Original Article

Perfusion index as a predictor of working pediatric caudal block under general anesthesia- A prospective observational study

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Abstract

Background and Aims: Advances in pulse oximeter technology have enabled us to measure parameters such as perfusion index (PI). We aimed to ascertain the utility of PI in the lower limb for evaluating the onset and adequacy of the pediatric caudal block under general anesthesia. The primary objective was to monitor PI trends after caudal block. The secondary objective was to compare the role of PI, heart rate (HR), and mean arterial pressure (MAP) in detecting onset and adequacy of caudal block and to ascertain whether PI was an earlier indicator in detecting adequate block.

Material and Methods: Twenty-five children between 1 and 6 years, who underwent general anesthesia (GA) with caudal block were included. Baseline PI, HR, and MAP were recorded prior to and post caudal block at 5, 10, 15, 20 min and on skin incision. The onset of adequate block was defined as 100% increase of PI from baseline, 15% decrease of MAP or HR from baseline. T-test was used to compare trends of PI with baseline and the number of patients who met or failed these criteria for each of these three parameters at various time intervals wasnoted.

Results: PI increased at all time intervals in 23 of 25 patients with working caudal block ($P < 0.0001$). By 10 min all those with a working caudal showed a 100% increase in PI. In contrast, 15% decrease in HR was not attained until 15 min where only 8 out of 23 achieved the above criteria, reaching a maximum of 20 patients at the time of incision; a 15% decrease in MAP was observed only in one patient at 5 min, reaching a maximum of eight patients at the time of incision.

Conclusion: PI is an earlier and more sensitive indicator of the onset of the caudal block under general anesthesia (GA) than HR and MAP.

Keywords: Caudal block, general anesthesia, heart rate, pediatric, perfusion index

Introduction

Caudal block under general anesthesia (GA) is quite popular for pediatric lower abdominal, perineal, and lower limb surgeries as it is one technique which fits all. It is relatively easy to learn with a high mean success rate[1] and a remarkable safety record.[2] However, failure of caudal block is about 4% due to abnormal anatomy, operator inexperience, and wrong choice of block.[3]

Recent advances in pulse oximeter technology have broadened the abilities to measure more parameters such as perfusion

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Access this article online	
Quick Response Code:	Website: https://journals.lww.com/joacp
	DOI: 10.4103/joacp.JOACP_34_21

How to cite this article: Rajan K, Dave N, Dias R, Muneshwar P, Kesarkar N, Saxena V. Perfusion index as a predictor of working pediatric caudal block under general anesthesia- A prospective observational study. J Anaesthesiol Clin Pharmacol 2022;38:635-9.

Submitted: 18-Jan-2021 **Revised:** 15-Apr-2021
Accepted: 28-May-2021 **Published:** 26-Dec-2022

index (PI).PI is a non-invasive numerical assessment of the pulsatile strength at a monitoring site providing useful information about the peripheral perfusion status of the patient. Decrease in PI can occur because of local vasoconstriction while vasodilatation results in an increase in PI in the skin at the monitoring site.[4] Recent studies recommend that PI can be used as an early and sensitive indicator to detect the development of epidural induced sympathectomy leading to vasodilation and increased perfusion in adults,[5] but such evidence in the pediatric population is limited especially in the Indian context.

It is often very difficult to assess the quality of analgesia in children intra-operatively as most of the regional blocks are performed under general anesthesia or sedation in contrast to adults. Conventionally one waits to see the patient's response to surgical skin incision to make a clinical decision of working caudal block. Unsuccessful block causes a rise in HR and blood pressure on skin incision due to pain.[6] This calls for a more reliable and faster objective parameter that can confirm the efficacy of caudal block in children. As demonstrated in adults whether PI can be applied to detect the onset and adequacy of the pediatric caudal block under GA remains to be elucidated. In this study, the primary outcome was to monitor PI trends after caudal block. The secondary outcome was to compare the role of PI, heart rate (HR), and mean arterial pressure (MAP) in detecting onset and adequacy of caudal block and to ascertain whether PI was an earlier indicator in detecting adequate block.

