EFFECT OF DIGITAL BLOCK ON PULSE OXIMETER SIGNAL DETECTION DURING GENERAL ANESTHESIA

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SUMMARY: Pulse oximetry is dependent upon the presence of a pulsating vascular bed. Low pulsatile blood flow in the digits is caused by various factors. Regardless of the cause, if there is sufficient arterial pulse pressure, blocking the sympathetic nerve should cause a local increase in capillary flow and pulse volume. This study was performed to evaluate the effect of digital nerve block on pulse oximetric signal detection (SpO_2, Lag time and amplitude of plethismographic wave) during general anesthesia.

After induction of general anesthesia in 105 patients, SpO_2, Lag time and amplitude of plethismographic wave in index fingers of two hands were determined by pulse oximeter. Then 2 ml of 2% lidocaine was injected to index fingers of one hand and these parameters were determined at 10, 20, 30, 40 and 60 minutes after digital nerve block, in blocked and unblocked fingers. The data were compared between two groups.

Mean lag time of plethismographic wave in 10, 20, 30, 40 and 60 minutes after digital block was shorter in blocked fingers than unblocked fingers ($p<0.05$). Mean amplitude of plethismographic wave in these times after digital block was greater in blocked fingers than unblocked fingers ($p<0.05$). No statistical difference in SpO_2 was determined between blocked and unblocked fingers.

In conclusion, the digital block is an effective and safe technique for better pulse oximetric signal detection during general anesthesia. Short lag time and high amplitude of plethismographic wave probably can facilitate the accuracy of SpO_2 calculation and therefore rapid detection of hypoxemia.

Key Words: Digital nerve block, pulse oximeter, lag time, amplitude, saturation.

INTRODUCTION

Pulse oximetry has become a standard component of anesthesia monitoring, and it has also gained wide acceptance in post anesthesia and intensive care units, as well as for patients undergoing a variety of diagnostic procedures (1). Pulse oximeters require adequate finger tip perfusion to allow them to distinguish absorbance of arterial blood from that of the background venous blood and tissue light absorption. Only 1–5% of total signal is processed to calculate the hemoglobin saturation (2). Pulse oximetry becomes unreliable during various conditions, which induce poor signal detection (3–5) and erroneous peripheral hemoglobin oxygen saturation (6–8). Hypothermia, vasoconstriction and low cardiac output may decrease peripheral perfusion. These may impair the plethismographic pulsation and the portion of total signal

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used to detect hemoglobin saturation (9, 10). In addition to failure in pulse oximetric oxygen saturation (SpO_2) reading, lag time and amplitude of plethismographic wave may also be changed in these conditions (11–13).

A variety of techniques has been proposed to improve pulse oximeter signal detection. Topical application of nitroglycerin ointment has been used to restore the signal although this can worsen hypotension (1). In addition topical application of EMLA cream (lidocaine 2.5%, prilocaine 2.5%) for 30 minutes has been reported to improve the signals (14). It has been shown in a case series report (n=4) that digital nerve block, increases the fingertip temperature and enhances pulse oximeter signal detection. Blocking the sympathetic digital nerve should cause a local increase in capillary flow and pulse volume, which may improve pulse oximeter signal detection (15).

Enhancement of the plethismographic wave detection may be useful in different low perfusion conditions, which is usually seen in critical care setting. Since no controlled study has addressed this effect, this study was performed to evaluate the effect of digital nerve block on pulse oximeter signal detection (SpO_2, amplitude and lag time of plethismographic wave) in a sample of adult patients during general anesthesia.

MATERIALS AND METHODS

After obtaining institutional approval and informed patient consent, 105 male adults scheduled for knee arthroscopy under general anesthesia in supine position. They were recruited for this study. The inclusion criteria were freedom from disabling illness (ASA grade I or II), and willingness to give written informed consent. The exclusion criteria were smoking, hypertension, history of cardiovascular diseases, anemia, coagulation or platelet abnormalities, central and peripheral neurologic disorders and deformity of hand fingers. Patients were also excluded if they had an aberrant arterial configuration at the wrist as demonstrated by an abnormal Allen's test. No premedication was given. After preoxygenation, anesthesia was induced with sodium thiopental 5 mg/kg, atracurium 0.6 mg/kg and morphine 0.1 mg/kg IV. The trachea was intubated and anesthesia was maintained with 1-1.5% isoflurane and 60% nitrous oxide in oxygen. Controlled ventilation was maintained throughout the procedure using a tidal volume of 10 ml/kg at a rate of 10/min. Ringer's solution infusion 6 ml/kg/hr was continued. Environmental temperature in operating room was maintained at about 22-24°C. Five minutes after tracheal intubation the probe of pulse oximeter (Capnosat, Type 8290600, Dragerwerk AG, Lubek, Germany) attached to the index finger of both hands and SpO_2, lag time and amplitude of plethismographic wave were recorded (baseline). To insure the repeatability of this technique, two measurements of these parameters under the same conditions were averaged. The probes were covered by opaque rubber sleeves to reduce the likelihood of cross-over radiation.

