Comparative study on the onset time and duration of brachial plexus block with addition of potassium chloride to bupivacaine versus plain bupivacaine

Shivani.V[1], G. Srinivas Rao[1], R. Pandu Naik[2*], Mohd Azmathullah Hussain[3]

[1]Assistant Professor, Department of Anesthesiology, Osmania Medical College, Hyderabad, India.
[2]Associate Professor, Department of Anesthesiology, Osmania Medical College, Hyderabad ,India
[3]Post Graduate, Department of Anesthesiology, Osmania Medical College, Hyderabad, India

ABSTRACT

Background: Peripheral nerve blockade remains a well accepted component of comprehensive anaesthetic care. The onset of brachial plexus block is slow because the anaesthetic is usually deposited at some distance from the nerve and must diffuse through various tissue barriers before reaching the nerve membrane. **Aim:** Comparative study on the onset time and duration of supraclavicular brachial plexus block with addition of potassium chloride to bupivacaine versus plain bupivacaine. **Methodology:** Sixty patients belonging to ASA class I and II were included in the study and were randomly divided into two groups with 30 patients in each group. Group – I: KCl group received 30 ml of 0.375% bupivacaine with 0.2 mmol of potassium chloride (prepared by adding 0.1 ml (0.2mmol) of potassium chloride and 7.5 ml of distilled water to 22.5 ml of 0.5% bupivacaine). Group – II: Non KCl group/ plain bupivacaine group received 30 ml of 0.375% bupivacaine. **Results:** The mean time for onset of sensory block in group I was 17.7 ± 2.80 min which was significantly faster when compared to group II with a mean time of 27.86 ± 2.55 min. The mean time for onset of motor block in group I was 14.86 ± 2.56 min which was significantly faster compared to group II with a mean time of 25.46 ± 3.04 mins. The mean duration of sensory block in group I was 357.8 ± 101.9 min which was significantly prolonged when compared to group II mean duration of 256.1 ± 71.48 min. The mean duration of motor block in group I was 429.1 ± 85.09 min which was significantly prolonged when compared to group II mean duration of 336.46 ± 81.88 min. The number of supplements used in group I were significantly less when compared to group II. There was no statistically significant difference found between the group's in terms of duration of surgery **Conclusion:** On the basis of the study one can draw the conclusion that addition of potassium chloride to bupivacaine hastens the onset of blockade and improves the duration of analgesia and motor blockade. It also improves the quality of analgesia, whereas quality of motor blockade remains the same.

Key words: Bupivacaine, Supraclavicular brachial plexus block, Peripheral nerve blockade.

Introduction

Brachial plexus nerve blockade forms an important component of comprehensive anaesthetic care of upper limb surgeries. Its role has expanded from the operating suite into area of postoperative and chronic pain management. The onset of brachial plexus block is slow because the anaesthetic is usually deposited at some distance from the nerve and must diffuse through various tissue barriers before reaching the nerve membrane. The duration of block may be related to several factors including comparatively slower rates of vascular absorption from the plexus sheath, larger doses of the drug required and longer segments of nerves exposed to local Anesthetics[1,2] .Several means have been tried in the past to shorten onset and prolong the duration of action. Adjuncts like neostigmine[3] , alkalinization[4] , clonidine[5] , enzymes, buffer and carbonated solution[6] , opioids[7] , vasoconstricting agents, warming up of local anaesthetic solution, potentiation of blockade by pain and muscular exercise all have been varyingly tried. Hence, here an attempt has been done to compare the effects of addition of potassium chloride to bupivacaine in supraclavicular brachial plexus block.

