Suez Canal University Medical Journal Vol. 25 (3), 2022
Pages 36-47

Spinal Anesthesia versus General Anesthesia in Neonates Undergoing Infraumbilical Surgeries

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Abstract

Background: **Neonatal anesthesia demands a systematic understanding of the rapidly changing physiology of neonates, the pathology of coexisting diseases, and both the pharmacokinetics and the pharmacodynamics of the medications used to deliver the anesthesia. *Objectives:* to compare general and spinal anesthesia for neonates regarding perioperative hemodynamics and complications. *Patients and Methods:* the single-blinded clinical trial included 36 patients randomly allocated into one of two groups. Group (A): Spinal anesthesia (SA) group received intrathecal bupivacaine 0.5% of dose 1 mg/kg for neonates weighing less than 5 kg and 0.4 mg/kg for those weighing >5 kg. Group (B): General anesthesia (GA) group received inhalational sevoflurane for induction and sevoflurane for maintenance of anesthesia with paracetamol 15 mg/kg IV for analgesia of patients. *Results:* Intraoperative hemodynamics were significantly better and more stable in the SA group than that in the GA group. Complications during surgery occurred in one patient in SA group, in the form of bloody tap, while in the GA group, two patients had hypoxia. The intraoperative complications were not significant between the two groups. Post-operative complications were statistically significantly lower in the SA group compared to the GA group (P-value < 0.05). Postoperative heart rate (HR) was statistically significantly lower in the SA group compared to the GA group (P-value < 0.05). *Conclusion:* Spinal anesthesia is a good alternative to general anesthesia in neonates for infraumbilical surgeries.**

Keywords: natal, spinal, anesthesia

Introduction

The physiology of the preterm and term neonates is characterized by high metabolic rate and limited cardiac, pulmonary, renal, and thermoregulatory reserve. These metabolic and hemodynamic changes in the perioperative period may be detrimental to the neurocognitive development in the neonatal stage. This immaturity generates differences in the pharmacokinetics and dynamics of the drug if compared to older children or adults(1,2). The use of regional anesthesia in neonates and infants may be beneficial in many clinical scenarios(3). These include the avoidance of respiratory depression or airway manipulation. Moreover, it improves perioperative pain management and decreases the possible neurotoxic effects of

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the drug used in general anesthesia[4]. Spinal anesthesia (SA), also known as subarachnoid or intrathecal block, involves the deposition of local anesthetic directly into the cerebrospinal fluid (CSF), causing dense surgical anesthesia and when it is combined with sedation or general anesthesia, it decreases the need for anesthetic agents, muscle relaxants, or opioids intraoperatively. SA allows a fast return to a bright and alert status and also an early return of normal appetite. This local technique is used widely in adult anesthesia and surgery as an alternative to general anesthesia (GA), although its use in infants and neonates has polished and diminished despite an established safety record[5,6]. General anesthesia is the use of drug to induce loss of consciousness even with painful stimulation with inability to maintain the ventilatory function. With GA, patients need positive pressure ventilation assistance to maintain a patent airway. Also, GA impair cardiovascular function. GA can be delivered by either inhalational or intravenous drugs[7]. Neonates are more vulnerable to hypotension that may lead to cerebral perfusion impairment. So, the maintenance of normotension and normocarbia is highly important intraoperatively[2, 8]. We conduct this work to compare between general and spinal anesthesia for neonates regarding perioperative hemodynamics and complications. We hypothesized that general anesthesia would cause an increase of the incidence of bradycardia, hypotension and arterial oxygen saturation; although, spinal anesthesia would have minimal effects on intra and postoperative hemodynamics. This will give the anesthetist the chance to select the safest mode of anesthesia with the least complications according to the condition of the baby.

Patients and Methods

Our study was a single blinded randomized controlled clinical trial. It included 36 neonatal patients, ASA I or ASA II, male and females, aged ≤ 28 days, who underwent elective minor infraumbilical surgeries at Suez Canal University Hospitals. Patients were equally randomly allocated into two groups by using computer generated random numbers which was concealed in opaque closed envelopes that were sequentially numbered. *Group (A):* General anesthesia group: received inhalational sevoflurane for induction and sevoflurane for maintenance of anesthesia with paracetamol 15 mg/kg IV for analgesia of patients. *Group (B):* Spinal anesthesia group: received intrathecal bupivacaine 0.5% with a dose of 1 mg/kg for neonates weighing less than 5 kg.

Data collection

I- Pre-operative visit

A simple explanation to parents about the methods of anesthesia and reassurance was given. A written consent from the parents was taken. Parents were informed about fasting hours (six hours for artificial formula, four hours for breast milk and two hours for non-particulated fluids).

