EGYPTIAN JOURNAL OF ANAESTHESIA
2024, VOL. 40, NO. 1, 69–74
https://doi.org/10.1080/11101849.2023.2301218

Comparison of two different methods as reliable predictors of successful caudal block in children

Yasser Essam Elfeil[a], Ahmed Ragab Zarad[a] and Ehsan Akram Deghidy[b]

[a]Department of anesthesia and surgical ICU, Faculty of Medicine, Alexandria University, Alexandria, Egypt; [b]Department of Biomedical Informatics and Medical Statistics, Medical Research Institute, Alexandria, Egypt

ABSTRACT

Background: To reduce the dosages of the intraoperative anaesthetic and analgesic agents, the caudal block is most frequently used in children. The work aims to investigate the efficacy of perfusion index (PI) and heart rate (HR) variations following the caudal block in determining the onset and appropriateness of the caudal block in children.

Patients and methods: After induction of general anaesthesia, 0.5–1 ml/kg of 0.25% bupivacaine according to the needed block level using a 22-gauge needle. Bupivacaine dose was given as an initial injection of 0.2 ml/kg for 3–4 s; the remaining dose was given at the same flow after 1 min. The lowest HRs were observed during and up to 1 min after the initial injection, as well as during and up to 1 min after the complete drug delivery. Prior to and every 2 min following the caudal block, the PI of all children was measured.

Results: There was a significant difference between the caudal success group and the caudal failure group regarding median PI ($p < 0.001$). At the initial and total caudal bupivacaine doses, there was a significant fall between the median HR caudal success group and the median HR caudal failure group ($p < 0.001$).

Conclusion: A decrease in HR of −2 and −3 beats/minute during or shortly after an initial and entire caudal drug injection, respectively, and median PI are reliable methods in the prediction of caudal success.

ARTICLE HISTORY
Received 26 October 2023
Revised 26 November 2023
Accepted 28 December 2023

KEYWORDS
Caudal block; perfusion index; change heart rate

1. Introduction

In children, caudal block is most frequently used because it is a straightforward technique with a quick learning curve and a lower incidence of disadvantages [1]. Children who exhibited caudal blocks had success 75% of the time. This percentage has been linked to a variety of variables, including the inadequacy of the landmark relationship assessment of the caudal anatomy, and the fact that the block is frequently performed after general anaesthesia (GA) due to the uncooperative nature of children [2].

The evaluation of caudal success in children has been explored using a variety of methods, including the whoosh and swoosh tests [3], which are subjective and sensitive to individual variance, and ultrasonography [4], which is operator-based. There has been continuous search for an impartial screening test to judge the effectiveness of caudal block. Ghai et al. [5] found that a decreased heart rate (HR) after initial and total bupivacaine injection is a marker of an adequate caudal block. The perfusion index (PI) is a non-invasive, continuous assessment of peripheral perfusion. PI might evaluate vascular-tone-related peripheral perfusion [6].

The ability to detect the commencement and success of the block early was hypothesized to depend on changes in PI following caudal block and a drop in HR following caudal block. In order to evaluate the initiation and success of caudal block in children, we decided to correlate changes in HR following caudal block with the PI.

2. Aim of the work

The work aims to investigate the efficacy of PI and HR variations following the caudal block in determining the success of the caudal block in children.

3. Methods

This randomised, controlled study was conducted from November 2021 to June 2023 after obtaining approval from the Institutional Ethics Committee. Inclusion criteria were children of 2–8 years of age, who were undergoing elective infra-umbilical procedures with American Society of Anesthesiologists (ASA) physical status of classes I and II. Those excluded from the study were children with anatomical abnormalities of the

CONTACT Yasser Essam Elfeil dryasser.elfeil.ye@gmail.com Department of anesthesia and surgical ICU, Alexandria University, Alexandria, Egypt

spine, coagulation disorders and a history of allergy to local anaesthetics (LAs), infection or redness at the injection site, liver, kidney and heart diseases. Before enrolment, the parent of every patient signed an informed and written consent (study protocol was explained in their native language) for participation in the study and the use of patient data for research and educational purposes.

