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Original Article

Anaesthesia Section

Ultrasound-guided versus Conventional Caudal Blocks in Children: A Randomised Clinical Study

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ABSTRACT

Introduction: Caudal epidural block is a popular regional anaesthetic technique in children undergoing infraumbilical surgeries. Conventionally, a landmark-guided method is used to perform caudal epidural blocks. Although widely practiced, this method is associated with procedural difficulties such as multiple attempts, decreased success rates at the first puncture, as well as higher rates of complications including dural puncture, rectal injury, and intraosseous/intravenous (i.v.)/subcutaneous injections. In order to overcome the shortcomings of the conventional technique, various other methods have been described in clinical practice, including imaging-assisted techniques with fluoroscopy and Ultrasound (US).

Aim: To compare the overall block success rates between the conventional and US-guided methods of caudal blocks in children.

Materials and Methods: The present randomised clinical study was conducted in the Department of Anaesthesiology, St. John's Medical College, Bengaluru, Karnataka, India, from November 2019 to September 2021. Sixty-four children, aged 1-8 years, belonging to the American Society of Anaesthesiologists (ASA) physical status grade I and II, and undergoing elective inguinal hernial surgery were included in the study. After induction of general anaesthesia, the children were administered caudal blocks based on the assigned groups: group A (conventional)- patients were given 0.5 mL/kg of 0.25% bupivacaine after the needle entered the sacral canal, and group B (USG)- patients were given 0.5 mL/kg of 0.25% bupivacaine immediately after the needle was visualised piercing the sacrococcygeal ligament in the longitudinal view. The parameters studied were overall block success rates, block performance times, and the number of attempts taken. Descriptive statistics were reported using mean±Standard Deviation (SD) for continuous variables and number or percentage for categorical variables. Independent t-test and Mann-Whitney U test were used for normally distributed and non-normally distributed variables, respectively. Chi-square test was used to analyse differences between categorical variables.

Results: A total of 64 children of both genders, aged 1-8 years, belonging to ASA physical status I and II, were included in the study. Overall block success rates were comparable between the two groups, with 28 (87.5%) in group A and 30 (93.8%) in group B. The mean block performance time was longer in group B (2.781±1.2439 minutes) compared to group A (1.578±0.5835 minutes) (p-value <0.001). The number of attempts was lower in group B, with 100% success in the first attempt, as opposed to 68.8% in group A (p-value <0.05).

Conclusion: Ultrasound-guided caudal block does not improve overall block success rates or block performance time, but it does improve success rates at the first attempt and thereby reduces the number of attempts.

Keywords: Attempts, Bupivacaine, Block performance, Inguinal hernia

INTRODUCTION

Caudal epidural block is a regional anaesthetic modality that can be used to provide analgesia and anaesthesia in both adults and children. The technique has found widespread use in the pediatric population for intraoperative and postoperative pain relief in surgeries performed below the level of the umbilicus. Affecting the dermatomes T10 to S5, it is a useful adjunct and alternative to systemic methods of analgesia. Originally discovered by French physicians Fernand Cathelin and Jean-Anthanase Sicard and was introduced into practice prior to lumbar epidural block [1]. Initially, it lacked popularity due to significant variations in the anatomy of the sacrococcygeal region, which were further exaggerated in the paediatric age group, especially infants and young children.

The anatomical landmarks important in this mode of regional anaesthesia include the Posterior Superior Iliac Spines (PSIS), sacral cornua, and sacral hiatus. The sacral vertebrae, while fusing to form the sacrum, retain discrete anterior and posterior intervertebral foramina. The laminae of S4 and S5 do not fuse, resulting in the sacral hiatus, which can be palpated as a groove above the coccyx along the midline. The sacral cornua, PSIS, and sacral hiatus form an equilateral triangle, which is the main landmark for performing and administering the caudal block. Both the PSIS and sacral cornua can be used as guides to identify the hiatus, through which the caudal block is performed using various techniques.