II- Pre-operative assessments

A- Medical history

History of medical disorders as genetic syndromes and congenital anomalies. Perinatal history (Maternal history: age of mother, chronic illnesses, medications problems with pregnancies. Birth (maternal illnesses during pregnancy, duration of pregnancy [full term or premature], type of delivery, birth length and weight, bottle or breast-fed). Newborn: any problems (infection, seizures, respiratory distress, bleeding, jaundice, cyanosis, others). Past history of operations, hospitalizations, any drugs or allergies. Family history of congenital anomalies or allergy.

B- Physical Examination:
General examination (heart rate, blood pressure, temperature). Abdominal, chest and heart examinations. head and neck examination for any deformity or adenotonsillar hypertrophy. Examination of spine and identification of anatomical landmarks.

C- Laboratory investigations:
Complete blood count, Prothrombin time (PT), partial tissue thromboplastin time (PTT) and international normalization ratio (INR), other investigations if needed as s. electrolytes for cases of intestinal obstruction or random blood glucose for diabetic infants.

III- Intra-Operative procedure:
A) Pre-induction period
The operating theatre temperature was controlled to be warm enough to the patients. Ideal monitoring of the patients including pulse oximeter, ECG, temperature, non-invasive blood pressure and precordial stethoscope. All general anesthesia equipment and resuscitative drugs were well prepared. Establishment of intravenous line by 22G or 24G cannula.

B. Administration of Anesthesia and Block
Baseline hemodynamics were recorded. For spinal anesthesia patients (group A), the following was done; patients were premedicated with EMLA ™ cream, 0.5-1 ml applied to the lumber region one hour before the procedure. And, Atropine, 0.01mg/kg, IM injection 20 minutes before induction of anesthesia. The patients were positioned in lateral position with head extension and hip flexion. After careful disinfection of the back with Betadine solution, lumbar puncture was done at L4-L5 interspace by midline approach using 38 mm, 25G or 27G Quincke spinal needles. After getting free CSF, a hyperbaric bupivacaine 0.5% was injected by the following doses 1 mg/kg for weight less than 5 kg. And 0.4 mg/kg for weight > =5 kg. Patients were put in supine position immediately after injection, with gentle fixation of legs to prevent movements of patient till stabilizing the level. The sensory level was assessed by firm skin pinch and pin prick test. The motor level was assessed by observation of the lower limb movement in response to pin prick. The following parameters was measured and recorded: Hemodynamics: (heart rate, blood pressure, temperature, respiratory rate and SPO2: immediately after the intrathecal injection (block), every 2.5 minutes for the first 20 minutes, every 15 minutes till the end of surgery. monitoring was recorded at the end of surgery, during Recovery, 60 minutes after recovery, and 2, 4, 6, 12, 24 hours postoperatively). Time needed for achieving spinal anesthesia technique. Number of trials for lumbar puncture. Restlessness during surgery, expressed by crying. Duration of the block. Complications of the technique if occurred: hypotension, bradycardia, apnea, desaturation, bloody tap, or failure of the block.

N.B. in cases of block failure, the patients received general anesthesia and excluded from the study. In cases of prolonged surgeries, the neonate received GA and excluded from the study.

For general anesthesia group (B) patients, the following was done; patients were premedicated with atropine, 0.01mg/kg, IM injection 20 minutes before induction of anesthesia. They received inhalational anesthesia induction by sevoflurane (Sevoflurane USP. Drager) without muscle relaxant through GE healthcare AVANCE CS^2 American ventilator through circle system. Then, they were intubated after reaching MAC 95% of their age (2.1 % ET sevo) by the oral endotracheal tube that fits them. The endotracheal tube size used was 3mm in diameter. Capnogram for measuring end tidal carbon dioxide (ETCO2) concentration was added to the standard monitoring. Time needed for intubation and the occurrence of desaturation or hypoxia during that time was recorded. The maintenance of anesthesia was achieved by using sevoflurane by mechanical ventilation with MAC 1.2% and the patients were mechanically ventilated on BIPAP mode. Patients received paracetamol infusion with a dose of 15 mg/kg for analgesia via IV accesses. The following parameters were measured carefully and recorded: Hemodynamics: (heart rate, blood pressure, Oxygen saturation and end tidal co_2: Pre-operative (baseline), immediately after intubation, every 2.5 minutes for the 1st 20 minutes, every 15 minutes till the end of surgery, at end of surgery, after extubation and during Recovery, 60 minutes after recovery, and at 2, 4, 6, 12, 24 hours postoperatively). ETCO2 was also measured and recorded since intubation till extubation. No. of trials of intubation. For both A and B groups the following were assessed and recorded: Time needed to achieve readiness of the patient to start surgery. Surgeon satisfaction. Duration of surgery. Time of recovery by crying in GA, and limb movement in SA.

Postoperative assessment

All the patients were assessed for hemodynamics. Post-operative complications: nausea or vomiting. Time of first meal given for the neonate after the end of surgery. Postoperative pain assessment. At recovery. After 2, 4, 6, 12 and 24 hours postoperatively. Analgesia required.

