Section: Anaesthesiology

Original Research Article

COMPARATIVE STUDY OF THE EFFICACY OF POTASSIUM CHLORIDE AND SODIUM BICARBONATE AS AN ADJUVANT TO BUPIVACAINE IN BRACHIAL PLEXUS BLOCK IN PATIENTS UNDERGOING UPPER LIMB SURGERIES

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Abstract

Background: Peripheral nerve blocks, such as brachial plexus blocks, offer effective anaesthesia for upper limb surgeries with prolonged postoperative pain relief and minimal haemodynamic changes. Sodium bicarbonate and potassium chloride, as additives to bupivacaine, improved block quality and enhanced sensory and motor blockade duration and onset times. This study aimed to compare the efficacy of sodium bicarbonate and potassium chloride as adjuvants to bupivacaine in supraclavicular brachial plexus block. **Materials and Methods:** This prospective, randomised, double-blind study at the Government Medical College Hospital, Namakkal included 60 patients. On the day of surgery, standard monitors were applied, intravenous access was established, and patients were positioned appropriately for supraclavicular brachial plexus block. Using landmarks, a 22G needle was used for local anaesthetic injection upon paraesthesia confirmation. The block characteristics were closely monitored, with vital signs and potential complications observed postoperatively for 24 h. **Results:** Group S (sodium bicarbonate) experienced significantly longer sensory and motor block durations, faster onset times, and extended analgesia than Group K (potassium chloride) (P=0.0001). Both groups showed no significant differences (P > 0.05) in demographic variables, surgery duration, heart rate, blood pressure, or SPO2 levels, indicating haemodynamic stability. **Conclusion:** The comparison of potassium chloride and sodium bicarbonate as adjuvants to bupivacaine for brachial plexus block showed that potassium chloride provided shorter onset times for sensory and motor blocks, whereas sodium bicarbonate extended the duration of these blocks and analgesia. Both adjuvants enhanced the block quality and were safe for use.

INTRODUCTION

Peripheral nerve block involves prevention of nociceptive afferent stimulus from injured tissue from reaching the central nervous system by preinjury neural blockade. Brachial plexus nerve blocks provide an excellent alternative to general anaesthesia for upper limb orthopaedic, plastic, and vascular surgeries. Peripheral nerve blocks provide ideal anaesthesia for surgery, with the added benefit of prolonged postoperative analgesia. They provide improved patient satisfaction, less nausea and vomiting, and produce minimal changes in haemodynamic parameters. Among the various approaches of brachial plexus block the supraclavicular approach is considered safe. Other approaches to brachial plexus block include the infraclavicular, interscalene, and axillary approaches.

In 1884, Halsted was the first to perform a brachial plexus block. He blocked the roots of the brachial plexus in the neck with a cocaine solution. In 1887,

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Crile performed shoulder disarticulation after blocking the nerve trunks of the brachial plexus by direct intraneural injection of cocaine solution. The First blind supraclavicular block of brachial plexus percutaneously was performed by D. Kulenkampff in 1991. The first axillary brachial plexus block was performed in 1991 by Hirschel.

Successful block placement requires extensive knowledge of nerve plexus anatomy, landmarks, needle placement, pharmacology of local anaesthetics, complications of the procedure, and local anaesthetic toxicity. To improve the quality of the block provided by plain local anaesthetic solutions, various adjuvants have been added to local anaesthetic solutions, including dexamethasone, dexmedetomidine, clonidine, epinephrine, sodium bicarbonate, and potassium chloride, to improve the duration of motor and sensory block, hasten the onset time of sensory or motor block, or improve both the onset time and duration of block. They are also known to improve the quality of postoperative analgesia and reduce the opioid requirements.

Aim

This study aimed to compare the efficacy of sodium bicarbonate and potassium chloride as adjuvants to bupivacaine in supraclavicular brachial plexus block.