Conventionally, a landmark guided method is used to perform caudal epidural blocks. The above mentioned anatomical structures are utilised to locate the sacral hiatus, through which a needle is inserted to pierce the sacrococcygeal ligament and inject local anaesthetic drugs [2]. Although widely practiced, this method is associated with procedural difficulties such as multiple attempts, decreased success rates at the first puncture, and higher rates of complications such as dural puncture, rectal injury, and intraosseous/IV/subcutaneous injections [3]. To overcome the shortcomings of the conventional technique, various other methods have been described in clinical practice. These include imaging-assisted techniques with fluoroscopy and Ultrasound (US) [4]. US-guided caudal epidural blocks offer advantages as they improve visualisation of the sacrococcygeal ligament and sacral hiatus, allowing for visualisation of the drug spread during injection. This ultimately improves success rates, success rates at the first attempt, reduces the number of attempts, and decreases associated complications [5].

The present study aims to understand the difficulties encountered during the performance of conventional and US-guided caudal blocks and compare the advantages and disadvantages of the two methods, with the goal of introducing more effective techniques for

routine clinical practice. Traditionally, conventional caudal blocks have a success rate of 75%, and the use of US is expected to increase this rate.

The aim of the present study was to compare landmark-guided versus US-guided caudal blocks, with the primary outcome being overall success rates and the secondary outcomes being block performance times, success rates at the first puncture, and the number of attempts.

MATERIALS AND METHODS

This randomised clinical study was conducted in the Department of Anaesthesiology at St. John's Medical College Hospital in Bengaluru, India, from November 2019 to September 2021. The study received approval from the Institutional Ethics Committee (IEC Study Ref no: 292/2019) and was registered with the ISRCTN registry (https://doi.org/10.1186/ISRCTN10599628).

Sample size calculation: The sample size was determined based on a study by Karaca O et al., in 2019 [3]. To detect a minimum difference of 24% between the two groups, with 80% power and a significance level of 5%, a total of 64 patients (32 in each group) were required. The sample size was calculated using nMaster 2.0 software.

Inclusion criteria: The study included patients aged 1-8 years, without any contraindications for caudal block, scheduled for elective inguinal hernia surgeries, and classified as ASA physical status I or II. Written informed consent was obtained from the guardians.

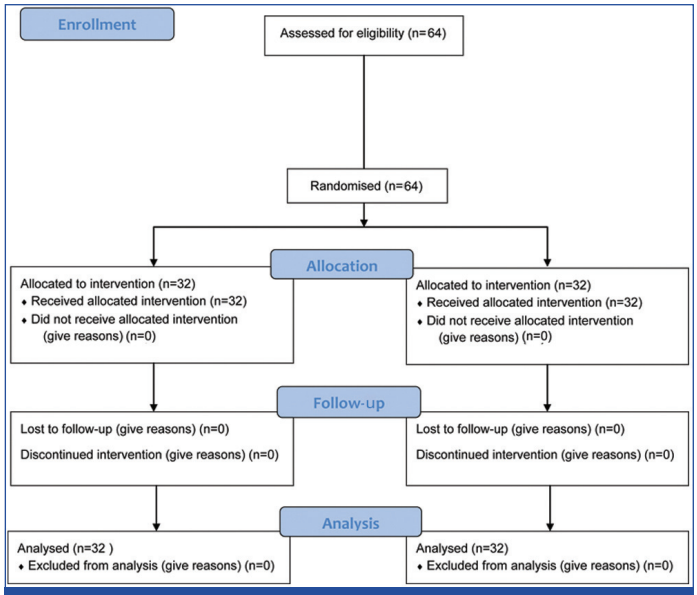
Exclusion criteria: Patients who refused to give consent, had infections at the injection site, had coagulation abnormalities, or had known hypersensitivity to the drugs used were excluded from the study.

Study Procedure

The children were kept Nil Per Os (NPO) prior to surgery in accordance with standard guidelines. They received intravenous fluids at maintenance rates (based on the Holliday Segar formula) during the NPO period. The operation theatres were prepared with checked anaesthesia workstations and ASA-recommended monitors. Measures were taken to maintain normothermia. Depending on the presence/absence of intravenous access, the child either received premedicated with 7 mcg/kg glycopyrrolate intravenously with/without 0.03 mg/kg midazolam intravenously and 0.15 mg/kg ondansetron intravenously, or intravenous access was established under inhalational sevoflurane. General Anaesthesia (GA) was induced using inhalational or intravenous sevoflurane, intravenous fentanyl 2-3 mcg/kg, and intravenous propofol 1-2 mg/kg. Under adequate depth of anaesthesia, an appropriate-sized Laryngeal Mask Airway (LMA) was inserted, and the child was maintained on isoflurane with spontaneous or assisted ventilation and intravenous Ringer's lactate as fluid support.