All patients were administered oral midazolam (0.5 mg/kg) as a preoperative medication, and ASA standard monitors were applied in the operating room. GA was induced with 1–2% sevoflurane and then increased to 8%, and 50% air in oxygen was administered via a face mask. An intravenous (IV) cannula was placed. After GA was induced, a laryngeal mask (Teleflex, Westmeath, Ireland) airway was inserted after deepening the plane of anaesthesia using O_2 and sevoflurane was administered until full jaw relaxation. GA was maintained using 2% sevoflurane and 50% air in oxygen.

After ensuring an end-tidal sevoflurane concentration of 2–3% (total minimum alveolar concentration equivalent 1.5) for 3 min, the patient's back was cleaned and draped. HR was recorded from the ECG, taken as baseline. The principle investigator (PI), who did not have audible or visual access to the monitor, performed the block. A 22-gauge needle was placed under full asepsis, and 0.5–1 ml/kg of 0.25% bupivacaine according to the needed block level to a maximum of 20 ml was injected. The drug was injected at the rate of 1 ml/3–4 s. An initial (0.2 ml/kg) 0.25% bupivacaine was injected and after 1 min, the total drug was administered at the same rate. An anaesthesiologist not involved in the study recorded the lowest HR during/until 1 min after the initial (0.2 ml/kg) injection as well as during/until 1 min after the total drug administration. This person was directed to inform the operator in case of any dysrhythmia or significant T-wave changes (increase in amplitude by 25% for 10 s compared with baseline) with the injection of the drug. At the basal value and every 2 min following caudal block, the PI of all children was measured using a Masimo pulse oximeter in the right lower limb (Biolight M69, Biolight Meditech®, Zhuhai, China). The following measurements were made: HR, systolic blood pressure (SBP) and diastolic blood pressure (DBP), and oxygen saturation. After the caudal block, the surgical incision was made 10 min later.

Another investigator blinded to HR changes and the clinical impression, based on the following criteria, defined the success of caudal block:

- No tachycardia on surgical stimulation (HR > 20% of baseline).
- The minimum end-tidal sevoflurane concentration needed to maintain anaesthesia is 3%.
- Postoperative pain score as assessed by objective pain score at 0 h and 30 min postoperatively is <4 of 12 with the Aldrete score [7]

4. Sample size calculation

Based on this study [5] to detect a drop in HR of 6 beats/minute, the difference from baseline after total drug administration and the SD (17.2), the study would require 70 subjects. At a significance level of 0.05 and power of 80%, it is sufficient to detect differences that occurred in HR, but we increased it to 100 subjects to take failure blocks into consideration as well.

Sample size was calculated using NCSS 2004 and PASS 2000 program, using a two-sided one-sample t-test.

5. Statistical analysis

Data were coded and entered using the Statistical Package for the Social Sciences (SPSS) version 25. According to the distribution of variables using Kolmogorov–Smirnov test, data were summarized by median as measures of central tendency and range as measures of dispersion for quantitative not normally distributed parameters. Mann–Whitney test was used to compare between two quantitative not normally distributed parameters.

Area under curve (AUC) was done to predict the outcome of a caudal block using "ΔHR at initial, total caudal bupivacaine dose administration, and ΔPI" and then comparing between three ROC curves using MedCalc Version 12.

6. Results

A total of 126 parturients were enrolled in the study, of which 100 parturients were included in the analysis (figure 1). This study was carried out on 100 children aged between 2 and 8 years, with mean of age 5.06 ± 2.05 years. The males made up 51%, while females 49%. Their mean weight and height was [17.95 ± 3.93 kg and 86.52 ± 4.19 cm, respectively]. Figure 2 clarifies the mean HR, SBP, and DBP changes from baseline to 30 min through the operation.

The success rate of caudal block among the study sample was 85%.

Regarding median PI, which existed at the following times: 2, 4, 6, 8 and 10 min, there was a significant difference between the caudal success group and the caudal failure group ($p < 0.001$). (Table 1 and Figure 3).

At initial and after total caudal bupivacaine doses, there was a significant decrease between the median **Δ**HR caudal success group and the median HR in caudal failure group, ($p < 0.001$) (Table 2).