Statistical Analysis

Statistical analysis was done using the Statistical Package for Social Sciences (SPSS 20 software). One-way analysis of variance (ANOVA) test was used to compare between both groups, followed by Tukey HSD Post Hoc tests. The differences between the studied groups were considered statistically significant only when ($P < 0.05$).

Results

Both groups (GA and SA) were matched regarding patient characteristics; age, sex, weight, ASAI and duration of surgery ($P > 0.05$) (Table 1). Intraoperative heart rate (HR) was statistically significantly lower in the SA group compared to the GA group at most time points during surgery ($P < 0.05$), while there was no statistically significant difference between the two groups of the study at the base line and 2.5 minutes after induction time points ($P > 0.05$) (Figure 1).

Table 1: Comparison between two groups regarding patients' characteristic

Patient characteristics	Spinal group (n=18)	General group (n=18)	P-value
Age (days)*	17.11 ± 7.07	12.50 ± 8.89	0.094 (NS)
Sex no. (%)			
Male	13 (72.2 %)	10 (55.56 %)	0.297 (NS)
Female	5 (27.8 %)	8 (44.44 %)	
Weight	4.04 ± 0.57	3.8583 ± 0.72	0.397 (NS)
ASA I N (%)	18 (100%)	18 (100%)	
Duration of surgery	43.05 ± 7.09	41.94 ± 4.24	0.573 (NS)

: data are presented as mean ± SD, NS: Statistically non-significant difference (P-value > 0.05).

Intraoperative systolic blood pressure (SBP) was statistically significant lower in the GA group compared to the SA group at 2.5 minutes and 50 minutes after induction time points (P-value < 0.05), while there was no statistically significant difference between the two groups of the study at most of points during surgery (P-value > 0.05) (Figure 2). Intraoperative diastolic blood pressure (DBP) was statistically significant lower in the GA group compared to the SA group at 2.5 minutes after induction time point (P-value < 0.05), while there was no statistically significant difference between the two groups of the study in DBP at most of points during surgery (P> 0.05) (Figure 3). Oxygen saturation was statistically significantly higher in the GA group compared to the SA group at most time points during surgery (P-value < 0.05), with no clinical significance as general anesthesia group patients received higher FiO_2 and none of spinal anesthesia group patients suffered from hypoxia.

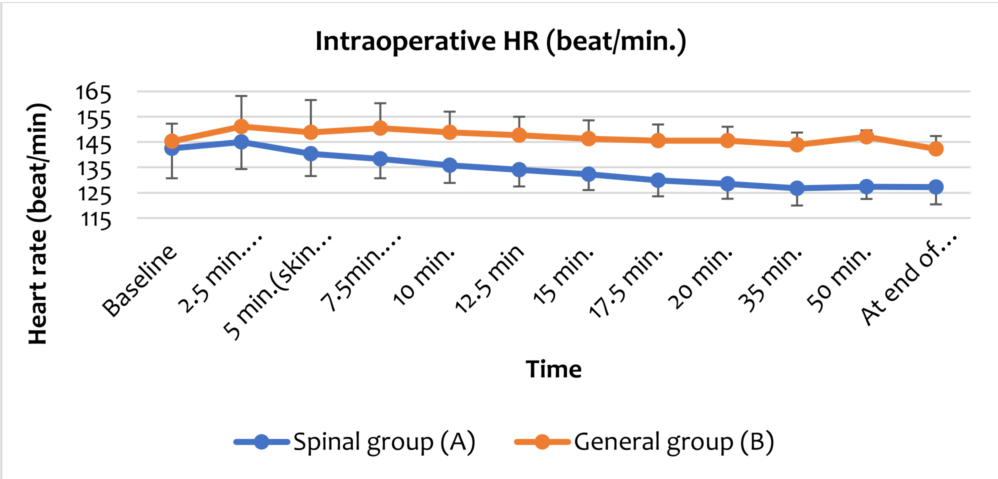

Figure 1: Intraoperative Heart Rate (HR) (beat /minute) with standard deviation (SD) in both groups of the study at different time points during surgery.

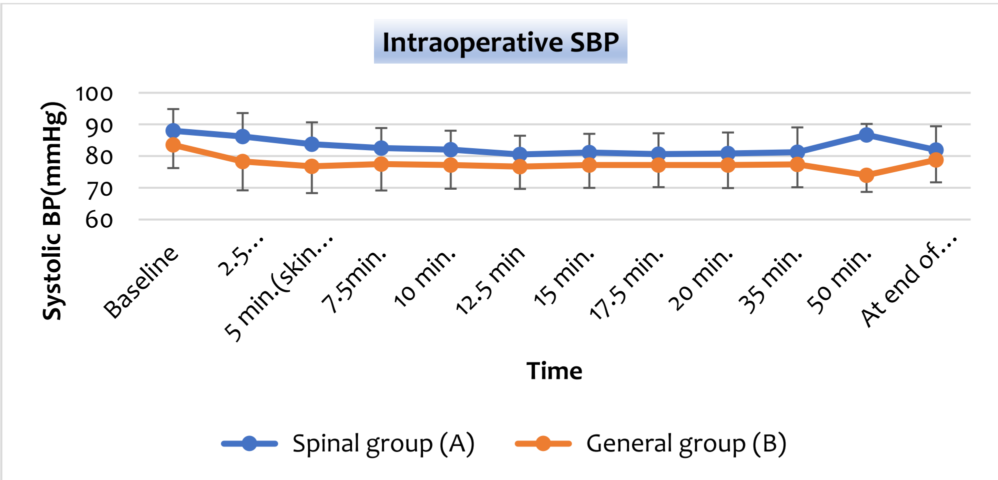

Figure 2: Intraoperative SBP with SD in both groups of the study at different time points during surgery

