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Is the change of percutaneous oxygen pressure available to judge the effects of brachial plexus block?

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Abstract

Background: To know the objective methods of the effects of the brachial plexus block, we studied the changes in percutaneous oxygen pressure ($tcPO_2$) with the hypothesis that $tcPO_2$ increases significantly on the blocked arm in comparison with the non-blocked arm, a phenomenon which is connected with vasodilation following the brachial plexus block.

Methods: Fifteen patients scheduled for upper extremity surgery, aged 20 to 70 years, with ASA physical status I or II were included. Before anaesthesia, the electrodes used to measure $tcPO_2$ were put on the radial side of the forearm and upper arm of both the right and left sides (a total of 4 electrodes). Oxygen at 6 L min^{-1} was administered by a facial mask. Once midazolam 1–2 mg and fentanyl 50 µg had been administered intravenously, a propofol infusion was started at a dose of 2 mg kg^{-1} h^{-1}. The interscalene block was performed by means of a nerve stimulator, using 20 mL of 1% lidocaine solution combined with 20 mL of 0.75% ropivacaine solution. $TcPO_2$ was measured just before the block and 30 minutes after the block.

Results: $TcPO_2$ in both forearm and upper arm significantly increased after the block in both sides namely, blocked and non-blocked. No difference was observed in $tcPO_2$ between the blocked side and non-blocked side.

Conclusion: Changes of $tcPO_2$ are not useful in order to assess the effects of the interscalene block under oxygen administration.

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Key words: brachial plexus block, interscalene block; brachial plexus blockade, efficacy; percutaneous oxygen pressure

For surgery of the upper extremities, the brachial plexus block is frequently used. Although the effects of the block are checked by pin prick or providing a cold sensation, these methods are not objective and not always reliable, especially in the elderly, those who have mental problems or those who does not understand the changes resulting from pin prick pain or cold sensation [1]. In addition, as recently the brachial plexus block has been performed under sedation, pin prick and cold sensation cannot be used in such cases.

The brachial plexus block induces the sympathetic block, which increases skin temperature by vasodilation [2]. There are some studies which show an increase in temperature on the blocked arm by the brachial plexus block [1, 3]. However, Wenger *et al.* [4] reported that the axillary block did not have any effect on the changes in temperature.

Blood flow may increase by vasodilation after the brachial plexus block, a phenomenon which also has been much studied [2, 4–7]. Wenger *et al.* [4] showed that an increase of forearm blood flow by skin temperature rise was not different between the brachial plexus block and the control [4].

Spinal anaesthesia also causes the sympathetic blockade. We have already shown that changes in percutaneous oxygen pressure ($tcPO_2$) may predict the effects of the spinal anaesthesia when combined with oxygen administration [8]. Therefore, in the present study, we studied the changes in $tcPO_2$ with the hypothesis that the changes in $tcPO_2$ may differentiate the blocked arm and non-blocked arm after the brachial plexus block.

METHODS

After the approval of the protocol by the institutional ethics committee and securing informed consent from the

Table 1. $TcPO_2$

		Before block	After block
Block side	Fore arm	135 ± 48	186 ± 59*
	Upper arm	136 ± 31	170 ± 36*
Non-block side	Fore arm	134 ± 48	193 ± 50*
	Upper arm	136 ± 19	187 ± 35*

Percutaneous oxygen pressure ($TcPO_2$) was shown as mm Hg, mean ± SD
*$P < 0.05$ vs the value before block

patients concerned, 15 patients qualified for upper extremity surgery, aged 20 to 70 years with ASA physical status I or II, were enrolled in this study. Those who had cardiac, vascular, respiratory, dermal, liver, or renal disease, allergy to local anaesthetics, obesity (body mass index > 30 kg m^{-2}), as well as those who had taken vasodilatory drugs before surgery were excluded from the study.

Before anaesthesia, the electrodes used to measure $tcPO_2$ (TCM 400^{TM}, Radiometer, Copenhagen, Denmark) heated at 44° C [8] were put on the radial side of the forearm and upper arm of both the right and left sides (a total of 4 electrodes).

Oxygen at 6 L min^{-1} was administered through a face mask. Once midazolam 1–2 mg and fentanyl 50 µg had been intravenously administered, a propofol infusion was started at a dose of 2 mg kg^{-1} h^{-1}. The interscalene block was performed using a nerve stimulator. The stimulation was done at 1 Hz and the current was set to 1 mA at first and then decreased to 0.5 mA. Moreover, where the biggest arm movement was obtained 20 mL 1% lidocaine combined with 20 mL 0.75% ropivacaine was injected. The ceasing of arm movement was then confirmed. An intravenous crystalloid was administered via the non-blocked arm at about 2–3 mL kg^{-1} h^{-1}. $TcPO_2$ was measured just before the block and 30 minutes after the block under oxygen administration. Sedation was maintained with a propofol infusion at 2–3 mg kg^{-1} h^{-1}. The success of the block was confirmed by no sudden awakening, no movements of the patient, and no significant increase in blood pressure and heart rate during surgery, as well as no postoperative pain. When the block was judged as having failed during surgery, fentanyl was administered and the patient was excluded from the study.