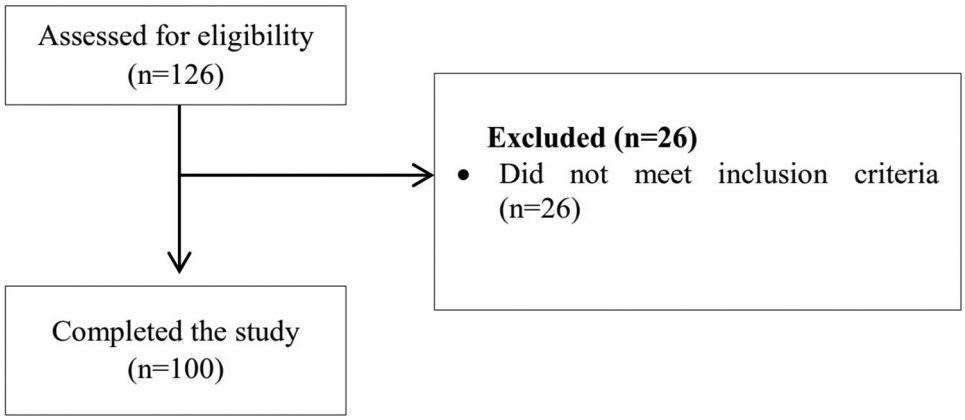
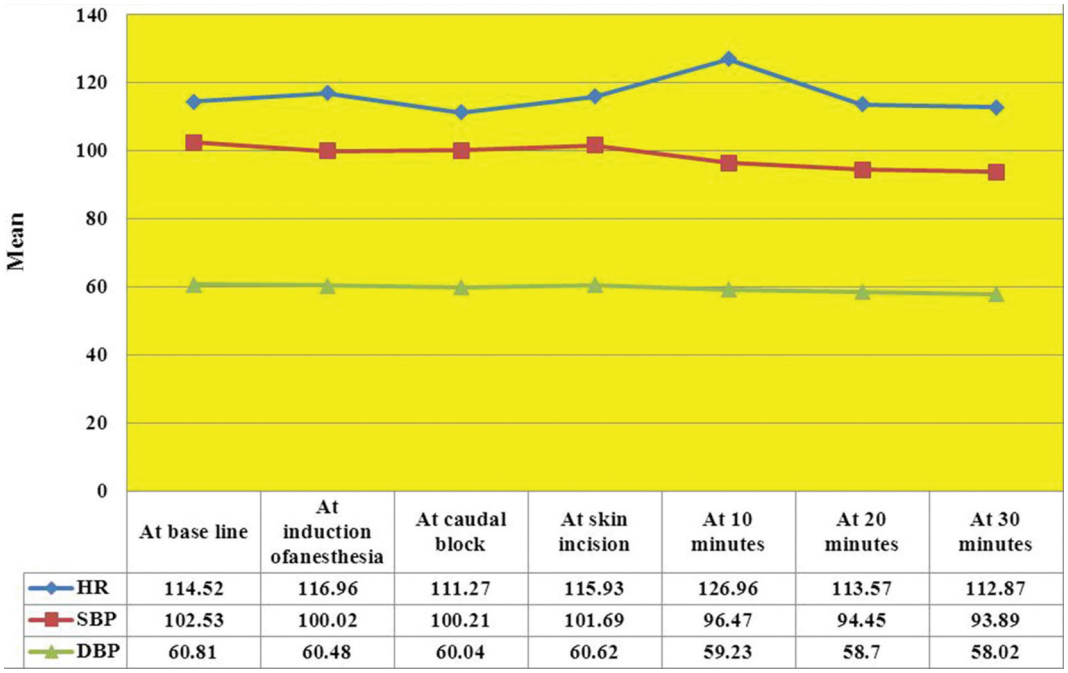


Figure 1. A consort flow diagram showing the sequence of patients.



	At base line	At induction ofanesthesia	At caudal block	At skin incision	At 10 minutes	At 20 minutes	At 30 minutes
HR	114.52	116.96	111.27	115.93	126.96	113.57	112.87
SBP	102.53	100.02	100.21	101.69	96.47	94.45	93.89
DBP	60.81	60.48	60.04	60.62	59.23	58.7	58.02

Figure 2. The line graph displays the mean of the patient's HR, SBP and DBP from the baseline, the caudal block, the skin incision, and the 10th, 20th, and 30th min of the procedure.

Table 1. Relation between PI changes with the success of caudal block (min–max).