The child was then positioned in the lateral position, and caudal block was performed under strict aseptic precautions using either the conventional landmark-guided method or the Ultrasound-Guided (USG) method. The block was performed by a trained anaesthesiologist with at least five years of practical experience. Due to the nature of the study design, blinding was not possible. The children were assigned to the following two groups using the envelope method [Table/Fig-1]:

Group A: Caudal block performed using the conventional method guided by anatomical landmarks. The Posterior Superior Iliac Spines (PSIS) and sacral cornua were palpated to locate the sacral hiatus using the equilateral triangle method. A 22G needle was inserted at an angle of 60-80 degrees until the sacrococcygeal ligament was punctured (resulting in a popping sensation). The angle was then reduced to 20-30 degrees, and the needle was advanced by 2-3 mm. Negative aspiration of Cerebrospinal Fluid (CSF) or blood was confirmed, and 0.5 mL/kg of 0.25% bupivacaine was injected [6].



[Table/Fig-1]: Consolidated Standards of Reporting Trials (CONSORT) flow diagram.

Group B: Caudal block performed using USG. The sacral hiatus was identified in the transverse view at the level of the sacral cornua using a linear probe of a Sonosite portable US machine (Fujifilm, United States of America). The typical appearance of the sacral cornua, sacral body, sacrococcygeal ligament, and sacral hiatus (resembling frog eyes) was noted. After negative aspiration of blood or CSF, 0.5 mL/kg of 0.25% bupivacaine was injected, and the spread of the drug was visualised [7,8].

Surgery commenced 15 minutes after the caudal block was performed, and vital signs were monitored and recorded every five minutes. Baseline Heart Rate (HR), Respiratory Rate (RR), and Motor Movement (MM) were noted at 0 minutes, 5 minutes after induction, 10 minutes after block performance, 25 minutes after surgical incision, and 60 minutes postoperatively for all cases. The primary outcome assessed was the success rate of the block, and the secondary outcomes were block performance times and the number of attempts. A successful block was defined as the absence of significant motor movement at the time of surgical incision or a significant increase in HR/RR. The block performance time was calculated as the duration from the identification of structures to the completion of the local anaesthetic injection. In the case of an unsuccessful block, analgesia was supplemented with intravenous fentanyl and/or intravenous/per rectum paracetamol. After completion of surgery, the Laryngeal Mask Airways (LMA) were removed, and the child was monitored in the Post-Anaesthesia Care Unit (PACU).

STATISTICAL ANALYSIS

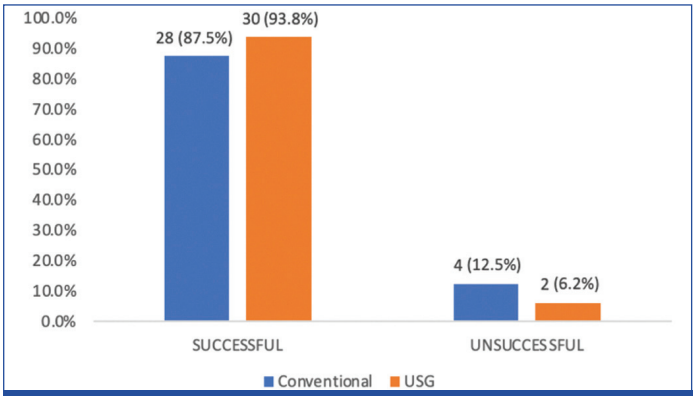
Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) software. Descriptive statistics were reported, including mean±SD for continuous variables and number/percentage for categorical variables. An independent t-test was used to compare continuous variables, such as block performance time and age, if the variable was normally distributed. If the variable was not normally distributed, the Mann-Whitney U test was used. The Chi-square test was used to test differences between categorical variables, such as sex and number of attempts. A p-value <0.05 was considered statistically significant, indicating a probability that the result is true.

