Section: Anaesthesia

Original Research Article

A COMPARATIVE STUDY OF ANESTHESIA WITH LIGNOCAINE WITH ADRENALINE VS ALKALINIZED LIGNOCAINE WITH ADRENALINE IN SUPRACLAVICULAR BRACHIAL PLEXUS BLOCK

Arora Varun[1], Shah Vijay Shantilal[2], Shah Dipeshkumar Pankajkumar[3], Vakil Mukesh[4]

[1]*Senior Resident, Department of Anaesthesia, Gujarat Cancer & Research Institute, Ahmedabad, Gujarat, India*
[2]*Associate Professor, Department of Anaesthesia, SAL Institute of Medical Sciences, Ahmedabad, Gujarat, India*
[3] *Assistant Professor, Department of Anaesthesia, SAL Institute of Medical Sciences, Ahmedabad, Gujarat, India*
[4]*Senior Consultant Anesthesiologist, SAL Hospital & Medical Institute, Ahmedabad, Gujarat, India*

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Corresponding Author:
Dr. Shah Dipeshkumar Pankajkumar,
Assistant Professor, Department of Anaesthesia, SAL Institute of Medical Sciences, Ahmedabad, Gujarat, India
Email: shahdipeshp@gmail.com

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ABSTRACT

Background: Alkalinization of local anesthetic solutions may enhance the onset and duration of nerve blocks. This study compares the efficacy of plain lignocaine with adrenaline versus alkalinized lignocaine with adrenaline for supraclavicular brachial plexus block.

Materials and Methods: A prospective, randomized study was conducted on 60 ASA I–II patients scheduled for upper limb surgeries. Participants were divided into two groups: Group A (n=30) received 2% lignocaine with adrenaline (1:200,000); Group B (n=30) received the same with added 7.5% sodium bicarbonate (alkalinized). Onset and duration of sensory and motor block, and complications, were evaluated.

Results: Group B had significantly faster onset of sensory and motor block ($p<0.001$) and longer duration of both blocks compared to Group A. The mean onset for complete sensory block in Group A was 14.36 ± 4.1 minute vs 8.4 ± 2.4 minute in Group B. The motor block onset (paresis) was 15.7 ± 4.2 minute in Group A vs 9.06 ± 2.2 minute in Group B. Sensory block duration was 109.4 ± 11.1 minute in Group B vs 89.9 ± 7.8 minute in Group A. Minimal complications were observed, with no major adverse events.

Conclusion: Alkalinization of lignocaine with adrenaline in supraclavicular brachial plexus block results in significantly faster onset and prolonged duration of anesthesia without increased complications.

Keywords: Lidocaine, Supraclavicular block, Alkalinization, Nerve block, Brachial plexus anesthesia

INTRODUCTION

Local anesthetics are the safest and most effective drugs employed for analgesia and pain management. Brachial plexus block has become the most common technique for anesthesia for the upper limb. Blockade of brachial plexus (C5-T1) will allow for surgical anesthesia for elbow, forearm and hand surgeries. Supraclavicular approach to brachial plexus described by Kulenkanff is the most popular approach among various approaches available.[1]

Various measures have been taken to hasten the onset and prolong the duration of local anesthetics in brachial plexus block. The addition of various adjuvants eg. dextran, hyaluronidase, potassium, steroids, alkalinization to adjust pH of the of solution.[2-6]

Observations of different researchers led to the suggestion that relative alkalinity of the local anesthetic agent can be a major determining factor in altering the onset and duration of the block. Alkalinization has been shown to improve neural blockade in animal models,[7] and research involving alkalinization of different local anesthetic solutions has been undertaken in various clinical settings in man: brachial plexus,[8-12] epidural anesthesia,[13-15] and various others.[16,17] The results produced have been conflicting, ranging from no effect to

improvement in both onset and duration of anesthesia. Technique, agent specificity, the addition of adrenaline, and the degree of change in pH have been suggested as possible explanations.[6,11] The choice of local anesthetic agent is also important in determining the latency of neural blockade.

Every local anesthetic has its pKa value that is the pH at which ionized and non-ionized portion are in equilibrium. Unfortunately, commercially available local anesthetics have lower pH set for their stability in the solution. As, lignocaine with adrenaline comes with acidic pH commercially.