MATERIALS AND METHODS

This prospective, randomised, double-blind study was conducted on 60 patients at the Government Medical College Hospital, Namakkal. This study was approved by the Institutional Ethics Committee before initiation, and informed consent was obtained from all patients.

Inclusion Criteria

Patients with ASA grades I and II, aged 18-60 years, both sexes, normal biochemical parameters, normal haematological parameters, Mallampati scores I and II, no neurological deficit, and no local sepsis were included in the study.

Exclusion Criteria

Patients with neurological disorders, allergies to local anaesthetics, history of bleeding disorders, cardiovascular disorders, respiratory disorders, or extreme obesity were excluded from the study.

Methods

Group K received 0.33% bupivacaine 30 ml with an Inj 7.5% solution of potassium chloride 0.2 ml and Group S received 30 mL of 0.33% bupivacaine with 7.5% sodium bicarbonate 0.2 ml.

Preoperative assessment was performed for all patients and the procedure was explained in detail. On the day of surgery, routine monitors including NIBP, ECG, and Pulse Oximetry were connected after arrival in the operating room. Preoperative baseline vital parameters were noted and intravenous access was obtained in the opposite arm. Paraesthesia was defined as an electric shock sensation in the elbow and forearm, and the patient was made to lie supine. The head was turned to the contralateral side, and the arm was held close to the body in the adducted position. A shoulder roll was placed to facilitate a 30° head-down position and the neck and supraclavicular regions were painted and draped.

Sternocledoid muscle is easily palpated when the patient raises his head. From the posterior border of the sternocledoid muscle, the belly of the anterior scalene muscle was palpated by rolling the fingers. The interscalene groove is present between the bellies of the anterior and middle scalene muscles. A mark was made approximately 2 cm posterior to the midpoint of the clavicle at the interscalene groove. At this point, the subclavian artery could be palpated. This confirmed the presence of a landmark in the brachial plexus. A 22G hypodermic needle was inserted and directed posterior, medial, and caudad to the subclavian artery. The needle was gently walked to induce paraesthesia. Once paraesthesia was elicited, a local anaesthetic solution was injected.

After drug administration, the block was evaluated every minute for the onset of sensory and motor blockade. Sensory block onset was determined by the loss of pin prick sensation in 4th cervical to 1st thoracic dermatome using a 26G hollow needle. The time of onset of the motor blockade was indicated by the loss of shoulder abduction. Failure to attain sensory and motor block within 20 min was considered block failure. These patients were excluded from the study and were administered general anaesthesia. Intraoperative vital signs, including heart rate and non-invasive blood pressure, were measured periodically. Continuous monitoring was performed for ECG and SPO2. Patients were monitored for manifestations of local anaesthetic toxicity, including circumoral numbness, convulsions, and twitching.

The Visual Analogue Pain Scale scores ranged from 0 (no pain), 3 (mild pain), 5 (moderate pain), 10 (most severe pain),

Statistical Methods

Statistical analysis was performed using the SPSS software (version 15.0) and Microsoft Excel 2013. The Student's unpaired t-test was used to analyse the parametric data. Parametric data were calculated as arithmetic mean ± standard deviation. Analysis of variance ANOVA was used to compare the continuous covariates. The chi-square test or Fisher's exact test was used to calculate the p-values. The P-value was reported at a confidence interval of 95%. Statistical significance was set at $P < 0.05$.

RESULTS

In Group K, the age distribution was as follows: up to 25 years (23%), 26-35 years (30%), 36-45 years (17%), 36-55 years (17%), and 56-65 years (13%),

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with a mean age of 37.80±13.727. In Group S, the distribution was as follows: 25 years (7%), 26-35 years (50%), 36-45 years (10%), 36-55 years (13%), and 56-65 years (20%), with a mean age of 38.9±12.786 years. The difference in age between the groups was not statistically significant (P=0.7492). In Group K, 57% of the participants were male, while in Group S, 46.7% were male. The difference in the gender distribution between the groups was not statistically significant (P > 0.05). [Table 1]

