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Predicting successful supraclavicular brachial plexus block using pulse oximeter perfusion index

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Abstract

Background. Supraclavicular nerve block is a popular approach for anaesthesia for upper limb surgeries. Conventional methods for evaluation of block success are time consuming and need patient cooperation. The aim of this study was to evaluate whether the perfusion index (PI) can be used to predict and provide a cut-off value for ultrasound-guided supraclavicular nerve block success.

Methods. The study included 77 patients undergoing elective orthopaedic procedures under ultrasound-guided supraclavicular nerve block. After local anaesthetic injection, sensory block success was assessed every 3 min by pinprick, and motor block success was assessed every 5 min by the ability to flex the elbow and the hand against resistance. The PI was recorded at baseline and at 10, 20, and 30 min after anaesthetic injection in both blocked and non-blocked limbs. The PI ratio was calculated as the PI after 10 min divided by the PI at the baseline. Receiver operating characteristic curves were constructed for the accuracy of the PI in detection of block success.

Results. The PI was higher in the blocked limb at all time points, and this was paralleled by a higher PI ratio compared with the unblocked limb. Both the PI and the PI ratio at 10 min after injection showed a sensitivity and specificity of 100% for block success at cut-off values of 3.3 and 1.4, respectively.

Conclusions. The PI is a useful tool for evaluation of successful supraclavicular nerve block. A PI ratio of >1.4 is a good predictor for block success.

Key words: nerve block; oximetry; perfusion; ultrasonography

Ultrasound-guided supraclavicular nerve block is a popular approach for anaesthesia for upper limb surgeries. The success of peripheral nerve blocks is usually evaluated by assessment of sensory and motor function; however, this method is subjective, time consuming, and depends on patient cooperation.[1] Various objective methods for evaluation of block success have been developed.[2–4] Objective methods for block assessment depend on the evaluation of the sympathetic block and consequent physiological changes, such as vasodilation and changes in blood flow[2 3] and skin temperature.[4] However, most of the objective methods are either time consuming or dependent on sophisticated equipment.

The perfusion index (PI) is a numerical value for the ratio between pulsatile and non-pulsatile blood flow measured by a special pulse oximeter.[5] Although the special probe for PI measurement is relatively more expensive compared with ordinary pulse oximeter probes, its benefits as a marker of peripheral perfusion[6] and as an index for sympathetic stimulation[7] have increased its use progressively in many institutes. Few data are available for the PI as a tool for evaluation of peripheral block success.[8] However, there is currently no cut-off value defined for the accuracy of the PI in the detection of successful block. The aim of this work was to evaluate the PI and PI ratio as

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Editor's key points

- A successful supraclavicular nerve block for limb surgery is associated with vascular dilatation.
- The perfusion index reflects the ratio between pulsatile and non-pulsatile blood flow and is a measure for the level of vascular dilatation.
- The perfusion index is a good predictor for block success and can be used as an alternative for sensory or motor function tests.

predictors of successful supraclavicular nerve block in comparison to neurological assessment, and to determine the best cut-off value for the PI in detection of block efficacy.

Methods

This prospective observational study was conducted in an orthopaedic theatre of the Cairo university hospitals after obtaining institutional ethical committee approval (number MD-3-2016). Written informed consent was obtained from all participants before enrolment in the study. The study included patients aged between 18 and 60 yr who were to undergo elective upper limb orthopaedic procedures under ultrasound-guided supraclavicular nerve block. Exclusion criteria were diabetes mellitus and peripheral vascular disease.

On arrival in the operating room, premedications included ranitidine (50 mg) and midazolam (0.03 mg kg^{-1}). Patients were monitored by three-lead ECG, automated non-invasive blood pressure monitoring, and pulse oximetry.

The supraclavicular nerve block was performed under guidance of a linear transducer (8–14 MHz; Acuson x300; Siemens Healthcare, Seoul, Korea) over the supraclavicular fossa in the coronal oblique plane immediately superior to the midclavicular point. The block was induced in the semi-sitting position, with the head of the patient turned away from the side to be blocked. A 22-gauge insulated block needle was inserted in-plane (lateral to medial) to the ultrasound probe. The brachial plexus was identified as a compact group of nerves, hypo-echoic, round or oval, located lateral and superficial to the pulsatile subclavian artery and superior to the first rib. A volume of 25 ml of local anaesthetic (bupivacaine 0.5%, 12.5 ml and lidocaine 2%, 12.5 ml) was injected under vision strictly perineural to surround all the nerve cords.