The time from the beginning of pulse oximetric probe attachments to the point of plethismographic wave appearance was measured by a chronometer and recorded as lag time. The amplitude of plethismographic wave was measured as the vertical distance between peak and nadir of a single plethismographic curve in millimeter.

After obtaining baseline data, the index finger of one hand was assigned to the case group (blocked), and that of the opposite hand to control group (unblocked). The order of assignment was alternated between right and left hand from case to case. Digital nerve block was performed by an anesthetist on bilateral interfinger web of the index finger using 1 ml of 2% lidocaine in each side with a 25-gauge hypodermic needle. Then in 10, 20, 30, 40 and 60 mins after digital block, SpO_2, lag time and amplitude of plethismographic wave in both fingers were determined by the same pulse oximeter. An assistant who was unaware of the particular intervention measured these parameters.

The patients who developed intraoperative hypotension (systolic arterial pressure $<$90 mmHg) were excluded from the study. Data were summarized as means$\pm$SD. Means of pulse oximetric data (SpO_2, lag time and amplitude of plethismographic wave) were compared between and within groups using repeated measure analysis of variance. A value of $p<0.05$ was considered to be statistically significant.

RESULTS

A total of 108 patients participated in the study. Three patients were excluded from the study due to intraoperative hypotension. Therefore, statistical analysis was performed on the remaining 105 patients. No statistically significant differences were found between two groups of fingers (case and control) before digital nerve block regarding SpO_2, lag time and amplitude of plethismo-

Table 1: Lag time, amplitude and SpO_2 at baseline (before block), 40 and 60 mins after digital nerve block during general anesthesia.

Variables	Before block	40 min after block	60 min after block
Lag time (sec)			
Unblocked fingers	7.81±1.88	8.41±3.24	8.44±3.27
Blocked fingers	7.76±2.45	5.36±4.34 *, +	6.29±4.28 *, +
Amplitude (mm)			
Unblocked fingers	12.65±4.12	12.49±4.50	12.23±3.30
Blocked fingers	12.69±3.95	16.85±3.40 #, +	14.95±3.20 #, +
SpO_2 (%)			
Unblocked fingers	98.34±0.75	98.64±0.67	98.32±0.75
Blocked fingers	98.44±0.64	99.47±0.96	99.42±0.84

Values are means±SD

SpO_2: Peripheral arterial hemoglobin oxygen saturation

* $p<0.05$: Compared with baseline values (before block)

# $p<0.001$: Compared with baseline values (before block)

+ $p<0.05$: Compared with values from unblocked fingers.

graphic wave. Mean SpO_2, lag time, and amplitude of plethismographic wave did not change significantly in unblocked fingers over time, but that of blocked fingers changed significantly compared to the baseline value and to unblocked fingers (Table 1, Figure 1).

Mean lag time of plethismographic wave at 10, 20, 30, 40 and 60 mins after digital nerve block was shorter in blocked than unblocked fingers ($p<0.05$). Forty minutes after digital block, mean lag time in blocked and unblocked fingers was 5.36±4.34 sec and 8.41±3.24 sec respectively. Mean amplitude of plethismographic wave in these times was greater in blocked than unblocked fingers ($p<0.05$). Forty minutes after digital block, mean amplitude in blocked and unblocked fingers was 16.85±3.40 mm and 12.49±4.50 mm respectively. No statistically significant difference in SpO_2 was determined after digital nerve block between blocked and unblocked fingers.

Maximum difference between blocked and unblocked fingers in lag time and amplitude occurred at 40 mins after digital block (36% and 34% respectively).