With this background we decided to conduct this present study to compare the anesthesia by alkalinization of 2% lignocaine with adrenaline with sodium bicarbonate solution in upper limb surgeries. As a choice of anesthetic technique, we have used a supraclavicular brachial plexus block.

MATERIALS AND METHODS

After obtaining Institutional ethical committee approval and written informed consent from the Patients posted for upper limb surgery under Supraclavicular brachial plexus block, the study was conducted on 60 ASA I and Il patients. This study followed a Comparative Prospective Randomized design and the study was done during December 2020 to January 2022 at SAL hospital and medical institute, Ahmedabad.

Inclusion and Exclusion criteria:

Patients of either sex with age between 20-60 years, weighing between 50kg-70kg (because we used fixed amounts of local anesthetics), belonging to American Society of Anesthesiologist (ASA) grade I and II, those undergoing elective surgery for upper limb below the shoulder joint were included in the study.

Patient refusal, Pre-existing Neurological deficits, Coagulopathies, Infection at the site of injection, History of adverse reaction to local anesthetics drugs, Patient weighing less than 50 kg or more than 70 kg, opposite sided pneumothorax/collapsed or partially collapsed lung, Patient with bilateral upper limb surgery or patients who required local anesthetics on two different sites were excluded from the study.

Sample size calculation:

$\eta = \{Z - [(\alpha / 2)\ \sigma] / E\}\ ^2$

where,

η is Sample Size,

Z is Standard Normal Variate,

α is Level of Significance (0.05)

σ is Standard Deviation,

E is Error Level = 5%. At 50% significance = 1.96.

Hence, the estimated sample size is 29.54 which is approximately 30.

For the study groups each of size 30 are investigated.

Statistical Analysis: Data analysis was done using SPSS (Statistical package for the social science) software for Windows by using appropriate test of significance like chi-square test, t-test, proportion test etc. A probability value of 0.05 accepted as the level of statistical significance.

All quantitative data (continuous variable like Sensory Block onset, Motor Block onset, Paresis, Paralysis, Duration of block) presented in mean ± SD at two decimal points.

Methodology

Pre-anesthetic assessment was done. Physical examination and necessary investigations of each patient were done and reviewed. Weight of patients was measured by a Digital Weighing scale. No premedication was administered before surgery or in operation theatre.

Randomization of the study was done using closed envelop technique, by preparing 60 sealed envelopes, each containing information about either Group-A or, Group- B. syringes were prepared by anesthetist not involved with the clinical care of patient.

Groups as mentioned below:

Group-A: (n=30) Patients received 22.5 ml of 2% lignocaine hydrochloride with adrenaline (1:200,000) plus 7.5 ml 0.9% sodium chloride. (pH=4.1)

Group-B: (n=30) Patients received freshly prepared alkalinized 22.5 ml solution of 2% lignocaine hydrochloride with adrenaline (1:200,000) by addition of 1 ml of 7.5% (w/v) sodium bicarbonate plus 6.5 ml. 0.9% sodium chloride. (pH=6.3)

Alkalization: Alkalinized solution was freshly prepared prior to injection by adding required amounts of sodium bicarbonate 7.5% (w/v) to 22.5ml of lignocaine hydrochloride with adrenaline solution. pH was estimated by an electronic pH meter before and after adding sodium bicarbonate. pH was estimated once and was standardized as 4.1 (non-alkalinized) and 6.3 (alkalinized) for the study.

On arrival in operation theatre baseline values of heart rate, blood pressure and oxygen saturation (SpO2) were recorded. An intravenous line was established with 18G cannula inserted into peripheral vein for infusion of intravenous fluids. Supraclavicular Block is given using peripheral nerve stimulator, after negative aspiration of blood.

Data collection encompassed the onset and duration of sensory and motor blockade, in addition to patient monitoring parameters. The onset of block was assessed by testing sensory and motor responses every 2 minutes up to 10 minutes and then every 5 minutes until 35 minutes from the time of complete drug injection.

Onset of Sensory block was determined by the absence of response to temperature (tested by cold water), touch (cotton wisp), pin prick (23G needle), and pressure (blunt tip of a toothpick).

