Efficacy and Complications of Ultrasound-Guided Continuous Brachial Plexus Block in Upper Extremity Surgery

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Objective: *Continuous brachial plexus block is part of multimodal analgesia for upper extremity surgery. This study evaluated the efficacy and complication rate of continuous ultrasound-guided brachial plexus analgesia for postoperative pain management after upper extremity surgery.*

Material and Method: *This prospective case series included ≥18-years old, ASA I-III patients, scheduled for upper extremity surgery. Depending on the surgical approach (upper or lower arm) ultrasound-guided interscalene or infraclavicular brachial plexus catheter (IS, IC) were applied. For both techniques 10 ml of lidocaine 2% with epinephrine 5 mg/ml was injected and followed by 10 ml (IS) or 20 ml (IC) of levobupivacaine 0.5%. The block was defined successful with complete sensory and motor blockade of upper extremity at 20 min post-procedure. Postoperative patient-controlled perineural levobupivacaine infusion plus multimodal analgesia were administered for pain management. The outcomes included pain evaluation using numeric rating scales (0 to 10), opioid requirement, side effects, ward nurses and patients' satisfaction and technique-related complications within 72 hours were daily evaluated.*

Results: *Twenty-two patients were included. The success rate of both techniques was 100%. Catheters were maintained 2.82±1.33 days. Within 72 h postoperatively, 95.5 to 100% and 77.3 to 95% of the patients had mild pain (NRS 0 to 3) at rest and on movement respectively. One third (36.4%) of the patients had opioid-free requirement. Most patients (81.8%) were very satisfied with pain management. There were 16 cases (72.7%) noted for technical problems with catheters. Three patients (13.6%) suffered from nausea and vomiting. There was no CBPB-related major adverse event, but one had partly reversible radial and ulnar nerve injury, possibly due to prolonged tourniquet application.*

Conclusion: *Continuous ultrasound-guided brachial plexus block is effective pain management and few major adverse events in upper extremity surgery.*

Keywords: *Continuous brachial plexus block (CBPB), Ultrasound-guided, Interscalene catheter, Infraclavicular catheter, Perineural infusion*

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Peripheral nerve blocks are effective for postoperative pain control. Single injection usually provides adequate analgesia for 10 to 24 hours[1], whereas some procedures such as shoulder, elbow and wrist surgery require longer lasting postoperative analgesia, which can be achieved with continuous peripheral nerve block[2]. However, these techniques have to be applied by the experienced anesthesiologist. In addition they may be time-consuming and costly. On the other hand, patients' suffering as well as long lasting sequelae seem to be underrated by therapists and society[3-5].

Aim of this study was to assess efficacy and complication rate of continuous brachial plexus block for postoperative pain management after shoulder, elbow and wrist surgery.

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Material and Method

After Institutional Review Board approval (Si 052/2009), 22 patients scheduled for upper extremity surgery giving informed consent were enrolled. Inclusion criteria were age >18 years, and ASA physical status I-III. Exclusions were uncooperative patients and those with significant morbidity, such

as BMI >35, coagulopathy, neurologic, infectious and cardiopulmonary disease, and local anesthetics allergy. Severe reactions to local anesthetics or patients unwillingness to continue led to drop-out.

All patients received acetaminophen 500 mg and COX2 inhibitor (celecoxib 400 mg or etoricoxib 90 mg) 2 hours before surgery.

At induction room standard monitoring was applied and the respective brachial plexus catheter, interscalene for shoulder- and humerus, infraclavicular for wrist- and hand-surgery was inserted under mild IV sedation with low dose midazolam/fentanyl and oxygen insufflation via mask.

