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Hemodynamic Changes after Spinal Anesthesia in Children below the Age of Four Years: A Single Centre Experience

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ABSTRACT

Background: Modern technology has produced better equipment than was available hitherto with the result that spinal anaesthesia is undoubtedly simpler, cheaper and above all, safer than it used to be. These notwithstanding, it is used infrequently

Aim of the study: The aim of the study was to analyze the success rate, complications, and hemodynamic stability-related to spinal anesthesia in pediatric patients aged 4 years over a period of 1-year.

Methods: This is a cross-sectional study, a total of 87 patients were enrolled and analyzed. The study was conducted at the Department of Anesthesiology, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh. The study duration was January 2021 to December2021. Informed consent was obtained from the patient/guardian of each patient for participation.

Result: In this cross-sectional study, a total of 87 patients were analyzed. Almost 80% of patients were female and 20% of patients were male. The hemodynamic changes in the children undergoing spinal anaesthesia are shown in figure 2. More than 40% of patients had surgery for hernia (Herniotomy), 11(12.64%) patients had colostomy surgery, and 7(8.05%) patients had Orchidopexy. The mean peak sensory level of the study was T4(C7-T10). There were 85(97.7%) patients who had the motor block and Bromage score of 1 and the mean duration of the block was 75minutes with a range of 30-180 minutes.

Conclusion: Spinal anesthesia in small children showed minimal variation in intra operative and post operative hemodynamic sand is a safer mode of anesthesia with sparing of respiratory alterations seen with general anesthesia..

Keywords: *hemodynamic changes, modified Bromagescale*

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INTRODUCTION

Regional anesthesia in children was first studied by August Bier in 1899. Since then, spinal anesthesia was practiced for years, and a number of cases were published in 1909-1910.[1] After some years, it fell into disuse owing to the introduction of various muscle relaxants and inhalational agents. In early 1980s, it was reintroduced as an alternative to general anesthesia (GA), especially in high-risk and preterm infants. Spinal anesthesia is a useful technique in infraumbilical and lower limb orthopedic surgeries.[2] Infants and children are at an increased risk for GA-related complications.[3-6] Thus, spinal anesthesia could also be indicated as an alternative to GA, especially in situations such as chronic respiratory disease, potentially difficult airway, and malignant hyperthermia.[7-12] Spinal anesthesia in infants has been associated with decreased incidence of hypotension, hypoxia, bradycardia, and postoperative apnea as compared to GA;[13-17] therefore, providing a high-degree of cardiovascular and respiratory stability. An important limiting factor for pediatric spinal anesthesia is duration, which can be prolonged by the addition of opioids and clonidine.[18] Spinal anesthesia though gaining popularity in infants and children, the misconceptions regarding its overall safety, feasibility, and reliability can only be better known with greater use and research. There is no published study from India that highlights the experience of spinal anesthesia in children regarding its safety, success rate, and complications. This made us design this study in which we had prospectively analyzed the success rate, complications, and hemodynamic stability-related to spinal anesthesia in pediatric patients aged 4 years over a period of 1-year.

METHODOLOGY & MATERIALS

This is a cross-sectional study, a total of 87 patients were enrolled and analyzed. The study was conducted at the Department of Anesthesiology, Bangladesh Shishu Hospital and Institute, Dhaka, Bangladesh. The study duration was January 2021 to December2021. Informed consent was obtained from the patient/guardian of each patient for participation. All patients undergoing the study were subjected to a thorough pre-anaesthetic evaluation with specific history taking and examination for infants for any cardiac arrhythmias (long QT syndrome), syncope, cyanosis at stress, or crying. The patient underwent a clinical examination of his/her back to find out the suitability of anesthesia before the procedure. Because an adult spinal cord level (spinal cord terminating at L1) is not achieved until 2 years of life, care was taken by the anaesthetist before the procedure regarding the placement of anesthesia. A lower-level approach was used for drug administration at L4-L5 or L5-S1 level as the spinal cord terminates at the L3 level at birth. Intravenous access was established and all patients were given a crystalloid solution of Ringer's lactate before SA. Fluid management was done according to The Holliday Segar 4-2-1 rule [19].