Onset of Motor block was assessed by observing paresis or paralysis, with the onset of paresis marked

by the loss of dorsiflexion of the wrist joint and paralysis marked by the loss of finger movements.
Duration of sensory block was defined as the time from complete onset of the block to the return of pin prick response.
Duration of motor block was measured from the loss of finger movements to the resumption of finger motion.
Throughout the procedure, patients were continuously monitored for pulse rate, blood pressure, electrocardiogram, and SpO_2, with careful observation for signs of local anesthetic toxicity at the time of injection, intraoperatively, and postoperatively. All cases were kept under observation for 24 hours postoperatively.

RESULTS

1. Age & Gender distribution of patients

[Table 1] shows mean age of patients is 39.16 ± 11.68 in Group A and 37.46 ± 10.56 in Group B. the calculated p value is >0.05 which suggests that the observed difference is not significant. It indicates that the study is age matched and the samples are drawn from the same population.
There are 25 males and 5 females in Group A and 23 males and 7 females in Group B. The calculated Chi square value is 0.416, which is not significant at 5% level of significance.
It indicates that the study is gender matched and samples are drawn from the same population.

2. Comparison of Onset of Sensory block between Group A and Group B

[Table 2] shows mean duration of loss of temperature, touch, pinprick and pressure sensation in Group A and Group B. When both the groups were compared statistically, taking in consideration all the parameters separately, the probability of the values were found to be highly significant.
The mean duration of complete onset of sensory block in Group A was 14.36 ± 4.1 minute and in Group B, it was 8.4 ± 2.4 minute.

Table 1: showing Age & Gender distribution of patients.

Sr. No.	Characteristic	Group A (n=30)	Group B (n=30)	
1	Age (in year) (Mean ± SD)	39.16 ± 11.68	37.46 ± 10.56	p-value >0.05
2	Sex of patients (Male: Femle)	25:5	23:7	Chi-square = 0.416

Table 2: Showing comparison of onset of sensory block between Group A and Group B.

Onset (in minute)	Temperature		Touch		Pin Prick		Pressure	
	Group A (n=30)	Group B (n=30)	Group A (n=30)	Group B (n=30)	Group A (n=30)	Group B (n=30)	Group A (n=30)	Group B (n=30)
0								
2		10		5				
4		18		14		11		2
6	9	2	6	7		9		5
8	17		15	4	3	9	2	13
10	3		7		16	1	8	8
15	1		2		9		14	2
20					2		5	
25							1	
30								
35								
Mean ± SD	7.83±1.82	3.46±1.16	8.53±2.1	4.6±1.81	11.96±3.32	6±1.81	14.36±4.1	8.4±2.4
p-value	<0.001		<0.001		<0.001		<0.001	

3. Comparison of Onset Motor block between Group A and Group B. PARESIS

Table 3 shows the mean duration of paresis by Group A was found to be 15.7 ± 4.2 minute. When this value was compared with mean duration of the attainment of paresis for Group B which is 9.06 ± 2.2 minute, the value was found to be highly significant.

Table 3: Showing comparison of onset of paresis between Group A and Group B.

Onset (in minute)	Group A (n=30)	Group B (n=30)
0		
2		
4		1
6		3
8	1	10
10	6	14
15	12	2
20	10	
25	1	
30		
35		
Mean ± SD	15.7 ± 4.2	9.06 ± 2.2
p-value	<0.001	

Table 4: Showing comparison of Onset of Paralysis between Group A and Group B.

Onset (in mins)	Group A (n=30)	Group B (n=30)
0		
2		
4		
6		
8		
10	1	3
15	3	13
20	9	11
25	15	3
30	2	
35		
Mean ± SD	22.33 ± 4.42	17.36 ± 4.01
p-value	<0.001	

[Table 4] shows Complete paralysis was achieved in a mean duration of 17.36 ± 4.01 minute by Group B and the value was found to be significant in relation to Group A who attained complete paralysis in a mean duration of 22.33 ± 4.42 minute.

4. Comparison of Duration of Sensory and Motor Block between Group A and Group B

Diagram 1 depicts that the duration of sensory block in Group B was 109.43 ± 11.13 minute as compared to Group A which was 89.9 ± 7.78 minute which is statistically significant.

Duration of motor block in Group B was 94.90 ± 10.15 minute and in Group A it was 79.56 ± 5.39 minute which is also statistically significant.

