

Predictors of ultrasound-guided brachial plexus block failure in upper limb surgery: a retrospective cohort study

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Abstract

Background

Ultrasound-guided brachial plexus block (USG-BPB) is widely used for upper limb surgery, but failure remains clinically important. This study aimed to identify predictors of USG-BPB failure and develop a clinical risk score.

Methods

We performed a retrospective cohort study of patients undergoing upper limb surgery with USG-BPB at a university hospital from 2018 to 2023. Block failure was defined as the need for supplemental block, additional multiple dose of analgesics or sedatives, deep sedation, or conversion to general anesthesia. Demographic, procedural, and surgical variables were analyzed using multivariable logistic regression. Model discrimination was assessed by the area under the curve (AUC). A point-based clinical prediction score was derived from the regression coefficients.

Results

Of 657 cases reviewed, 606 were included in the analysis. Block failure occurred in 112 cases (18.5%). Significant predictors of failure were liver disease (OR = 4.81, $p = 0.031$), humerus/elbow or forearm surgery compared with hand surgery ($p = 0.019$), surgical duration > 120 minutes (OR = 3.54, $p < 0.001$), block-to-incision interval > 30 minutes (OR = 1.80, $p = 0.012$), single local anesthetic solution versus mixed solution (OR = 3.04, $p = 0.002$), and block performed by first- or second-year residents compared with regional anesthesiologists (OR = 5.84, $p < 0.001$). Diabetes mellitus (OR = 0.43, $p = 0.004$) and larger local anesthetic volume (OR = 0.93, $p = 0.012$) were protective factors. The final model showed good discrimination (AUC = 0.75, 95% CI 0.70–0.79). The derived clinical risk score also showed good discrimination (C-statistic = 0.75, 95% CI 0.70–0.80).

Conclusion

USG-BPB failure was associated with operator inexperience, liver disease, surgery at the humerus/elbow or forearm, prolonged duration, delayed incision, and single-agent local anesthetic use. Diabetes mellitus and higher block volume were protective. The point-based clinical risk score showed good discrimination and may help identify patients at risk of block failure.

Trial registration

: Not applicable

Introduction

Ultrasound-guided brachial plexus blocks (USG-BPB) have become the preferred anesthetic technique for patients undergoing upper extremity surgery due to it has a greater benefit over general anesthesia such as hemodynamic stability(1). While using brachial plexus block provides a high efficacy in surgical anesthesia without additional supplemental anesthetic drugs and better postoperative pain control(2). Moreover, regional anesthesia offers advantages over general anesthesia such as reduced opioid use(3), shortened post-anesthesia care unit (PACU) stay(2)(4), increased patient satisfaction(5)(6) and promoted the Enhanced Recovery After Surgery (ERAS) protocol(7).

Although, implemented ultrasound for brachial plexus block promised the direct vision of needle advancement and real-time assessment of local anesthetic drug spreading surrounding the nerve, However, unexpected brachial plexus block failures were up to 15% in the literature(8)(9). Previous studies aimed to identify risk factors of failure brachial plexus block, including patient factors, procedural and surgical factors. Patient factor high systolic blood pressure and obesity while procedural and surgical factors consist of prolong time from block to start operation, brachial plexus block approaches, The prolonged intervals from finish block procedure to the start of surgery, volume of local anesthetic drugs(10)(11). Conversely, there was no significant difference in success rates between brachial plexus block approaches (axillary, infraclavicular and supraclavicular)(9)

Therefore, this study aims to identify factors associated with USG-BPB failure, aiding in the design of prevention strategies for regional anesthesia techniques, including the approach site, type of local anesthetic, dose, total volume, and even the choice of the surgical procedure. This could lead to a further reduction in the risk of unpredictable block failure, avoiding the need for general anesthesia.

Methods

This study was a single-center retrospective cohort study conducted in patients who underwent upper extremity surgery using USG-BPB at Songklanagarind Hospital between January 2018 and December 2023. The study protocol was reviewed and approved by the Institutional Ethics Committee of the Faculty of Medicine, Prince of Songkla University (REC-67-249-8-4) on 11 June 2024. Informed consent and withdrawal criteria were not applicable due to the retrospective study design. The inclusion criteria was American Society of Anesthesiologists (ASA) physical status classification I–III and aged over 18 years who underwent USG-BPB. While those who received USG-BPB for analgesic purposes only, those with incomplete outcome records, or cases with an undetermined objective of the brachial plexus block were excluded from the study.

All the information including patient baseline characteristics and perioperative profiles were obtained from the hospital information system (HIS) and anesthetic records. Independent variable including 1) Patient characteristics included age, gender, weight, height, body mass index (BMI), comorbidities, and American Society of Anesthesiologists (ASA) physical status classification (I–III). Data on preoperative analgesics administered before surgery (opioids, non-steroidal anti-inflammatory drugs [NSAIDs], and

paracetamol) were recorded 2) Intraoperative variables included operator levels [regional anesthesiologist, anesthesiologist staff (categorized as experience > 10 years, 5–10 years and < 5 years), or anesthesia residents (first-, second-, or third-year)], brachial plexus block (BPB) approach (supraclavicular, costoclavicular, lateral infraclavicular, or axillary), urgency of surgery (elective or emergency), type of local anesthetic used (bupivacaine, lidocaine, or mixed), volume of local anesthetic (mL), and doses (mg/kg). Sedation and perioperative adjuvant analgesics (weak opioids, NSAIDs, and paracetamol) were recorded. 3) Surgical variables included surgical site (hand, forearm, elbow, distal humerus), surgical duration, tourniquet time, and time interval from block to incision. 4) Block-related outcomes included an additional block at the surgical site by the either surgeon or anesthesiologists or a rescue block (local infiltration, selective nerve block, or repeat nerve block) by the surgeon or anesthesiologists due to inadequate anesthesia after surgery commenced for more than 30 minutes. The primary outcome was blocking failure, defined as the inability to achieve adequate sensory blockade resulting in pain or discomfort during the surgical procedure, and meeting at least one of the following criteria: 1) Conversion to general anesthesia due to inadequate surgical anesthesia after 30 minutes from block performance. 2) Supplemental local anesthetic infiltration or rescue block administered after 30 minutes from block performance. 3) Requirement for perioperative intravenous analgesia with more than two doses of strong opioids (e.g., fentanyl, morphine). 4) Requirement for deep sedation equivalent to general anesthesia (e.g., propofol infusion > 100 mcg/kg/min). 5) Requirement for combined intravenous anesthetic drugs of more than two types (e.g., midazolam and ketamine, or fentanyl, or dexmedetomidine infusion).

Sample size calculation

The sample group used in this study was patients who underwent surgery in Songklanagarind Hospital. Which is taken from the incidence report of patients who received services in the month From January 2018-December2023.

Sample size was calculated from the pilot data that it was collected in patients who underwent distal upper extremities surgery under USG-BPB between January-December 2022. The total cases were 168 patients, in which 18 cases were block failure while 150 cases were block success. From this pilot study, the sample size was calculated using formula for cohort study that was used the proportion of brachial plexus block failure in men ($p_1 = 0.56$) and women ($p_2 = 0.39$). The sample size required 546 subjects with the ratio (1:6) to have 95% confidence and 80 power to see detect the association between the factor and outcomes interest. To compensate with drop out the sample sized was added 10% to 601 cases

Statistical analysis

Data were entered with Kobotoolbox and analyzed in program R version 4.2.1. The categorical variables; baseline characteristic, BPB approach, operators, type of local anesthetic drug and surgical site, duration of surgery and time interval from block and skin incision were presented with frequency and percentage. While all continuous variables were presented with median and interquartile range (IQR) due to non-

normal distribution of the data. The chi-square test or Fisher's exact test were used to compare the categorical variables. While the Wilcoxon rank sum test was used to analyze the non-parametric categorical variables.

