ISSN: 2091-2749 (Print)
2091-2757 (Online)

Hemodynamic changes after spinal anesthesia in children below the age of four years

Rikal Man Shrestha[1], Sunita Gurung[2], Sujan Surya Prajapati[3], Biplav Pokharel[4], Indra Kumar Shrestha[4], Manoj Krishna Shrestha[5], Sadikshya Ghimire[6], Brahma Dev Jha[7]

[1]Senior Consultant, [2]Senior Registrar, [3]Consultant, [4]Medical Officer,[7]Head of Dept., Dept. of Anesthesiology, and [5]Senior Consultant Pediatric Surgeon, Kathmandu Model Hospital, Kathmandu, Nepal
[6]Medical Officer, Nepal Mediciti Hospital, Lalitpur, Kathmandu, Nepal

Correspondence
Dr. Rikal Man Shrestha, Senior Consultant, Dept. of Anesthesiology, Kathmandu Model Hospital, Kathmandu, Nepal
Email: rikalms@gmail.com

Peer Reviewers
Prof. Dr. Ganesh Dangal, Kathmandu Model Hospital, Kathmandu, Nepal

Prof. Dr. Jay Shah, Patan Academy of Health Sciences, Kathmandu, Nepal

Submitted
20 Apr 2021

Accepted
07 Jun 2021

How to cite this article
Rikal Man Shrestha, Sunita Gurung, Sujan Surya Prajapati, Biplav Pokhrel, Indra Kumar Shrestha, Manoj Krishna Shrestha, et al. Hemodynamic changes after spinal anesthesia in children below the age of four years. Journal of Patan Academy of Health Sciences. 2021Aug;8(2):91-97.

https://doi.org/10.3126/jpahs.v8i2.37690

Abstract

Introduction: Spinal anesthesia has become the anesthesia of choice for most of the surgeries of the abdominal-pelvic region. Cited with benefits such as lesser risks of apnea, minimal cardiopulmonary alteration, and abnormalities associated with neurocognitive development, it incorporates all components of balanced anesthesia, especially in pediatric surgeries. Encouraging results on the safety, efficacy, and feasibility of spinal anesthesia has increased its utility. The objective of our study was to assess the hemodynamic change occurring in children below four years undergoing lower abdominal and pelvic surgeries following spinal anesthesia.

Method: This is a cross-sectional study conducted over 2 years and includes children undergoing surgery of the lower abdomen in Kathmandu Model Hospital. The information was data regarding patients' demography, hemodynamic status prior, during, and after the procedure of spinal anesthesia, measuring systolic blood pressure (SBP), diastolic blood pressure (SBP), mean arterial pressure (MAP), heart rate (HR), sensory and motor block characteristics (modified Bromage scale) and complications.

Result: The intraoperative and postoperative hemodynamics did not show major differences. The mean peak sensory level was T4 (C7-T10) during the block. Recovery of sensory and motor blocks was complete in all patients. Modified Bromage scale was 1 in 57(98.27%), 2 h post-surgery. The average duration of the block was 75 min (30-180). 1(1.72%) patient developed apnea during the surgery.

Conclusion: Spinal anesthesia in small children showed minimal variation in intraoperative and postoperative hemodynamics and is a safer mode of anesthesia with sparing of respiratory alterations seen with general anesthesia.

Keywords: hemodynamic changes, modified Bromage scale

Introduction

Local and regional anesthesia, in contrast to systemic, general anesthesia (GA), involves the reversible numbing of a specific region of the body to prevent any sensation of pain.[1] Spinal anesthesia (SA) involves infiltration of the anesthetic agent in the subarachnoid space and does not require sedation and does not impair vital bodily functions such as respiration.[2] Though initially only practiced on moribund ex-preterm infants (<60 w post conception) to reduce the incidence of postoperative apnea when compared to GA,[3] numerous emerging literature are showing encouraging results regarding safety and efficacy of SA for older children too.[4, 5] SA in children has many advantages over GA with minimal cardio-respiratory disturbance i.e. lower incidences of hypotension, post-operative apnea, hypoxia, and bradycardia.[6-9] Unlike GA, the SA allows infants to be managed throughout surgery with minimal anesthetic medications, thereby avoiding respiratory depressing effects of opioids and volatile agents, lesser equipment requirement, and shorter length of hospital stays. [10]

Animal studies have shown the harmful effects of GA on the young developing brain.[11] The GA may further contribute to apnea postoperatively due to a decrease in upper airway muscle tone, and airway obstruction.

Despite the benefit of SA compared to GA, many have reservations regarding SA due to the reliability of GA and the technical difficulty of regional anesthesia in small children; like uncooperative population, unique anatomical features, and lack of expertise of the physician. This study focuses on assessing the intraoperative and postoperative hemodynamic changes following spinal anesthesia to establish its efficacy and safety in patients below 4 y.