Both groups had similar mean weights and durations of surgery. However, the onset times for sensory and motor blocks were significantly shorter in Group K, with sensory block onset at 6.53±0.860 min compared to 11.1±0.845 min in Group S (P= 0.0001) and motor block onset at 4.07±0.785 min compared to 8.00±0.743 min in Group S (P= 0.0001). The durations of both sensory and motor blocks were significantly longer in Group S, with sensory block duration at 661±38.213 min compared to 541±45.119 min in Group K (P=0.0001), and motor block duration at 461±37.357 min compared to 352±33.123 min in Group K (P= 0.0001). The duration of analgesia was longer in Group S than in Group K. [Table 2]

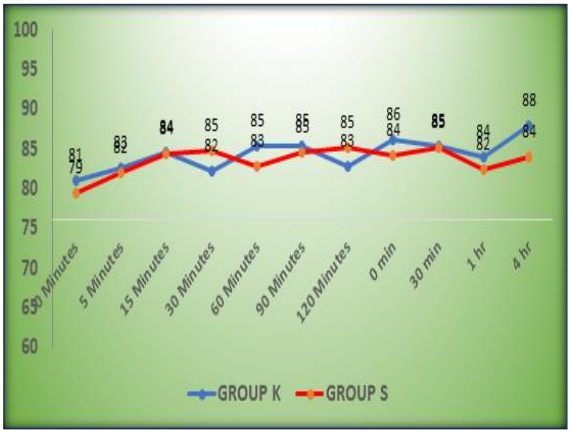

Figure 1: Changes in heart rate between the groups

The mean heart rates during the intraoperative and postoperative periods at the different intervals between the two groups were not statistically significant (P > 0.05). [Figure 1]

Figure 2: Changes in systolic blood pressure between the groups

The mean systolic blood pressures during the intraoperative and postoperative periods at different intervals between the two groups were not statistically significant (P > 0.05). [Figure 2]

Figure 3: Changes in diastolic blood pressure between the groups

The mean diastolic blood pressures during the intraoperative and postoperative periods at different intervals between the two groups were not statistically significant (P > 0.05). [Figure 3]

Figure 4: Changes in SPO2 between the groups

The mean SPO2 values of the intraoperative and postoperative periods at the above different intervals between the two groups were not statistically significant (P > 0.05). [Figure 4]

Table 1: Distribution of age and gender in both groups

		Frequency		P value
		Group K	Group S	
Age (years)	Up to 25	7 (23%)	2 (7%)	0.749
	26-35	9 (30%)	15 (50%)	
	36-45	5 (17%)	3 (10%)	
	36-55	5 (17%)	4 (13%)	
	56-65	4 (13%)	6 (20%)	
Gender	Male	17 (57%)	14 (46.7%)	> 0.05
	Female	13 (43%)	16 (53.3%)	

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Table 2: Various parameters of the study

	Mean		P value
	Group K	Group S	
Weight	57.23±6.36	57.47±5.79	0.879
Duration of surgery	103.67±20.424	106.33±19.911	0.611
Sensory block onset	6.53±0.860	11.1±0.845	0.0001
Motor block onset	4.07±0.785	8.00±0.743	0.0001
Sensory block duration	541±45.119	661±38.213	0.0001
Motor block duration	352±33.123	461±37.357	0.0001
Duration of analgesia	483±32.605	524.3±35.785	0.0001

DISCUSSION

Brachial plexus blocks are used with excellent success and safety profiles as the preferred anaesthetic technique for various upper limb surgeries. They are known to provide good operating conditions, better patient acceptance, and a very low incidence of intraoperative and postoperative complications, thus making them the ideal choice for upper limb procedures.

Various techniques of brachial plexus block are available, including landmark-guided paraesthesia, peripheral nerve stimulators, and ultrasound-guided blocks. Although ultrasound-guided blocks provide a better success rate with the added advantage of reduction in complications as it facilitates real-time visualisation of vital structures, the availability of ultrasound machines is limited. However, landmark-guided and paraesthesia techniques are widely used for various procedures.