Material and Methods

This prospective observational pilot study was approved by the Institutional Ethics Committee. CTRI No: EC/OA-118/2018, Institutional Ethics Committee, Seth GS Medical College and KEM Hospital, Mumbai. The study was conducted over a period of 3 months from January 2019 to March 2019in a tertiary care teaching hospital. The sample size required was estimated from a similar study by Mohamed *et al*.[7] using the formula $N \geq 2 \times (Z\alpha/2 + Z\beta)^2 \times SD^2/(\delta 0)^2$with the power of study as 80% to detect a difference of P value less than 0.05 and was calculated to be 25 cases. Twenty-five American Society of Anaesthesiologists (ASA) classes I and II patients between 1 and 6 years of age posted for elective lower abdominal surgery under GA with caudal block were enrolled from the pre-anesthetic clinic (PAC) a day prior to surgery. The study protocol was explained to the parents/legal guardians during the PAC and informed consent was obtained. Those who refused to consent, septic, and critically ill children on inotropes were excluded. Sampling was consecutive.

All patients were fasted as per the standard nil per oral NPO guidelines permitting clear fluids up to 2 h prior and with intravenous IV access secured in the ward. All patients received midazolam premedication 0.05 mg/kg (IV) in the preoperative holding area. On shifting to the operating room, standard monitors including electrocardiogram, non-invasive blood pressure (NIBP), pulse oximetry, end-tidal carbon dioxide, and volatile anaesthetic monitoring were instituted. NIBP cuff was attached on the arm opposite to the side of intravenous access in all the patients. The core temperature was monitored using a nasopharyngeal probe in all the patients and was maintained between 36.5 and 37.5°C. All parameters were recorded using Drager Perseus®A500 anesthesia delivery system and monitor, Dragerwerk AG and Co. Lubeck, Germany. Ringer lactate was administered as the intraoperative maintenance fluid at the rate of 6 mL/kg/h. After 3 min of preoxygenation with 100% oxygen, GA was induced with injection fentanyl 2 μg/kg and propofol 3 mg/kg IV, followed by insertion of a supraglottic airway device of appropriate size. Maintenance of anesthesia was with oxygen, air, and sevoflurane titrated to a minimum alveolar concentration MAC of 1.

Masimo Radical-7 SET® (Masimo Corporation Irvine, CA) pulse oximeter probe for monitoring PI was placed on the big toe and wrapped with gauze to reduce heat loss and to avoid the interference of ambient light. Prior to the caudal block procedure, the baseline PI was recorded, corresponding to the value at 0 min. Also, the baseline HR and MAP were recorded. The caudal block was performed by a qualified anesthesiologist with at least 3 years of experience, with the patient in the left lateral position using the landmark technique. After appreciating the definite pop during insertion of the needle and negative aspiration for blood and cerebrospinal fluid 1mL/kg of 0.125% of bupivacaine was injected at the rate of 1mL/3 s and the patients turned supine immediately. Following the caudal block, PI, HR, and MAP were recorded at 5, 10, 15, and 20 min as well as on skin incision. A working caudal block was defined as any one of the following criteria achieved, whichever occurred earlier: 100% increase of PI value from baseline, 15% decrease of MAP, or 15% decrease of HR from the baseline.[7,8]Also, the percentage of patients who met the criteria for each of these three parameters at incision was noted.

Data were analyzed using the statistical software SPSS version 24 (SPSS Inc., Chicago, IL, USA). Data were tested for normality using the Shapiro–Wilk's test. Parametric data were expressed as mean ± standard deviation SD, while non-parametric data were expressed as numbers and percentage. Comparing PI at various time intervals with baseline was done using paired Student's *t*-test where P value < 0.05was considered significant.