RESULTS

In both groups A and B, the majority of children belonged to the 5-10 kg weight range. There were no observable differences between the two groups in terms of the ages, weights, ASA grades, and genders of the children [Table/Fig-2]. The overall block performance rates were comparable and statistically insignificant between the two groups [Table/Fig-3].

Variables	Group A n (%)	Group B n (%)	p-value
Sex			
Male	30 (93.8)	29 (90.6)	0.641
Female	2 (6.2)	3 (9.4)	
ASA grade			
I	22 (68.8)	26 (81.2)	0.248
II	10 (31.2)	6 (18.8)	
Age (years) Mean±SD	3.44±2.462	3.06±2.313	0.532
Weight (kg) Mean±SD	13.128±5.5337	12.828±4.9704	0.820

[Table/Fig-2]: Categorical variables.
Chi-square test



[Table/Fig-3]: Bar graph comparing success rates of block between both groups (p-value=0.391).

There was a statistically significant difference in block performance times (mean) between the two groups, with the USG group having a higher time [Table/Fig-4]. The overall block performance rates were comparable between the two groups, but there was a statistically significant difference in terms of the number of attempts and block performance times [Table/Fig-4]. There was no statistical significance between the two groups in terms of Heart Rate (HR) and Respiratory Rate (RR) across all time points [Table/Fig-5,6].

Variables		Group A	Group B	p-value
Block performance time in minutes (Mean±SD)		1.578±0.5835	2.781±1.2439	**0.000006**
Overall block success rate, n (%)		28 (87.5)	30 (93.8)	0.391
Number of attempts, n (%)				
1		22 (68.8)	32 (100)	**0.003**
2		9 (28.1)	0	
3		1 (3.1)	0	
Presence of motor movement at 25 minutes, n (%)	Absence	30 (93.8)	32 (100)	0.151
	Presence	2 (6.2)	0	

[Table/Fig-4]: Outcome variables.
Independent t-test; The p-value in bold font indicates statistically significant values

Time interval (in minutes)	Group A			Group B			t	df	p-value
	N	Mean	SD	N	Mean	SD			
0	32	101.063	16.4080	32	112.469	16.7447	-2.752	62	**0.008**
5	32	97.313	15.7346	32	108.469	16.8139	-2.741	62	**0.008**
10	32	96.531	16.2202	32	107.125	17.2229	-2.533	62	**0.014**
15	32	95.875	16.2456	32	106.281	16.9272	-2.509	62	**0.015**
20	32	95.438	15.7704	32	104.750	16.8810	-2.280	62	**0.026**
25	32	97.125	17.1835	32	105.219	16.5388	-1.920	62	0.059
30	32	94.844	16.1247	32	101.969	16.3342	-1.756	62	0.084
60	32	95.813	14.8746	32	100.875	16.4998	-1.289	62	0.202

[Table/Fig-5]: Heart rate variabilty between the two groups.
The p-value in bold font indicates statistically significant values

Time interval (in minutes)	Group A			Group B			t	df	p-value
	N	Mean	SD	N	Mean	SD			
0	32	22.281	6.1447	32	22.719	4.7671	-0.318	62	0.751
5	32	21.438	5.8361	32	21.531	5.0799	-0.069	62	0.946
10	32	20.844	5.7029	32	20.906	4.8217	-0.047	62	0.962
15	32	21.000	5.5822	32	20.438	4.7037	0.436	62	0.664
20	32	20.656	5.4513	32	20.125	5.0145	0.406	62	0.686
25	32	21.156	5.5944	32	20.313	4.6659	0.655	62	0.515
30	32	20.656	5.0584	32	20.094	4.3579	0.477	62	0.635
60	32	20.813	4.8887	32	19.406	4.4855	1.199	62	0.235

[Table/Fig-6]: RR variability between the two groups.

DISCUSSION

As early as the 1980s, Veyckemans F et al., observed that it was more challenging to locate anatomical landmarks in very small children, especially those weighing less than 10 kg [9]. Three decades later, Abukawa Y et al., and Kim YH et al., independently found that the conventional equi-angular triangle method for locating the sacral hiatus was unreliable in younger children, and the use of imaging methods like ultrasound improved identification [8,10]. Liu JZ et al., further added that the use of ultrasound and direct visualisation of the sacral canal improved success rates and block performance times [11]. Chen CP et al., determined that the identification of the sacral hiatus by ultrasound was as good as the gold standard fluoroscopy [12]. Therefore, ultrasound-guided caudal blocks were chosen to be studied against conventional caudal blocks in this study population.