**Correspondence*
Dr. R Pandu Naik
Associate Professor,Department of Anesthesiology, Osmania Medical College, Hyderabad,India
E Mail: ramvathpandu9@gmail.com

Methodology

After obtaining approval from the departmental ethics committee and informed written consent from the patients, the study was conducted on 60 patients planned for upper limb elective surgical procedures. Pre-anaesthetic

checkup was conducted and detailed history and complete physical examination recorded. **Inclusion criteria**: Adult patients between 18-60 years of both sexes, Patients belonging to ASA grade I and II, Elective surgeries on upper limb. **Exclusion criteria** included patient's refusal, history of bleeding disorders or patients on anticoagulant therapy burns, local infection, hyperkalaemia, severe kidney or liver dysfunction, respiratory disease, known allergy to local anaesthetic drugs and ASA grade III and IV patients.Each patient was visited pre operatively and the procedures were explained and informed written consent was obtained. Intravenous access with obtained with a 20 guage IV cannula on the contralateral upper limb under aseptic techniques. All the patients were pre-medicated with injection Midazolam 2 mg slow IV 30 minutes before surgery. Each patient was randomly assigned to one of the two groups of 30 patients each, group I or group II.

Group – I: KCl group received 30 ml of 0.375% bupivacaine with 0.2 mmol of potassium chloride (prepared by adding 0.1 ml (0.2mmol) of potassium chloride and 7.5 ml of distilled water to 22.5 ml of 0.5% bupivacaine),Group – II: Non KCl group/ plain bupivacaine group received 30 ml of 0.375% bupivacaine

Each patient was made to lie supine without a pillow, arms at the side, head turned slightly to the opposite side with the shoulders depressed posteriorly and downward by moulding the shoulders over a roll placed between the scapulae. The supraclavicular area was aseptically prepared and draped. The anaesthesiologist stood on the side of the patient**'s arm** to be blocked, facing the head of the patient, since this position allows better control of needle.An intradermal wheal was raised approximately 1 cm above the midclavicular point. The subclavian artery palpable in supraclavicular fossa was used as landmark. The tip of index finger was placed over supraclavicular fossa directly on the arterial pulsation. A 22 gauge, 4 cm needle was held in right hand and inserted through skin and advanced slowly downward (caudal) rolled slightly inward (medially) and slightly backward (posteriorly).Patient was instructed to say as soon as he felt a "tingle" or "electric shock like sensation" going down his arm. As soon as paresthesia was elicited, the needle was fixed in position and after confirming negative aspiration of blood, 30ml of the respective drug was injected depending on whether the patient was allotted to either of group I or II .Time of onset of sensory block was recorded using pinprick in skin dermatomal levels C4-T2 once in every 3 minutes for the first 30 minutes after injection and thereafter every 30 minutes till patient regained normal sensations. The same observer assessed the motor block at the same time intervals.The person doing the procedure did not know whether the dilution contained plain bupivacaine or with potassium chloride. Onset of sensory block was from the time of injection of drug to time of loss of pain on pinprick. Onset of motor block was from the time of injection to time of complete loss of movement of limb.Sensory block was assessed by pinprick with a short beveled 23G needle as 0 - no pain,1 - mild pain –grimace,2 - moderate pain-withdrawal and 3 - severe pain - screams.

Motor block was graded according to the movement of upper limb by the patient

Grade 5 - normal movement of upper limb,Grade 4 - movement against resistance,Grade 3 - movement against gravity,Grade 2 - movement along gravity but not against resistance,Grade 1 - flickering movement andGrade 0 - no movement. Grades 3, 2, 1 were partial block.Grade 0 - complete motor paralysis that is when the patient could not move his limb at all.

Duration of sensory blockade was the time in minutes from the onset of analgesia to the recurrence of pain to pin prick. Duration of motor blockade was the time in minutes from the onset of paresis to the recurrence of motor movements. The quality of sensory and motor block was studied and graded as per whether the blocks were complete, incomplete or totally absent.The usage of supplements after the block was graded according to whether the surgery was done under general anaesthesia (Grade 3) due to complete failure of block, whether opioids were used during intra operative period (Grade 2) or if supplements of any kind were not used throughout the surgery (Grade 1).The heart rate, saturation, respiratory rate and blood pressure were recorded at intervals of 5 minute. The patients were watched for bradycardia, convulsions, restlessness, disorientation, drowsiness and any other complications.All the values are expressed in Mean +SD. p value of <0.05 as statistically significant, a p value of <0.01 as statistically highly significant and a p value of <0.001 as statistically very highly significant.