- **Inclusion criteria**:

Children aged below 4 years were included in this study who underwent various surgeries under spinal anesthesia.

- **Exclusion criteria**:

Patients with anatomical deformity of the spine, cardiac abnormalities, sepsis, local infection at the site of lumbar puncture, coagulopathy, increased intracranial pressure, patient's guardian refusal, surgeries above the umbilicus, and all emergency surgeries were excluded from our study.

Preoperative vital comprising heart rate, blood pressure, and oxygen saturation were measured using standard devices.A 0.2mg to .4 mg/kg Bupivacaine Heavy was used as anesthetic agent and maintain a cooperative environment to achieve the block. It is known that children become agitated before surgeries due to being away from their parents, due to the presence of strangers around, or fear of pain.Monitoring of the vitals was done with standard monitoring devices like a non-invasive blood pressure monitor, pulse oximeter, and electrocardiogram monitor. The pinching method was used for assessing the sensory level of the block and the height of the block at the dermatomal level [20]. A block was considered successful only when there was an inability to sense pinprick on bilateral T10 level, within 15 minutes of intrathecal drug administration. The pinching method was performed every 2-3 minutes apart from the administration of SA for up to 15 minutes. The table was manipulated in a reverse Trendelenburg up to 30 degrees if the block was achieved above the T4 level. In infants or non-verbal patients, careful observation of flinching or facial expression was observed in response to the painful stimuli. The quality of the block was assessed using a modified Bromage scale.All data were presented in a suitable table or graph according to their affinity. A description of each table and graph was given to understand them clearly. All statistical analysis was performed using the statistical package for social science (SPSS) program, and Windows. Continuous parameters were expressed as mean±SD and categorical parameters as frequency and percentage. Comparisons between groups (continuous parameters) were made by Student's t-test. Categorical parameters compared by Chi-Square test. The significance of the results as determined by a 95.0% confidence interval and a value of $P<0.05$ was considered to be statistically significant.

RESULT

In this cross-sectional study, a total of 87 patients were analyzed. Almost 80% of patients were female and 20% of patients were male (Figure 1). Table 1 shows the demographic characteristics of children undergoing spinal anaesthesia, the mean age was 1.115 years and the range is 2 days-3.66 years and the weighted mean is 8.44 kg with a range of 6.6 kg to 17 kg. The hemodynamic changes in the children undergoing spinal anaesthesia are shown in figure 2. More than 40% of patients had surgery for hernia (Herniotomy), 11(12.64%) patients had colostomy surgery, and 7(8.05%) patients had Orchidopexy. The mean peak sensory level of the study was T4(C7-T10). There were 85(97.7%) patients who had the motor block and Bromage score of 1 and the mean duration of the block was 75minutes with a range of 30-180 minutes.

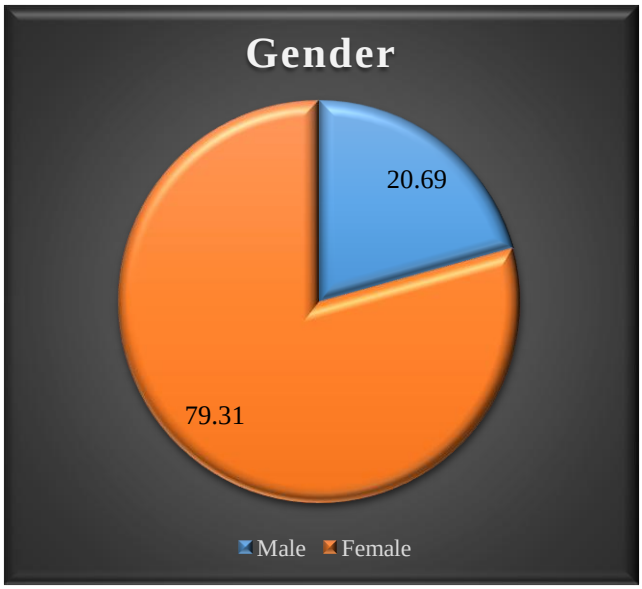

Figure 1: Gender distribution of the study population.