Method

This was a cross-sectional study conducted from March 2018 to March 2020. Ethical approval was obtained from the Institutional Review Committee of Kathmandu Model Hospital, Bagbazaar, Kathmandu, Nepal. Informed consent was obtained from patient/guardian of each patient for participation.

All patients undergoing the study were subjected to a thorough pre-anesthetic evaluation with specific history taking and examination for infants for any cardiac arrhythmias (long QT syndrome), syncope, cyanosis at stress, or cry. 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 y of life, care was taken by the anesthetist 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 L3 level at birth. 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. We therefore selectively included only the patients falling under the American Society of Anesthesiology category 1 and 2 in our study.

We followed the American Society of Anesthesiologist recommendation that patients be NPO for 2 h for clear liquids, 4 h for breast milk, and 6 h for solids or non-human milk before undergoing sedation for elective procedures.[12] 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.[13] Preoperative vitals comprising heart rate, blood pressure, and oxygen saturation was measured using standard devices.

A 50 mcg/kg of IV midazolam with or without inhalation of 2% sevoflurane was used to calm, and maintain a co-operative environment to achieve the block. It is known that children become agitated before surgeries due to being away from parents, due to the presence of strangers around, or fear of pain.

Spinal anesthesia was given with the patient placed in the left lateral position avoiding the extreme flexion of the neck to prevent airway obstruction. To avoid obstruction, a face mask was placed over the patient's mouth and bag movement was observed for any obstruction and adjusted accordingly. The block was performed under all aseptic conditions after identifying the L4-L5 or L5-S1 level via the midline approach using a 25G Quincke needle for insertion in the subarachnoid space. Once the free flow of clear cerebrospinal fluid was seen exiting the needle, 0.5% hyperbaric bupivacaine at a dose of 0.8 mg/kg was injected into the subarachnoid space. The patient was then immediately placed in a supine position avoiding the Trendelenburg or reverse Trendelenburg position of the table.

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.[14] 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 Trendelenberg up to 30 degrees if the block was achieved above 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.

Demographic information of the patients such as age, the indication of surgery, type, and duration of surgery was noted. The anesthesiologist does thorough monitoring of vitals (systolic blood pressure, diastolic blood pressure, mean arterial pressure, heart rate, and saturation of oxygen) every 5 minutes and records it in the proforma. Complications related to anesthesia such as high spinal block, vomiting, apneic spells, shivering, post-dural puncture headache, desaturation, and any manifestation suggestive of neurological injury were also recorded. Before shifting the patient to the post-operative ward, we ensured stable vital signs, intact gag, swallowing and cough reflexes, and adequate respiration. Patients were monitored postoperatively with the recording of the vital parameters every 15 minutes up to 2 hours and the nurses were instructed to inform the concerned anesthesiologist in case of any fluctuation in hemodynamics, patient irritability, and drowsiness. Complications were identified, recorded, and intervened by the consulting anesthesiologist in the operation theatre itself and/or when notified by the ward nurses in the post-operative wards. Complete recovery from the spinal block was assessed using the Bromage scale and clinically.

Result

A total of 58 patients were included in our study. There were minimal changes observed in the blood pressure pattern of systolic, diastolic, and mean arterial pressure, Figure 1. Pulse rate showed an increase in 15(26%) patients after 5 min of the subarachnoid block as compared with baseline. The oxygen saturation was static throughout the procedure. One case of apnea (1.7%) occurred, which was successfully managed and no other variation in respiratory hemodynamics was noted intra-operatively and post-operatively among the children.

The mean age was 15 mo and weight 8.44 kg, Table 1. Out of 58 children, 52(89.65%) were of American Society of Anesthesia category 1, and the remaining were category 2, (10.35%).

The mean duration of the block was 75 m, Table 2. The level of block assessed by the Modified Bromage scale[15,16] was: 1. complete block (unable to move foot or knees), 2. almost complete block (able to move feet only), 3. partial block (just able to move knees), 4. detectable weakness of hip flexion while supine (full flexion of knees), 5. no detectable weakness of hip flexion while supine, 6. able to perform partial knee bend.

Modified Bromage score of 1 was obtained within the duration of block in 57(98.27%) patients. Sensory and motor block reversal was complete in all and were identified using a modified Bromage scale. The mean duration of the block was 75 m, Table 2.