Interscalene catheter insertion

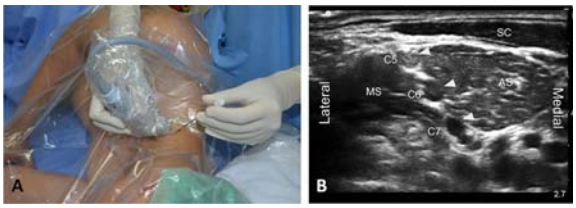
With the patient in lateral position, surgical-side up, linear high frequency (6 to 13 MHz) ultrasound transducer (MicroMaxx™ system, SonoSite Inc., Bothell, USA) was applied to identify anterior scalene, interscalene muscle and the C5, 6, 7 nerve roots at the level of cricoid cartilage in the cross-section view. Vertebral artery and vein were also identified in order to prevent accidental puncture. After local infiltration at the puncture site, a 5 cm 18G Tuohy needle (Contiplex®, B. Braun Melsungen AG, Germany), was inserted in-plane approach from posterior to anterior direction beneath the ultrasound transducer toward C5 and C6 nerve roots. Lidocaine 2%, 10 ml with epinephrine 5 µg/ml was injected through the needle, then a non-stimulating 20G closed tip polyamide nylon with 3 lateral eyes was advanced through the needle 3 cm beyond needle tip. The needle was then removed, and levobupivacaine 0.5%,10 ml was incrementally injected. Proper position of the catheter was confirmed by the spread pattern under ultrasound visualization (Fig. 1).

The catheter was tunneled and bridged close to the puncture site, and covered by a translucent occlusive dressing.

Infraclavicular catheter insertion

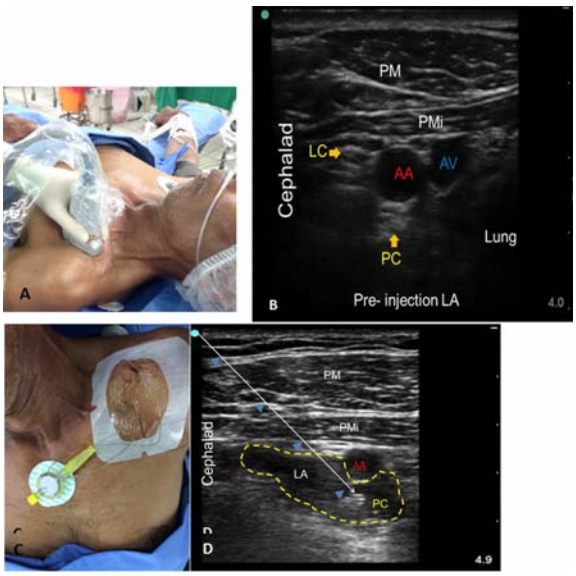
Contrast to interscalene catheter insertion technique, infraclavicular insertion was performed in supine position. The linear high frequency ultrasound transducer was placed vertically beneath the clavicle and medial to the coracoid process. The length of Tuohy needle was chosen 5 cm or 10 cm (Contiplex®, B. Braun Melsungen AG, Germany), depended on the thickness of patient's chest wall. Tuohy needle was inserted in cephalad to caudad direction beneath the ultrasound transducer. When putting the needle at 6 o'clock posterior to axillary artery, lidocaine 2%, 10 ml with epinephrine 5 µg/ml was incrementally injected and followed by levobupivacaine 0.5%, 20 ml. Proper position of the catheter was confirmed by the spread pattern under ultrasound visualization (Fig. 2).

During and after catheter insertion patients



SC = sternocleidomastoid muscle; AS = anterior scalene muscle; MS = middle scalene muscle

Fig. 1 Continuous interscalene brachial plexus block. A) Patient was placed in lateral position, needle inserted from the posterior to anterior direction. B) Catheter tip was targeted between the C5 and C6 nerve root through brachial plexus sheath at the medial side of nerve root.



PM = pectoralis major muscle; PMi = pectoralis minor muscle; AA = axillary artery; LC = lateral cord; PC = posterior cord; MC = medial cord

Fig. 2 Continuous infraclavicular brachial plexus block. A) patient was placed in supine position and needle inserted from cephalad to caudad direction. B) brachial plexus cords are around axillary artery. C) catheter fixation method. D) local anesthetic spreading.

were closely observed for toxicity symptoms, such as abrupt change of blood pressure, dysrhythmia, tinnitus, abnormal tasting, circumoral numbness. Sensory and motor function of shoulder and arm were evaluated every 5 min until 20 min postprocedure to ascertain the success of the blockade. Then, general anesthesia (GA) with endotracheal intubation or LMA was applied after continuous interscalene BPB. For the lower arm surgery, continuous infraclavicular BPB should be sufficient for surgical anesthesia, GA could be added by the decision of the anesthesiologist. Intraoperative opioid and sedation medication consumption were recorded.