All parameters were analyzed using univariate analysis to explore the association between independent factors and dependent outcomes. The chi-square test and Fisher's exact test were used to test the association between categorical variables, Student's t-test was used for normally distributed continuous variables, and the Wilcoxon rank sum test was used for non-normally distributed continuous variables.

After univariate analysis, independent variables that were clinically relevant and those with a p-value < 0.1 were selected for further analysis using multivariate logistic regression. A backward stepwise selection process based on the Akaike Information Criterion (AIC) was then applied to determine the final model. The final model identified predictors of USG-BPB failure in patients undergoing distal upper limb surgery. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to indicate the strength and direction of association between independent predictors and USG-BPB failure. Statistical significance was set at $p < 0.05$. Model performance was assessed using discrimination (area under the receiver operating characteristic curve, AUC). The optimism-corrected C-index was performed to assess the fitness of the model with a 200-sample bootstrap dataset. The coefficients of each factor from the final model were converted to a point-based clinical risk score, and the internal validity of point-based clinical risk score was tested to estimate the Brier score.

Results

Data from 2018 to 2023 were analyzed, yielding a total of 657 ultrasound-guided brachial plexus block (BPB) cases. After excluding 51 cases that were performed BPB for perioperative analgesia, incomplete data records, and unclear objectives, 606 cases remained for final analysis. The overall success rate was 494 patients (81.5%), while 112 patients (18.5%) were experience block failure. (Fig. 1) The most common cause of brachial plexus block failure was the need for perioperative intravenous analgesia with more than two doses of strong opioids (54.5%), followed by the need for deep sedation (33.0%). Other causes included conversion to general anesthesia due to inadequate surgical anesthesia (19.6%), supplemental local anesthetic infiltration or rescue blocks (19.6%), and the combination of more than two types of intravenous anesthetic drugs (16.2%). (Table 1)

Table 1
The distribution of the caused of USG-BPB block failure

Cause of USG-BPB failure	N = 112
Conversion to general anesthesia due to inadequate surgical anesthesia	22 (19.6%)
Supplemental local anesthetic infiltration or Rescue block after BPB block for 30 minutes	22 (19.6%)
Need administer perioperative IV analgesia More than 2 doses of strong opioids (e.g. fentanyl, morphine)	61 (54.5%)
Need for deep sedation	37 (33.0%)
Combine IV anesthetic drug more than 2 types	18 (16.2%)
BPB = Brachial plexus block, IV = Intravenous	

The demographic characteristics and baseline data are presented in Table 2. The median age of patients in the success group was 58 [42–69] years compared to 57 [34.5–66] years in the failure group ($p = 0.083$). Male patients had a higher failure rate compared to females (54.5% vs. 43.9%, $p = 0.042$). Patients who experienced block failure had significantly higher body weight (63 [54–70] kg vs. 60 [52–69] kg, $p = 0.042$) and greater height (160 [154–166] cm vs. 159 [154–165] cm, $p = 0.062$). ASA classification, case category (elective vs. emergency), and the presence of trauma were comparable between groups ($p > 0.05$). Most comorbidities were evenly distributed; however, liver disease tended to be more frequent in the failure group (4.5% vs. 1.4%, $p = 0.052$), otherwise were not statistically significant different between groups.

Table 2
Patient characteristic, procedure and surgical factors according to USG-BPB failure.

Characteristic	Success N = 494	Failure N = 112	Total N = 606	p-value
Patient factors				
Age (years)	58.0 [42.0, 69.0]	57.0 [34.5, 66.0]	58 [41.0–69.0]	0.083
Sex; n (%)				0.043
Female	277 (56.1%)	51 (45.5%)	328 (54.1)	
Male	217 (43.9%)	61 (54.5%)	278 (45.9)	
Weight (kg)	60 [52, 69]	63 [54, 70]	61 [53, 70]	0.042
Height (cm)	159 [154, 165]	160 [155, 169]	160 [154, 166]	0.062
ASA classification; n(%)				0.940
I	36 (7.3)	9 (8.0)	45 (7.5)	
II	217 (43.9)	50 (44.6)	267 (44.0)	
III	241 (48.8)	53 (47.4)	294 (48.5)	
Case category; n (%)				0.440
Elective	416 (84.2)	91 (81.2)	507 (83.7)	
Emergency	78 (15.8)	21 (18.8)	99 (16.3)	
Traumatic case; n (%)	147 (29.8)	42 (37.5)	189 (31.2)	0.110
Cardiovascular disease; n (%)	269 (54.5)	58 (51.8)	327(54.0)	0.610
Respiratory disease; n (%)	27 (5.5)	7 (6.3)	34 (5.6)	0.740
Endocrine disease; n (%)	144 (29.1)	25 (22.3)	169 (27.9)	0.150
Liver disease; n (%)	7 (1.4)	5 (4.5)	12 (2.0)	0.052
Renal disease; n (%)	193 (39.1)	41 (36.6)	234 (38.6)	0.630
CNS disease; n (%)	32 (6.5)	9 (8.0)	41 (6.8)	0.550
Diabetes mellitus; n (%)	122 (24.7)	19 (17.0)	141 (23.3)	0.080
Procedure factors				
BPB Approach; n (%)				0.590
ASA= American Society Association, BPB = Brachial plexus block, mg = milligram, kg = kilogram				

Characteristic	Success N = 494	Failure N = 112	Total N = 606	p-value
Patient factors				
Axillary	276 (55.9)	58 (51.7)	334 (55.1)	
Infraclavicular	36 (7.3)	7 (6.3)	43 (7.1)	
Supraclavicular	182 (36.8)	47 (42.0)	229 (37.8)	
BPB selection appropriated to incision; n (%)				0.330
appropriate	470 (95.1)	104 (92.9)	574 (94.7)	
inappropriate	24 (4.9)	8 (7.1)	32 (5.3)	
Operator; n (%)				0.005
Regional anesthesia specialist	105 (21.3)	10 (8.9)	115 (19.0)	
Senior staff (experience > 10 year)	44 (8.9)	7 (6.3)	51 (8.4)	
3rd yr resident to staff experience < 10 yrs	200 (40.5)	50 (44.6)	250 (41.2)	
Resident under supervision	57 (11.5)	12 (10.7)	69 (11.4)	
First&second years of resident	88 (17.8)	33 (29.5)	121 (20.0)	
Type of local anesthesia for BPB; n (%)				0.047
Mixed (Lido/Bup)	443 (89.7)	93 (83.0)	536 (88.5)	
Single local anesthetic	51 (10.3)	19(17.0)	(5.1)	
Bupivacaine	28 (5.7)	11 (9.8)	39 (6.4)	
Dose of local anesthetic drug				
Lidocaine (mg/kg)	3.45 [2.71, 4.35]	3.03 [2.53, 3.70]	3.37 [2.67, 4.25]	0.005
Bupivacaine (mg/kg)	0.83 [0.69, 1.00]	0.77 [0.62, 0.93]	0.82 [0.67, 0.98]	0.010
Volume of local anesthetic drug; (ml)	20 [20, 25]	20 [20, 20]	20 [20, 25]	< 0.001
Intercostobrachial block; n (%)	129 (26.1)	28 (25.0)	157 (25.9)	0.810
Preblock sedation; n (%)	175 (35.4)	40 (35.7)	215 (35.5)	0.950
Preblock narcotic; n (%)	304 (61.5)	83 (74.1)	387 (63.9)	0.012
ASA= American Society Association, BPB = Brachial plexus block, mg = milligram, kg = kilogram				