ΔPI	Group with succeeded caudal block (no. = 85)	Group with failed caudal block (no. = 15)	Test of significance (P)
At 2 min	0.90 (0–1)	0.2 (−0.10–0.50)	U = 1240, $p < 0.001$*
At 4 min	1.60 (0–2)	0.3 (0.10–1.10)	U = 1243.5, $p < 0.001$*
At 6 min	2.10 (0–3)	0.4 (0.10–1.50)	U = 1246.5, $p < 0.001$*
At 8 min	3.20 (0–4)	0.6 (0.10–2.90)	U = 1234, $p < 0.001$*
At 10 min	3.70 (0–5)	0.8 (0.40–3.20)	U = 1248.5, $p < 0.001$*
Average intraoperative ΔPI	2.28 (0.06–2.78)	0.42 (0.20–1.84)	U = 1245.5, $p < 0.001$*

U, Mann–Whitney test; *, statistically significant.

The effectiveness of "ΔHR at initial, total caudal bupivacaine dose administration and ΔPI" in predicting caudal block outcome is seen in Table 3.

By comparing between all ROC curves, there was no significant difference between them in predicting caudal block outcome ($p = 0.133$).

7. Discussion

Caudal block is one of the most widely utilised regional methods for treating children. It is frequently done under sedation, making it difficult to assess the caudal block's efficiency and beginning. For validating successful insertion, the majority of practitioners rely on

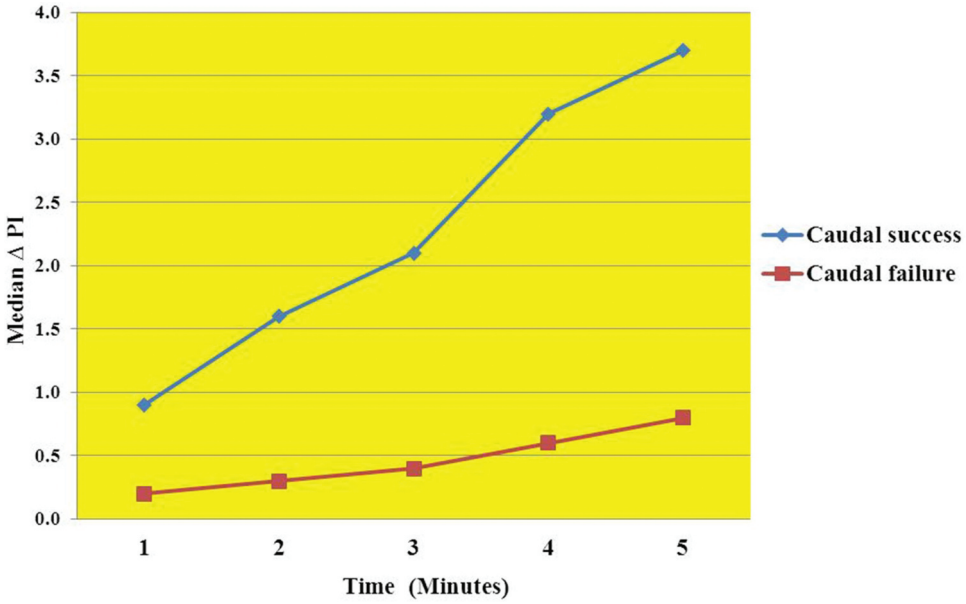


Figure 3. The line graph shows a significant difference between caudal success group and caudal failure group as regards median PI, which occurred in the following intraoperative times: 2, 4, 6, 8, and 10 min ($p < 0.001$).

Table 2. Relation between HR changes with the success of caudal block (min–max).

ΔHR	Group with succeeded caudal block (No. = 85)	Group with failed caudal block (No. = 15)	Test of significance (P)
At initial caudal bupivacaine dose	−3(−5–4)	1(- 4–4)	U = 188, $p < 0.001$*
At total caudal bupivacaine dose	−4(−7–3)	1(−6–6)	U = 147, $p < 0.001$*

U, Mann–Whitney test; *, statistically significant.

Table 3. Ability to predict the outcome of a caudal block using "ΔHR at initial, total caudal bupivacaine dose administration, and ΔPI".