Patient-controlled analgesia (PCA) of levobupivacaine 0.1% with a basal infusion 6 ml/h, bolus dose 4 ml in 30 min-lockout interval via the respective catheter was started one hour before the end of surgery until 3 days postoperatively. Using numeric rating scale (NRS) pain score was assessed immediately after the arrival at PACU, 1 hour postoperatively and every four hours for 3 days. Multimodal analgesia was applied to all patients with paracetamol 500 mg every 6 hours for 3 days plus optional etoricoxib 90 mg (Arcoxia®) once a day or celecoxib 200 (Celebrex®) twice a day for 5 days. For breakthrough pain, defined as NRS >4, patients were advised to activate the PCA for administering a bolus dose; in case of persisting pain after 15 minutes, tramadol 50 mg was given in 6 hours interval. All patients followed the standardized physical therapy protocol starting the first postoperative day.

Measurements

Data collection started the day before surgery. Postoperatively at 12, 24, 36, 48, 60 and 72 hours, the following data were collected: pain assessment at rest and on movement, based on numeric rating scale (0 = no pain, 10 = worst pain imaginable), daily morphine requirement and -related side effects, patients' and ward nurses' satisfaction (rated as unsatisfied, satisfied and very satisfied), technique-related complications such as adverse reaction on local anesthetics, or nerve injury.

Statistical analysis

Sample size was calculated by using the incidence of 24-hour visual analog pain score $\leq$3 at rest of patients from Capdevila et al study which was 65% with the allowable error of 20%, and two-sided level of significance (alpha error) was set of 5%. The estimated sample size was at least 22 patients.

Data were analyzed using PASW Statistics for Windows, 18.0 Chicago: SPSS Inc. Data are shown in mean $\pm$ SD, median and min, max value.

Results

Twenty-two patients, 7 in the IS group and 15 in the IC group, 12 males and 10 females were enrolled in this case series study with no drop-out. All 22 patients received successful perineural brachial plexus catheter insertion ascertained by sensory and motor blockade within 20 min post-procedure. Characteristics of the patients, anesthetic technique and intraoperative anesthetic drugs used are shown in Table 1.

In 11 patients, solely continuous infraclavicular brachial plexus block combined with sedation was applied, whereas 4 patients received blocks plus general anesthesia (ETT/LMA). The average dose of intraoperative fentanyl and midazolam was 82.95$\pm$28.23 mg, 3.14$\pm$1.49 mg, respectively. Patients' postoperative NRS pain scores are shown in Table 2.

About one third (36.4%) of the patients had opioid-free requirement within 72 hours postoperatively, 81.8% were maximally satisfied (score 9 to 10); mean daily morphine requirement at 24, 48, 72 hours was 6.68$\pm$7.06, 7.95$\pm$9.08, 6.32$\pm$9.06 mg respectively. The majority of nurses were either 'very satisfied' or 'most satisfied' with the type of postoperative pain management. Only 4.5% of them were 'just satisfied' because of the catheter problems and technical unfamiliarity.

There were also 16 cases (72.7%) with catheter-related problems (leakage, catheter withdrawn in advertently, migration and kinking). Accidental withdrawal of the catheter was observed in 4 patients with interscalene and 1 patient with infraclavicular approach. Leakage of local anesthetics at puncture site occurred in 8 patients with infraclavicular and 1 patient with interscalene approach. Catheter securement technique was insufficient in one case and in another case local anesthetics could not been infused due to kinking of the catheter. Three patients experienced relevant symptoms of nausea or vomiting. No major adverse events such as acute respiratory failure, recurrent laryngeal nerve paralysis or local anesthetic systemic toxicity was noted. The average length of patients' hospital stay was 7.91$\pm$5.37 (mean $\pm$ SD) days.

