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EFFECT OF INTRAVENOUS LOW-DOSE KETAMINE ON POST-SPINAL HYPOTENSION IN PATIENTS UNDERGOING ELECTIVE CESAREAN SECTION: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Spinal anaesthesia is the preferred technique for elective cesarean section due to its safety and rapid onset. However, hypotension after spinal anaesthesia is still a common and potentially serious complication. Its incidence is reported to be above 50%. Ketamine, has sympathomimetic properties that may help mitigate hypotension by maintaining vascular resistance and cardiac output. This study was undertaken to evaluate the effect of two intravenous low-dose ketamine regimens on the incidence of post-spinal hypotension in women undergoing elective cesarean section.

Materials and Methods: A prospective observational study was conducted at Burdwan Medical College and Hospital over 18 months involving 100 ASA I–II full-term pregnant women scheduled for elective cesarean section under spinal anaesthesia. Participants were randomly assigned into two groups: Group Ka received 0.15 mg/kg ketamine and Group Kb received 0.25 mg/kg ketamine intravenously post-delivery. Hemodynamic parameters were recorded at defined intervals. Hypotension was defined as more than 20% fall in mean arterial pressure (MAP) from baseline. It was treated with fluid boluses and vasopressors. Postoperative analgesia, sedation, APGAR scores, and adverse effects were assessed up to 24 hours. For statistical purpose p value less than 0.05 was taken as significant.

Results: The incidence of hypotension was found to be significantly lower in Group Kb (2%) as compared to Group Ka (16%) (p=0.03). At 10 minutes post-delivery, systolic blood pressure and MAP were better maintained in Group Kb as compared to Group Ka and the difference was statistically significant (p=0.001). The VAS score reached threshold of 4 or more later in Group Kb as compared to patients in Group Ka (12 hours). Ramsay Sedation Scores remained below 3 and was found to be comparable in both the groups. APGAR scores at 1 and 5 minutes were comparable and not clinically significant, as ketamine was administered after delivery.

Conclusion: Intravenous low-dose ketamine, especially at 0.25 mg/kg, is effective in reducing the incidence of post-spinal hypotension and prolonging postoperative analgesia without compromising maternal or neonatal safety. It is a safe and beneficial intravenous adjunct in spinal anaesthesia for elective cesarean sections.

Keywords: Ketamine, Hypotension, Spinal Anaesthesia, Cesarean Section, Postoperative Analgesia.

INTRODUCTION

Spinal anaesthesia has become the gold standard anaesthetic technique for elective cesarean section.[1] It is a simple, fast performed, powerful, and reliable procedure. Although spinal anaesthesia has been considered the safer technique, it has many adverse effects, including hypotension, nausea, vomiting,

bradycardia, and other dysrhythmias.[2] The most common serious problem associated with spinal anaesthesia remain rapid onset of profound hypotension. This hypotension is associated with a decrease in cardiac output and utero-placental flow which may induce fetal morbidity.[3] It is therefore crucial to prevent and/or to treat it quickly and effectively.

The spinal anaesthesia for cesarean section indeed requires a sensory block upto T5, which always leads to an extended sympathetic block and hypotension occurs in 55% to 90% of cases, despite the partial left lateral decubitus with the objective of limiting the aorto-caval compression caused by the gravid uterus.[4] The pathophysiological mechanism involved in the occurrence of hypotension is decreased systemic vascular resistance and central venous pressure from sympathetic block with vasodilation.[5] Bradycardia can occur from shift in cardiac autonomic balance toward the parasympathetic system, from activation of left ventricular mechanoreceptors from a sudden decrease in left ventricular volume, known as the Bezold-Jarisch Reflex.[6]

The main treatment is the vascular filling with crystalloids or starches and use of vasopressors. However, many studies showed that it was not so effective in all cases and a recent review found that no intervention reliably prevents hypotension during spinal anaesthesia for cesarean section. To prevent hypotension, we generally use vasopressor drugs like mephenteramine, ephedrine, and phenylephrine.[7]