Nevertheless, there was no statistically significant difference between the two groups of the study at the base line, 2.5 minutes, 7.5 minutes and 50 minutes after induction time points (P> 0.05) (Figure 4).

Postoperative HR was statistically significant lower in the SA group compared to the GA group at 2, 4 and 6 h. postoperative time points (P< 0.05), while there was no statistically significant difference between the two groups of the study at 12 & 24 h. postoperative time points (P > 0.05) (Figure 5). Normal respiratory rate in neonates is ranging between 24-40 breath/minute.

Table 2: Post-operative complications (number of patients) in both groups			
	Patients with complications	Normal	p-value
Spinal group no. (%)	1 (5.56 %)	17 (94.44 %)	0 .0161 (*)
General group no. (%)	7 (38.89 %)	11 (61.11 %)	

All the patients given spinal anesthesia showed normal intraoperative respiratory rate according to their age. This denotes that spinal anesthesia doesn't affect the respiratory rate (Figure 6). Normal $EtCO_2$ in neonates is accepted in a range between 35-45 mmHg. The mean value of intraoperative $EtCO_2$ of the patients given general anesthesia showed elevated levels according to their age in the first 15 minutes after induction and normal levels from 17.5 minutes till the end of surgery. (Figure 7).

Table 3: Types of post-operative complications in both groups		
Type of complications	Spinal group n=18	General group n=18
Agitations	1	2
Nausea & vomiting	0	2
Agitation & vomiting	0	3

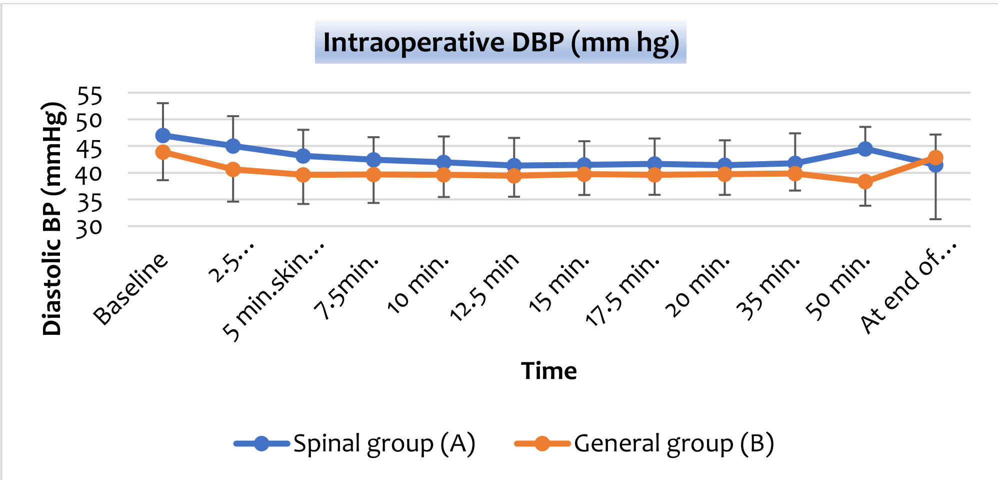

Figure 3: Intraoperative DBP in (mmHg) with SD in both groups of the study at different time points during surgery.

In general anesthesia group, about 67% of the neonates needed to increase sevoflurane concentration more than MAC 1.2 to achieve resting neonates for surgery. Time of recovery after surgery in spinal anesthesia group to regain full motor activity was 30.00±7.50. Time of recovery in general anesthesia group to regain full consciousness was 5.00±6.12. We tried to make surgeon satisfaction an objective point of study not a subjective one, so we put some measurable factors to assess it, these factors were: 1) Number of trials needed to do a successful lumbar puncture in spinal anesthesia group (13 patients from the first trial and five patients from the second trial) and intubation in general anesthesia group (15 patients from the first trial, two patients from the second trial and one patient from the third trial). 2) Time consumed by anesthesia to make the patient ready for surgery: the time needed to start surgery after anesthesia was 5.65±1.06 and 5.59±1.46, in minutes, in spinal and general anesthesia groups respectively. 3) Time to restart feeding of the patients after surgery: patients of spinal anesthesia group took their first meal after cessation of the block (~30 min after end of surgery) and after two hours after end of surgery in general anesthesia group. 4) Interruption of surgery after its start whether to manage a complication or change anesthesia plan from SA to GA due to incomplete block: surgery was interrupted to manage hypoxia in one patient from GA group). There was no statistically significant difference between the two groups of the study according to surgeon satisfaction (p> 0.05), which was assessed as unsatisfied, fair, or satisfied in the study groups (Figure 8). Complications during surgery occurred in one patient in spinal anesthesia group, in the form of bloody tap, while in general anesthesia group, two patients had hypoxia. The result was not significant between the two groups (P > 0.05) (Figure 9).