A 23 years-old, very thin female patient (body mass index 15 kg/m^2) with 30 days-length of hospital stay, suffering from stiff elbow received continuous infraclavicular brachial plexus block for open capsulolysis. One day after surgery a right wrist drop grade 0/5, and decreased sensation at the dorsum of hand, the palm and 4th, 5th fingers were noticed. Local anesthetic infusion was discontinued immediately. Within one week the patient experienced complete

Table 1. Demographic data and intraoperative anesthesia technique

	Age	Sex	ASA	BMI	Preop Pain Rest	Preop Pain Move	Surgery	CPNB technique	Anesth Tech
1	55	Female	1	19.9	1	5	Open capsulolysis elbow	IC	Sedation
2	65	Male	2	26.4	2	10	Total shoulder arthroplasty	IS	ETT
3	35	Male	1	18.9	0	2	Forearm amputation	IC	Sedation
4	72	Male	2	22.5	1	3	Revision total elbow arthroplasty	IC	Sedation
5	66	Female	2	22.7	0	4	Total shoulder arthroplsty	IS	ETT
6	33	Male	1	21.6	0	0	Remove prosthesis elbow	IC	Sedation
7	29	Female	1	17.9	0	2	Corrective osteotomy elbow	IC	Sedation
8	61	Male	2	25.4	5	10	ORIF humerus	IC	Sedation
9	28	Male	1	25.4	0	0	Arthroscopic contracture release elbow	IC	LMA
10	52	Female	1	22.2	1	4	ORIF humerus	IS	LMA
11	57	Female	2	25.5	1	3	ORIF elbow	IC	ETT
12	20	Male	1	27.5	0	0	Arthroscopic bankart repair shoulder	IS	LMA
13	20	Male	1	27.4	0	2	Open capsulolysis elbow	IC	Sedation
14	56	Male	2	34.3	2	3	Arthroscopic rotator cuff repair	IS	ETT
15	28	Male	1	19.4	0	2	Remove prosthesis elbow	IC	Sedation
16	34	Male	1	19.4	0	3	Open capsulolysis elbow	IS	LMA
17	59	Female	2	16.9	1	3	ORIF elbow	IC	LMA
18	61	Female	2	33.7	1	3	Hemiarthroplasty humerus	IS	ETT
19	37	Female	1	26.2	0	5	Open capsulolysis elbow	IC	Sedation
20	57	Male	2	29.4	0	3	Remove prosthesis humerus	IC	Sedation
21	23	Female	1	14.7	5	10	Open capsulolysis elbow	IC	Sedation
22	76	Female	2	23.1	0	0	Total elbow arthroplasty	IC	LMA
Total N	22	22	22	22	22	22	22	22	22

IS = continuous interscalene brachial plexus block; IC = continuous infraclavicular brachial plexus block; CPNB = continuous peripheral nerve block; LMA = Laryngeal mask airway; ETT = endotracheal tube

recovery of sensory deficit at the palm, with persistence of the other symptoms, such as wrist drop slightly recovering within 6 months. Electromyography (EMG) on postoperative day 75 showed severe right radial, mild ulnar nerve injury at the operated arm. This patient lost follow-up since the EMG investigation.

Discussion

Our data show that regarding intra- and postoperative analgesia continuous brachial plexus block provided a success rate of 100% without catheter-related serious complications. As a result patients' satisfaction as well as nurses acceptance were high. However, rate of catheter-related problems e.g. migration and leakage was high, though it had little influence on postoperative pain; but highlighted the importance of catheter caring process which could be improved.

Continuous peripheral nerve block (PNB) allows titration of local anesthetics to achieve the desired effect. Ullah et al showed better pain relief with continuous interscalene brachial plexus block in major shoulder surgery compared to parenteral opioid analgesia[6]. There is a large body of evidence supporting the advantages of single or continuous PNB analgesia when compared with opioid analgesia[2,5,7-10]. The result from our study also supported the previous data when analgesia can be kept longer with continuous infusion via the catheter.