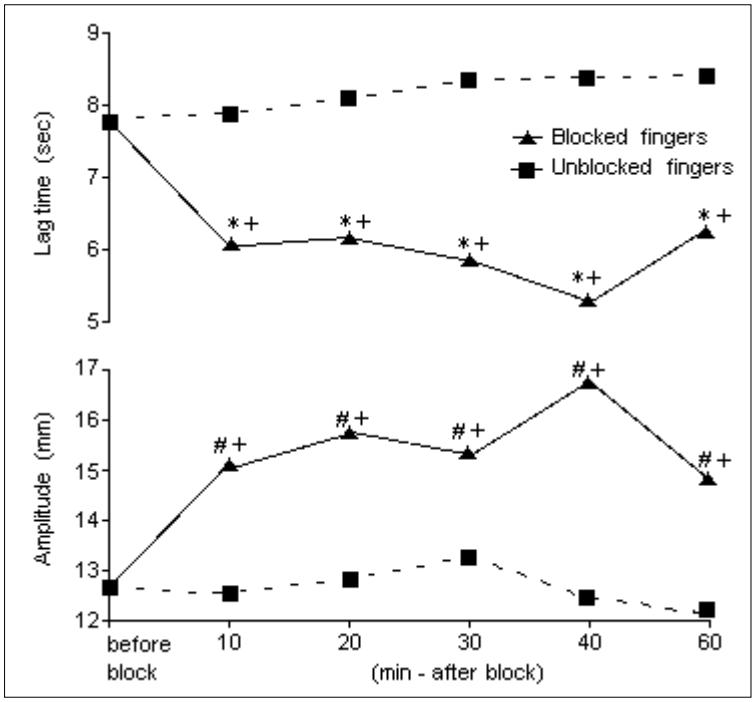
DISCUSSION

The results of this study show that digital nerve block with 2 ml of 2% lidocaine can improve pulse oximeter signal detection during general anesthesia. Evidence for this is the significantly shorter lag time and greater amplitude of plethismographic wave in blocked compared to unblocked fingers and also to base line values.

Pulse oximetry is the standard of care for the continuous and non-invasive monitoring of SpO_2 as a substitute for arterial hemoglobin oxygen saturation during anesthesia and the postoperative period in all age groups. Reduced blood flow to the extremity results in a diminished signal and can cause inability to obtain an SpO_2 reading (7) or a falsely low reading possibly in part due to greater fractional tissue consumption of arterial oxygen (16).

Previous work has shown that the lag time of pulse oximeter is prolonged by cold-induced vasoconstriction or by inflating a sphygmomanometer cuff round the upper arm, which decrease the blood flow in upper limb (11). The results of one study suggested that lag time of finger pulse oximeter response is not primarily determined by the pulse oximeter itself, but by the circulation time. When the circulation time decreases, the lag time to pulse oximeter response will be reduced and, conversely, an increased circulation time will result in a prolonged lag time (12). The results of other studies have shown that pulse oximetry during lumbar epidural anesthesia gives falsely low readings in SpO_2 when the probe is placed at the upper limb and the amplitude of plethismographic wave increases when the probe is attached at the lower limb. Compensatory vasoconstriction in the upper limb

Figure 1: Changes in lag time and amplitude of pulse oximetry plethismographic wave (means±SD) before and after digital nerve block during general anesthesia. * p<0.05: Compared with baseline values (before block), # p<0.001: Compared with baseline values (before block), + p<0.05: Compared with values from unblocked fingers.



and vasodilatation in the lower limb due to sympathetic block during epidural anesthesia may be attributed to these findings (13, 17).

During anesthesia arteriolar vasoconstriction in the digits is caused by vasoactive agents, hypovolemia, hypotension or hypothermia (18, 19). Regardless of the cause, if there is sufficient arterial pulse pressure, blocking the sympathetic nerves should cause a local increase in capillary flow and pulse volume. It seems reasonable that digital nerve block affected some improvement in local tissue perfusion in our patients, which results in diminished lag time and increased amplitude of plethismographic wave. Short lag time and high amplitude of plethismographic wave probably can increase the reliability of SpO_2 calculation and therefore more accurate detection of hypoxemia.

The volar sympathetic nerves can be blocked at the level of the interfinger web. The total volume injected should be less than 8 ml to prevent ischemia from compression (15). In our study the volume of lidocaine was 2 ml in each finger and there have been no complications.

The maximum effect of this technique at 40 mins after digital block may be due to full infiltration of lidocaine around the digital nerve at this moment. Lag time and amplitude of plethismographic wave in blocked finger approach returns near the baseline value at 60 mins after block. This may be due to elimination of drug from tissue at this time (20). In the present study the SpO_2 did not change after digital block. This may be due to high fraction of inspiratory oxygen (FIO_2) which is normally used during general anesthesia.

In conclusion digital nerve block may be used as an effective and safe technique for better pulse oximetric signal detection during general anesthesia. When pulse oximeter information deteriorates, other, more serious, causes must first be excluded or treated before turning to digital blocks. Digital nerve block probably can improve the pulse oximeter signal detection in abnormal conditions during general anesthesia. It is advisable to undertake further studies to evaluate the effect of digital nerve block in low perfusion states such as hypovolemia, hypotension, hypothermia and shock.

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