Ultrasound assessed a new method of needle insertion at an angle of 90° to the apex of the sacral hiatus for caudal block in newborns: a randomized controlled study

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Research article

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Abstract

Background Caudal block is widely used in paediatric anaesthetic practice. Many angles for needle insertion were compared to find an optimal angle during caudal block with high successful caudal injection and minimal risk of complications. The aim of this study is to evaluate the safety and effectivity of a new method of needle insertion at an angle of 90° to the apex of the sacral hiatus for caudal block in newborns. **Methods** Sixty patients were included in our study, aged 0 to 28 days, posted for inguinal hernia surgery, randomly divided into two groups: a conventional method (CM) group and a new method (NM) group. In both groups, 1 ml•kg⁻¹ 0.5% lignocaine at a rate of approximately 0.5 ml•s⁻¹ was given for caudal blocks after anaesthesia, and ultrasonographic observation of local anesthetic in the epidural space. Failure rate at the first attempt, puncture frequency, complications, and durations of block were recorded. **Results** The failure rate at the first attempt of caudal block were 16.7% in the conventional method group and 3.3% in the new method group ($p < 0.05$). The mean time required (standard deviation) to perform needle insertion in the conventional method group was 2.6±0.5 minutes and in new method group 1.6±0.5 minutes ($p < 0.05$). There were three cases aspirating the needle to find blood and one case to find cerebrospinal fluid in the conventional method group. The majority level which the local anesthetic reached are L1 by ultrasound imaging, 86.7% in the conventional method group and 83.3% in the new method group. **Conclusion** The study found that using the new method, the chance of performing a successful caudal injection can be increased, the time and the risk can be minimized compared to conventional technique. It is a safe and effective method.

Introduction

Caudal block is one of the most useful regional blocks in paediatric anaesthetic practice. Successful caudal block and minimal risk of complications depend on the optimal angle of needle insertion in the caudal space by proper anatomical landmarks. The conventional method is that the needle inserted at the midpoint of sacral cornu vertically to the skin until it pierced the sacrococcygeal ligament, then redirected rostrally at 20-30° to the skin before advanced for few millimeters^[1]. An improved method have been reported that the needle should be inserted at a 60° angle to the coronal plane, flattened to an angle of 20° and advanced an additional 2-3 mm once it has pierced the sacrococcygeal ligament^[2]. But for newborns, rotating the needle after puncture of the sacrococcygeal ligament in a narrow caudal space was dangerous and not necessary, because the needle was already inserted into the caudal space which is alignment with the caudal canal^[3].

Therefore, 'one step techniques' with the angles of 20-60° to the skin without rotation have been introduced in children, they were demonstrated a decrease in the time required to perform and an encouraging absence of bloody tap compared with the conventional technique^[3-4]. But for the infants the level of the dural sac end in relation to the vertebral body was S3-L5^[5], they are more likely to be suffered from dural puncture even total spinal anesthesia with the techniques have been reported^[4-6].

In this study, we tried to change the angle to 90° to the skin at the apex of the sacral hiatus, inserted into the caudal space, without rotation before injection, which could avoid the risk of vessel puncture and dural puncture according to anatomy.

Methods

The registry Uniform Resource Locator of this study is chictr.org.cn (ChiCTR-OOR-17013982, registration date: 16 December 2017). Ethical approval for this study (File NO. 088/2012) was provided by Institutional Review Board of Children's Hospital Affiliated Chongqing Medical University, Chongqing, China (Chairperson Professor Lu Zhong-yi) on 31 December 2017. The study started on 15 January to 30 April 2018. Written informed consent was taken from all parents or legal guardians.

The inclusion criteria were children under the age of 0 to 28 days (American Society of Anesthesiologists physical status I to II) undergoing high ligation of hernial sac. Exclusion criteria were coagulopathy, sepsis, local skin pathology at the puncture site, anatomic abnormality, local anaesthetics allergy and parental refusal. Sixty patients were randomly divided into two groups according to random number table method: CM group (a needle was inserted at a right angle to the skin until it pierced the sacrococcygeal ligament, and then the needle was redirected rostrally at 20 to 30° to the skin before being advanced 2 to 3 mm into the sacral canal) and NM group (caudal block performed by needle insertion at 90° to the skin at the apex of sacral hiatus without rotation).

The patients were fasted and received no premedicate before induction of anesthesia. Electrocardiography, non-invasive blood pressure, pulse oximetry and respiratory rate were monitored for all patients. Anaesthesia was induced with sevoflurane and midazolam.