A power analysis was performed in order to detect the differences of $tcPO_2$ between the blocked arm and non--blocked arm with a power of 0.80 and an effect size of 0.3 using G Power^{TM} software (University Mannheim, Germany).

Data were shown as a mean ± standard deviation (SD) or a number of patients. A statistical analysis was performed with repeated measures analysis of variance (ANOVA) followed by the Student-Newman-Keuls test for $tcPO_2$ using StatView 5.0^{TM}. A P value less than 0.05 was considered to be statistically significant.

RESULTS

As the power analysis showed 14 patients were necessary for the study, we included 15 patients. The patients' demographic data were as follows: age was 56 ± 13 (range: 35–67) years; there were 9 men and 6 women; body mass — 60 ± 11 (42–73) kg; and height — 161 ± 13 (150–174) cm. The duration of surgery was 105 ± 29 (70–140) minutes. None of the patients failed the block.

$TcPO_2$ in both the forearm and upper arm significantly increased after the block in both the blocked and non-blocked sides. No difference was observed in $tcPO_2$ between the blocked side and non-blocked side (Table 1).

DISCUSSION

The present study showed that the changes in $tcPO_2$ after the interscalene block were not different between the blocked arm and non-blocked arm under oxygen inhalation.

We used 44°C for the electrode temperature as it is our previous study [8]. The high temperature of the electrodes might already vasodilate more than expected by the brachial plexus block. However, as 44°C is the standardized temperature of the electrode, we used it. Nevertheless, further studies with different electrode temperatures should be done.

In our previous study on spinal anaesthesia [8], we measured $tcPO_2$ in room air at first, and after spinal anaesthesia, we administered oxygen. Consequently, we recognized the difference in the changes in $tcPO_2$ by oxygen administration. However, in the present study, we administered oxygen before starting any measurements. As we sedate patients before the block, we routinely administer oxygen before the block, therefore, we performed this study under oxygen administration.

Many studies have shown that the brachial plexus block increases blood flow in the blocked arm. The axillary block induced a 23% increase in upper limb blood flow using angiodynography, according to Doppler [3]. Moreover, arterial blood flow increased with decreased arterial resistance by the interscalene [6]. Ebert *et al.* [7] showed that arterial blood flow increased up to 1.9 times after the axillary block. Furthermore, the axillary block increased diastolic blood flow velocity, then peak systolic velocity, end-diastolic velocity, and mean velocity measured by a pulsed-wave Doppler ultrasound, as well as skin temperature, and decreased vascular resistance and the pulsatility index [9]. The supra- or infra- clavicular block increases plethysmographic measurement of haemoglobin concentration, which showed intravascular haemoglobin concentration and the perfusion index, which indicates blood flow, in the blocked arm [10]. Indeed, the perfusion index, which is an indicator of peripheral blood flow, was increased by the infraclavicular block in a study by Kus *et al.* [5]. They concluded that the perfusion index is useful in order to evaluate the effects of the infraclavicular block [5]. However, the perfusion index displays quite large individual variations, while their results had a large standard deviation. The peripheral flow index, the ratio of the pulsatile to non-pulsatile component of the pulse oximetry plethysmograph and an accurate indication of changes in digital blood flow [11], increased significantly due to the axillary block [12]. Cross *et al.* [13] reported that the supraclavicular block increased blood flow in the fingers on the blocked hand, as well as cardiac output and blood flow of the non-blocked arm, while the increases in the non-blocked arm returned during the postoperative period. These increases in the non-blocked arm might be induced by the increase of cardiac output by epinephrine added to lidocaine for the block [13]. Therefore, their results had some differences from other studies. Although Wenger *et al.* [4] did not find any difference in the blood flow changes between the blocked arm and non-blocked arm due to the axillary block, many other studies showed increase of blood flow by brachial plexus block.

When blood flow increases, we can expect an increase in PO_2. Capillary and venous PO_2 increased within the blocked area while venous PO_2 decreased outside the blocked area after the axillary or supraclavicular block [14]. Lumenta *et al.* [15] also showed that venous PO_2 increased in the blocked arm after the axillary block. Arterio-venous oxygen difference decreased and venous PO_2 increased due to the axillary block [16]. Moreover, the axillary block increased $tcPO_2$ in the room air and, more significantly, during hyperbaric oxygen [3]. Therefore, although we expected an increase of $tcPO_2$ in the blocked arm under oxygenation by the interscalene block, the results did not confirm this. As the interscalene block caused hemidiaphragmatic paresis, which increased ventilation-perfusion mismatch, PaO_2 decreased [17]. This may be why we could not have had a significant increase in $tcPO_2$ in the blocked arm in the present study, while we did not measure respiratory function. Therefore, although we should say that $tcPO_2$ was not available in order to know the effects of the interscalene block, it would be so for the axillary and supraclavicular blocks.

CONCLUSION

Changes of $tcPO_2$ is not useful in order to judge the effects of the interscalene block under oxygen administration.

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