	AUC (95% CI)	*p* value	Cutoff point	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
ΔHR at initial caudal bupivacaine dose	0.85 (0.768 to 0.916)	<0.0001*	≤-2	97.65 (91.8–99.7)	26.67 (7.8–55.1)	88.3 (80.0–94.0)	66.7 (22.3–95.7)
ΔHR at total caudal bupivacaine dose	0.85 (0.805 to 0.940)	<0.0001*	≤ −3	90.59 (82.3–95.8)	93.33 (68.1–99.8)	98.7 (93.0–100.0)	63.6 (40.7–82.8)
Δ PI	0.977 (0.925 to 0.997)	<0.0001*	>0.64	97.65 (91.8–99.7)	93.33 (68.1–99.8)	98.8 (93.5–100.0)	87.5 (61.7–98.4)

AUC: area under curve. PPV: positive predictive value. NPV: negative predictive value.

irrational clinical predictions such as a "pop" while piercing the sacrococcygeal membrane, ease of injection, and absence of subcutaneous oedema. Clinical impressions, however, have reportedly been found to have low specificity [8].

In our investigation, the groups with succeeded and failed caudal block had significantly different median HR change at the initial and after total caudal bupivacaine dosages. Additionally, with the cutoff points of HR change being −2 and −3, respectively, HR changes at initial and total caudal bupivacaine dosages can statistically significantly predict caudal block success. This was in agreement with Ghai et al. [5] who discovered that a drop in HR of 2 beats/minute during the initial injection was a highly effective predictor of the caudal block. The stimulation of baroreceptors may be the cause of these effects. Pressure receptor stimulation may cause a drop in HR to stimulate a sleeping child's breathing with a sacral epidural injection. A medication delivery into the treated region is likely to stimulate the pressure receptors either within or outside of the sacral nerve roots in the caudal space or in adjacent CSF in the dural cuff at S2. We hypothesise that pressure receptors in the lumbar region may also be activated by drug ascent since, in our investigation, we observed a sustained reduction in HR of up to 5 beats/minute after the initial medication injection, which climbed to 7 beats/minute with the total drug dose. Moreover, with an additional stronger medication, a larger reduction in HR was linked to a larger drug injection volume. Another mechanism that could be involved is the pressure wave that penetrates the

cerebrospinal space [9]. This was the same explanation by Fisher [10].

The median PI at the following times, 2, 4, 6, 8, and 10 min after the caudal block, differed significantly between the caudal success group and the caudal failure group. With a cutoff value of PI change > 0.64, more than three times the basal value, the capacity of "PI" to predict caudal block success made a statistically significant contribution to the prediction of caudal block outcome. Similar investigations by Makkar et al. [11], Ginosar et al. [12] and Mohamed et al. [13] demonstrated equivalent outcomes with PI, despite the fact that their comparisons comprised additional characteristics such as cremasteric reflex and skin gradients in temperature. Long believed to be a dependable sign of a successful caudal block, the loss of the cremasteric reflex is only applicable to male patients, and it typically takes significantly longer for the consequences of a caudal block to manifest [14,15]. Leg-to-toe temperature gradients recorded from the skin's surface have been successfully employed as a sympathectomy indication [16,17]. However, this is not always possible because there are not enough temperature probes and the ambient temperature is not standardised.

Our study population's strength was a large, homogeneous sample of children who were evenly distributed in terms of age, surgical procedure and regional analgesia. PI and HR alterations are valuable, objective, non-invasive tools to evaluate the impact of caudal block in paediatric patients because we use them frequently in all patients throughout surgery. In addition to not using confounding medications like ketamine and atropine, we employed sevoflurane instead of halothane. This study did have certain restrictions, though. GA itself can result in vasodilatation, making it a potential complicating factor. Since caudal block only affects the lower extremity, it is possible to compare PI values from the upper and lower extremities to cancel out its influence. Although this would have been ideal, it was not feasible in our investigation because an additional pulse oximeter probe that could detect PI was not provided. As an alternative, we did not use absolute values but rather PI trends. Further observations can be made with the aforementioned alterations to produce reliable results, providing guidance for future research.

8. Conclusion

A decrease in HR of −2 and −3 beats/minute during or shortly after an initial and entire caudal drug injection, respectively, and median PI were reliable methods in the prediction of caudal success.

Disclosure statement

No potential conflict of interest was reported by the author(s).

ORCID

Yasser Essam Elfeil http://orcid.org/0000-0001-8407-5832
Ehsan Akram Deghidy http://orcid.org/0000-0002-7584-8722

Consent

Trial registration numbers PACTR202305574486145.

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