Table 1: Demographic characteristics of children undergoing spinal anesthesia.

Characteristics	Finding	Range
Mean age (Year)	1.15 year	2 day - 3.66 year
Mean weight (kg)	8.44 kg	(2.6 - 17 kg)

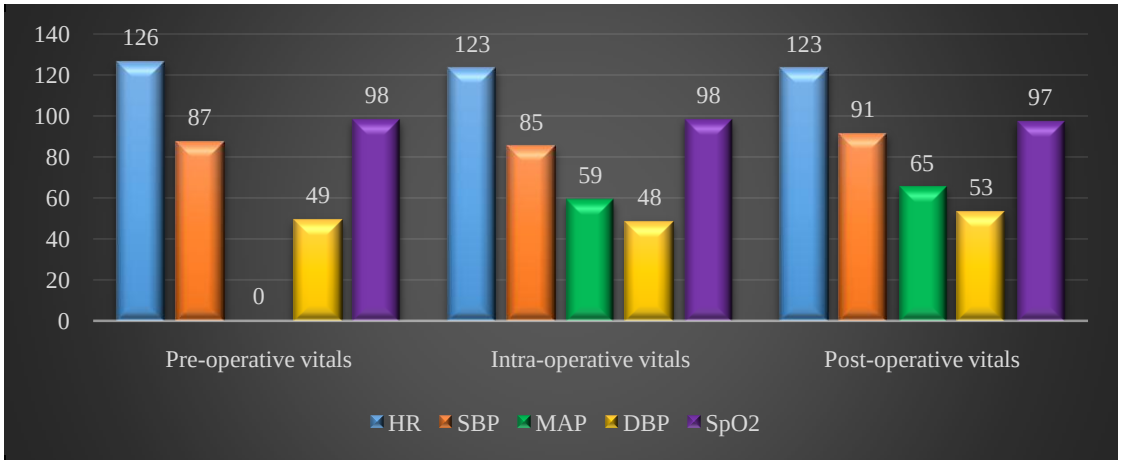

Figure 2: Hemodynamic changes in the children undergoing spinal anaesthesia.
HR: heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, MAP: mean arterial pressure, SpO2: saturation of oxygen.

Table 2: Perioperative characteristics of children undergoing spinal anesthesia.

Characteristics	Findings	
Type of surgery	Frequency	Percentage
Herniotomy	36	41.38
Colostomy	11	12.64
High ligation of processusvaginalis	9	10.34
Orchidopexy	7	8.05
Circumcision	6	6.90
Other gastrointestinal surgeries (anterior septal anorectoplasty, ileostomy, laparotomy)	9	10.34
Genitourinary surgeries (pyeloplasty, urethroplasty)	9	10.34
Mean peak sensory level	T4(C7-T10)	
Motor block, Bromage score of 1	85	97.7
Mean duration of the block	75 m (30-180 m)	