Results

The present study was conducted on 60 consenting patients aged between 18-60 years.

Table 1: Age and weight distribution of study groups

Parameter	Drug	Mean	Std deviation	p value
Age Distribution	Group I	32	13	**0.289**
	Group II	35.9	15.2	
Weight	Group I	53.73	5.35	**0.89**
	Group II	53.96	7.61	

The minimum age of the patient was 18 years and the maximum age was 60 years. The mean age of the patients in KCl group was 32 ± 13 and in Non KCl group was 35.9 ± 15.2 years. Age incidences between two groups were comparable. Mean weight between the two groups is not statistically significant. (p>0.05)

Table 2: Time for onset and duration of sensory and motor block (mins)

Parameter	Group	Min	Max	Mean± S.D.	p value
Onset of Sensory blockade(mins)	Group I	12	26	17.7±2.8	< 0.0001***
	Group II	20	30	27.86 ±2.1	
Onset of motor blockade (min)	Group I	11	23	14.86±2.56	< 0.0001***
	Group II	17	29	25.46±3.04	
Duration Sensory blockade(mins)	Group I	151	555	357.8±101.9	< 0.0001***
	Group II	122	395	256.1±71.48	
Duration motor blockade(mins)	Group I	225	567	429.1±85.09	< 0.0001***
	Group II	156	483	336.4 ±81.88	

***Highly significant,p-value<0.05 significant

Time for onset and duration of sensory and motor blockade are highly significant in compared to group-I and group-II

Table 3: Quality of sensory and motor blockade

Sensory blockade			
Grade-0	26	14	40
Grade-1	4	16	20
Total	**30**	**30**	**60**
Motor blockade			
Grade-0	21	14	35
Grade-1	0	1	1
Grade-2	6	10	16
Grade-3	3	5	8
Total	**30**	**30**	**60**

$X^2 = 10.8$, $p < 0.001$, highly significant

The quality of sensory blockade was better in group I and the value was statistically significant when compared with group II.The quality of motor blockade was similar in both the groups.

Table 4: Supplement used

Supplement	Group I	Group II	Total
Grade 1	21	13	34
Grade 2	08	16	24
Grade 3	01	01	02
Total	**30**	**30**	**63**

$X^2 = 3.99$, $p < 0.05$, significant.

The usage of supplements after the block was graded according to whether the surgery was done under general anaesthesia (grade 3) due to complete failure of block, whether opioids were used during intra operative period (grade 2) or if adjuvants of any kind were not used throughout the surgery (grade 1). The number of supplements used in group I were significantly less when compared to group II. The p value was < 0.05 which is statistically significant.

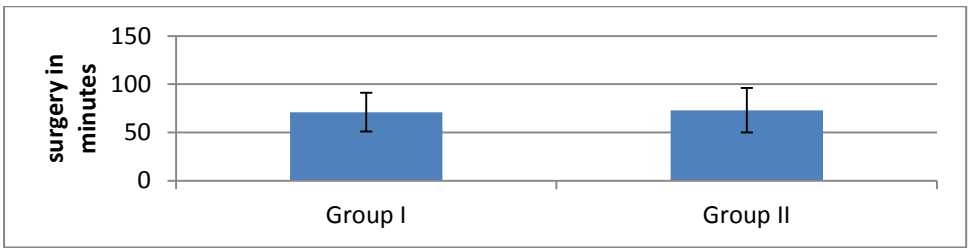

Figure 1: Duration of surgery in minutes

t = 0.35, p > 0.05, Not significant There is no statistically significant difference found between the two groups in terms of the duration of surgery. Hence the two groups were comparable in terms of duration of surgery.