Spinal block paralyses the preganglionic sympathetic fibres while ketamine induces activation of sympathetic nervous system and increases catecholamine levels in blood thereby increasing pulse rate and blood pressure. Cardiovascular stability is far better with low dose ketamine supplementation because it has cardiotonic effects. Respiratory depression is not seen with low doses of ketamine. Ketamine preserves vascular resistance and systemic arterial blood pressure by increasing release and inhibiting reuptake of catecholamines in circulation and the central nervous system. The favorable cardiovascular effect of ketamine makes it an optimal anesthetic agent in hypotensive patients.[8]

History of ketamine can be traced back to 1962 when a phencyclidine derivative CI-581 called R (-) ketamine was synthesised by Stevens.[8] The first human experiment of R (-) ketamine in volunteers was performed in 1964, followed by its safe use in childbirth in 1966. In 1970, ketamine was approved by FDA as a clinical anesthetic in adults. Ketamine used to be widely used in obstetric anaesthesia either as a sole anesthetic agent or combined with inhalational anesthetics in vaginal delivery and cesarean delivery in the 1970s.[9]

Effective postoperative analgesia following cesarean section is important because parturient are at a higher risk for thromboembolic events due to immobility following inadequate pain control. The presence of severe pain during 36 hours after cesarean section has been associated with an increased likelihood of developing postpartum depression and reduces the ability for effective breastfeeding. There is growing evidence that ketamine, which is an N-methyl-D-aspartate receptor antagonist, is efficacious when used as an adjuvant for postoperative pain control. When used at subanaesthetic doses (<0.3 mg/kg), it provides analgesia with less pronounced psychoactive side effects.[10]

Consensus guidelines from the American Society of Regional Anaesthesia and Pain Medicine, the American Academy of Pain Medicine and the American Society of Anaesthesiologists support the use of subanaesthetic bolus dose of ketamine up to 0.35 mg/kg and infusions up to 1 mg/kg/hour for acute pain as adjuncts to opioids for perioperative analgesia.[11] Ketamine at less than 2 mg/kg intravenously injected in parturient does not depress the neonates assessed by Apgar scores, and clinical experiences have demonstrated that ketamine is safe for fetus and neonate in obstetric anaesthesia.[12]

MATERIALS AND METHODS

This prospective observational study was conducted at Burdwan Medical College and Hospital over a period of approximately one and a half years. The study population included parturients admitted to the gynaecological ward for elective Cesarean section under spinal anaesthesia. After approval from institutional ethics committee, 100 pregnant women were included in this study on the basis of predefined inclusion and exclusion criteria.

Patients were enrolled and randomized equally into two groups of 50 women in each group using a computer-generated randomisation. Allocation concealment was done by sealed envelope method. Sample size was estimated to achieve 80% power with a 95% confidence interval based on expected differences in the incidence of post-spinal hypotension. The study drugs were administered intravenously immediately after delivery of the neonate as per the following group protocol:

- Group Ka – received 0.15 mg/kg ketamine (2 ml),
- Group Kb – received 0.25 mg/kg ketamine (2 ml) with both volumes adjusted using normal saline to maintain uniformity.

After securing intravenous access with an 18-gauge cannula, all parturients were preloaded with Lactated Ringer's solution at a dose of 10 ml/kg. Premedication with ranitidine 50 mg intravenously and metoclopramide 10 mg intramuscularly was done 30 minutes before administration of spinal anaesthesia.

Immediately after arriving in the operating room, baseline hemodynamic parameters including blood pressure (BP), heart rate (HR) and peripheral oxygen saturation (SpO_2) were recorded.

Spinal anaesthesia was administered in the sitting position at interspace L3–L4 or L4–L5 using Quincke spinal needle of 25-gauge with 12.5 mg of 0.5%

hyperbaric bupivacaine. Immediately after subarachnoid block, patients were positioned supine with a 15° wedge placed under the right buttock to achieve left uterine displacement.