Also, duration of motor block was less then sensory block in both the groups.

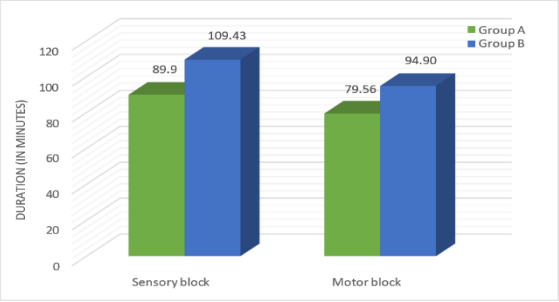

Diagram 1: Showing the mean duration of sensory and motor block in both the groups.

5. Complications

Out of 60 cases, tachycardia was seen in total 5 patients, 3 in Group A and 2 in Group B. Arterial puncture which is common complication was encountered in 6 cases, 4 cases in Group A and 2 cases in Group B. There were no any cases of pneumothorax, phrenic nerve palsy, Horner's syndrome or local anesthetic toxicity during our study.

DISCUSSION

The present study is an attempt to compare onset of anesthesia with lignocaine hydrochloride at different pH with regards to brachial plexus block by supraclavicular approach.

A local anesthetic is a drug which reversibly blocks the transmission of peripheral nerve impulses. Local anesthetics are usually injected as acid solutions of the hydrochloride salt. In this form amine group is ionized and the drug becomes soluble in water and therefore suitable for injection. Alkalization appears most effective with commercially prepared epinephrine containing local anesthetics, because these solutions are formulated at a lower pH. Thus, the relative effects of raising pH are larger than with plain local anesthetic solutions.[18]

Catchlov et al,[19] demonstrated into in vitro studies that the exposure of axons to equal amounts of carbonate or hydrochloride lignocaine, resulted in a tenfold increase in the degree of block for the carbonate salt compared to the hydrochloride salt.

Ritchie et al,[20] postulated that the non-ionized base form is more soluble in connective tissue than is the ionized form and more readily diffuses through the nerve sheath. This component of the local anesthetic binds to intracellular receptor sites and blocks nerve conduction once diffusion has occurred.

In our study the change in pH was from 4.1 in the control group to 6.3 in the study group. This change in pH after addition of sodium bicarbonate was adequate to achieve the benefits of alkalinization. The variation in the pH achieved with alkalinization was different for different studies. In various studies reviewed, the rise in pH achieved ranged from 3.2 in control to 7.15 in case groups. The variation was because of different anesthetic volume and addition of variable amount of sodium bicarbonate.

The demographic and operative data in the groups were comparable. Male: Female ratio in study was 48:12 with 25:5 in Group A and 23:7 in Group B respectively.

In this study, both the sensory and motor components of regional anesthesia were observed.

1. Onset of Sensory Block

The onset of sensory block was estimated by temperature, touch, pinprick, and pressure sensation. We found that in both groups the first sensory parameter to be lost was temperature which was followed by touch, pinprick and lastly pressure sensation. Cases in Group B took minimum time in comparison to cases in Group A for the loss of all the sensory parameters individually.

The 41.50% reduction in latency of sensory block observed in our study with group B is almost similar to 43.59% reduction noted in the study done by Dr

Ruby Mehta et al.[21] In their study, they used 2% lignocaine and randomized 3 groups taking 0 ml, 1 ml and 2 ml of 7.5% (w/v) sodium bicarbonate respectively. Radha Sukhani et al,[22] in their study they compared 1% lidocaine hydrochloride with 1.1% lidocaine carbonate. The reduction in the onset of time they attributed was due to greater rapidity of spread, tissue penetration and intraneural diffusion more with the carbonate than with hydrochloride salt. Schulte-Steinberg et al,[23] when in their study compared 1.73% carbonated lignocaine (pH=6.5) with 2% lignocaine hydrochloride (pH=4) they found latency for complete analgesia to be averaged 4-5 minutes for carbonated solutions and 4-22 minutes for hydrochloride solutions. Despite various technical difficulties surgery was started within 10 minutes of first injection with carbonated solution while with hydrochloride solution a waiting period of approximately 15 minutes was required. Gormley et al,[24] demonstrated in their study using 1.5% lignocaine with adrenaline (pH=4.2) and alkalinized 1.5% lignocaine with adrenaline (pH=7.2) on axillary plexus block that there was a significant reduction in time to useful anesthesia and reduced requirements for the adjuvants in the alkalinized group. Dhananjay Ambike et al.25 adjusted pH of lignocaine 1.5% with adrenaline from 5.91 to 6.72 by the addition of 2 ml of sodium bicarbonate, group receiving alkalinized solution had significant shorter onset of sensory blockade. DiFasio et al,[13] adjusted the pH of 1.5% lignocaine with adrenaline from 6 to 7 by addition of 2 mEq of sodium bicarbonate. The mean onset time of alkalized solution was 2.68 minute and was significantly shorter than the lignocaine with adrenaline group.