Catheter insertion success is higher using ultrasound guidance compared with nerve stimulation for most but not all insertion sites. The technique is suggested to improve surrogates for block quality and performance, including faster sensory block onset,

Table 2. Percentage of patients with numeric rating scale pain score (0-10) at rest and on movement

Number of patients (%)		4 h	8 h	12 h	16 h	20 h	24 h	36 h	48 h	60 h	72 h
Pain score at rest	Mild (0-3)	21 (95.5)	22 (100)	19 (86.4)	19 (86.4)	20 (90.9)	22 (100)	22 (100)	22 (100)	22 (100)	22 (100)
	Moderate (4-6)	1 (4.5)		2 (9.1)	2 (9.1)	2 (9.1)					
	Severe (7-10)			1 (4.5)	1 (4.5)						
Pain score on movement	Mild (0-3)	19 (81.8)	16 (72.7)	17 (77.3)	17 (77.3)	17 (77.3)	17 (77.3)	19 (86.4)	19 (86.4)	20 (90.9)	21 (95.5)
	Moderate (4-6)	3 (13.6)	4 (18.2)	4 (18.2)	2 (9.1)	4 (18.2)	4 (18.2)	3 (13.6)	3 (13.6)	2 (9.1)	1 (4.5)
	Severe (7-10)	1 (4.5)	2 (9.1)	1 (4.5)	3 (13.6)	1 (4.5)	1 (4.5)				

fewer vascular punctures, faster performance time, and fewer needle-passes[11-13]. In our study, rare but significant adverse events of continuous interscalene brachial plexus block such as respiratory impairment, dyspnea or hoarseness have not been observed; this at least ensured the safety of catheter insertion under ultrasound guidance.

Capdevila et al, including 1,416 orthopedic patients, reported an incidence of technical problems due to catheters and devices of 17.9%[14]. In our study the incidence was much higher (72.6%), mainly due to dislodgment, leakage, and kinking of the catheter. Fixation of regional catheters dedicated to be in situ for several days is a general problem. A novel needle-over cannula technique may lead to less leakage and dislodgement, as reported by Tsui et al[15,16] comparing the new technique versus a catheter-through-needle approach for peripheral nerve block. Our data indicate that we need to improve the technique of catheter fixing relevantly.

Postoperative neurological symptoms (PONS) after brachial plexus analgesia is not generally related to the regional block but may be consequence of the specific surgical technique, such as applying a tourniquet or positioning of the patient[12]. In our study there was one case of tourniquet-related nerve injury, confirmed by electromyography. The site of nerve injury was distal part of forearm, so nerve injury from the brachial plexus blockade may not be the etiology. Most probable etiology is the pressure on nerves of the upper arm during prolonged tourniquet application (two times 120 min and 40 min-inflation with 150 mmHg over baseline systolic pressure and 10 min deflation). There has been, however, a combination of adverse conditions, such as very thin arms, high inflation pressure and prolonged tourniquet application. Benzon et al[17] performing a study in volunteers applied ulnar nerve somatosensory evoked potentials reporting about complete signal-abolition after 15 to 30 min of tourniquet application with 100 mmHg above baseline systolic blood pressure. They found that these changes were due to nerve ischemia and reversible with tourniquet deflation. The (US) Association of peri Operative Registered Nurses (http://www.aorn.org/, AORN) recommend regarding the use of pneumatic tourniquets that the inflation pressure should be determined by the surgeon or anesthesia professional based on the patient's systolic blood pressure and limb circumference, and that it should be limited to the effective minimum (time and pressure)[18]. Even though there is no completely safe tourniquet time, the

recommendation of safe duration of tourniquet-induced ischemia is one hour ideally. Deflation of the cuff has to be performed intermittently during about 10 minutes to minimize the "reperfusion trauma"[19].

This case series has limitations, as it is non-comparative and the number of patients included is small.

Conclusion

In conclusion, continuous brachial plexus block is effective within a multimodal analgesia strategy to manage pain after upper extremity surgery. Fixation of catheters requires adequate care to avoid premature migration and leakage.

What is already known on this topic?

Continuous brachial plexus block (CBPB) is effective pain management after upper extremity surgery. CBPB has the advantages of a prolonged duration of analgesia while administering more dilute local anesthetic solutions.

What this study adds?

CBPB is effective and safe (no major adverse events such as respiratory failure, local anesthetic toxicity) in multimodal pain management for upper limb surgery. High rate of postoperative catheter-related problems was high (72.7%) at our institute (leakage, kinking, accidental withdrawal, migration). The importance of catheter securement should be improved.

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Potential conflicts of interest

None.