Assessment of sensory block was performed bilaterally along the mid-clavicular line using the pinprick method at 1-minute intervals. Surgery was commenced once the sensory block level reached T6. Motor block was assessed at 1-minute intervals by using the Modified Bromage Score. Supplemental oxygen was provided via a simple face mask at a flow rate of 4 L/min.

Hemodynamic variables including HR, systolic BP, diastolic BP, mean arterial pressure (MAP), and SpO_2 were monitored at 2, 4, 6, 8, and 10 minutes following spinal anaesthesia and thereafter at 5-minute intervals until the end of surgery.

Hypotension was defined as a fall in MAP greater than 20% below the pre-anaesthetic baseline value and was treated with a 200 ml intravenous fluid bolus and mephentermine 3 mg IV. Bradycardia (HR less than 50 beats per minute) was treated with atropine 0.6 mg IV.

Ketamine was administered intravenously immediately after delivery of the baby as per group allocation. Neonatal outcome was assessed by calculating APGAR scores at 1 and 5 minutes after birth.

Postoperative pain was evaluated using the Visual Analogue Scale (VAS), where 0 indicated no pain and 10 indicated the worst pain imaginable, at 2, 6, 10, 12, and 24 hours postoperatively. Intravenous tramadol 100 mg was administered as rescue analgesia when VAS score was found to be equal to or more than 4. The time interval from intrathecal injection of the anaesthetic solution to the first request for analgesia, the total number of analgesic doses, and the total dose of analgesic required over 24 hours were recorded.

Postoperative sedation was assessed using the Ramsay Sedation Score after completion of surgery and at 2, 4, and 6 hours postoperatively (1 = cooperative and oriented; 2 = responds to commands only; 3 = brisk response to light glabellar tap or loud noise; 4 = sluggish response; 5 = no response).

Postoperative nausea and vomiting (PONV) during the first 24 hours following cesarean section was recorded and treated with ondansetron 4 mg and/or dexamethasone as required. Postoperative complaints of disturbing dreams were recorded up to 72 hours following cesarean section and were treated with midazolam 1 mg IV.

Patient satisfaction was assessed 24 hours after surgery and graded as excellent, satisfactory, or non-satisfactory. Categorical variables were presented as number and percentage and compared using Chi-square test or Fisher's exact test as appropriate. Continuous variables were expressed as mean ± standard deviation (SD). Inter-group comparisons were performed using unpaired t-test for normally distributed data and Mann–Whitney U test for non-normally distributed data. All analyses were performed using SPSS version 20. A p-value <0.05 was considered statistically significant.

Inclusion Criteria

1. Those who were ready to give informed and written consent to be part of the study.
2. The age of the patient above 18 years.
3. Pregnant women undergoing elective cesarean section under spinal anaesthesia.
4. Singleton pregnancy at term (≥37 weeks of gestation).
5. ASA Physical Status I or II.

Exclusion Criteria

1. Refusal to give informed and written consent to be part of the study.
2. Age less than 18 years.
3. Emergency cesarean sections.
4. Multiple gestation pregnancies.
5. Known allergy or hypersensitivity to ketamine or local anaesthetics.
6. Pre-existing hypertension, cardiovascular disease, or psychiatric illness.
7. Patients receiving medications that may interfere with hemodynamic response (e.g., beta-blockers).
8. Contraindications to spinal anaesthesia (e.g., coagulopathy, local infection at injection site).

RESULTS

The demographic parameters of patients in both groups regarding Age, Weight, ASA status were comparable and showed no significant difference (P > 0.05) between the two study groups. The duration of Surgery in Ka group is 28.30 ± 6.67 mins and in Kb group is 27.20 ± 6.04 mins. There was no significant difference between the two groups regarding the duration of surgery [Table 1].

Table 1: Patient Demographics and ASA grades.

