logistic regression was used to estimate relevant influencing factors by calculating the odds ratio (OR) and 95% confidence interval (CI). All statistical tests were 2-tailed, and their significance level was set to 0.05.

Results

In this cross-sectional study, a total of 140 patients were

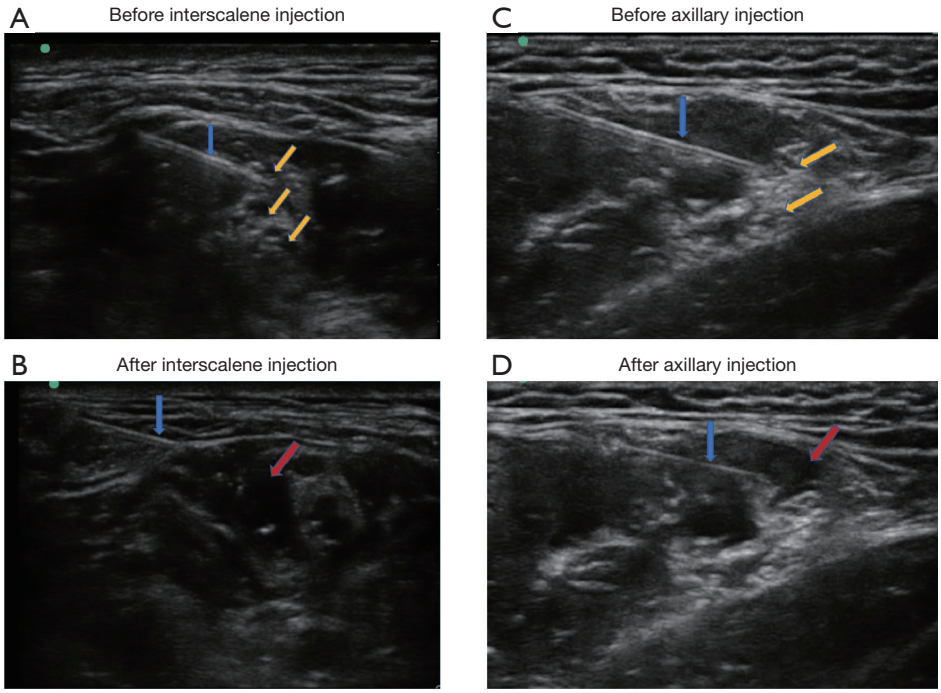

Figure 1 Imaging images of a patient undergoing an ultrasound-guided injection of a drug to block the brachial plexus. The blue arrows represent the puncture needle; the red arrows represent the infused drug; and the yellow arrows represent the brachial plexus.

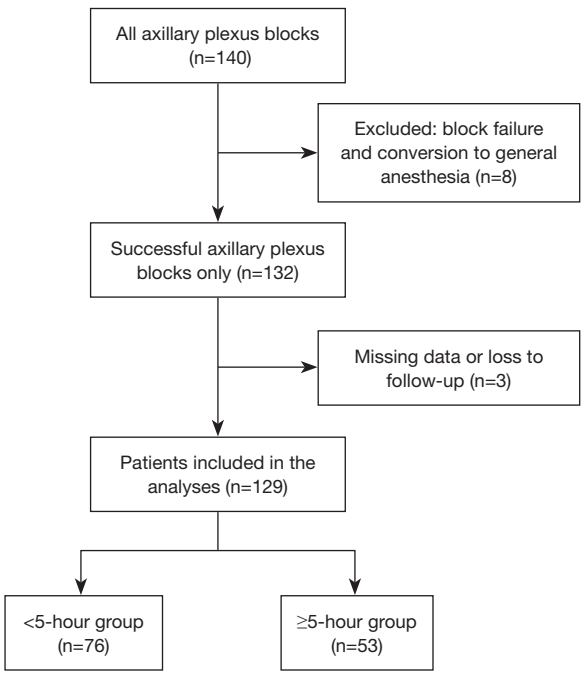

Figure 2 Research flow chart.

recruited. However, 8 patients received general anesthesia after a plexus block failure, and the follow-up data of 3 patients were missing. Finally, 129 patients were analyzed, and a research flow chart was made (*Figure 2*).

Through data collection and statistical analysis, the results showed that the average age of the 129 patients was 51.01±16.54 years. The median time of brachial plexus block was 5.09 hours (5.09±1.82 hours), the longest duration was 12 hours and the shortest was 2 hours (*Figure 3*).