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ประสิทธิภาพและภาวะแทรกซ้อนของการระงับปวดด้วยเทคนิคการใส่สายให้ยาชาตลอดเวลาที่เส้นประสาทเบรเคียวด้วยอัลตราซาวด์สำหรับการผ่าตัดรยางค์บน

สุวิมล ต่างวิวัฒน์, บุศรา ศิริวัณสาณฑ์, ปฐม หลีละเมียร, วิมลลักษณ์ สนั่นศิลป์, ฐิติมา ชินะโชติ, ต่อพล วัฒนา, จุฑารัตน์ เริ่มลึก, พนาภรณ์ คงมั่น

วัตถุประสงค์: *การใส่สายให้ยาชาที่เส้นประสาทเบรเคียวด้วยเครื่องอัลตราซาวด์เป็นวิธีหนึ่งสำหรับการระงับปวด แบบผสมผสานสำหรับการผ่าตัดรยางค์บน การศึกษานี้ต้องการทราบประสิทธิภาพและภาวะแทรกซ้อนของเทคนิคการระงับปวดนี้*

วัสดุและวิธีการ: *การศึกษาแบบไปข้างหน้าสำหรับการผ่าตัดทางออร์โธปิดิกส์ของรยางค์บนในผู้ป่วยอายุ ≥18 ปี ASA I-III ใช้เทคนิคการใส่สายให้ยาชาที่เส้นประสาทเบรเคียวที่ interscalene หรือ infraclavicular การเลือกเทคนิคขึ้นกับตำแหน่งของการผ่าตัดทั้งสองเทคนิคให้ยาชาไลโดเคน 2% ที่มียาอะดรีนาลิน 5 ไมโครกรัมต่อมล. ปริมาณ 10 มล. และตามด้วย 0.5% ลีโวบิวพิวาเคน 10 มล. (interscalene) หรือ 20 มล. (infraclavicular) ความสำเร็จของการฉีดยาชาหมายถึงการหมดความรู้สึกและอ่อนแรงของแขนที่เวลา 20 นาทีหลังจากฉีดยาชา การระงับปวดหลังผ่าตัดเป็นแบบผสมผสานด้วยยาแก้ปวดและการให้ยาชาทางสายให้ยาชาตลอดเวลา วัดผลหลังผ่าตัด 72 ชั่วโมง ด้วยคะแนนความปวด (0 ถึง 10) ความต้องการยาแก้ปวดมอร์ฟีน ผลข้างเคียง ความพึงพอใจของผู้ป่วยและพยาบาลที่ดึกผู้ป่วย รวมถึงภาวะแทรกซ้อนจากการใส่สายให้ยาชา*

ผลการศึกษา: *ผู้ป่วย 22 ราย ความสำเร็จของการใส่สายให้ยาชาเท่ากับร้อยละ 100 ระยะเวลาการใส่สายเท่ากับ 2.82±1.33 วัน หลังผ่าตัดภายใน 72 ชั่วโมง ร้อยละ 95.5 ถึง 100 และร้อยละ 77.3-95 ของผู้ป่วยมีความปวดน้อย (คะแนน 0-3) ขณะพักและเมื่อเคลื่อนไหวตามลำดับ หนึ่งในสามของผู้ป่วย (ร้อยละ 36.4) ไม่ต้องการยาแก้ปวดมอร์ฟีนภายใน 72 ชั่วโมง ร้อยละ 81.8 มีความพึงพอใจมากต่อเทคนิคระงับปวด พบปัญหาที่เกิดจากสายให้ยาชาสูงถึง 16 ราย (ร้อยละ 72.7) อาการคลื่นไส้อาเจียนหลังผ่าตัดพบในผู้ป่วย 3 คน (ร้อยละ 13.6) ไม่พบภาวะแทรกซ้อนรุนแรง จากการใส่สายให้ยาชา แต่พบผู้ป่วย 1 รายเกิดการบาดเจ็บของเส้นประสาทเรเดียวและอัลนา คาดว่าเกิดจากการรัดเครื่องห้ามเลือด*

สรุป: *การใส่สายให้ยาชาที่ตำแหน่งเส้นประสาทเบรเคียวด้วยอัลตราซาวด์สำหรับการระงับปวดหลังผ่าตัดรยางค์บน เป็นวิธีที่มีประสิทธิภาพและปลอดภัย ไม่พบภาวะแทรกซ้อนที่รุนแรง*