Anesthetized patients were placed in the lateral position with the hips flexed and the landmarks for caudal puncture were identified. The lumbo sacral junction was determined and the spinous process of L5 was identified by manual palpation, thereby the spinous process of L1-4 and T10-12 was identified in the same way. The 12th rib was subsequently identified by ultrasound visualization and to further verify that the spinous process of Th12 had been correctly identified. The skin overlying the spinous process of Th10 to L5 was then marked. The caudal block were performed by one anaesthetist who did not know the purpose of this study. The data was collected and analyzed by another anaesthetist who did not know which group the patient was in.

The ultrasound equipment used for the study was a LOGIQ5 (GE Healthcare, Wauwatosa, WI, USA) with a 7 to 13 MHz linear array probe. The transducer was placed in a longitudinal view to identify the epidural space. A 22 G, 2.5cm needle was used for caudal block. The ultrasound probe was maintained at the point of L2-4 to visualize the spread of the local anesthetic within the epidural space during injection (Figure 1). The local anesthetic flow was

evidenced by an anterior displacement of the dura mater(Figure 2). The probe was moved cranially to follow the advancement of the front of local anesthetic. No blood and cerebrospinal fluid were aspirated, 1 ml•kg⁻¹ 0.5% lignocaine at a rate of approximately 0.5 ml•s⁻¹ was given. If the needle was not in the proper position at the first attempt of caudal block, a second attempt was made.

Successful caudal block was assumed when the spread of the local anesthetic within the epidural space was visualized by ultrasound during injection, no reaction to skin prick before surgery and the vital signs are stable during the operation. If it was not successful, caudal block was instead of general anesthesia.

Data were obtained include the patients' age, weight, gender, ASA physical status. The time of caudal block,which defined as the time from the needle insertion into the skin to the completion of needle insertion, the number of attempts required for successful block, the number of bloody taps and dural puncture were recorded. Other data included results of the highest portion which the local anesthetic reached, vital signs such as electrocardiography, non-invasive blood pressure, pulse oximetry and respiratory rate were recorded at the time of after anesthesia induction(t1), at the beginning of the operation(t2), at 10 min after the beginning of the operation(t3), at the end of operation(t4).

Statistical analysis

Data were analysed with SPSS 22.0 (SPSS Inc. Chicago, IL, USA). Normal distribution measurement data was compared using the t-test, count data was analysed using Fisher's exact test. A probability of < 0.05 was considered statistically significant.

Result

A total of 60 infants were enrolled in the study. Demographic data are presented in Table 1, the difference of age, weight and height between two groups had no statistical significance.

The failure rate at the first attempt of caudal block were 16.7% in the CM group and 3.3% in the NM group. The mean time required to perform caudal block in the CM group and NM group were 2.6±0.5 minutes and 1.6±0.5 minutes respectively. There were three cases aspirating the needle to find blood and one case to find cerebrospinal fluid in the CM group,these are presented in Table 2.

The majority level which the local anesthetic reached are L1, 88.5% in the CM group and 83.3% in the NM group respectively. The level which the local anesthetic reached are presented in Table 3, the difference between two groups had no statistical significance ($P=0.479$).

Data of vital signs during the operation are presented in Table 4, all the vital signs were stable. The difference of heart rates, blood pressure, respiratory and pulse oximetry between two groups had no statistical significance($P\geq 0.05$).

Discussion

Compared with the conventional technique, our present study demonstrated that the one-step technique was associated with a shorter time and less attempts required to perform the block. Shin KM et al^[3] introduced a similar method to our technique: the needle was inserted into the caudal space at an angle of 20°to the skin without turn. This technique required shorter time which was in line with our study.

For the incomplete ossification of the sacrum and the vertebrae in young children, the spread of local anesthetics inside the spinal canal can be visualized by the use of real-time high frequency ultrasound. The current study found that the median cranial spread of local anesthetic was L1. In Triffterer 's study^[9], the caudal blockade was performed under ultrasound observation using ropivacaine 1 ml/kg and an injection given at either 0.25 ml•s⁻¹ or 0.5 ml•s⁻¹, they demonstrated that ultrasound-assessed median cranial spread was L3 in the low-speed group, and L3/L4 in the high-speed group respectively. The reason makes the difference between two studies is "secondary spread" of caudal block, which was concluded by M. Lundblad et al.^[10], the ultrasound was used to assess the local anesthetics spread within the caudal– epidural space and epidural pressure was followed during 15 min after initial injection (1.5 ml•kg⁻¹ ropivacaine 0.2%) in 16 infants, they observed that the median ultrasound-assessed cranial spread was Th10 and Th8 at 0 and 15 min respectively. It can explain the different ultrasound assessed cranial level among different studies.