Characteristic	Success N = 494	Failure N = 112	Total N = 606	p-value
Patient factors				
Preblock narcotic report as morphine equivalence dose (mg)	2.5 [0, 5]	2.5 [0, 5]	2.5 [0,5]	0.006
Paracetamol preemptive; n (%)				0.032
None	420 (85.0)	94 (83.9)	514 (84.8)	
1 tablet	49 (9.9)	6 (5.4)	55 (9.1)	
2 tablet	25 (5.1)	12 (10.7)	37 (6.1)	
Surgical factors				
Department of surgery; n (%)				0.560
General surgery department	209 (42.3)	44 (39.3)	253 (41.8)	
Orthopaedic department	285 (57.7)	68 (60.7)	353 (58.2)	
Surgical site; n (%)				0.003
Hand	158 (32.0)	20 (17.9)	178 (29.4)	
Forearm	203 (41.1)	52 (46.4)	255 (42.1)	
Humerus/Elbow	133 (26.3)	40 (35.7)	173 (28.5)	
Duration of surgery; n (%)				< 0.001
< one hour	129 (26.1)	16 (14.3)	145 (23.9)	
One hours – 2 hours	262 (53.0)	49 (43.7)	311 (51.3)	
> 2 hours	103 (20.9)	47 (42.0)	150 (24.8)	
Tourniquet use; n (%)	195 (39.5)	50 (44.6)	245 (40.4)	0.310
Duration of tourniquet; n (%)				0.028
Not use	299 (60.5)	62 (55.4)	361 (59.6)	
≤ one hour	79 (16.0)	12 (10.7)	91 (15.0)	
One hour – ≤ 2 hours	91 (18.4)	25 (22.3)	116 9.1)	
> 2 hours	25 (5.1)	13 (11.6)	38 (6.3)	
Duration from block to surgery; n (%)				0.011
ASA= American Society Association, BPB = Brachial plexus block, mg = milligram, kg = kilogram				

Characteristic	Success N = 494	Failure N = 112	Total N = 606	p-value
Patient factors				
≤ 30 minutes	303 (61.3)	54 (48.2)	357 (58.9)	
> 30 minutes	191 (38.7)	58 (51.8)	249 (41.1)	
ASA= American Society Association, BPB = Brachial plexus block, mg = milligram, kg = kilogram				

Procedure factors

The distribution of block approaches (supraclavicular, infraclavicular and axillary approach) and appropriateness of block selection did not significant different between groups. However, Operator experience showed a significantly association with the block failure ($p = 0.004$). Failure, was more frequent when block were performed by junior residents 1 and 2 compared to regional anesthesiologists (29.5% vs 8.9%). In term of dose of local anesthetic drugs there were significant both volume of local anesthetic ($p < 0.001$) and dose (mg/kg) of local anesthetic drugs (Bupivacaine; $p = 0.01$ and Lidocaine; $p = 0.005$). While, mixed local anesthetic solutions (lidocaine and bupivacaine) were most frequently used. In addition, adding intercostobrachial nerve block and sedation supplement during procedure were not different between the groups. However, pre-emptive paracetamol and opioids before the procedure was higher in failure groups. (Table 2)

Surgical factors

The type of surgery (orthopedic vs. general) was similar between groups. However, surgical site distribution was significantly different ($p = 0.003$), with elbow and humerus surgery more frequent in the failure group (9.8% vs. 3.8% and 25.9% vs. 23.1%, respectively), while hand surgery was lower in failure group (17.9% vs 32.0%). The duration of surgery was significantly longer in the failure group ($p < 0.001$), with 42% of failed blocks occurring in cases lasting more than 120 minutes compared with only 20.9% in the success group. Tourniquet application did not significantly differ, but prolonged tourniquet duration (> 120 minutes) was more common in the failure group (11.6% vs. 5.1%, $p = 0.028$). Additionally, the interval from block to surgical incision was longer than 30 minutes is more occur in the failure group (51.8% vs. 38.7%; $p = 0.011$). (Table 2)

Univariate Analysis

Univariate analysis identified several significant predictors of block failure (Table 3). Patient weight showed a borderline significant association (OR 1.02, 95% CI 1.00–1.03, $p = 0.051$). Liver disease was associated with increased odds of failure (OR 3.25, 95% CI 0.95–10.4, $p = 0.060$), while diabetes mellitus appeared protective (OR 0.62, 95% CI 0.36–1.04, $p = 0.072$). Operator experience remained highly

significant ($p = 0.004$), with first- and second-year residents having the highest odds of failure (OR 3.94, 95% CI 1.90–8.84) compared to regional anesthesia staff. Surgical site was also significant ($p = 0.004$), with hand surgery showing the lowest odds of failure compared to elbow surgery (OR 0.22, 95% CI 0.09–0.53).

Duration-related factors showed strong associations: surgery duration > 120 minutes (OR 3.68, 95% CI 2.01–7.04, $p < 0.001$), prolonged tourniquet use (OR 2.51, 95% CI 1.19–5.10 for 120–265 minutes, $p = 0.041$), and delayed surgical start > 30 minutes after block (OR 1.70, 95% CI 1.13–2.58, $p = 0.011$).

Table 3
Univariate analysis of independent variables.

Characteristic	OR	95% CI	P-value
Patients			
Weight (kg)	1.02	1.00, 1.03	0.051
Type of surgery; general = ref			0.560
Orthopedic surgery	1.13	0.75, 1.73	
Case category; elective = ref			0.450
Emergency	1.23	0.71, 2.07	
Liver disease; no = ref	3.25	0.95, 10.4	0.060
Diabetes mellitus; no = ref	0.62	0.36, 1.04	0.072
Trauma; no = ref	1.42	0.92, 2.17	0.110
Approach; axillary approach = ref			0.590
Infraclavicular	0.96	0.36, 2.07	
Supraclavicular	1.22	0.80, 1.88	
Operator; regional anesthesiologist = ref			0.004
Senior staff (experience > 10 yrs)	1.67	0.57, 4.63	
3rd years resident - staff experience < 10 yrs	2.62	1.33, 5.68	
Residents under supervision	2.21	0.90, 5.54	
First&second year residents	3.94	1.90, 8.84	
Surgical site; Hand = ref			0.007
Forearm	2.02	1.18, 3.60	
Humerus	2.38	1.34, 4.33	
Duration of surgery; ≤ 60 min = ref			< 0.001
one – 2 hours	1.51	0.84, 2.83	
> 2 hours	3.68	2.01, 7.04	
Duration from block to surgery; ≤ 30 min = ref			0.011
> 30 minutes	1.70	1.13, 2.58	
BPB = brachial plexus block, OR = odd ratio, CI=confidence interval, cm= centimeter			