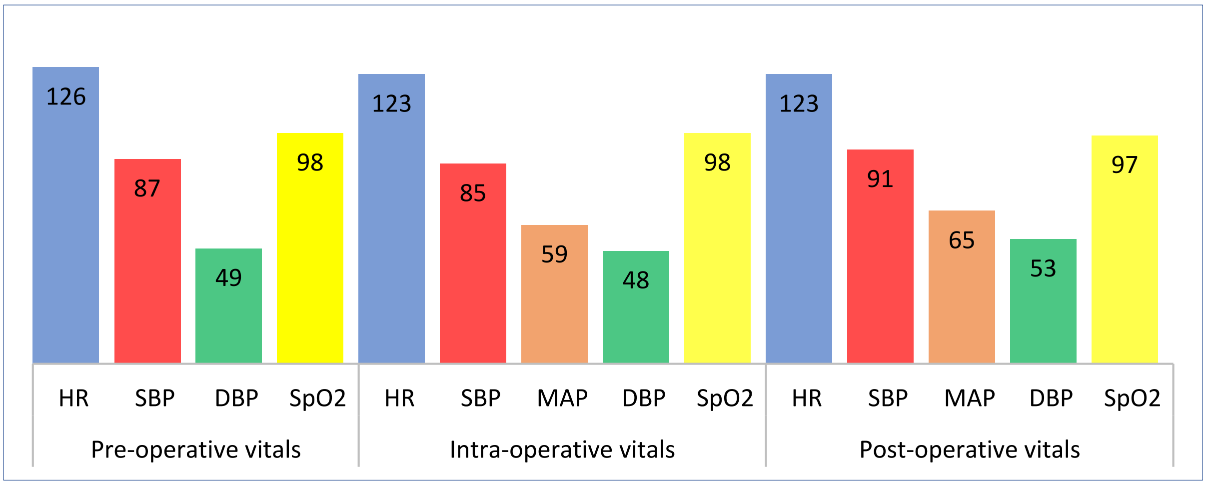

Figure 1. Hemodynamic changes in the children undergoing spinal anesthesia

Note: HR: heart rate, SBP: systolic blood pressure, DBP: diastolic blood pressure, MAP: mean arterial pressure, SpO2: saturation of oxygen

Table 1. Demographic characteristics of children undergoing spinal anesthesia (n=58)

Characteristics	Finding
Mean age	15 mo (range 2 d - 44 mo)
Male	12(20.68%)
Female	46(79.31%)
Mean weight	8.44 kg (2.6 - 17 kg)

Table 2. Perioperative characteristics of children undergoing spinal anesthesia

Characteristics	Findings
Type of surgery	N(%)
Herniotomy	24(41.37%)
Colostomy	7(12.06%)
High ligation of processus vaginalis	6(10.34%)
Orchidopexy	5(8.62%)
Circumcision	4(6.89%)
Other gastrointestinal surgeries (anterior septal anorectoplasty, ileostomy, laparotomy)	6(10.34%)
Genitourinary surgeries (pyeloplasty, urethroplasty)	6(10.34%)
Mean peak sensory level	T4(C7-T10)
Motor block, Bromage score of 1	57(98.27%)
Mean duration of the block	75 m (30-180 m)

Discussion

In our study, among all 58 children below 4 y 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. [22]

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.[17] The German study found that among a total of 40 children age 2-5 y undergoing pediatric surgeries, 3 out of 20 became restless 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.[18]

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.[19] 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.[20]

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.[19]

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 require minimal use of narcotics and sedatives.

In small children ligaments are less densely packed, and the feel 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.[22] 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.[24] 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 administrations. We did not individually analyze these parameters. Similarly, the dosage of sedatives may have contributed to respiratory depression or apnea.

Conclusion

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, equipment, and thus limited adverse outcomes this results in considerable safety without compromising the quality of care.

Conflict of Interest
None

Funding
None

Author Contribution
All authors contributed significantly in conceptualizing, designing, planning, data collection, interpretation, and evaluation of the study. Accountability of the work is by all authors.

Reference

1. Wulf H. The Centennial of Spinal Anesthesia. Anesthesiology. 1998;89(2):500-6. | DOI | PubMed | Google Scholar |
2. Bang-Vojdanovski B. 10 years of spinal anesthesia in infants and children for orthopedic surgery. Our clinical experience. Anaesthesist. 1996;45:271-7. | DOI | PubMed | Google Scholar |
3. Abajian JC, Paul Mellish RW, Browne AF, Perkins FM, Lambert DH, Mazuzan JE. Spinal anesthesia for surgery in the high-risk infants. Anesthesia and Analgesia. 1984;63(3):359-62. | DOI | PubMed | Weblink |
4. Frumiento C, Abajian JC, Vane DW. Spinal anesthesia for preterm infants undergoing inguinal hernia repair. Arch Surg. 2000;135(4):445-51. | DOI | PubMed | Google Scholar |
5. Gupta A, Saha U. Spinal anesthesia in children: a review. J Anaesthesiol Clin Pharmacol. 2014;30(1):10-8. | DOI | PubMed | Google Scholar |
6. Williams RK, Adams DC, Aladjem EV, Kreutz JM, Sartorelli KH, Vane DW, Abajian JC. The safety and efficacy of spinal anesthesia for surgery in infants: The Vermont infant spinal registry. Anesthesia & Analgesia. 2006;102(1):67-71. | DOI | Weblink |