Park JH et al., studied and confirmed that an angle of 20 degrees for needle insertion in ultrasound-guided blocks was optimal, while Doo AR et al., stated that there was a statistically significant advantage in terms of block success rate if the drug was injected immediately after piercing the sacrococcygeal ligament in the ultrasound-guided group [13,14]. As a result, a sequential combination of these two techniques was chosen to perform caudal blocks in the ultrasound-guided group, resulting in good overall block success rates, better success rates at the first attempt, and a decreased number of total attempts.

The primary objective of this study was to compare the overall block success rates between the conventional and ultrasound-guided methods of caudal blocks. Although the ultrasound-guided group had a higher success rate of 93.8% compared to the conventional group's 87.5%, the difference between the two groups was not statistically significant. Similar results were found in studies conducted by Karaca O et al., (96.2% vs 94.7%) and AhiskaliogluA et al., (97% vs 93%) [3,15]. Wang LZ et al., also noted comparable success rates between both groups, with slightly higher rates in the conventional group (95.7% vs 92.8%) [16].

The secondary objectives of the present study were to compare block performance times and the number of attempts, thereby noting the success rates at the first attempt. There was a statistically significant difference in mean block performance times between the two groups, with the conventional method being quicker. This finding is consistent with the study by Kollipara N et al., who also observed longer block performance times in the ultrasound-guided group [17]. However, Karaca O et al., and Ahiskalioglu A et al., reported comparable times between the two groups [3,15]. On the contrary, Wang LZ et al., demonstrated quicker times in the ultrasound-guided group [16]. The discrepancies in findings could be attributed to operator factors, such as unfamiliarity with using ultrasound and the learning curve. Additionally, the definition of block performance times varied among the studies, which could also contribute to the differences in outcomes.

Regarding the number of attempts and success rates at the first attempt, the authors noted a statistically significant difference between the two groups. All blocks in the ultrasound-guided group were successfully performed at the first attempt, resulting in a 100% success rate. In contrast, in the conventional group, only 68.8% of the blocks were successful on the first attempt. Similar advantages of ultrasound use were reported by Karaca O et al., (90.2% vs 66.2%), Wang LZ et al., (92.8% vs 60%), Ahiskalioglu A et al., (80% vs 63%), and Kollipara N et al., (90.6% vs 64.2%) [3,15-17]. Similar to these studies, the outcomes in the present study were not affected by the demographic profiles of the study population.

Conventional caudal blocks are associated with the risk of complications such as intraosseous injection, subcutaneous bulging, dural puncture, intravascular injection and systemic toxicity, subdural block, and rectal penetration. Wang LZ et al., reported a reduction in the number of bloody taps in the ultrasound-guided group compared to the conventional group (5.7% vs 18.6%). Subcutaneous bulging was observed in 6 patients in the conventional group and none in the ultrasound-guided group [16]. Ahiskalioglu A et al., also reported similar rates of complications [15]. Karaca O et al., noted 14 bloody taps, 10 subcutaneous bulges, and 32 intraosseous injections in their conventional group, but none in their ultrasound-guided group [3]. In the present study, no complications were noted in the ultrasound-guided group due to the direct visualisation of the needle and sacral dilatation [18,19].

Limitation(s)

The use of ultrasound was operator-dependent, and although an anaesthesiologist with five years of practical experience performed the block, there was still a learning curve involved in using ultrasound. Blinding was not possible in this study. The rates of direct needle visualisation and sacral canal dilatation were not noted and compared between the two views (transverse and longitudinal).

CONCLUSION(S)

Upon analysing the results of this study, it was concluded that the use of ultrasound does not increase the overall success rates of caudal epidural blocks. However, Ultrasound-Guided (USG) blocks significantly decrease the number of attempts taken to perform the block, thereby increasing the success rate at the first attempt. Although an increase in block performance time was noted when using ultrasound, this could be attributed to unfamiliarity with using the apparatus and discrepancies in the definition of block performance time. Ultrasound also has the added advantage of decreasing the risk of complications.

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