Characteristic	OR	95% CI	P-value
Patients			
Preblock narcotic; none = ref	1.79	1.14, 2.87	0.011
BPB volume (ml)	0.94	0.89, 0.98	0.009
Additional block; none = ref	1.31	0.72, 2.27	0.360
BPB = brachial plexus block, OR = odd ratio, CI=confidence interval, cm= centimeter			

Multivariate Analysis

After adjusting for confounding variables in the multivariate logistic regression model (Table 4), several factors remained independently statistically significant associated with block failure: 1) **Patient factors** including weight, each kilogram increase in body weight was associated with a 2% increase in failure odds (adjusted OR 1.02, 95% CI 1.00-1.04, $p = 0.034$). In addition, Patients who has liver disease had 5-fold higher odds of block failure (adjusted OR 4.81, 95% CI 1.16–19.6, $p = 0.031$). While patients who has diabetes had significantly lower odds of block failure (adjusted OR 0.43, 95% CI 0.23–0.76, $p = 0.004$) 2) **Procedure factors** includes; operator experience remained the strongest predictor of block failure. For the first- and second-year residents had the adjusted OR 5.84 (95% CI 2.447–14.9). While, the third-year residents/young staff had adjusted OR 3.09 (95% CI 1.40–7.46) and Residents under staff supervision had adjusted OR 3.21 (95% CI 1.19–8.96) compared to regional anesthesiologist. Single local anesthetic drug was associated with higher risk of failure rates compared to mixed solutions (OR 3.04 95% CI 1.49–6.12). 2), while local anesthetic volume increasing reduce the risk of block failure by 7% (OR 0.93, 95% CI 0.87–0.98). 3) **Surgical Factors**; the following factors; surgical site, surgical duration and duration from block to skin incision were found significant association with block failure. Forearm and humerus/elbow surgery increased the risk of block failure (OR 1.94 95% CI 0.107–3.62 and 2.72 95% CI 1.42–5.32, respectively) compared to hand surgery. Surgery duration longer than 2 hours and delayed skin incision increased risk of block failure (OR 3.54 95% CI 1.82–7.19 and OR 1.80, 95% CI 1.14–2.87).

Table 4

Univariate and multivariate logistic regression analysis of possible factors associated USG-BPB failure, and a clinical risk score

Characteristic	Unadjusted			Adjusted			clinical risk score
	OR	95% CI	p-value	OR	95% CI	p-value	
Weight (kg)	1.02	1.00, 1.03	0.051	1.02	1.00, 1.04	0.034	+ 2 per 10 kg
Emergency vs elective (ref)	1.23	0.71, 2.07	0.450	1.55	0.83, 2.86	0.17	+ 4.5
Trauma case; No = ref	1.42	0.92, 2.17	0.110				
Liver disease; No = ref	3.25	0.95, 10.4	0.060	4.81	1.16, 19.6	0.031	+ 16
Diabetes mellitus; No = ref	0.62	0.36, 1.04	0.072	0.43	0.23, 0.76	0.004	- 8.5
Approach; Axillary = ref			0.590				
Infraclavicular	0.93	0.36, 2.07					
Supraclavicular	1.23	0.80, 1.88					
Inappropriate BPB approach	1.51	0.62, 3.31	0.350	1.11	0.39, 2.93	0.840	+ 1
Operator; Regional anesthesiologists = ref			0.004			0.002	
Senior staff (experience > 10 yrs)	1.67	0.57, 4.63		2.55	0.79, 7.93		+ 9.5
3rd residents – staff experience < 10 yrs	2.62	1.33, 5.68		3.09	1.40, 7.46		+ 11.5
Residents under supervision	2.21	0.90, 5.54		3.21	1.19, 8.96		+ 11.5
First, second year residents	3.94	1.90, 8.84		5.84	2.47, 14.9		+ 17.5
Single drug vs mixed LA (ref)	1.77	0.98, 3.10	0.057	3.04	1.49, 6.12	0.002	+ 11
BPB volume	0.94	0.89, 0.98	0.009	0.93	0.87, 0.98	0.012	- [volume (ml)]
USG-BPB =. Ultrasound-guided brachial plexus block, BPB = brachial plexus block, OR = odd ratio, CI = confidence interval							

Characteristic	Unadjusted			Adjusted			clinical risk score
	OR	95% CI	p-value	OR	95% CI	p-value	
							x 0.728]
Preblock narcotic; No = ref	1.79	1.14, 2.87	0.011				
Orthopaedic vs General surgery (ref)	1.13	0.75, 1.73	0.560				
Surgical site; Hand = ref			0.004			0.019	
Forearm	2.02	1.18, 3.60		1.94	1.07, 3.62		+ 7
Humerus/Elbow	2.38	1.34, 4.33		2.72	1.42, 5.32		+ 11
Duration of surgery (min); ≤ 60 min = ref			< 0.001			< 0.001	
One – 2 hours	1.51	0.84, 2.83		1.41	0.75, 2.75		+ 3.5
> 2 hours	3.68	2.01, 7.04		3.54	1.82, 7.19		+ 13
Duration of tourniquet (min) ; No = ref			0.041				
≤ one hour	0.73	0.36, 1.38					
One – 2 hours	1.32	0.78, 2.21					
> 2 hours	2.51	1.19, 5.10					
Duration from block to surgery(min); ≤ 30 min = ref			0.011			0.012	
> 30 min	1.70	1.13, 2.58		1.80	1.14, 2.87		+ 6
Additional block; No = ref	1.31	0.72, 2.27	0.36				
USG-BPB =. Ultrasound-guided brachial plexus block, BPB = brachial plexus block, OR = odd ratio, CI = confidence interval							

Logistic regression and derivation of clinical risk score for USG-BPB failure

The receiver operating characteristic (ROC) curve of the final logistic regression model was shown in Fig. 2A. The performance of the model demonstrated a good discrimination to predict the USG-BPB failure with the apparent area under the curve (AUC) was 0.747 (95% CI 0.700-0.794). The internal validity also was performed using bootstrap resampling 200 dataset demonstrated fair discrimination with optimism-corrected C-index of 0.70. The internal validity with calibration curve of multivariate regression model for predicting BPB failure was shown in Fig. 2B. It showed good agreement between predicted and observe probability of brachial plexus block failure. Calibration matrix found the average calibration error 0.036 (95% CI 0.021–0.068) which mean that it has error around 2.1 to 6.8%, and the expected calibration index (ECI) was 0.220 (95% CI = 0.074–0.746).

Table 5
The cut-point of clinical risk score and a probability of USG-BPB failure.