Dr Ruby Mehta et al,[21] took temperature, fine touch, pin prick and deep pressure sensation as a parameter for sensory block evaluation same as ours. Dr M.D Bedder et al,[26] Dr Mark Y.Chow et al,[27] Radha Sukhani et al,[22] and Dr Ramesh Koppal et al,[28] have used pin prick as a parameter of evaluation of sensory block. Dr Mark Y Chow et al,[27] had tested sensations in area according to nerve distribution.

The onset of sensory blockade according to our study for temperature was 7.83±1.82 minute in Group A and 3.46±1.16 minute in Group B, for touch 8.53±2.1 minute in Group A and 4.6±1.81 minute in Group B, for pin prick 11.96±3.32 minute in Group A and 6±1.81 minute in Group B, for pressure 14.36±4.1in Group A and 8.4±2.4 minute in Group B. In Dr Ruby Mehta,[21] the corresponding findings for temperature was 5.8±2.44 minute (control) 3.25±1.48 minute (study), touch 9.1±3.64 minute (control) 5.1±1.83 minute (study), pin prick 12.1±4.43 minute (control) 6.7±2.07 minute (study) and deep pressure 18.35±6.80 minute (control) 10.35±2.97 minute (study). The early onset in our study is probably due to higher concentration of lignocaine. We used 22.5ml of 2% lignocaine in our study as compared to 20ml of Lignocaine by Dr Ruby Mehta et al.[21] Another difference was the pH of our solution was 6.4 as compared to 6.2 in their study.

Dr.MD Bedder et al,[26] studied Bupivacaine as a sole local anesthetic agent with two solutions of different pH. They did not find significant difference in the solution with the higher pH. The logical reason for this could be the difference in the physicochemical properties of the Bupivacaine as compared to Lignocaine. Precipitation and pH adjustment study by Peter Freund et al18 suggests that lignocaine is particularly suited for alkalinization. This is because it can be alkalinized to a pH close to the pKa value without the occurrence of precipitation.

Gormley W.P,[24] studied the effect of alkalinization of local anesthetic in axillary brachial plexus block. They noticed significant reduction in onset of anesthesia and also suggested that there is reduction in requirement of systemic supplementation to the block by adjuvant like sedatives and analgesic because of the profound anesthesia. That means that the quality of anesthesia improves with alkalinization of the local anesthetic agent. This finding is similar to our observation. A similar advantage was observed by Quinlan et al.[12]

2. Onset of Motor Block

In assessing the onset of motor block, the onset time of paresis was the time taken from the injection to loss of dorsiflexion of wrist joint and paralysis was from the time of injection to complete loss of finger movements.

Mean value for the onset time of paresis is 15.7 ± 4.2 minute in Group A and 9.06 ± 2.2 minute in Group B. Cases in Group B showed significant reduction by 42.29% from Group A. This reduction in paresis was statistically significant ($p<0.0001$)

Complete paralysis was achieved at 22.33 ± 4.42 minute in Group A and 17.36 ± 4.01 minute in Group B. Mean values of onset of paralysis in cases in Group B showed reduction in onset by 22.25% from the Group A value.

Dr Ruby Mehta,[21] observed onset time of paresis was significantly reduced by 40.92% and paralysis by only 25.20% from the control value. The results were onset of paresis at 20.65±5.22 minute (control), 12.2±2.44 minute (study) and for paralysis 30.15±8.56 minute (control) 22.55±8.58 minute (study).