7. Krane EJ, Haberkern CM, Jacobson LE. Postoperative apnea, bradycardia, and oxygen desaturation in formerly premature infants: prospective comparison of spinal and general anesthesia. Anesth Analg. 1995;80(1):7-13. | DOI | PubMed | Google Scholar |
8. Somri M, Gaitini L, Vaida S, Collins G, Sabo E, Mogilner G. Postoperative outcome in high-risk infants undergoing herniorrhaphy: Comparison between spinal and general anesthesia. Anesthesia. 1998;53(8):762-6 | DOI | PubMed | Google Scholar |
9. Blaise G, Roy WL. Spinal anesthesia in children. Anesthesia & Analgesia. 1984;63(12):1140-1. | Google Scholar | Weblink |
10. Gautam SN, Acharya S, Bajracharya GR, Hyoju S. Efficacy and safety of spinal anaesthesia in paediatric age group between 3 to 14 years for infraumblicus surgery. Nepal Medical College Journal. 2019;21(2):147-52. | Google Scholar | Weblink |
11. Bromage PR. A comparison of the hydrochloride and carbon dioxide salts of lidocaine and prilocaine in epidural analgesia. Acta Anaesthesiol Scand Suppl. 1965;16:55-69.| DOI | PubMed | Google Scholar |
12. Tobias JD, Leder M. Procedural sedation: a review of sedative agents, monitoring, and management of complications. Saudi J Anaesth. 2011;5(4):395-410. | DOI | PubMed | Google Scholar |
13. Meyers RS. Pediatric fluid and electrolyte therapy. J Pediatr Pharmacol Ther. 2009;14(4):204-11. | DOI | PubMed | Google Scholar |
14. Goyal R, Jindal K, Baj B, Singh S, Kumar S. Pediatric spinal anesthesia. Indian J Anaesth. 2008;52:264-70. | Weblink |
15. William JM, Stoddart PA, Williams SA, Wolf AR. Post-operative recovery after inguinal herniotomy in ex-premature infants: Comparison between sevoflurane and spinal anaesthesia. Br J Anaesth. 2001;86(3):366-71. | DOI | PubMed | Google Scholar |
16. Imarengiaye CO, Song D, Prabhu AJ, Chung F. Spinal anesthesia: functional balance is impaired after clinical recovery. Anesthesiology. 2003;98(2):511-5. | DOI | Weblink |
17. Kokki H, Hendolin H, Vainio J, Partanen J. Pediatric surgery. a comparison of spinal anesthesia and general anesthesia. Anaesthesist. 1992;41:765-8. | PubMed |
18. Verma D, Naithani U, Gokula C, Harsha. (2014). Spinal anesthesia in infants and children: A one Year prospective audit. Anesthesia: Essays and Researches. 2014;8(3):324-9. | DOI | PubMed | Weblink |
19. Ahmed M, Ali NP, Kabir SMH, Nessa M. Spinal anaesthesia: is it safe in children? JAFMC Bangladesh. 2010;6(1):25-8. | DOI | Weblink |
20. Imbelloni LE, Vieira EM, Sperni F, Guizellini RH, Tolentino AP. Spinal anesthesia in children with isobaric local anesthetics: report on 307 patients under 13 years of age. Pediatric Anesthesia. 2006;16(1):43-8. | DOI | Google Scholar | Weblink |
21. Rukewe A, Alonge T, Fatiregun A. Spinal anesthesia in children: no longer an anathema! Pediatric Anesthesia. 2010;20(11):1036-9. | DOI | Google Scholar | Weblink |
22. Dohi S, Seino H. Spinal anesthesia in premature infants: Dosage and effects of sympathectomy. Anesthesiology. 1986;65:559 -61. | PubMed | Google Scholar |
23. Pascucci RC, Hershenson MB, Sethna NF, Loring SH, Stark AR. Chest wall motion of infants during spinal anaesthesia. J Appl Physiol. 1990;68:2087–91. | PubMed | Google Scholar |
24. Geiduschek JM. Pediatrics. In: Brown DL, editor. Regional anaesthesia and analgesia. 1st ed. Philadelphia: WB Saunders Company; 1996. p559-62. | Google Scholar |