Clinical prediction score	Probability of BPB failure	95% CI
0–25	0.047	0.023, 0.076
25–35	0.189	0.138, 0.236
35–45	0.254	0.181, 0.339
45–70	0.622	0.457, 0.757
USG-BPB = ultrasound-guided brachial plexus block, BPB = brachial plexus block, CI = confidence interval		

The Point-base clinical score which was generated from the coefficients of regression of the final model shows in **Table 4**. The summation of the point-base clinical score is used to predict the risk of USG-BPB failure, and it is classified according to the probability of brachial block failure and 95% confidence of interval (**Table 5**). The performance of this classified risk group of point-base clinical score was determined using the receiver operating characteristic (ROC) and found that the apparent C-index was 0.749 (95%CI=0.700-0.797). (**Fig 2C**) Again, the internal validity was performed using bootstrap dataset and the corrected C-index (CI) was 0.75. The calibration of risk classification was performed and found that the calibration was adequate with the average calibration error of 0.035 (95% CI=0.019-0.064) with estimate calibration index of 0.210 (95% CI=0.060-0.649). (**Fig 2D**)

Discussion

This retrospective study aimed to identify the risk factors of USG-BPB failure and to develop a clinical risk score to estimate the probability of brachial plexus block failure. Under our conditions the failure rate of USG-BPB was 18.5%, with operator experience emerging as the strongest independent predictor of block failure. Our findings revealed a complex interplay of patient, anesthetic, and surgical factors influencing block failure, providing valuable insights for clinical practice and training programs. The clinical-based risk score demonstrated good predictive performance for USG-BPB failure across multiple approaches - supraclavicular, costoclavicular, lateral infraclavicular, and axillary approaches – in upper

extremity surgery (apparent C index = 0.749). To our knowledge, this is the first study to predict the risk of USG-BPB failure using a comprehensive set of clinical factors encompassing patient, anesthetic and surgical variables.

The failure rate of 18.5% observed in this study is higher than the range reported in contemporary literature, where the ultrasound-guided brachial plexus block failure rates vary from 7% to 15% depending on the approach, operator experience, and definition of failure (9)(11)(10). Prospective studies specifically examining ultrasound-guided techniques have reported success rates exceeding 90% - corresponding to failure rates below 10% - for supraclavicular (12)(13)(14)(15), infraclavicular (16)(17) and axillary (9)(12) approaches, all of which are lower than the 18.5% observed in our study. The variation in reported failure rates likely reflects differences in study populations, block failure definitions, and outcome measurements.

The most common cause of block failure in our study was the need for perioperative intravenous analgesia with multiple doses of strong opioids (54.5% of failures), followed by the requirement for deep sedation (33.0%). This pattern suggests that inadequate analgesia rather than complete block failure, was the predominant clinical problem. Conversion to general anesthesia was required in only 19.6% of failed blocks, indicating that most failures were partial rather than complete. In this study, all the cases requiring extensive pain treatment or deep sedation after skin incision were classified as a block failures, given their clinically significant impact on perioperative management. Although a standardized definition of block success following brachial plexus block remain lacking, a systematic review by Abdallah et al (18) identified that the most commonly used criterion for a successful block was the achievement of surgical anesthesia within a designated time frame. Most study employed a varieties criterion including complete sensory and motor block assessment, with or without general anesthesia conversion and comfortable during surgery (18). In the context of this retrospective study, block failure brachial plexus block was defined in accordance with the review by Bottomley T et al., as a block that does not provide the anticipated level of anesthesia or analgesia sufficient to allow planned procedure to proceed without additional intervention. (19)

Operator experience was identified as the strongest independent predictor of block failure, consistent with established literature on regional anesthesia learning curves (19)(20). First- and second-year residents had a 6-fold higher risk of block failure compared to regional anesthesia staff (adjusted OR 5.84, 95% CI 2.47–14.9), representing the highest risk category in this study. This finding underscore the importance of adequate supervision and structured training programs in resident education. Evidence from the literature suggests that the learning curve for ultrasound-guided axillary brachial plexus block developed rapidly, with steep improvement in the early phase. Success rates approaching 90% have been achieved within as few as 14 attempts in anesthesia residency training programs. (21) Several educational methods have been evaluated for their impact on the learning curve; ultrasound workshops incorporating a cognitive framework have been shown to improved both knowledge and confidence among residents, (22) while simulation-based practice has demonstrated improvements in residents's proficiency in ultrasound-guided peripheral nerve block. (23) These finding support the implementation

of structured educational strategies to enhance residents' competency in ultrasound-guided regional anesthesia. Notably, with adequate training and supervision, the performance gap between supervised trainees and consultants may be smaller than commonly assumed. (24)

The association between increased body weight and block failure (adjusted OR 1.02 per kg increase) is supported by previous research demonstrating that obesity can complicate ultrasound-guided regional anesthesia (25). Our findings extend this relationship across all brachial plexus approaches and suggests that even modest increases in body weight may adversely impact block success. The protective effect of diabetes mellitus against block failure (adjusted OR 0.43, 95% CI 0.23–0.76) is an intriguing finding that warrants further discussion. Previous studies have demonstrated that femoral and sciatic nerve blocks in diabetic exhibit a higher threshold of current required for nerve stimulation, faster onset of sensory block, and prolong duration of both sensory and motor blockade compared to non-diabetic patients produced had higher testhole of current to stimulate, faster onset of sensory blockade and prolong duration of motor and sensory blockage compard to nondiabetic patients. (26–28). Several mechanisms have been porposed to explain these findings, particulary in patient with diabetic nerve blockk with diabetic neruopathy: 1) Peripheral nerves demonstrate increased sensitivity to local anesthetics, resulting in faster onset and prolonged duration of nerve block; 2) altered pain perception and elevated stimulus thresholds reduce analgesic requirements; 3) diabetic induced microvascular dysfunction promote local retention of local anesthetic agent, prolong duration of blockade; and 4) local anesthetics carry a higher risk of neurotoxicity in diabetic nerves, increasing potential for nerve injury. (29) Taking together, these mechanisms may contribute to the lower observed failure rate in diabetic patietns, though this finding should be interpreted with caution given the retrospective nature of the study.

Conversely, liver disease emerged as a strong independent predictor of block failure (adjusted OR 4.81, 95% CI 1.16–19.6). This association may be attributable to altered drug metabolism, coagulation abnormalities affecting block placement, or fluid retention affecting tissue anatomy. The relatively wide confidence iterval reflects the small number of patients with liver disease in this cohort, suggesting this finding should be interpreted cautiously.

This study also found that mixed local anesthetic solutions (lidocaine combined with bupivacaine) were superior to single agents (adjusted OR 3.04) supporting the theoretical advantage of adding rapid-onset, short-acting agents to long acting local anesthetic to achieve faster onset and more reliable blockade. However, the systematic review and meta-analysis demonstrated that while mixed local anesthetic solutions provided faster onset of block,(30) they were associated with shorter duration of sensory and motor blockade compared to long-acting local anesthetic alone. (30–32) Furthermore, that systematic review found no significant difference in block success rate between combined and long-acting local anesthetic regimens. (30) The contradictory results observed in our study may be attributable to differences in outcome definition; our study used clinical criteria to determine block failure, whereas the randomized controlled trials included in those systematic review employed onjective outcomes measures.

The inverse relationship between local anesthetic volume and block failure (adjusted OR 0.94 per ml increase) aligns with dose-response principles in regional anesthesia, consistent with previous study demonstrating that higher doses were associated with higher success rate of brachial plexus block (33). However, increasing volume must be balanced against the risk of local anesthetic systemic toxicity.

The significant variation in block failure rates by surgical site reflects the differential innervation patterns of upper limb regions. Humeral/elbow carried approximately twice the risk of USG-BPB failure compared to hand surgery, likely because humeral and elbow are supplied by proximal branches of brachial plexus that may not be completely anesthetized by more distal approaches (34). Elbow surgery in particular often required adequate coverage requires adequate coverage of the radial nerve and posterior cutaneous nerve of the arm, which may be insufficiently blocked with certain approaches. (11) Additionally, anatomical variations of intercostobrachial nerve, which provides sensory innervation extending to the elbow, may contribute to incomplete blockade in this region. (35).