Results

All 25 patients provided complete data and were included in the analysis. Demographic characteristics and surgical procedures are depicted in Table 1. In 23 out of 25 patients, the PI values increased at all time intervals and werestatistically significant (P < 0.0001) [Table 2]. In the remaining two cases, the PI did not double and remained at lower values and corresponded to an increase in the HR and MAP at the time of skin incision indicating an unsuccessful block.

Among the 25 patients, a 100%increase in PI from the baseline was recorded in 21 patients at 5 min and in 23 patients at 10 min. So, by the first 10 min, all those with a working caudal showed a 100% increase in PI. In contrast, a 15% decrease in HR was not attained until 15 min where only 8 out of 23 achieved the above criteria, reaching a maximum of 20 patients at the time of incision. A 15% reduction in MAP was observed only in onepatient at 5,10,15 min, reaching a maximum of eightpatients at the time of incision [Figure 1]. The number of patients satisfying the definition of working caudal block at the incision is expressed in percentage showing the efficiency of PI in indicating the adequacy of the caudal block [Table 3].There were no adverse effects related to caudal block (bloody tap, inadvertent dural puncture, bleeding at puncture site) in any of the patients.

Discussion

Management of intraoperative pain in children remains challenging because most regional blocks are done under sedation or GA and no gold standard exists for the assessment of procedural pain. The pain intensity in children is usually assessed by physiological measures, self-report scales, and behavioral scales. The former is mainly used for measuring intraoperative analgesia. However, pain studies in children have shown that physiological measures like HR, oxygen saturation, blood pressure, or respiratory rate are neither sensitive nor specific enough.[9-11]

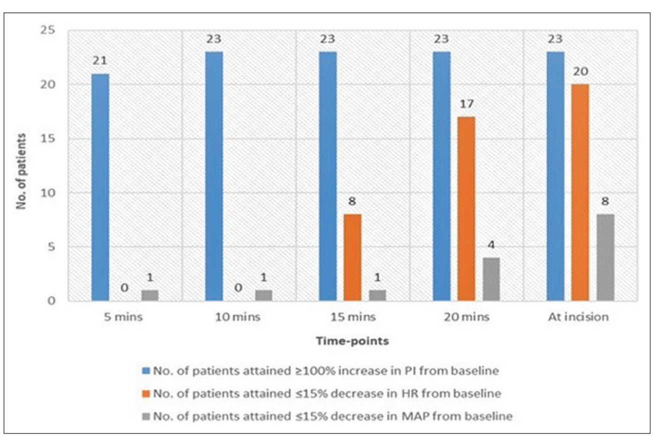

Figure 1: Number of patients whomet the definition criteria at specific time-points for PI, HR, and MAP

PI is a non-invasive numerical technique derived from a pulse oximeter signal that reflects real-time changes in peripheral perfusion. It is calculated by the ratio of infrared light absorbed by the pulsating arterial flow (AC) against the non-pulsatile signals in blood and tissues (DC) and expressed as (AC × 100/DC%).[12,13] It has a wide range from 0.02 to 20. Though various factors including peripheral vascular resistance, blood volume, and elasticity of the vascular wall can affect the peripheral PI; peripheral vascular resistance controlled by the autonomic nervous system contributes most to the changes in peripheral PI.[14,15]It was reported that the PI decrease caused by pain and other stressful stimuli was due to vasoconstriction of the peripheral arterial bed rather than the changes in the pulse pressure[16]; instead PI increase on the toe following caudal block was most likely due to sympathectomy-related vasodilatation of peripheral arterial bed and redistribution of blood volume.

