Original Article

The perfusion index could early predict a nerve block success: A preliminary report

ABSTRACT

Introduction: In literature, there is plenty of material regarding regional anesthesia techniques and block safety, but lacks about block success prevision. The perfusion index (PI) is an oximetry reliability indicator, available on many monitors as non-invasive parameter, indicating the ratio of arterial blood flow (pulsatile flow) to venous, capillary, and tissue blood flow (non-pulsatile blood flow). We hypothesized that that analysis of PI variations after performing regional anesthesia could have a role in predicting a successful nerve block.

Methods: Twenty-four consecutive patients regularly scheduled for limb surgery in regional anesthesia were included in our observation. PI measurements were recorded before regional anesthesia, and 1, 2, 3, 5, and 10 min after needle withdrawal. Along with PI, also sensation to cold (ice test), tactile sensation, and motor function were recorded before regional anesthesia, and 1, 2, 3, 5, and 10 min after needle withdrawal on the limb where the block were performed.

Results: Ten sciatic nerve blocks, 6 spinal anesthesia, 8 brachial plexus block were performed and resulted successful. In all cases, PI values tripled at 5 min after the block execution and increased linearly, reaching at 10 min an average PI value 3.8 times higher for the interscalene group, 4 times for the spinal group, and 8 for the sciatic group.

Conclusions: A tripled PI within 5 min from performing regional anesthesia showed to be a reliable indicator of nerve block success, but a bigger trial involving more patients and different anesthetic concentrations may be necessary to confirm this assumption.

Key words: Nerve block; oximetry; regional anesthesia; spinal anesthesia

Introduction

Nowadays regional anesthesia is widespread among anesthesiologists, especially since the introduction of the neuro-stimulation and ultrasound guidance in the common clinical practice. In the latest years, there are more and more descriptions of innovative approaches to the old nerve blocks and discoveries of new fascial plane blocks. There is also an increasing concern about safety, making the nerve perforation and the intra-neural injection something to avoid. The ultrasound guidance, the nerve stimulation, and the injection pressure monitor help the anesthesiologist to avoid such situations, reducing the risk of nerve injury to the minimum. In literature, there is plenty of material regarding regional anesthesia techniques and block safety, but lacks about

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Romualdo Del Buono, Giuseppe Pascarella[1], Fabio Costa[1], Felice Eugenio Agrò[1]

Department of Anaesthesia, Intensive Care and Pain Management, Humanitas Mater Domini, Via Gerenzano 2, 21053 Castellanza (VA), [1]Department of Anaesthesia, Intensive Care and Pain Management, Università Campus Bio-Medico di Roma, via Álvaro del Portillo 21, 00128 Rome, Italy

Address for correspondence: Dr. Romualdo Del Buono, Unit of Anesthesia, Resuscitation, Intensive Care and Pain Management, Humanitas Mater Domini Hospital, via Gerenzano 2, 21053 Castellanza (VA), Italy. E-mail: romualdodelbuono@gmail.com

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block success prevision. Actually, there is no clear definition of "block success." In the review by Abdallah and Brull, only half of the 22 trials evaluated gave the definition of "block success" as a surgical block within a predetermined period of time; the other half described the success in different ways, such as a sensory block within a period of time or no conversion to general anesthesia.[1]

The PI is an oximetry reliability indicator that was first introduced by MASIMO in 1995, but nowadays it is available on other monitors as well. When a pleth-wave is displayed onscreen, what is shown is only the top and variable part of the curve corresponding to the entire light absorption recorded by the light receiver during time.

The PI measures the ratio of arterial blood flow (pulsatile flow) to venous, capillary, and tissue blood flow (non-pulsatile blood flow) and it is showed as a percentage or absolute value.[2]

Regarding regional anesthesia, in literature there are works reporting a PI increase after peripheral nerve blocks. In a study performed on dogs, a PI increment on the blocked limb was a reliable indicator of sciatic nerve block success.[3] In humans instead, PI increments were found after brachial plexus block,[4-6] stellate ganglion block,[7] after caudal anesthesia in children and after digital nerve blocks.[8-10] In each of these studies the pulse-oximeter was placed on the same limb where the block was performed.

We hypothesized that the analysis of PI variations after performing regional anesthesia could have a role in predicting a successful nerve block.

Methods

Twenty-four consecutive patients regularly scheduled for limb surgery in regional anesthesia (10 sciatic nerve blocks, 6 spinal anesthesia, 8 brachial plexus blocks) were included in our observation.

Patients with limb vascular abnormalities or whose PI signal was lost during measurements were not considered for this study. All the procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional or regional) and with the Helsinki Declaration.

An i.v. cannula was placed before any procedure. The Philips Intellivue MP40 (Philips Healthcare, Amsterdam, Netherlands) was used to monitor the non-invasive blood pressure, heart rate, SpO2, and PI.