The strong association between surgical duration and block failure (adjusted OR 3.54 for procedures exceeding 120 minutes) is consistent with the pharmacokinetic properties of local anesthetics. Even with long-acting agents like bupivacaine, sensory block duration typically ranges from 8–24 hours depending on the dose and injection site. Our findings suggest that the procedures anticipated to exceed 2 hours may benefit from continuous perineural catheter techniques or supplemental analgesic strategies.

The association between delayed surgical start – defined as more than 30 minutes from block performance to skin incision – and increased block failure risk (adjusted OR 1.80) may reflect several contributing factors. Prolonged delays may allow partial regression of sensory blockade before surgical stimulation begins, particularly when blocks were assessed as adequate at early time point. Additionally, extended waiting time may indicate logistical challenges or greater case complexity, both of which could independently contribute to adverse block outcomes.

Although the clinical-based risk score requires several variables to calculate, it demonstrated good discrimination between successful and failed brachial plexus blocks in the bootstrap validation analysis. This score may assist anesthesiologists in predicting block failure in routine ultrasound-guided brachial plexus block practice. While its discriminative accuracy may be lower than that of the perfusion index (36,37), it may nonetheless offer practical value in clinical settings where perfusion index monitoring is unavailable.

The clinical implication of our findings are several. First, our results strongly support the implementation of structured training programs for regional anesthesia, with particular emphasis on adequate supervision for junior residents. The 6-fold difference in failure rates between first- and second-year residents and experienced staff suggests that current training models may require enhancement. Simulation-based training, which has demonstrated success rates of 96% in controlled settings [24], should be considered as a valuable supplement to direct clinical experience. Furthermore, the identification of specific patient-related risk factors enables more informed consent and individualize

perioperative planning. Patients with higher body weight or underlying liver disease may benefit from alternative anesthetic techniques or additional intraoperative monitoring.

Second, The protective effect of diabetes, while unexpected, suggests that these patients may be particularly suitable candidates for regional anesthesia, and this consideration may be incorporated into preoperative anesthetic planning.

Third, the superiority of mixed local anesthetic solutions and the importance of adequate local anesthetic volume provide actionable guidance for clinical practice. However, the optimal combination and volume should be individualized based on patient characteristics, surgical requirements, and institutional protocols while strictly adhering to maximum safe dose thresholds to minimize the risk of local anesthetic systemic toxicity.

Lastly, the strong association between surgical duration and block failure suggests that procedures expected to exceed 2 hours should be carefully evaluated for alternative or supplementary anesthetic strategies. These may include continuous perineural catheter technique, combined regional-general anesthesia, or, where feasible, modified surgical approaches aimed at reducing operative time.

Strengths & Limitations

This study benefits from a relatively large sample size ($n = 606$) and comprehensive data collection including patient, anesthetic, and surgical variables. The multivariate analysis allows identification of independent risk factors while controlling for confounding variables. The inclusion of multiple operators and approaches enhances the generalizability of findings and it represents the real-world setting in the university hospital. Several limitations should be acknowledged. First, this is a single-center study, which may limit external validity due to institutional practices and patient populations. The definition of block failure, while clinically relevant, may not be directly comparable to other studies using different success criteria. Second, the retrospective design limits our ability to assess certain variables that might influence outcomes, such as specific anatomical variations, needle trajectory, or real-time decision-making during block placement. The relatively small number of patients in certain subgroups (particularly those with liver disease) results in wide confidence intervals for some estimates. Third, we did not assess long-term outcomes or patient satisfaction, focusing primarily on immediate block success. The learning curve analysis is limited by the cross-sectional nature of the data, which does not capture individual operator progression over time.

Conclusion

This study identifies operator experience as the primary determinant of ultrasound-guided brachial plexus block failure, with first-year residents having 6-fold higher failure rates than experienced staff. Patient factors including higher body weight and liver disease increase failure risk, while diabetes appears protective. Technical factors such as local anesthetic selection and volume, along with surgical factors including site and duration, significantly influence outcomes. These findings support the

implementation of structured training programs with adequate supervision, careful patient selection and counseling, and consideration of alternative anesthetic strategies for high-risk scenarios. The identification of modifiable risk factors provides opportunities for quality improvement initiatives aimed at optimizing regional anesthesia outcomes.

Abbreviations

AIC	Akaike Information Criteria
ASA	American Society of Anesthesiologist
AUC	Area Under the Curve
BMI	Body Mass Index
BPB	Brachial plexus block
CI	Confidence Inteval
CNS	Cerebral Nervious System
ERAS	Enharnce Recovery After Surgery
HIS	Hospital Information System
IQR	Interquatile Rang
IV	Intravenous
LA	Local anesthetic drug
OR	Odd Ratio
PACU	Postanesthetic Care Unit
ROC	Receiver Operating Characteristic
USG-BPB	Ultrasound-guided Brachial Plexus Block

Declarations

Ehic approval: by Human Research Ethic Committee of Faculty of Medicine, Prince of Songkla University
EC No 67-249-8-4 Approval date 11 June 2024
Consent from participants was waived because the retrospective study.

Consent for publication: Not applicable

Availability of data and materials: The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The author declare that they have no competing interests

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Authors' contributions: NR: desing of research, literature review, EC submission, data collection, data analysis, interpretation of data and first draft manuscript. JP: Research question, literature review, design the project, plan of research, interpretation of data, final manuscript, WS: research plan for collecting data, data analysis, interpretation of data, approved final manuscript, CK: data collection and final manuscript approval, WW: acquisition and final manuscript approval. KS: data collection, prepare and plan for data collection and data entry.

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References

1. Wu Z, Wang Y. Development of Guidance Techniques for Regional Anesthesia: Past, Present and Future. *J Pain Res.* 2021 Jun;Volume 14:1631–41. doi:10.2147/JPR.S316743
2. Hadzic A, Arliss J, Kerimoglu B, Karaca PE, Yufa M, Claudio RE, et al. A Comparison of Infraclavicular Nerve Block versus General Anesthesia for Hand and Wrist Day-case Surgeries. *Anesthesiology.* 2004 Jul 1;101(1):127–32. doi:10.1097/00000542-200407000-00020
3. Nho JH, Jang BW, An CY, Yoo JH, Song S, Cho HB, et al. General versus Brachial Plexus Block Anesthesia in Pain Management after Internal Fixation in Patients with Distal Radius Fracture: A Randomized Controlled Trial. *Int J Environ Res Public Health.* 2022 Jul 27;19(15):9155. doi:10.3390/ijerph19159155
4. Liu SS, Strodbeck WM, Richman JM, Wu CL. A Comparison of Regional Versus General Anesthesia for Ambulatory Anesthesia: A Meta-Analysis of Randomized Controlled Trials: *Anesth Analg.* 2005 Dec;1634–42. doi:10.1213/01.ANE.0000180829.70036.4F
5. O'Donnell BD, Ryan H, O'Sullivan O, Iohom G. Ultrasound-Guided Axillary Brachial Plexus Block with 20 Milliliters Local Anesthetic Mixture Versus General Anesthesia for Upper Limb Trauma Surgery: An Observer-Blinded, Prospective, Randomized, Controlled Trial. *Anesth Analg.* 2009 Jul;109(1):279–83. doi:10.1213/ane.0b013e3181a3e721
6. Sertcakacilar G, Yildiz GO, Bayram B, Pektas Y, Cukurova Z, Hergunsel GO. Comparing Preoperative Anxiety Effects of Brachial Plexus Block and General Anesthesia for Orthopedic Upper-Extremity Surgery: A Randomized, Controlled Trial. *Medicina (Mex).* 2022 Sep 16;58(9):1296. doi:10.3390/medicina58091296