Adjuvants are agents which improve the quality of the block provided by local anaesthetics when administered at appropriate doses. The various adjuvants tested for local anaesthetics include dexamethasone, clonidine, dexmedetomidine, sodium bicarbonate, epinephrine, and potassium chloride. These agents improve the quality of blockade by improving the duration of sensory or motor blocks, by fastening the block onset, or both. They also help to reduce the total dose of local anaesthetics, and thus help to reduce complications.

In this study, sodium bicarbonate and potassium chloride were used as adjuvants for bupivacaine. Both drugs have novel mechanisms of action by which they augment the block provided by local anaesthetic drugs. Sodium bicarbonate alkalizes the local anaesthetic solution, resulting in pH changes that lead to the liberation of the free base, facilitating better blockade of nerve impulses.

Potassium chloride, when added as an adjuvant to the local anaesthetic solution, increases the concentration of extracellular potassium in the vicinity of nerves. The accumulated potassium ions outside the nerve membrane reinforce the block provided by local anaesthetics. The dose of potassium chloride used in this study was 2 mmol which is safe and does not carry any risks of adverse effects.

With sodium bicarbonate as an adjuvant to 30 ml of 0.33% bupivacaine, the mean sensory onset time was 11 minutes with a range of 7 to 13 minutes; the mean motor block onset time was 8 minutes with a range of 6 to 9 minutes; the mean sensory block duration was 661 minutes with a range of 600 to 720 minutes; the mean motor block duration was 461 minutes with a range of 410 to 530 minutes, and the mean duration of analgesia was 524 minutes, with a range of 470 to 590 minutes.

With potassium chloride as adjuvant to 30 ml of 0.33% bupivacaine, the mean sensory onset time was 6.5 minutes with (range, 5–8 min), the mean motor block onset time was 4 min (range, 3–6 min), the mean sensory block duration was 541 min (range, 470–600 min), the mean motor block duration was 352 min (range, 290–420 min), and the mean duration of analgesia was 483 min (range, 430–540 min).

Shreedhar et al. in their study concluded that when potassium chloride was added as an adjuvant to 0.375% bupivacaine, it significantly shortened the sensorimotor block onset times and prolonged the duration of the sensorimotor block compared with the block provided by plain 0.375% bupivacaine. Their study data correlated with the parameters observed in the potassium chloride group (Group K) in this study.[1]

In their study, Baruah compared the block obtained from alkalised 0.33% bupivacaine by the addition of sodium bicarbonate and that obtained from plain 0.33% bupivacaine, and concluded that faster onset times and prolonged durations of sensory and motor blocks were observed with alkalised bupivacaine. Their study data were comparable with the results obtained for the sodium bicarbonate group (Group S) of this study.[2]

Various studies have established the superiority of block quality achieved by adding either potassium chloride or sodium bicarbonate as adjuvants to various local anaesthetic solutions. In this study, we compared the block quality of potassium chloride with bupivacaine, and sodium bicarbonate with bupivacaine. Neither potassium chloride nor sodium bicarbonate as adjuvants to bupivacaine produced any adverse events intraoperatively or postoperatively. None of the patients in this study required additional sedatives or analgesics during the intraoperative period. The time required for the first dose of rescue analgesic was prolonged in both groups, with the sodium bicarbonate group achieving a better duration of analgesia than the potassium chloride group.

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CONCLUSION

A comparison of potassium chloride and sodium bicarbonate as adjuvants to bupivacaine for brachial plexus block showed that potassium chloride provides shorter onset times of sensory and motor blocks than sodium bicarbonate, whereas the duration of sensory and motor blocks was prolonged with sodium bicarbonate compared to potassium chloride. The duration of analgesia was longer with sodium bicarbonate. Both drugs can be safely used as adjuvants to bupivacaine to improve the quality of the brachial plexus block.

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