Before performing a regional anesthesia, 1–2 mg midazolam was administered to each patient.

All the anesthetic procedures were performed by the same operator in the recovery room, before surgery.

Among the 24 patients, the regional anesthesia techniques were performed as follows:

- 10 patients were scheduled for hallux repair surgery. An ultrasound (US)-guided popliteal sciatic nerve block was performed injecting 200 mg of 2% mepivacaine plus 75 mg of 0.75% ropivacaine;
- 6 patients were scheduled for anterior cruciate ligament repair, and a spinal anesthesia with 15 mg hyperbaric bupivacaine was performed;
- 8 patients were scheduled for arthroscopic shoulder surgery, and an US-guided interscalene nerve block was performed injecting 200 mg of 2% mepivacaine plus 75 mg of 0.75% ropivacaine;

The pulse-oximeter was placed on the toe or the index finger of the limb where surgery was going to be performed.

PI measurements were recorded 5 min before regional anesthesia, and 1, 2, 3, 5, and 10 min after needle withdrawal. Along with PI, also sensation to cold (ice test), tactile sensation, and motor function were recorded before regional anesthesia, and 1, 2, 3, 5, and 10 min after needle withdrawal on the limb(s) where the block were performed. After 10 min, the patients were transferred to the operating theater.

Results

The mean PI values recorded before the block, 1, 2, 3, 5, and 10 min after needle withdrawal for the sciatic nerve block, interscalene nerve block, and spinal anesthesia are shown in Figure 1.

Ten patients received US-guided popliteal sciatic nerve block: the mean values of PI recorded [Figure 1, orange line] started increasing after 1 min, and continued to increase in a linear fashion until 10 min. Regarding the effects of the block, thermal alterations started 1 min after needle withdrawal [See Figure 2]. Tactile alterations started from 3 min after the block, whereas motor block appeared only in 20% patients after 10 min.

Six patients received spinal anesthesia: the mean values of PI recorded [Figure 1, gray line] started increasing after 1 min, and continued to increase in a linear fashion until 10 min. Regarding the effects of the block, thermal alterations started

1 min after needle withdrawal [Figure 3]. Tactile alterations started from 3 min after the block, whereas motor block started appearing in 16% of the patients after 3 min, resulting in 83% of patients completely blocked after 10 min.

Eight patients received interscalene nerve block: the mean values of PI recorded [Figure 1, blue line] started increasing after 1 min, and continued to increase in a linear fashion until 10 min. Regarding the effects of the block, thermal alterations started 2 min after needle withdrawal in half of the patients [Figure 4]. Tactile alterations started 5 min after the block along with motor block, resulting in 83% patients completely blocked after 10 min.

After the 10-min-observation in recovery room, all 24 patients were transferred to the operating theater. When surgery began, all 24 had a complete motor block.

Discussion

The PI is not a measurement of blood flow but rather a measurement of its pulsatility.[4] Every vasoconstrictor stimulus as well as any activator of the sympathetic nervous system reduces the PI, because the height of the pulsatile part of the curve is reduced. On the contrary, every vasodilator stimulus, any activator of the parasympathetic or inhibitor of the sympathetic nervous system increases the PI, because the height of the pulsatile part of the curve is increased.

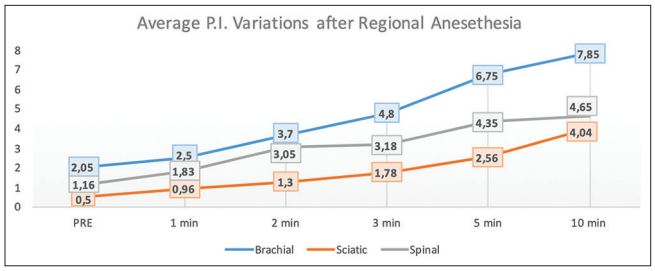

Figure 1: The numbers display the average PI value at each timestamp

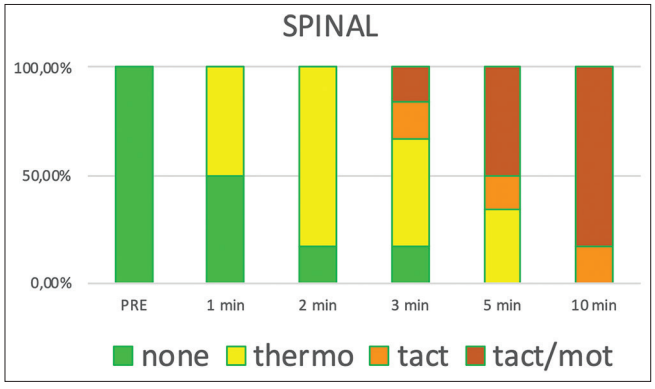

Figure 3: Sensory/motor alterations in a lower limb after spinal anesthesia

In literature, there are studies that correlate the PI with external influences. Takayama *et al.* described the PI as a parameter resembling the body response to pain or stress hormones.[11] The gravitational posture influence on PI has been investigated by Colombo *et al.*[12] Furthermore, many authors presented the PI as a parameter to assess fluid responsiveness, but the results are controversial.[13] In the work by Tanaka *et al.*, the PI was described as an early indicator of blood losses after delivery, earlier than other parameter alterations such as heart rate and blood pressure.[14] There may be several other elements that influence the PI in different clinical scenarios and during general anesthesia, but they go beyond the purpose of this study and will not be discussed further.