7. Bajwa SJS, Jain D, Anand S, Palta S. Neural blocks at the helm of a paradigm shift in enhanced recovery after surgery (ERAS). *Indian J Anaesth*. 2021 Sep;65(Suppl 3):S99–103. doi:10.4103/ija.ija_807_21
8. Chin KJ, Singh M, Velayutham V, Chee V. Infraclavicular brachial plexus block for regional anaesthesia of the lower arm. In: The Cochrane Collaboration, editor. *Cochrane Database of Systematic Reviews* [Internet]. Chichester, UK: John Wiley & Sons, Ltd; 2005 [cited 2026 Jun 8]. p. CD005487. Available from: <https://doi.wiley.com/10.1002/14651858.CD005487> doi:10.1002/14651858.CD005487
9. Albrecht E, Mermoud J, Fournier N, Kern C, Kirkham KR. A systematic review of ultrasound-guided methods for brachial plexus blockade. *Anaesthesia*. 2016 Feb;71(2):213–27. doi:10.1111/anae.13347
10. Vazin M, Jensen K, Kristensen DL, Hjort M, Tanggaard K, Karmakar MK, et al. Low-Volume Brachial Plexus Block Providing Surgical Anesthesia for Distal Arm Surgery Comparing Supraclavicular, Infraclavicular, and Axillary Approach: A Randomized Observer Blind Trial. *BioMed Res Int*. 2016;2016:1–10. doi:10.1155/2016/7094121
11. Abe S, Kondo H, Tomiyama Y, Shimada T, Bun M, Kuriyama K. Risk factors for insufficient ultrasound-guided supraclavicular brachial plexus block. *J Exp Orthop*. 2023 Jan;10(1):48. doi:10.1186/s40634-023-00611-1
12. Nijs K, Hertogen P 'S, Buelens S, Coppens M, Teunkens A, Jalil H, et al. Axillary Brachial Plexus Block Compared with Other Regional Anesthesia Techniques in Distal Upper Limb Surgery: A Systematic Review and Meta-Analysis. *J Clin Med*. 2024 May 29;13(11):3185. doi:10.3390/jcm13113185
13. Tran DQH, Russo G, Muñoz L, Zaouter C, Finlayson RJ. A Prospective, Randomized Comparison Between Ultrasound-Guided Supraclavicular, Infraclavicular, and Axillary Brachial Plexus Blocks: *Reg Anesth Pain Med*. 2009 Jul;34(4):366–71. doi:10.1097/AAP.0b013e3181ac7d18
14. Techasuk W, González AP, Bernucci F, Cupido T, Finlayson RJ, Tran DQ. A Randomized Comparison Between Double-Injection and Targeted Intracuster-Injection Ultrasound-Guided Supraclavicular Brachial Plexus Block. *Anesth Analg*. 2014 Jun;118(6):1363–9. doi:10.1213/ANE.0000000000000224
15. Tran DQH, Muñoz L, Zaouter C, Russo G, Finlayson RJ. A Prospective, Randomized Comparison Between Single- and Double-Injection, Ultrasound-Guided Supraclavicular Brachial Plexus Block: *Reg Anesth Pain Med*. 2009 Sep;34(5):420–4. doi:10.1097/AAP.0b013e3181ae733a
16. Gürkan Y, Hoşten T, Solak M, Toker K. Lateral sagittal infraclavicular block: clinical experience in 380 patients. *Acta Anaesthesiol Scand*. 2008 Feb;52(2):262–6. doi:10.1111/j.1399-6576.2007.01504.x
17. Yazer MS, Finlayson RJ, Tran DQH. A Randomized Comparison Between Infraclavicular Block and Targeted Intracuster Injection Supraclavicular Block: *Reg Anesth Pain Med*. 2015;40(1):11–5. doi:10.1097/AAP.0000000000000193
18. Abdallah FW, Brull R. The Definition of Block “Success” in the Contemporary Literature: Are We Speaking the Same Language? *Reg Anesth Pain Med*. 2012;37(5):545–53.

doi:10.1097/AAP.0b013e3182583b00

19. Bottomley T, Gadsden J, West S. The failed peripheral nerve block. *BJA Educ.* 2023 Mar;23(3):92–100. doi:10.1016/j.bjae.2022.12.002
20. Yeniocak T, Canbolat N. Retrospective Analysis of Ultrasound-Guided Infraclavicular Block: Effect of Experience of Anesthesiologists on Volume of Local Anesthetic Administered. *Pain Res Manag.* 2019 May 6;2019:1–5. doi:10.1155/2019/4846956
21. Luyet C, Schüpfer G, Wipfli M, Greif R, Luginbühl M, Eichenberger U. Different Learning Curves for Axillary Brachial Plexus Block: Ultrasound Guidance versus Nerve Stimulation. *Anesthesiol Res Pract.* 2010;2010:1–7. doi:10.1155/2010/309462
22. Harmon DJ, Boscardin CK, Cohen NH, Braehler MR. The efficacy of an anatomy and ultrasonography workshop on improving residents' confidence and knowledge in regional anesthesia. *BMC Med Educ.* 2023 Sep 14;23(1):665. doi:10.1186/s12909-023-04653-y
23. Miranda PF, Araneda AL, Molina NP, Miranda FG, Morrison C, Corvetto MA, et al. Simulated-based training for ultrasound-guided popliteal sciatic nerve block: determining the learning curve and transference to real patient. *Adv Simul.* 2025 Nov 11;10(1):55. doi:10.1186/s41077-025-00389-5
24. Punchuklang W, Nivatpumin P, Jintadawong T. Total failure of spinal anesthesia for cesarean delivery, associated factors, and outcomes: A retrospective case–control study. *Medicine (Baltimore).* 2022 Jul 8;101(27):e29813. doi:10.1097/MD.00000000000029813
25. Nielsen KC, Guller U, Steele SM, Klein SM, Greengrass RA, Pietrobon R. Influence of Obesity on Surgical Regional Anesthesia in the Ambulatory Setting: An Analysis of 9,038 Blocks. *Anesthesiology.* 2005 Jan 1;102(1):181–7. doi:10.1097/00000542-200501000-00027
26. Wei Q, Rong H, Zhang G, Xie Y, Dai W. Nerve Block Extends Nerve Function Recovery in Patients with Diabetic Foot Ulcers. *J Pain Res.* 2024 Nov;Volume 17:3949–57. doi:10.2147/JPR.S491539
27. Prasad G, Misquith JCR, Ribeiro KNS, Naik SA. Comparison of the Analgesic Duration Using Ultrasound-guided Popliteal Sciatic Nerve Block between Diabetics with Neuropathy and Nondiabetics without Neuropathy. *Ann Afr Med.* 2024 Oct;23(4):663–8. doi:10.4103/aam.aam_89_23
28. Baeriswyl M, Taffé P, Kirkham KR, Bathory I, Rancati V, Crevoisier X, et al. Comparison of peripheral nerve blockade characteristics between non-diabetic patients and patients suffering from diabetic neuropathy: a prospective cohort study. *Anaesthesia.* 2018 Sep;73(9):1110–7. doi:10.1111/anae.14347
29. Ten Hoope W, Looije M, Lirk P. Regional anesthesia in diabetic peripheral neuropathy. *Curr Opin Anaesthesiol.* 2017 Oct;30(5):627–31. doi:10.1097/ACO.0000000000000506
30. Lin C, Guerrero AL, Jesin J, Tangri R, Luginaah NA, Kumar K, et al. Comparing block characteristics of mixtures of short/intermediate- and long-acting local anesthetics for peripheral nerve block: a systematic review and meta-analysis. *Braz J Anesthesiol Engl Ed.* 2025 May;75(3):844617. doi:10.1016/j.bjane.2025.844617