Discussion

Brachial plexus blockade for upper limb surgeries is the most common major peripheral nerve block technique. It is widely used in our practice for elective forearm and hand surgeries either solely with sedation or combined with general anaesthesia. The supraclavicular approach to brachial plexus is technically easy with little risk of damage to vital structures It provides good intra-operative and postoperative analgesia. Many patients although preferring General Anaesthesia, accept regional blockades for its post operative analgesic effect. Peripheral nerve blocks with local anaesthetics provide superior analgesia and are associated with decreased opioid use, decreased opioid related side effects, postoperative pain relief .nk . Brachial plexus block with plain bupivacaine has delayed onset usually around 30 minutes. It is due to the local anaesthetic solution which is deposited at some distance from the nerve and must diffuse through various tissue barriers before reaching the nerve membranes. We conducted studies on sixty patients with demographic data in terms of age, sex and weight that were being similar in both the groups. The data collected was analyzed for statistical significance by student **'t'** test and chi-square test. In general, agents of intermediate potency exhibit a more rapid onset than the more potent compounds do. Onset times of approximately 14 minutes for lidocaine and mepivacaiune have been reported versus approximately 23 minutes for bupivacaine. The variation in duration of anaesthesia after the brachial plexus blockade is also considerably greater than that observed with other types of conduction block. For example: Duration of anaesthesia varying from 4 to 30 hrs have been reported for bupivacaine[1].Many substances have been added as adjuvants to local anaesthetic agents in an attempt to prolong their duration of action. It is a common practice to add adrenaline to local anaesthetics in-order to prolong the duration of action. But adding adrenaline causes sympathomimetic side effects like tachycardia and hypertension. Adjuvants like neostigmine[3],sodium bicarbonate, clonidine, enzyme[5] , buffer and carbonated solutions[6] ,opioids[7] have all been tried. Among them addition of carbonated solution and potassium to local anaesthetic have stood the test of time.Potassium salts were first used as adjuvants to local anaesthetics in 1912. They have been proved to enhance the onset of action and prolong the duration of the block[3,6]. Addition of potassium chloride to local anaesthetic solutions increases the extracellular potassium concentration and depolarizes the membrane, depending upon the concentration and this enfeeblement of membrane potential may be sufficient to prevent the passage of a propagated impulse from a weakly narcotized area into a normal segment of a nerve.Hence an attempt has been made to assess the efficacy of potassium chloride as an adjuvant to Bupivacaine (0.375%) in brachial plexus block (supraclavicular approach) in terms of onset time and duration of blockade. This prospective randomized study was done in patients undergoing upper limb surgeries with similar surgical demographical profile. A total of 60 patients within the age group of 18-60 years were included in the study , 30 in each group.Out of which the mean age of group I/KCL Group (receiving Potassium chloride with Bupivacaine) was 32± 13.0 years and the mean age of group II / Non KCL group (receiving only Bupivacaine) was 35.9±15.2 years. The difference was not statistically significant ($p>0.05$). The mean age in two groups were similar in the age distribution. Hence both groups were comparable with regard to age. Male to female ratio was almost the same. In both groups Males were predominant accounting to 21 male out of 30 members in group I and 20 males out of 30 members in group II. The difference was not statistically significant ($p>0.05$). Hence the two groups were similar on the basis of sex. The mean weight of group I (receiving Potassium chloride with Bupivacaine) was 53.73 ± 5.35 kilograms and the mean weight of group II (receiving only Bupivacaine) was 53.96 ± 7.61 kilograms The differences in average weight in two groups was also statistically insignificant ($p>0.05$). Hence both groups were comparable with regard to weight .All the patients were pre-medicated with injection Midazolam 2mg slow IV 30 minutes before surgery. The mean onset of sensory blockade in group I was 17.7+2.80 min and mean onset of sensory blockade in group II was 27.86 ± 2.55 minutes whereas the mean onset of motor blockade in group I was 14.86 ± 2.56 minutes and mean onset of motor blockade in group II was 25.46 ± 3.04 minutes. The onset of sensory and motor blockade in group I (receiving Potassium chloride with Bupivacaine) was earlier when compared to group II (receiving only Bupivacaine). The results of our study support the findings of Khosa et al [9] who showed that addition of potassium chloride to bupivacaine significantly enhanced the onset of the sensory and motor blockade. Khosa DS et al carried out a study on study on 50 patients (20-70 year old) of either sex posted for upper limb surgery under supraclavicular brachial plexus block. Brachial plexus blocks were instituted using lignocaine and bupivacaine solutions with and without potassium chloride. Addition of 0.2 mmol KCl to bupivacaine enhanced the onset of sensory blockade while onset to analgesia with lignocaine was not affected. Total duration of analgesia by bupivacaine