In this study, caudal blocks were considered successful, and all surgical procedures could be completed without any indications of insufficient analgesia. But according to the anatomy, level T12 should be blocked for herniorrhaphy, in the present study, the median cranial spread of local anesthetic was L1. In Triffterer's study, the median cranial spread of infants and children undergoing penile, anal, or inguinal surgery was L3 and L3/L4^[9]. The difference between the initial ultrasound assessed cranial level and the final level determined by cutaneous testing also can be explained by the theory of "secondary spread" of caudal block^[10].

The caudal space was much narrower than that of adult whose mean antero-posterior measurement of the caudal epidural canal (SD) was 3.6 mm (1.4) in the transverse view^[11], so the conventional methods is more likely to lead to puncture of the anterior bony wall of the caudal canal and bloody tap .Using the new method , the risk of dural puncture can be avoided, the risk of intraosseous injection or vessel damage is significantly reduced than the conventional methods,In the present study, although the angles to the skin of two methods were the same, none of the infants in CM group experienced bloody tap, because the sacral canal is much more wider at the vertex of sacral hiatus than at the midpoint of sacral cornu.

There are several limitations in our study. First, we only recruited patients aged 0-28 days in our study, the anatomy of elder children is different and caudal space is larger. Our results may have been more precise if the study had been designed to include stratification according to age. Second, no complication occurred in NM group, it is probably because of a small sample size.

In conclusion, using the new method, the time of performing a successful caudal injection can be decreased and the risk can be minimized compared to conventional technique. The new method of needle insertion at an angle of 90° to the apex of the sacral hiatus for caudal block in newborns is safe and effective.

Declarations

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PRESENTATION: NONE.

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Tables

Table 1 Demographic data of the patients

	CM	NM	P
Number of patients	30	30	
Age $\bar{x}$ day, $\pm s$	15.1 $\pm$ 10.3	15.0 $\pm$ 8.1	0.97
Weight $\bar{x}$ kg, $\pm s$	2.8 $\pm$ 0.8	2.8 $\pm$ 0.7	0.85

Table 2 The number of failures at the first attempt, the mean time and complication of caudal block

	CM	NM	P
Number of failures 1st attempt	5(16.7%)	1(3.3%)	0.073
Time of caudal block (minutes , $\pm s$)	2.6 $\pm$ 0.5	1.6 $\pm$ 0.5	0.000
bloody tap(number of patients)	3	0	0.038
dural puncture(number of patients)	1	0	0.236

Table 3 Maximal cranial levelNumber of patients

	CM	NM
T11	1	2
T12	1	2
L1	23	21
L2	1	3
L3	0	2

Table 4 Data of vital signs $\bar{x}\pm s$

	CM				NM			
	t1	t2	t3	t4	t1	t2	t3	t4
Heart rate (beatsper minute)	121.8 $\pm$ 10.8	119.4 $\pm$ 11.3	115.7 $\pm$ 9.2	120.2 $\pm$ 10.0	122.5 $\pm$ 10.1	118.3 $\pm$ 8.8	117.4 $\pm$ 11.3	121.2 $\pm$ 8.1
Systolic blood pressure (mmHg)	71.0 $\pm$ 5.4	69.6 $\pm$ 5.6	67.8 $\pm$ 4.6	69.0 $\pm$ 5.9	71.4 $\pm$ 5.0	69.1 $\pm$ 4.4	68.6 $\pm$ 5.6	71.7 $\pm$ 4.7
diastolic blood pressure(mmHg)	39.2 $\pm$ 5.7	39.9 $\pm$ 4.8	40.4 $\pm$ 5.5	40.0 $\pm$ 5.2	39.6 $\pm$ 4.4	40.7 $\pm$ 4.5	40.7 $\pm$ 5.3	40.0 $\pm$ 6.3
Respiratory rate (beatsper minute)	35.5 $\pm$ 4.8	35.4 $\pm$ 4.7	34.2 $\pm$ 3.8	34.7 $\pm$ 3.5	33.9 $\pm$ 4.3	34.5 $\pm$ 4.0	35.5 $\pm$ 3.3	34.8 $\pm$ 4.1
Pulse oximetry (%)	99.1 $\pm$ 1.2	98.9 $\pm$ 1.2	98.6 $\pm$ 1.0	98.7 $\pm$ 1.2	98.7 $\pm$ 1.0	99.1 $\pm$ 1.1	98.9 $\pm$ 1.0	98.7 $\pm$ 1.1

Figures

Figure 1

Figure 2