31. Temberg JL, Pisljagic S, Steensbæk MT, Yousef S, Andersen LC, Lange KHW, et al. Effects of Combining Short- and Long-Acting Local Anaesthetics in Peripheral Nerve Blocks—A Systematic Review With Meta-Analysis and Trial Sequential Analysis. *Acta Anaesthesiol Scand*. 2026 Jan;70(1):e70141. doi:10.1111/aas.70141
32. Cansian JM, Bracht VS, Biolo LV, Schmidt AP. Comparative effectiveness of bupivacaine and lidocaine-bupivacaine mixtures in brachial plexus block: a systematic review and meta-analysis. *Anesth Pain Med*. 2025 Jul 31;20(3):252–65. doi:10.17085/apm.25264
33. Vandepitte C, Gautier P, Xu D, Salviz EA, Hadzic A. Effective Volume of Ropivacaine 0.75% through a Catheter Required for Interscalene Brachial Plexus Blockade. *Anesthesiology*. 2013 Apr;118(4):863–7. doi:10.1097/ALN.0b013e3182850dc7
34. Betteridge N, Taylor A, Hartley R. Clinical anatomy of the nerve supply to the upper limb. *BJA Educ*. 2021 Dec;21(12):462–71. doi:10.1016/j.bjae.2021.07.007
35. Cirocchi R, Matteucci M, Randolph J, Duro F, Properzi L, Avenia S, et al. Anatomical variants of the intercostobrachial nerve and its preservation during surgery, a systematic review and meta-analysis. *World J Surg Oncol*. 2024 Apr 11;22(1):92. doi:10.1186/s12957-024-03374-w
36. Bolívar J, Sabogal RC, Palacio-Arango V, Robledo S. Relationship Between Pulse Oximetry Perfusion Index and Anesthetic Brachial Plexus Block for Upper Limb Surgery in Adults. *Cureus*. 2025 Dec 16. doi:10.7759/cureus.99394
37. Wang J, Deng L, Xu A. Evaluation of prediction effect of perfusion index for supraclavicular brachial plexus block in children: protocol for a randomized trial. *Trials*. 2022 Dec;23(1):629. doi:10.1186/s13063-022-06597-y

Figures

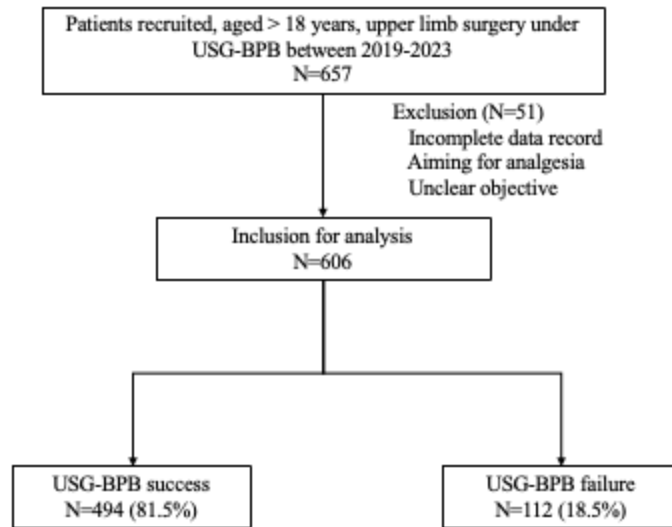


Figure 1

Diagram demonstrates number of patients recruited and success rate and failure of ultrasound-guided brachial plexus block.

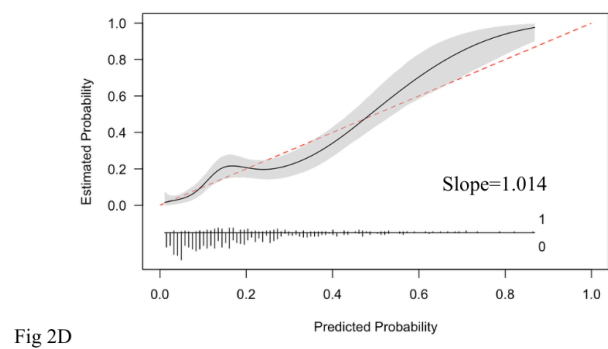
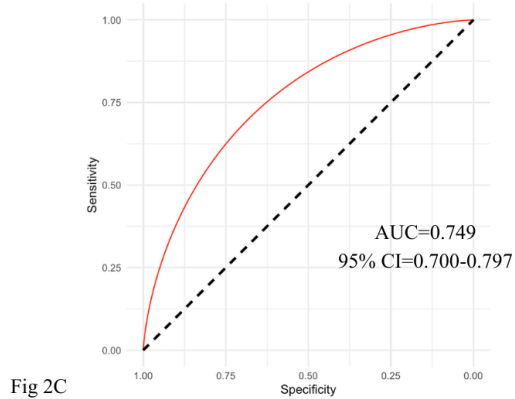
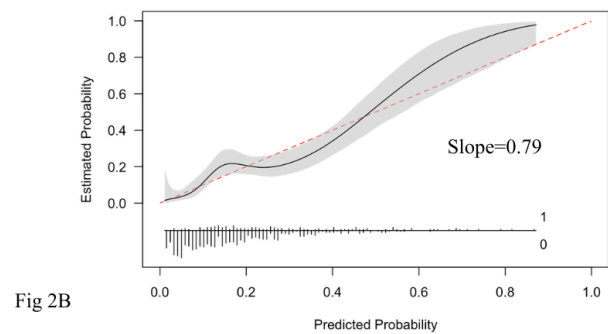
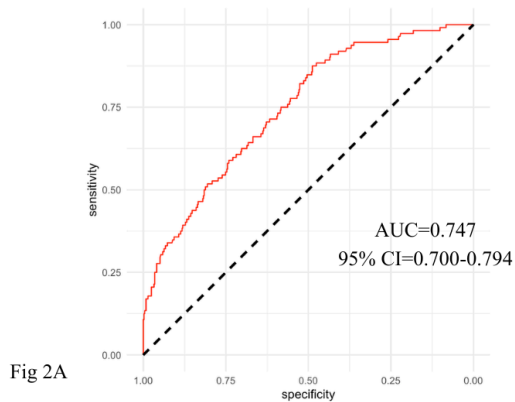


Figure 2

Receiver operating characteristic curve of multivariable logistic regression model (A) and the clinical-based risk prediction score (C) of USG-BPB failure, and calibration plot between predicted and estimated probability of brachial plexus block failure of both logistic regression model (B) and clinical point-based prediction score (D)

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table2Patientcharecteristic.docx](#)
- [Table4UnivariateandmultivariatelogisticregressionanalysisofpossiblefactorsassociatedUSG.docx](#)