was moderately prolonged in presence of KCl[9]. In contrast to our study, the delayed onset of motor blockade proposed by Parris and Chamber[10] may be due to the lower concentration of bupivacaine (0.25%) when compared to our study (0.375%). The mean duration of motor block in group I (receiving Potassium chloride with Bupivacaine) was 429.1 ± 85.09 min and in group II (receiving only Bupivacaine) was 336.46 ± 81.88 min. The statistical analysis by **student's** unpaired **'t'** test showed that, the duration of motor block in group I was significantly prolonged when compared to group II ($p< 0.05$).The mean duration of sensory block in group I was 357+ 101.9 min and in group II was 256.1+ 71.48 min . The student unpaired **'t'** test showed that, the duration of sensory block in group I was significantly prolonged when compared to group II ($p< 0.05$).In our study duration of both sensory and motor blockade was significantly increased ($p< 0.001$) in group I when compared to group II. The quality of sensory blockade was significantly better with potassium chloride when compared to other group. Bromage and Burfoot also found that quality of blockade was intense when potassium was added to lignocaine in epidural blockade[11].But the quality of motor blockade with potassium chloride was the same that of plain bupivacaine group in our study. This is in contrast to Bromage and Burfoot who found that quality of motor blockade was also intense with potassium containing lignocaine when used for epidural blockade[11]. They studied using hyaluronidase and potassium chloride as adjuvants to lignocaine hydrochloride with adrenaline in epidural blockade. They observed an early onset of action and a more intense sensory blockade with potassium chloride group when compared to the control group and hyaluronidase group.The requirement of supplements was decreased in bupivacaine + KCl group when compared to other group. This implies that better quality of anaesthesia was found with KCl group. The results of our study support the findings of Parris and Chambers[10]. MR Parris, WA Chambers carried out a double blind comparision of prilocaine and prilocaine plus potassium chloride, and of bupivacaine with bupivacaine plus potassium chloride, in brachial plexus blockade (axillary approach) was obtained in two groups of 20 patients. The addition of potassium chloride made no difference to the characteristics of the block with prilocaine, but resulted in a more rapid onset of sensory loss when added to bupivacaine[10].Fink BR, Calkins DF suggested that addition of potassium chloride in physiological amounts is desirable as it shortens the latency period and prolongs the duration of blockade[12].They carried a study on conduction in isolated nerve can be accelerated by raising the extraneural potassium concentrations. Potassium and glucose are usually lacking in solutions employed for nerve conduction block. The significance of this for impulse conduction was studied in rabbit vagus nerve in-vitro, incubated for 2 hr in **Ringer's** bicarbonate solution either containing or lacking 5 mM glucose and 4 mM potassium chloride ($n=5$ for each conditions). The c-fiber action potential was recorded by periodic stimulation and the Na and K content of the desheathed nerve core was determined at the end of the incubation. In the presence of glucose, apparently normal conduction persisted for at least 2hrs, even-though the nerves incubated in potassium-free medium lost 20% of their potassium. In the absence of glucose, reversible extinction of conduction was complete in 78 ± 9 min when external potassium was present, and in 110 ± 10 min when external potassium was absent. The data suggests that lack of glucose may reinforce C-fiber inexcitability during conduction block and that inclusion of a physiologic amount of potassium chloride in the solution may also be desirable.Kircha S, Barsa I, Fink BR have demonstrated that the potentiation of lignocaine 1mg in a rats infraorbital nerve block preparation with addition of physiological adjuvants, including potassium chloride[13].They carried a study on the potentiation of nerve block in-vivo by physiological adjuvants in the solution. One hundred and seventy-four rats received a standardized 0.4-ml injection into the left infraorbital nerve and all solutions contained lignocaine 0.25 g/dl. In groups 1–4, the solutions were iso-osmotic and contained, besides sodium chloride, potassium chloride 0 or 4 mmol/litre and glucose 0 or 20 mmol/litre (0 or 360 g/dl). For groups 5–8, the solutions were hypoosmotic, containing sodium chloride to 0.6 of normal tonicity, but were otherwise identical to solutions 1–4. Presence and duration of sensory block were determined from the reflex sublingual electromyographic response to periodic homolateral and contralateral electrical stimulation of the upper lip. In groups 1–4, the presence of potassium chloride 4 mmol/litre approximately doubled the duration of blockade($p<0.001$) . Groups 5-8 showed that hypoosmolarity also douled the duration of block($p<0.001$), but hypoosmolarity and potassium chloride did not have additive effects. It is concluded that addition of KCl 4 mmol/lit to isotonic solution of lignocaine is likely to enhance their clinical effectiveness[14].McKeown DW and Scott Db. Influence of the addition of potassium to 0.5% prilocaine solution during intravenous regional anaesthesia [15].Six volunteers underwent i.v. regional anaesthesia on two occasions using 0.5% prilocaine 40 ml with potassium 0 or 4 mmol/litre added. Addition of potassium produced more rapid sensory blockade to pinprick at five of the six sites tested, although this was statistically significant at only one site ($p<0.05$) and more rapid sensory blockade to pinch with Allis forceps