Dhananjay Ambike et al,[25] observed motor blockade 5.00 ±1.5 (study group) as compared to 10.10±2.0 (control group).

These findings are contrary to the study of Radha Sukhani et al,[22] who observed that the onset of paralysis was significantly faster with the carbonated lidocaine (pH=6.8) than with the hydrochloride (pH=6.5). They found a 30% reduction in onset time for paresis and 50% reduction in onset time for paralysis with carbonated lignocaine.

Quinlan et al,[12] while working with alkalinized Mepivacaine on axillary block concluded that no significant difference in time to onset of paresis was

noted but it significantly shortened the time to onset of both proximal and distal paralysis.

In contrast to our study, Martin R et al,[29] concluded that in the context of his study carbonated lidocaine, was not significantly different from lidocaine hydrochloride in onset of block.

Mark Chow et al,[27] compared lidocaine with adrenaline solution with adrenaline solution pH 6.24 with alkalinized lidocaine with adrenaline solution pH 7.15 for axillary plexus block. He concluded that the difference in overall success and adequacy of axillary plexus anesthesia did not reach statistical significance between the two groups.

From our study, we can conclude that alkalization of lignocaine does improve the onset of sensory and motor block. As the mean onset of sensory block was less in both groups it can be fairly said that the onset of sensory fibers precedes the onset of motor fibers.

3. Duration of block

In the present study, duration of sensory block was taken from time of complete onset of sensory block till the patient responds to pin prick and the duration of motor block was taken from the time of loss of finger movements till the patient started moving the fingers.

Mean duration of sensory block for Group A was 89.9±7.78 minute and for group B 109.43±11.13 minute.

Mean duration of motor block for group A was 79.56 ± 5.39 minute and for group B 94.90 ± 10.15 minute. Increase in values was significant in both sensory and motor block duration.

Dhananjay Ambike et al,[25] in their study observed duration of analgesia (sensory block) in the group receiving alkalized lignocaine Group B was 110 ± 5.0 minute and motor block of 102 ± 4.2 minute as compared to the group lignocaine with adrenaline Group A 88 ± 8.2 minute and 81 ± 7.5 minute respectively. This difference was statistically significant.

Dr Ruby Mehta,[21] demonstrated that alkalization of lignocaine hydrochloride improves the duration of motor block while having no effect on sensory block.

Ririe DG et al,[30] performed median nerve blocks on 10 volunteers to compare the efficacy of 1% plain lidocaine with 1% lidocaine mixed with sodium bicarbonate 0.1 mmol/litre. Their data suggested that addition of bicarbonate to lidocaine for median nerve block significantly increased the rate of motor block.

Difazio et al,[13] compared pH adjusted lidocaine solution for epidural anesthesia and demonstrated that the degree of improvement in time to onset and duration is directly related to extend of difference in the pH of the solutions.

Radha Sukhani et al,[22] in their study observed that the duration of anesthesia was virtually similar with 1% lignocaine hydrochloride and 1.1% lignocaine carbonate solution.

From our study we can conclude that alkalization of lignocaine does improve the duration of sensory and motor block. As the mean duration of motor block was less in both groups it can be fairly said that the recovery of motor fibers precedes the recovery of sensory fibers.

4. Complications

The significant reduced complication can be explained by the use of proper technique and less volume of drug in our study.

Schulte-Steinberg et al,[23] in the comparative study of lignocaine hydrochloride and lignocaine carbonated observed one case of phrenic nerve palsy in patient receiving carbonated solution.

Moore found 40-60% incidence of phrenic nerve palsy when he used 50ml of local anesthetic solution for brachial plexus block. He also reported 70-90% cases of stellate ganglion block in his case study.[31]

Limitations

Limitations are mentioned below were faced while performing this study:

1. We used fixed amounts of drugs.
2. Cases were observed only for 24 hours.
3. Small sample size (total 60) in our study.
4. We did not study the onset of block according to the nerve distribution.

CONCLUSION

Based on our results we can conclude that:

Alkalinization using sodium bicarbonate in Lignocaine with adrenaline solution provides faster onset of sensory and motor block.

It prolongs the duration of sensory and motor blockade

It has stable hemodynamic profile without any noticeable side-effects.

We recommend the use of alkalinized solution as it provides faster onset and prolongs the duration of action.

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