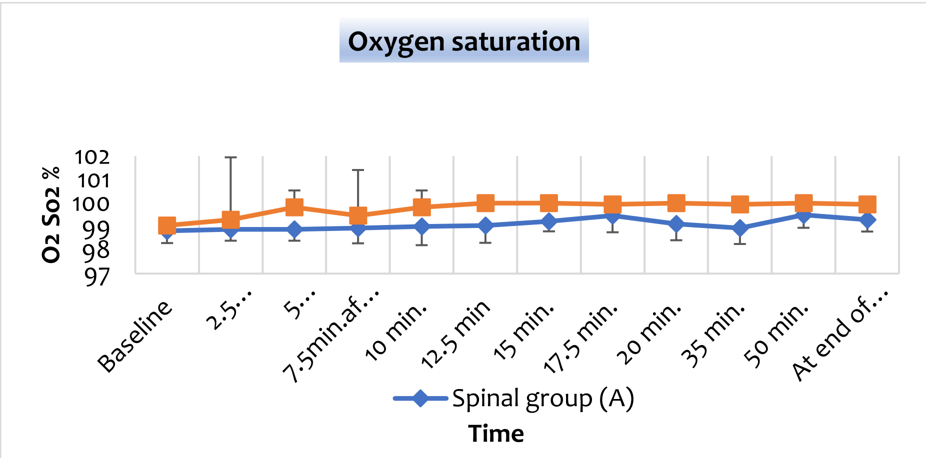

Figure 4: Intraoperative oxygen saturation with SD in both groups of the study at different time points during surgery.

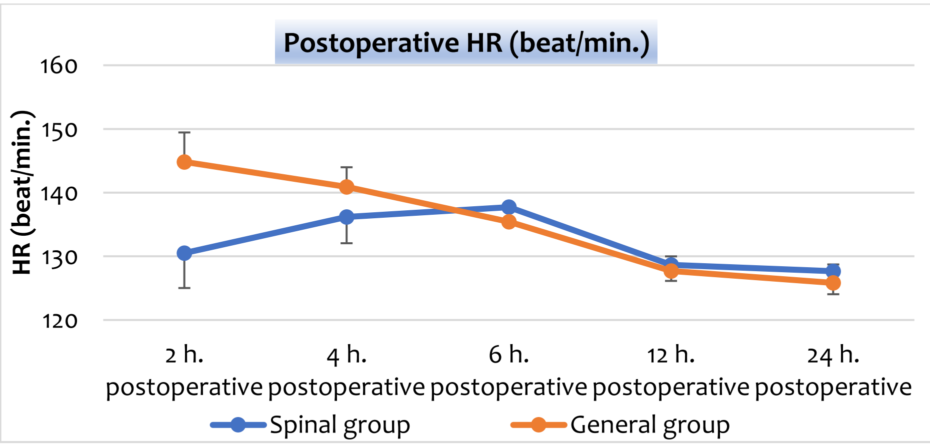

Figure 5: Postoperative heart rate (beat/minute) with SD in both groups of the study at different time points after surgery.

N.B: failure of spinal block occurred in two patients (after a third trial of lumbar puncture), they took general anesthesia and were excluded from the study. Post-operative complications were significantly lower in spinal anesthesia group compared to general anesthesia group ($P < 0.05$). In the spinal anesthesia group, only one patient developed post-operative agitation. In the general anesthesia group, 2 patients developed post-operative vomiting, 2 patients developed post-operative agitation and 3 patients developed post-operative vomiting and agitation. (Table 2, 3, and Fig. 10).