at four of the six sites. Recovery of sensory blockade was rapid and only one site showed any significant effect, pinprick blockade being prolonged by potassium ($p<0.05$), although there was no overall effect. It is suggested that the addition of physiological (extracellular) concentrations of potassium to prilocaine for i.v. regional anaesthesia confers no advantage, but that further study of other agents and sites of blockade is required [9]. Aldrete JA, Barnes DR, Sidon MA, et al showed that inclusion of 180 mM potassium chloride nearly doubled the duration of peripheral nerve blockade attainable with 2% lignocaine[16]. In our study heart rate, blood pressure, SpO_2 and respiratory rate were recorded at every 5 minutes throughout the procedure. Variations in heart rate, blood pressure, SpO_2 and respiratory rate at 5 mins were statistically not significant between the two groups. KCl group showed lesser heart rate, blood pressure and respiratory rate at 15 mins implying that block was successful so lesser sympathetic stimulation. SpO_2 in both the groups were comparable.Variations in heart rate, blood pressure, SpO_2 and respiratory rate at 30 and 45 mins were statistically not significant between the two groups and were as group I. None of the patient in our study developed any significant side effects.Thus potassium chloride definitely has a role as an adjuvant to bupivacaine hydrochloride improving the quality of blockade in brachial plexus block. Apart from anatomic variations, individual patient's responses and discrepancies in the number of patients studied should also be taken into account to explain the differences among the studies. Further study of other agents and sites of blockade is required.

Conclusion

On the basis of the study one can draw the conclusion that addition of potassium chloride to bupivacaine is a safe, simple and cost effective way to hasten the onset of brachial plexus blockade and to improve the duration of analgesia and motor blockade. It also improves the quality of analgesia, whereas quality of motor blockade remains the same.

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