DISCUSSION

In our study, among all 87 children below 4 years of age who underwent various surgeries under spinal anesthesia, we found only a few parameters showed small alterations in hemodynamics, and the overall changes during and after the procedure were not clinically considered significant. Even when the height of the block was high, the hemodynamic alterations were small. Studies show hemodynamic suppression following SA is minimal to absent in children due to a smaller peripheral blood pool, immature sympathetic autonomic system, and compensatory reduction in vagal efferent activity [21].In our study, hemodynamic stability was maintained throughout the surgery without changes in systolic, diastolic, and mean arterial blood pressure. However, an increase in heart rates was noted in 15(26%) patients. This result is similar to a study conducted in Germany, comparing general and spinal anesthesia in pediatric surgeries [22]. The German study found that among a total of 40 children age 2-5 years undergoing pediatric surgeries, 3 out of 20 became restles after spinal anesthesia with no other changes in hemodynamic pattern and respiratory function. They reported 11 out of 20 patients after general anesthesia suffered arterial desaturation (SpO2 <90%).The high levels of the block (T2-4) reduce outward motion of the lower ribcage, decrease intercostal muscle activity, and may lead to paradoxical respiratory movement in children. However, the diaphragm compensates for the loss of ribcage contribution in most cases [23]. In our study the mean peak level of sensory block was T4 (C7- T10), which is in contrast to a study conducted in India where the mean peak sensory block achieved was T6 (the desired level was T10) in 96.1% of the patients which was considered as a successful block. Similarly, since our study included infraumbilical surgeries and the level of block needed was below T10 in all patients, adequate dermatomal level analgesia was present throughout the surgery thus, not demanding an added dose of anesthesia. Similar to our findings, the above study from India also concluded that pediatric spinal anesthesia is a safe and effective anesthetic technique for lower abdominal and lower limb surgeries with a high success rate. Owing to early motor recovery, it can be a preferred technique for the pediatric population [24].The mean peak sensory block achieved shows a wide variation in the level of sensory block in surgeries of the lower part of the body ranging from T1-T7 with the mean being T4. In contrast to our findings, a study in Bangladesh shows that the time for the need of rescue anesthesia after the weaning level of prior anesthesia was reached as 118 minutes [25. In contrast, the average time duration of the block was 75 m (30-180 m) in our study, adequate for most of the surgeries.Apnea was seen in a 7-d old infant as one of the intraoperative complications in our study, and no other complications were encountered during our study. Apnea was managed with bag and mask ventilation until the patient had adequate spontaneous respiration. Apnea seen in this patient could be the effect of intravenous sedatives. Anesthetic agents and sedatives in lesser doses or avoiding their use may result in a lower incidence of apnea or respiratory depression in children.Respiratory compromise is one of the major concerns while using sedatives and narcotics, especially in GA. In comparison, such is not a problem associated with spinal anesthesia due to the lesser use of drugs that cause respiratory suppression. Our study had a similar result as a previous study in Brazil where no change in oxygen desaturation was observed [26].Compared to GA, there are lesser hemodynamic alterations in SA. Therefore, SA is considered a safe, effective, and feasible form of anesthesia with the characteristic of completely balanced anesthesia [25].Even with the advent of sophisticated forms of anesthetic techniques, SA is still marked as an easy and cost-effective technique. It provides a stable and uniform sensory and motor block and therefore is a good option in day-to-day pediatric surgeries without the need for narcotics and sedatives, or only requires minimal use of narcotics and sedatives.In small children, ligaments are less densely packed, and the feeling of loss of resistance is less marked. Increased spine flexibility limits normal thoracic kyphosis and facilitates cephalad spread and a higher level of sensory block [21]. Laminae are cartilaginous; hence, the paramedian approach was avoided and the midline approach was implemented.Anatomical variations and hemodynamic parameters vary according to different age dynamics within the pediatric age group and the adult parameters are achieved as one age, special consideration of anatomy and physiology is essential to achieve non-problematic anesthesia. At birth, the dural sac terminates at S3 and the spinal cord at L3 vertebral levels. Adult level (S2 and L1 respectively) is not reached until 2 y of life. Thus, it is prudent to use a low approach (L4-5 or L5-S1) to avoid damage to the spinal cord [27]. We also used a low approach in our study. The intercristal line (Tuffier's line) remains a reliable landmark similar to adults since in younger children, it passes through L4-5 /L5-S1. Newborns have a narrow subarachnoid space (6-8 mm) and low CSF pressure, necessitating greater precision and avoidance of lateral deviation.One of the limitations of this study was that hemodynamic alterations may have been affected by the fasting duration and amount of fluid administration. We did not individually analyze these parameters. Similarly, the dosage of sedatives may have contributed to respiratory depression or apnea.

Limitations of the study: Every hospital-based study has some limitations and the present study undertaken is no exception to this fact. The limitations of the present study are mentioned. Therefore, the results of the present study may not be representative of the whole of the country or the world at large. The number of patients included in the present study was less in comparison to other studies. Because the trial was short, it was difficult to remark on complications and mortality.

CONCLUSION AND RECOMMENDATIONS

Spinal anesthesia appeared safe, effective, and feasible method of anesthesia in the pediatric population. It causes limited cardiopulmonary alterations. With the need for a limited anesthetic drug, and equipment, and thus limited adverse outcomes this results in considerable safety without compromising the quality of care.

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