In addition, based on the median duration of brachial plexus block, patients were divided into a <5-hour group and a ≥5-hour group. The results showed that the number of male patients in the <5-hour group was higher than that in the ≥5-hour group (P<0.001). The duration of US-guided brachial plexus block was shorter in the <5-hour group than in the ≥5-hour group (P<0.001) (*Table 1*).

Multivariable logistic regression analysis (*Table 2*) showed that after adjusting all covariates, gender (OR: 3.314; 95% CI: 1.330 to 8.257, P=0.010), ALT (OR: 5.817, 95% CI: 1.509 to 22.472, P=0.011), and GFR <60 (OR: 22.700; 95% CI: 1.994 to 198.386, P=0.012) were risk factors for

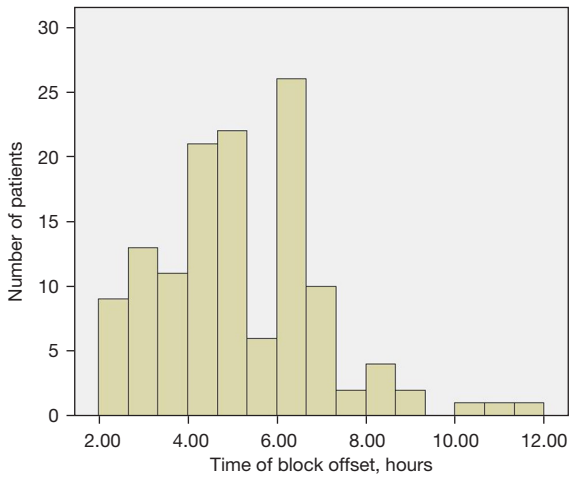

Figure 3 Histogram with the duration of brachial plexus block (hours).

the duration of US-guided brachial plexus block. Further analysis showed that compared to patients aged below 40 years, 40–49 years (OR: 4.841; 95% CI: 1.033 to 22.695, P=0.045), 50–59 years (OR: 4.730, 95% CI: 1.149 to 19.474, P=0.031), and ≥60 years (OR: 8.540; 95% CI: 1.605 to 45.449, P=0.012) were associated with prolonged duration of US-guided brachial plexus.

Discussion

In this study, we evaluated the risk factors associated with the duration of US-guided brachial plexus block. The results of the study revealed that the median duration of brachial plexus block was 5.09 hours, when a combination of interscalene and axillary blocks were performed in patients requiring the upper limb surgery. Furthermore, gender, age,

Table 1 Baseline characteristics of the study population

Variables	Total (n=129)	<5-hour group (n=76)	≥5-hour group (n=53)	P value
Age (years)	51.01±16.54	48.24±15.63	54.98±17.14	0.905
<40	31.15±6.01	31.97±5.23	28.80±7.70	0.154
40–49	44.12±2.34	43.13±1.64	45.00±2.59	0.100
50–59	53.83±2.50	53.32±2.49	54.73±2.37	0.140
≥60	69.77±6.62	69.05±4.54	70.39±8.06	0.514
Male, n (%)	66 (51.2)	48 (63.2)	18 (34.0)	<0.001
Weight (kg)	65.95±11.78	67.51±0.65	63.72±13.02	0.078
BMI (kg/m^2)	24.24±3.22	24.43±2.81	23.98±3.74	0.458
FBG (mmol/L)	5.69±2.37	5.51±1.52	5.94±3.18	0.317
GFR (mL/min)	109.58±27.85	113.09±24.87	104.50±31.24	0.090
SBP (mmHg)	137.60±17.11	137.72±14.72	137.43±20.20	0.925
DBP (mmHg)	79.97±8.88	80.55±7.92	79.13±10.12	0.374
ALT (U/L)	25.87±21.41	25.38±21.26	26.57±21.82	0.756
ASA classification*, n (%)				0.463
ASA I	76 (58.9)	45 (59.2)	31 (58.4)	
ASA II	53 (41.1)	31 (40.8)	22 (41.6)	
Duration of block (hours)	5.09±1.82	3.90±0.95	6.79±1.36	<0.001
Location, n (%)				0.082
Metacarpal	16 (12.4)	13 (17.1)	3 (5.7)	
Radius	62 (48.1)	31 (40.8)	31 (58.5)	
Humerus	12 (9.3)	6 (7.9)	6 (11.3)	
Clavicle	39 (30.2)	26 (34.2)	13 (24.5)	

Data are presented as n (%) or mean ± SD. *ASA classification, according to The American Society of Anesthesiologists classification system. BMI, body mass index; FBG, fasting blood glucose; GFR, glomerular filtration rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; ALT, alanine aminotransferase.