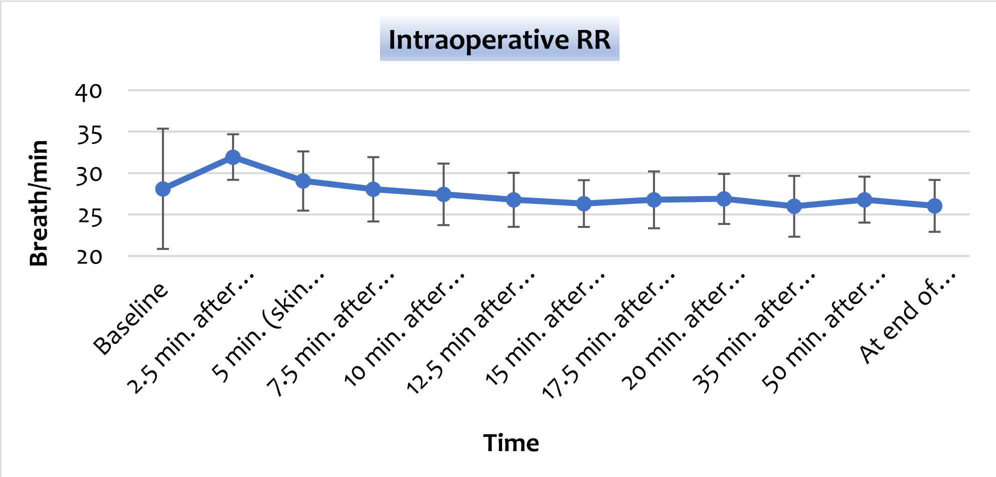

Figure 6: Intraoperative respiratory rate (RR) (cycle/minute) in spinal anesthesia group at different time points during surgery

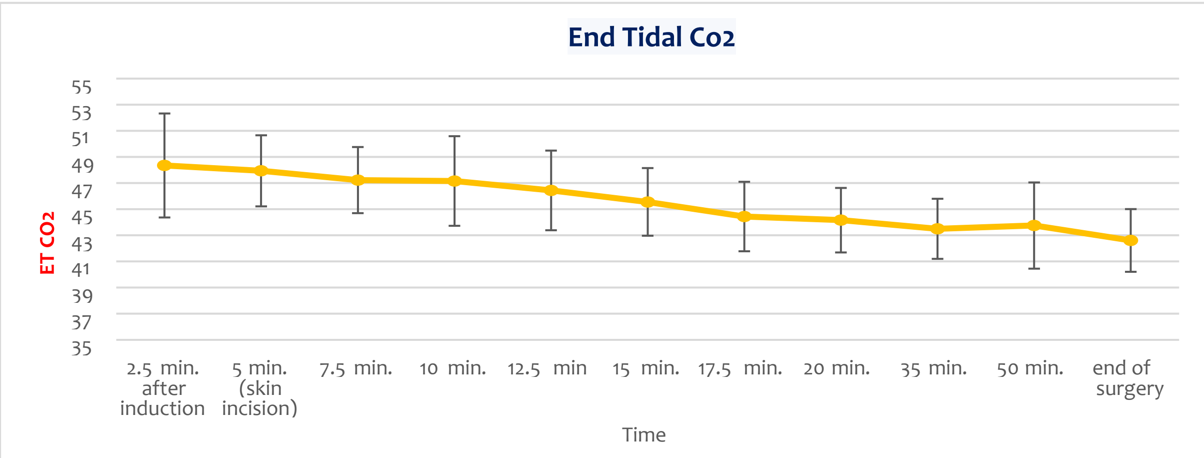

Figure 7: Intraoperative $ETCo_2$ in general anesthesia group with SD at different time points during surgery.

Discussion

Our study was designed to evaluate and compare the effect of spinal anesthesia and general anesthesia on reducing the possible intraoperative and postoperative complications in neonates. This study included 36 patients. They were randomly assigned to two equal groups (18 patients / group); spinal anesthesia group (group A) and general anesthesia group (group B). The primary outcome of the study was measurement and comparison of intraoperative hemodynamics in neonates undergoing infraumbilical surgeries between both study groups. Comparing the intraoperative HR between both groups in the current study showed lower values in the SA group compared to GA group at most time points during surgery with statistically significant difference between both groups (P < 0.05).