	Ka (Mean ± SD)	Kb (Mean ± SD)	p Value
Age (Years)	28.0 ± 3.77	29.42 ± 3.47	0.053
Weight (Kgs)	61.14 ± 2.37	61.05 ± 2.23	0.346
Duration of surgery (Minutes)	28.30 ± 6.67	27.20 ± 6.04	0.657
ASA			
ASA I	40 (80 %)	38 (76 %)	0.390
ASA II	10 (20 %)	12 (24 %)	

The mean systolic blood pressure in the Ka group showed a gradual decline from baseline values following delivery of the baby and entered the hypotensive range at 10 minutes (105.32 ± 8.99

mmHg). In contrast, although the mean systolic blood pressure in the Kb group also decreased after delivery, it never reached hypotensive levels, with the lowest recorded value being 115.70 ± 3.30 mmHg at 15 minutes. On intergroup comparison, the reduction in systolic blood pressure at 10 minutes was statistically significant, favouring the Kb group.

The mean diastolic blood pressure in the Ka group decreased from baseline after delivery and reached hypotensive values at 15 minutes (64.36 ± 3.04 mmHg). A similar trend was observed in the Kb group, with hypotensive values recorded at 15 minutes (64.28 ± 3.01 mmHg). However, at 10 minutes, the reduction in mean diastolic blood pressure was more pronounced in the Ka group compared to the Kb group, and this difference was statistically significant ($p < 0.05$).

Mean arterial pressure showed a decline from baseline values in both groups during the study period. In the Ka group, the lowest mean arterial pressure was observed at 10 minutes, representing a decrease greater than 20% from baseline, which resulted in hypotension in a proportion of patients. In contrast, although mean arterial pressure decreased from baseline values in the Kb group, none of the observed values at any time point showed a reduction exceeding 20% of baseline, and therefore, the incidence of hypotension was not observed statistically in this group.

The mean heart rate in the Ka group increased from baseline following delivery and demonstrated tachycardia at 4, 6, and 8 minutes. Similarly, in the Kb group, the mean heart rate increased from baseline and showed tachycardia at 4, 6, and 10 minutes. However, in both groups, the increase in mean heart rate did not exceed 20% of baseline values at any time point and was therefore not considered clinically significant.

Overall Kb group exhibited better hemodynamic stability compared to the Ka group, particularly with respect to systolic blood pressure and mean arterial pressure, with a lower incidence of clinically significant hypotension [Table 2].

Table 2: Comparison of hemodynamic parameters in both the groups.