Table 2 Binary logistic regression for influencing factors

Variables	OR	95% CI	P value
Age (years)			
<40	Reference	Reference	0.047
40–49	4.841	1.033–22.695	0.045
50–59	4.730	1.149–19.474	0.031
≥60	8.540	1.605–45.449	0.012
Gender	3.314	1.330–8.257	0.010
ALT (U/L)	5.817	1.509– 22.472	0.011
GFR (mL/min)			
≥90	Reference	Reference	0.015
60–89	2.896	0.926–9.059	0.068
<60	22.700	1.994–198.386	0.012

Models are adjusted for age, gender, ALT, GFR. ALT, alanine aminotransferase; GFR, glomerular filtration rate; CI, confidence interval; OR, odds ratio.

ALT, and GFR were the factors influencing the duration of brachial plexus block.

In this study, the duration of brachial plexus block was found to be significantly longer in patients aged above 40 years, especially in those aged above 60 years (OR: 8.54), than patients aged below 40 years. This result is consistent with those of the previous studies. Paqueron *et al.* (11) showed an approximately 2.5 times longer lasting ropivacaine-induced brachial plexus block in the elderly (median age of 77 years) when compared with younger patients (median age of 39 years), indicating that the duration of complete sensory block was significantly correlated with age. The mechanism of correlation with age might be related to the reduced conduction velocities; smaller diameter of nerve fibers; and decrease in peripheral nerve Na^+, K^+-ATPase activity during aging (11).

Our research showed that the duration of brachial plexus block in patients with ALT values greater than 40 U/L was 5.817 times that of the duration in patients with ALT less than 40 U/L, indicating that the brachial plexus block would take longer to subside in patients with abnormal liver function. Generally, the clearance rate of ropivacaine depends on the activity of the enzyme (18). Therefore, impaired liver metabolism will change the clearance rate of the drug (19). Previously, it was reported that the clearance rate of ropivacaine in patients with end-stage liver disease decreased by 60%, and the half-life of the drug was extended by 4.2 times with the administration of ropivacaine (18). It is also believed that the pharmacokinetics of ropivacaine are less affected in patients with a less severe form of liver disease (18). Therefore, the effect of different degrees of liver disease on the duration of brachial plexus blocks needs to be evaluated in future studies. Our research suggests that it is advisable to use the lowest effective dose for the shortest possible time when using ropivacaine in patients with elevated ALT.

In this study, the duration of brachial plexus block in patients with GFR <60 mL/min was prolonged by 22.7 times compared to those with normal GFR. Similarly, in a previous study, after an axillary plexus block with 300 mg of ropivacaine in 29 uremic and 28 nonuremic patients, the uremic patients had about 40% lower apparent clearance of ropivacaine than patients without renal insufficiency (20). However, some reports have shown that the pharmacokinetics of ropivacaine is not affected by renal failure (21). Furthermore, in another study, no significant differences were observed in the duration of brachial plexus block using 20 mL of 1.5% mepivacaine in patients with renal failure compared to those without renal failure (22). Therefore, study population, difference in drugs, drug dosage, and other factors affecting drug metabolism may explain the differences in the duration of brachial plexus block in patients with renal failure.

Our research has some limitations. First, the block excursion time was not measured objectively using the commonly used techniques, such as restoration of acupuncture sensation or the Bromage scale (4,8,10). However, from the patient's point of view, the most important measure of block excursion time is the onset of pain and the ability to move the limb. Furthermore, patients enrolled in the study were ASA I–II grade patients, therefore, the conclusion may not be generalized.

Conclusions

In conclusion, gender, age, ALT, and decrease in GFR are risk factors affecting the duration of US-guided brachial plexus block. Individualized US-guided brachial plexus block programs may be developed in future studies.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6365/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-6365/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-6365/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. In this planned project, the participants' rights and interests were protected sufficiently, which satisfies the requirements of the World Medical Association's Declaration of Helsinki (as revised in 2013) and the Medical Ethics Committee. This study protocol was approved prior to the commencement of the study. This study was approved by the Ethics Committee of Anting Hospital of Jiading District (RLSC-KY2021-06). All patients provided informed consent.

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