In the present study, 23 cases out of 25 did attain one of the defined criteria at the time of incision indicating a successful caudal block. In these 23 cases, PI values significantly increased

Table 1: Patient characteristics and surgical procedures

Variables	Values
Age (years)	3.88±1.72
Weight (kg)	13.68±3.31
Surgical procedures	(n=25)
Open herniotomy	8
Open orchiopexy	7
Hypospadiasis repair	10

**Age, weight represented as mean±SD*

Table 2: Perfusion Index (PI) at various time intervals compared to baseline

Time-point	Mean±SD	*P*
0 min	1.17±0.92	-
5 min	3.41±1.24	<0.0001
10 min	4.44±1.44	<0.0001
15 min	5.26±1.46	<0.0001
20 min	5.94±1.48	<0.0001
At incision	6.38±1.56	<0.0001

Table 3: Number of cases satisfying the definition of working caudal block at incision expressed in percentage

Predefined criteria	Number of cases	Percentage
100% in PI	23	100
15% decrease in HR	20	86.95
15% decrease in MAP	8	34.78

at all time intervals from the baseline ($P < 0.0001$). Umera *et al*.[17]conducted a similar prospective study on 40 children undergoing inguinal herniorraphy to ascertain the value of PI monitoring in predicting the success of epidural block under GA. They concluded that the PI significantly increased reflecting the vasodilatation induced by the successful block which was in accordance with our results.

We further compared the number of cases that met the predefined criteria for each of the bedside indices used for the assessment of caudal block onset. A 100% increase in PI in the 23 cases with a working caudal block was attained in the first 10 min and was sustained through to the time of incision. Comparing PI with other studied indicators, we found no significant changes in HR or MAP after the caudal block. In contrast to PI, a 15% decrease in HR or MAP was never attained in all the cases with a working caudal even at the time of incision reaching a maximum of 86.95% (20 cases out of 23) and 34.78% (8 cases out of 23), respectively. This shows that PI is able to detect the onset of successful caudal block much earlier and more consistently than either HR or MAP. It was also noted that in the two cases of failed caudal block, the PI did not double and remained at lower values and corresponded to an increase in HR and MAP at the time of skin incision.

Similar studies by Ginosar *et al*.[4]and Mohamed *et al*.[7]also showed comparable results with PI, though their comparison involved other parameters like cremasteric reflex and skin temperature gradients. The loss of cremasteric reflex has long been thought as a reliable indicator of a successful caudal block, but it only applies to male patients and it usually takes much longer to show the effects of a caudal block.[18,19] Cutaneous temperature recordings including leg-toe temperature gradient have been used as an effective indicator of sympathectomy.[20,21] But this is not always feasible due to a lack of multiple temperature probes and lack of standardization of ambient temperature.

Our study population included a homogenous sample of children who were well-matched for age, type of surgery, and regional analgesia. This age group represents a vulnerable population in whom pain assessment can be challenging and there are potential risks of not treating pain adequately. As we routinely use pulse oximeter in all patients during operation, PI value is a useful objective, and non-invasive method to evaluate the effect of caudal block in pediatric patients. However, there were certain limitations to this study. Since GA itself can cause vasodilatation, it can be a confounding factor. To nullify its effect, PI values obtained from the upper extremity can be compared with those obtained from the lower extremity as caudal block affects only the lower extremity. Though this would have been ideal it was not possible in our study since there was no provision for an extra pulse oximeter probe that could detect PI. Hence as an alternative, we followed the trends of PI rather than absolute values. We did not compare the changes of skin temperature gradient in the lower limb pre- and post-caudal block with PI due to lack of temperature probes. As a directive for future research, further observations with the above-mentioned modifications can be conducted to yield robust results.

Conclusion

Our study results show that PI trends measured in the lower limb provide a more sensitive indicator for assessing the onset and efficacy of caudal block under GA than HR and MAP. Failure of increase in PI might give the anesthesiologist an early warning of the failure of caudal block, which may help to optimize the analgesia. Our results may encourage anesthesiologists to use PI instead of other traditional indicators to ensure the efficacy of pediatric caudal block.

Financial support and sponsorship

This study was supported by departmental resources.

Conflicts of interest

There are no conflicts of interest.

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