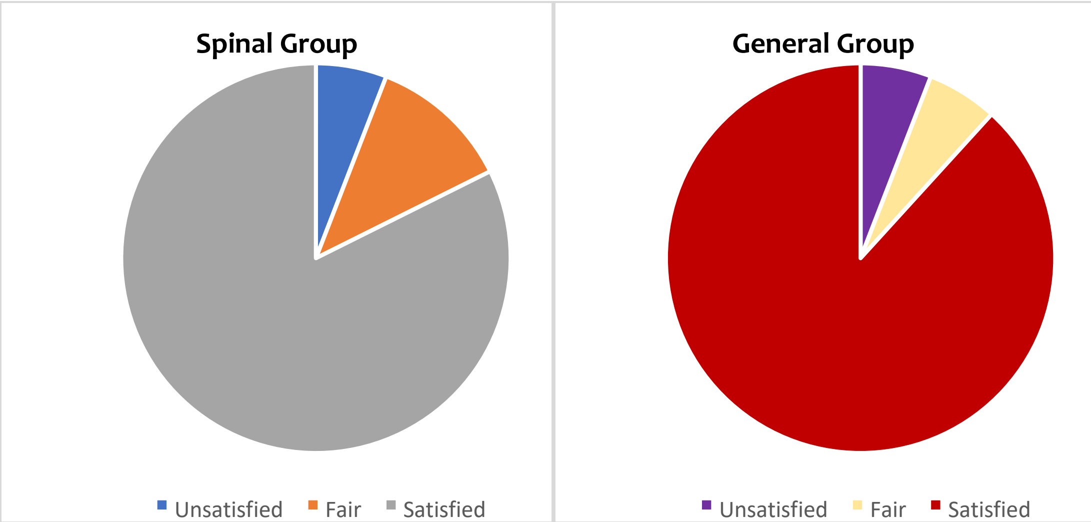

Figure 8: Surgeon satisfaction in both groups of the study

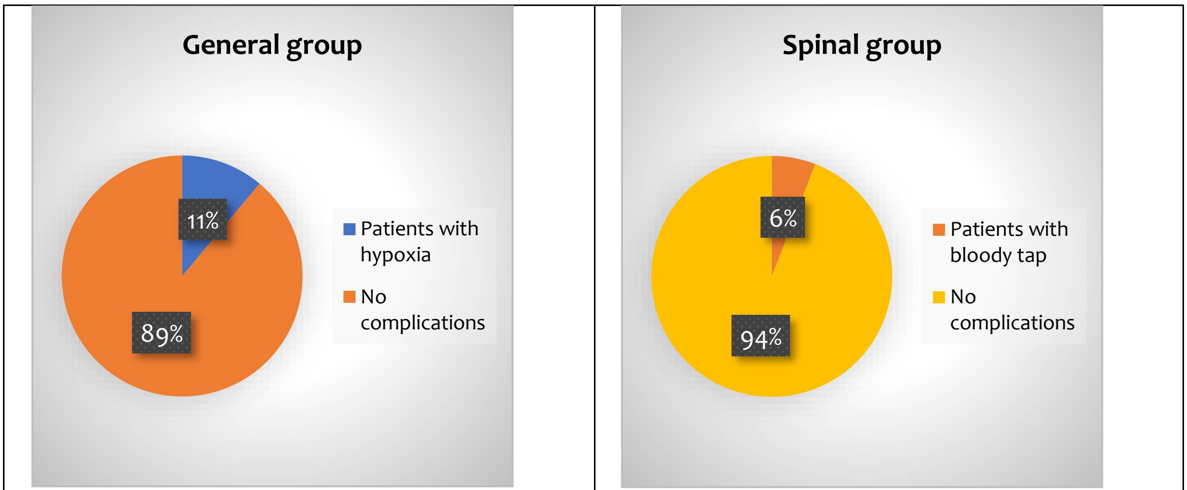

Figure 9: Complications during surgery (%) in both study groups

These findings were documented in many studies such as that of Sánchez-Conde et al., who reported that baseline HR was lower in neonates, undergoing hypertrophic pyloric stenosis surgeries, of SA group compared to GA group (140±17 vs 155±21 in GA group). Also, the last recording of HR in the operating room was lower in neonates under SA (145±14 vs 159±17 in the GA group)[9]. Ghosh et al., who compared the effect of spinal anesthesia with propofol (A) with general anesthesia (B) in children undergoing infraumbilical surgeries also reported that heart rates were higher in group B at 45 minutes and 60 minutes during surgery than SA group[10]. In the current study comparing the intraoperative SBP and DBP between the two groups, there was no statistically significant difference between the two groups of the study at most of points during surgery (P>0.05). However, blood pressure was statistically significant lower in GA than SA group at 2.5 minutes after induction. In contrast to our study, McCann et al., documented that infants ≤ 60 weeks postmenstrual age undergoing inguinal herniorrhaphy were subjected to more frequent hypotension in the GA group compared with the RA group. Also, interventions for hypotension occurred more commonly in the GA group compared with the RA group[11]. Moreover, Ing et al., reported that the mean intraoperative SBP was 18.8 mmHg higher in the SA patients compared to the GA patients. Neonates undergoing GA however experienced significantly lower intraoperative BP than SA patients.