From the data obtained in our 24 patients, some elements arise. First, the PI increases when regional anesthesia is performed on the same limb the pulse-oximeter is on. This finding agrees with other works in literature.[3-10] Even though the starting PI values vary among the three groups (sciatic, spinal, interscalene), all of them increase linearly through the subsequent 10 min, reaching an average PI value at 10 min of 3.8× bigger for the interscalene group, 4× for the spinal group, and 8× for the sciatic group.

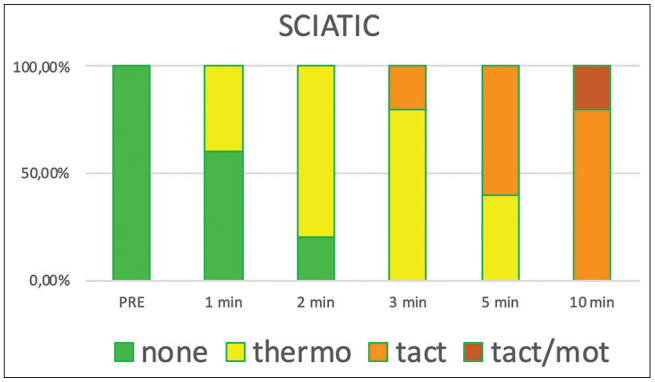

Figure 2: Sensory/motor alterations in the lower limb after sciatic nerve block

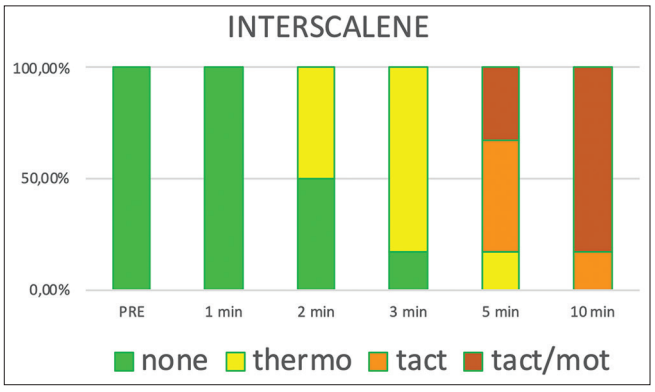

Figure 4: Sensory/motor alterations in the upper limb after interscalene nerve block

It is also interesting to note that the starting PI for each group was at least doubled after 3 min, and at least tripled after 5 min. If we focus on the first 3 min-period, all the patients have had a PI increase but few of them have had a complete motor+sensitive block (only 16%, 1 patient, from the spinal group had motor block after 3 min).

We'd like to notice that all 24 patients received a regional anesthesia procedure that has had different results after 10 min from needle withdrawal in terms of block intensity (only sensory, or motor+sensory), but all of them had eventually a complete block (motor+sensitive) at the time of the surgery, occurred >10 min after block needle withdrawal.

In this 24-patient population, a peripheral regional anesthetic procedure was performed and the PI was recorded on the same limb. In all cases the PI was at least tripled after 5 min from block needle withdrawal, and the patients eventually had a complete block even though a "cloudy" block was recorded at first (e.g., only thermal or tactile alterations).

This report has some limitations: it is mainly a preliminary observation on a small population.

Moreover, all the nerve blocks were performed by the same expert clinician, thus we had no way to analyze the PI values in case of a failed block. However, we found a strong correlation between specific PI variation and nerve block success just after only 5 min from the block and this certainly makes our observation worthy of being reported.

Conclusion

Even though there is no definition of a "successful block" nor a "block success," we can state that a "satisfactory block" is the one that provides adequate analgesia and good surgical conditions. To date, there is no predictor of block success. It is possible that the PI increase could be a valid aid to the anesthesiologist to forecast the successfulness of a "cloudy" block in a 5-min period, avoiding a subsequent second block.

A tripled PI within 5 min from performing regional anesthesia showed to be a reliable indicator of nerve block success, but a bigger trial involving more patients and different anesthetic concentrations may be necessary to confirm this assumption.

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Conflicts of interest

There are no conflicts of interest.

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