Parameter	Time	Ka (Mean ± SD)	Kb (Mean ± SD)	p Value
SBP	Baseline	134.68 ± 3.08	134.74 ± 2.91	0.920
	2 min	114.78 ± 2.95	114.92 ± 3.13	0.819
	4 min	122.72 ± 8.29	125.20 ± 9.23	0.161
	6 min	118.64 ± 9.83	121.28 ± 12.68	0.248
	8 min	129.40 ± 6.60	131.02 ± 6.03	0.203
	10 min	105.32 ± 8.99	122.18 ± 8.07	0.001
	15 min	114.44 ± 3.55	115.70 ± 3.30	0.070
	20 min	125.14 ± 3.16	125.32 ± 3.14	0.776
	25 min	126.66 ± 10.11	124.70 ± 8.71	0.302
	30 min	124.46 ± 9.68	124.44 ± 8.93	0.490
DBP	Baseline	84.78 ± 3.12	84.18 ± 3.07	0.336
	2 min	77.56 ± 4.87	77.12 ± 4.98	0.656
	4 min	80.20 ± 6.60	80.48 ± 6.30	0.829
	6 min	68.56 ± 6.42	69.82 ± 5.46	0.293
	8 min	84.84 ± 3.10	84.66 ± 3.17	0.775
	10 min	66.10 ± 7.40	75.18 ± 3.29	0.001
	15 min	64.36 ± 3.04	64.28 ± 3.01	0.895
	20 min	70.24 ± 5.95	69.82 ± 6.40	0.735
	25 min	84.00 ± 3.32	85.24 ± 3.04	0.063
	30 min	80.72 ± 7.52	81.54 ± 7.20	0.579
MAP	Baseline	101.42 ± 2.39	101.03 ± 2.37	0.425
	2 min	89.96 ± 3.37	89.72 ± 3.53	0.722
	4 min	94.37 ± 4.79	95.38 ± 5.43	0.325
	6 min	85.25 ± 4.67	86.97 ± 5.00	0.079
	8 min	99.69 ± 2.72	100.11 ± 2.95	0.462
	10 min	79.17 ± 8.17	90.84 ± 3.29	0.001
	15 min	81.05 ± 2.40	81.42 ± 2.54	0.460
	20 min	88.54 ± 4.12	88.32 ± 4.61	0.802
	25 min	98.22 ± 4.12	98.39 ± 3.14	0.814
	30 min	96.03 ± 6.17	95.92 ± 5.84	0.930
HR	Baseline	89.64 ± 17.78	90.08 ± 15.99	0.631
	2 min	93.88 ± 14.80	88.30 ± 16.32	0.392
	4 min	102.36 ± 17.05	104.28 ± 17.14	0.475
	6 min	101.94 ± 18.71	105.40 ± 17.82	0.833
	8 min	101.10 ± 16.86	107.38 ± 15.81	0.933
	10 min	98.28 ± 13.19	106.98 ± 13.08	0.068
	15 min	83.68 ± 15.57	95.56 ± 17.99	0.647
	20 min	88.52 ± 16.92	90.26 ± 16.40	0.623
	25 min	87.74 ± 18.99	87.22 ± 19.14	0.270
	30 min	87.92 ± 18.92	93.38 ± 16.22	0.302

The Mean Ramsay Sedation Score in both Ka and Kb group never reached 3 following deliveries of baby in next 24 hrs, and patients were arousable to commands. Thus, ketamine with the study dose has

not produced any over sedation in study groups [Figure 1].

Figure 1: Comparison of Ramsay Sedation score in studied groups.

In VAS, the Mean VAS score in the Ka group reached 4 at 10 hrs post-delivery of baby, whereas the Mean VAS score in Kb group reached 4 at 12 hrs post-delivery of baby. Thus, analgesic effect of Ketamine in Kb group was more prolonged as compared to Ka group [Figure 2].

Figure 2: Comparison of VAS Score in studied groups.

The Mean APGAR score in both Ka and Kb groups were comparable at 1 and 5-minutes following delivery of baby. It was statistically not significant and also of no clinical significance, as the study drug were administered following delivery of the baby [Table 3].

Table 3: Comparison of APGAR score in studied groups.

APGAR	Ka (Mean)	Kb (Mean)	p Value
1 min	8.1 ± 1.38	8.11 +/- 1.32	0.895
5 min	9.90 ± 0.3	9.61 +/- 0. 28	0.892

Incidence of Hypotension in the study groups Ka and Kb were 16 % and 2 % respectively and there was statistically significant difference between two groups. Though the Mean MAP values decreased from baseline value in Kb group, none of the MAP values at any point of time decreased more than 20 % of the baseline value [Table 4].

Table 4: Comparison of incidence of Hypotension in studied groups.

Hypotension	Ka N (%)	Kb N (%)	p Value
Present	8 (16 %)	1 (2 %)	0.03
Absent	42 (84 %)	49 (98 %)	

DISCUSSION

In this prospective observational study, intravenous low-dose ketamine was administered as an adjunct showed greater hemodynamic stability with a lower incidence of hypotension in the Kb group. Spinal anaesthesia is the preferred technique for cesarean section as it decreases the risk of difficult or failed intubation as well as chances of pulmonary aspiration associated with general anaesthesia.[13] This also allows mother to remain awake and interact with the newborn immediately after delivery. However, hypotension remains the most common complication of spinal anaesthesia and can adversely affect the fetus due to reduced uterine blood flow.