The limb was evaluated for block success every 3 min for the sensory block and every 5 min for the motor block. Sensory function was assessed using pinprick in the dermatomal areas supplied by the four main nerves (median nerve, radial nerve, ulnar nerve, and musculocutaneous nerve). Motor block was assessed by the ability to flex the elbow and the hand against gravity. The supraclavicular nerve block was considered successful with regard to neurological examination when brachial plexus dermatomes (C5–T1) were completely blocked. The gold standard for unsuccessful block was the need for general anaesthesia because of pain sensation at the site of the operation.

The PI was measured using Masimo SET pulse oximetry (Masimo Corporation, Irvine, CA, USA) applied on the index finger. The PI was recorded at baseline and at 10, 20, and 30 min after local anaesthetic injection in both the blocked limb and the contralateral unblocked limb using two separate oximeters. The PI ratio was calculated as the ratio between the PI at 10 min after injection and the baseline PI. In every patient, a comparison between the blocked and unblocked limb was performed.

Statistical analysis

Sample size was calculated using MedCalc Software version 14 (MedCalc Software bvba, Ostend, Belgium) to detect an area under the receiver operating characteristic (AUROC) curve of 0.8 with null hypothesis with AUROC curve of 0.5. We took into consideration that the rate of block failure is usually 10%. A minimal number of 70 patients (with at least seven failed blocks) was required to obtain a study power of 80% and α error of 0.05.

Statistical calculations were performed using the Statistical Package for the Social Sciences (SPSS) software version 15 for Microsoft Windows (SPSS Inc., Chicago, IL, USA). Categorical data were presented as frequency (percentage). Continuous data were presented as mean (SD) or median (quartiles) as appropriate. Data were tested for normality using the Shapiro–Wilk test. Comparison of PI between blocked and non-blocked limbs was done using analysis of variance for repeated measures with *post hoc* pairwise comparisons using the Bonferroni test. A receiver operating characteristic (ROC) curve was constructed for the ability of the PI at 10 min and the PI ratio to detect a successful block *vs* a failed block. The positive predictive value and negative predictive value were calculated for both the PI at 10 min and the PI ratio and compared with neurological examination for prediction of block success. A *P*-value <0.05 was considered significant.

Results

Ninety-six patients were assessed for eligibility, of whom 77 patients received an ultrasound-guided supraclavicular nerve block. The block was successful in 70 patients. Patient characteristic data are presented in Table 1.

The baseline PI was comparable between blocked and non-blocked limbs. A successful block was paralleled by an increased PI when compared with the unblocked limb at 10, 20, and 30 min after anaesthetic injection. The PI increased in the blocked limb at 10, 20, and 30 min compared with the baseline reading (Table 2 and Fig. 1). The PI ratio was higher in the blocked limb compared with the unblocked limb [2.4 (0.4) *vs* 1 (0.0); $P<0.001$; Table 2].

Both the PI at 10 min and the PI ratio showed a good ability to predict block success. The AUROC curve for the PI at 10 min after anaesthetic injection was 1 (0.95–1.00), with a cut-off value of >3.3. The AUROC curve for the PI ratio was 1 (0.95–1.00), with a cut-off value >1.4 (Table 3). The positive predictive value of 100% with a 95% confidence interval of 95–100% and negative predictive value of 100% with a 95% confidence interval of 57–100% were calculated for the PI as a predictor of block success. None of patients with a successful block according to neurological examination needed general anaesthesia; thus, sensitivity of 100% and

Table 1 Patient characteristic data. Data are presented as the mean (SD) or *n* (%)

Characteristic	Value
Age (yr)	34.9 (11.1)
Male [*n* (%)]	33 (47)
BMI (kg m^{-2})	23.7 (3.2)
Haemoglobin (g dl^{-1})	11.5 (1.5)
Duration of surgery (min)	78.8 (30.7)