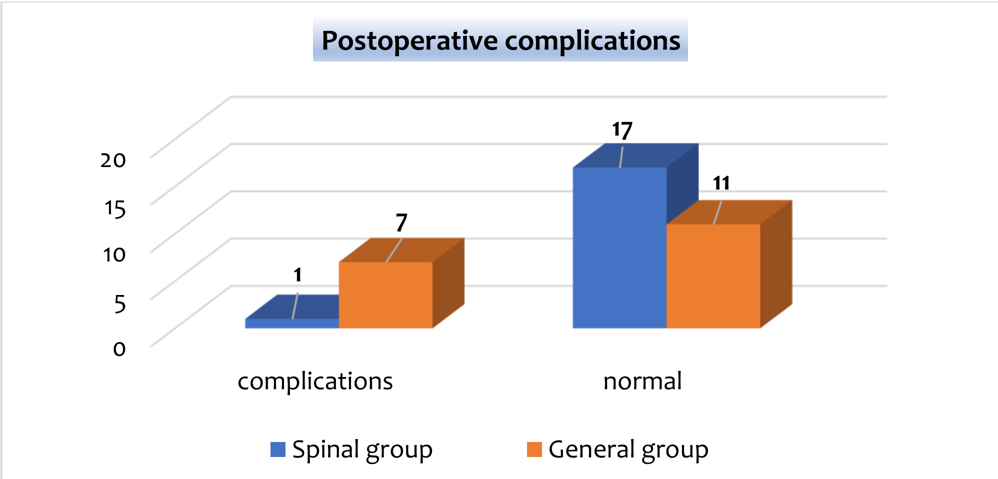

Figure 10: Post-operative complications (no. of patients) in both study groups

This could be explained by neuroaxial anesthesia in neonates and infants is thought to be hemodynamically stable, blood pressure and heart rate are maintained even with thoracic four blockade levels, due either to a minimal impact on sympathetic activity, or a reflex reduction in vagal activity that balances the decreased sympathetic activity[12]. In our study, intraoperative Oxygen saturation was statistically significantly higher in the general anesthesia group compared to the spinal anesthesia group at most time points during surgery ($P < 0.05$), but no cases reached hypoxic level and the difference was of no clinical significance as minimum mean of SO_2 in SA group was > 98.ich remained stable throughout the surgery. These results are consistent with those of Ghosh et al., study, in which intraoperative lower SpO_2 was found more evident in children receiving SA in comparison to those receiving GA[10]. On the contrary, results were reported by those of Sánchez-Conde et al., study, showed that oxygen saturation remain stable throughout the surgery in neonates of both spinal and general anesthesia groups with no statistical significant differences between the two groups ($P > 0.059$)[9]. In SA group in the current study, all the neonates showed normal intraoperative respiratory rate according to their age. This could be by the fact that awake spinal anesthesia is associated with minimal respiratory changes in neonates and infants. Patients are spontaneously breathing, avoiding tracheal intubation and ventilation and their potential complications which may be beneficial those with increased risk of postoperative respiratory complications[13]. In our study, complications during surgery occurred in one patient in SA group, in the form of bloody tap. It has been reported in many studies to use sedation to allow the block to be performed because this removes some technical difficulties in performing neuraxial techniques and decreases the incidence of complications with a moving and often crying neonate[14]. Furthermore, SA is often not an option in neonatal operations as the block does not last long enough for most of the surgeries and with decreasing use, surgeons are becoming unfamiliar with the SA technique leading to increase the possibilities of complications or spinal block failure[15]. Two patients were excluded from the study after failure of the spinal block. spinal anesthesia in these patients is more challenging due to their small size[9]. In the current study, two patients in GA group, had intraoperative hypoxia. However, the differences between two groups was statistically insignificant regarding intraoperative complications ($P > 0.05$). This was due to advancement of the endotracheal tube during its fixation or during patient's positioning. Unlike our findings, Sánchez-Conde et al., demonstrated that no cases of hypoxia was reported with the use of GA in neonates. This could be due to the fact that they recorded O_2 saturation at wide intervals (only recorded baseline, after anesthesia performance, every 15 minutes, before the end of surgery and postoperative) while in our study we recorded every 2.5 minutes in the first 20 minutes and hypoxia happened during fixation of endotracheal tube and managed rapidly[9]. In our study, postoperative HR was significantly lower in the Spinal anesthesia group compared to the general anesthesia group at 2, 4 and 6 h. postoperative time points ($P < 0.05$), while there was no statistically significant difference between the two groups of the study at 12 & 24 h. postoperative time points. Limited studies compared postoperative HR between SA and GA, so no sufficient data are available. We also reported that post-operative complications were statistically significant lower in spinal anesthesia group compared to general anesthesia group ($P < 0.05$). In the spinal anesthesia group, only one patient developed post-operative agitation. In the general anesthesia group, two patients developed post-operative vomiting, two patients developed post-operative agitation and three patients developed post-operative vomiting and agitation. In contrast to our study, Sánchez-Conde et al., reported that there was no statistically significant difference between the two groups (SA and GA) regarding postoperative vomiting ($P > 0.378$). This could be explained by the groups in their study had high incidence of vomiting (38% in SA and 45% in GA) as they started the first meal earlier than in our study (13 minutes for patients in SA group in their study versus 30 minutes in our study and 16 minutes for patients in GA group in their study *vs.* 120 minutes in our study)[9]. In the current study, there was no statistically significant difference between the two groups of the study according to surgeon satisfaction ($p > 0.05$), which was assessed as unsatisfied, fair or satisfied in the study groups. Many studies reported similar results. One study compared SA with propofol and GA in children aged 2-5 yrs[10]. Surgeons were fully satisfied with all 39 children under GA, but only with 37 of 44 children under SA. The rest of the cases under SA were moderately satisfied ($P > 0.05$).

Conclusion

Spinal anesthesia is a good alternative to general anesthesia in neonates for infraumbilical surgeries with better hemodynamics stability, avoiding hypoxic events, and decreasing postoperative vomiting and agitation that might occur with GA when time of surgeries < 60 minutes.

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