In the present study, systolic blood pressure trends differed between the two groups. In the Kb group, the mean systolic blood pressure decreased to a minimum value of 115.70 ± 3.30 mmHg and did not reach the hypotensive range at any point. In contrast, in the Ka group, the mean systolic blood pressure fell to hypotensive levels at 10 minutes (105.32 ± 8.99 mmHg) during the study period. Sen S et al reported no significant difference in mean arterial blood pressure compared with the control group when intravenous ketamine was used at a dose of 0.15 mg/kg after initiation of spinal anaesthesia.[14] Salah D, using ketamine 0.5 mg/kg intravenously following spinal anaesthesia, also did not observe a decrease in mean arterial pressure compared with controls.[15] Although a lower dose of ketamine (0.25 mg/kg) was used in one of our study groups, the findings related to mean arterial pressure are in agreement with these observations. Similar Hemodynamic effects of ketamine in patients undergoing cesarean sections under spinal anaesthesia were also reported by the authors such as Aboelsuod MAA et al[16] and Kareem Oleiwi Atabi T et al.[17]

The incidence of hypotension in our study was found to be 16% in the Ka group (0.15 mg/kg) as compared to 2% in the Kb group (0.25 mg/kg). Traina F et al[18] reported an incidence of hypotension of 20% with ketamine 0.25 mg/kg whereas Salah D observed hypotension in 6% of patients when ketamine 0.5 mg/kg was used.[15] Thus, the incidence of hypotension observed in our study is comparable with these earlier reports. The mean heart rate in both Ka and Kb groups in our study showed an increase that was consistent with tachycardia but this increase did not exceed 20% of baseline heart rate values. Salah D reported tachycardia in both ketamine and

control groups. The findings of study by Salah D did not fully correlate with our results, possibly due to the higher dose of ketamine (0.5 mg/kg) used in their study.[15]

A secondary objective of the present study was to evaluate prolongation of postoperative analgesia. Sen S et al. reported that with ketamine 0.15 mg/kg intravenously, the VAS score reached 3 or more at 180 minutes following spinal anaesthesia.[14] In our study, the VAS score reached 3 at 120 minutes in the Ka group, whereas in the Kb group it reached 3 or more only at 360 minutes. These findings suggest that ketamine at a dose of 0.25 mg/kg significantly prolongs postoperative analgesia. Salah D observed Ramsay Sedation Score changes only during the intraoperative period with ketamine 0.5 mg/kg. As our observation period extended to 24 hours and the ketamine doses used were considerably lower, direct comparison of sedation findings is not appropriate.[15] Adverse effects such as diplopia, nystagmus, and hallucinations were reported by Salah D et al in patients receiving ketamine 0.5 mg/kg.[15] In contrast, none of the patients in either group in our study experienced diplopia, nystagmus, or hallucinations, which can be attributed to the lower doses of ketamine used. With respect to neonatal outcomes, Sen S et al[14] reported APGAR scores of 9 and 10 at 1 and 5 minutes respectively whereas Salah D15 reported APGAR scores of 7.9 ± 0.4 and 9.6 ± 0.6 at 1 and 5 minutes after delivery. In our study, ketamine was administered after delivery of the baby and the corresponding APGAR scores were comparable in both the groups. These findings were similar to the findings reported by the authors such as Samuel H et al[19] and Manjula BP et al.[20]

CONCLUSION

Intravenous low-dose ketamine administered after delivery of the baby provides improved hemodynamic stability following spinal anaesthesia for elective cesarean section. A dose of 0.25 mg/kg was associated with better maintenance of systolic blood pressure and mean arterial pressure along with a significantly lower incidence of post-spinal hypotension compared to 0.15 mg/kg. The higher dose also resulted in prolonged postoperative analgesia without causing clinically significant tachycardia, excessive sedation, psychomimetic adverse effects or neonatal compromise. These findings indicate that low-dose ketamine is a safe and effective adjunct in parturients undergoing cesarean section under spinal anaesthesia.

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