International Journal of Medicine Research
ISSN: 2455-7404
www.medicinesjournal.com
Volume 3; Issue 2; April 2018; Page No. 50-55

Intravenous regional anaesthesia: A clinical evaluation of atracurium besylate, lignocaine hydrochloride combination and its comparison with lignocaine hydrochloride alone

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Abstract

Objective: To compare Lignocaine Hydrochloride and Atracurium Besylate combination with Lignocaine Hydrochloride Alone for Onset and Recovery of Sensory and Motor Block in Intravenous Regional Anaesthesia (IVRA) (Bier's Block).

Method: 75 patients of ASA I and II scheduled for routine and emergency upper extremity surgeries (lasting upto 1 hour) were randomly selected. Patients were divided into three groups (25 in each) – Group A (0.5% lignocaine hydrochloride (preservative free) 40ml)-Control Group. Group B (0.5% lignocaine hydrochloride 40ml + atracurium 2mg) Study Group. Group C (0.5% lignocaine hydrochloride 40ml + atracurium 4mg) Study Group. After preoperative preparation, a padded double cuff tourniquet was positioned around the upper arm, on the side to be operated. Exsanguination of the limb was done, and then proximal tourniquet was inflated to 50 mm Hg above the systolic pressure. According to the groups, the drug was injected. Onset of sensory and motor block, degree of motor block was assessed. After complete analgesia, distal cuff was inflated 50mm Hg above the systolic pressure and proximal cuff deflated. After the completion of surgery, the cuff was deflated. Haemodynamic parameters (Pulse rate, SBP, DBP, RR), any complications and recovery of sensory and motor block was assessed.

Results: The mean time for the onset of sensory block was 7.04 $\pm$ 1.59 mins, 5.52$\pm$ 1.19 min and 4.64 $\pm$ 1.29 min in group A,B,C respectively. The mean onset of motor block was 13.84 $\pm$ 2.13 min, 6.92 $\pm$ 1.26 min, 5.88 $\pm$ 1.62 min in group A,B,C respectively. The onset of sensory and motor block was early in the study group as compared to control group and was statistically significant. Grading of motor block was excellent in study group. Group B and C had longer sensory and motor recovery time and was statistically significant. Haemodynamic parameters did not show any difference in three groups. No complications were noted.

Conclusion: 0.5% lignocaine hydrochloride 40ml produces good sensory and motor blockade during IVRA. Addition of atracurium along with lignocaine hydrochloride shortens the onset of sensory and motor block and also improves the degree of motor block and increases the recovery time of sensory and motor block. Addition of atracurium to lignocaine is advantageous during IVRA in regard to onset of block and muscle relaxation.

Keywords: intravenous regional anaesthesia, lignocaine hydrochloride, atracurium besylate, bier's block, double cuff tourniquet

Introduction

The technique of Intravenous Regional Anaesthesia (IVRA) or Bier's Block was first introduced in 1908 by August Bier for anaesthesia of hand and forearm [1]. Bier's block can be used for brief surgical procedure or manipulation of upper or lower extremity.

IVRA is an anaesthetic technique for surgical procedures on the body's extremity where a local anaesthetic is injected intravenously [2, 3]. The technique usually involves exsanguinations, which forces blood out of the extremity followed by application of pneumatic tourniquet to safely stop blood flow. The anaesthetic agent is introduced into the limb and allowed to set in. [4]

Several local anaesthetics like 0.5% lignocaine, 0.5% procaine, 0.5% chlorprocaine, 0.5% mepivacaine, 0.25% bupivacaine and recently ropicavaine 0.2% were tried [5]. But still lignocaine have remained popular agents for IVRA.

Regional anaesthesia have several advantages over general anaesthesia. In regional anaesthesia patient's consciousness and protective airway reflexes are preserved. It has lower cost. It provides both intra-operative anaesthesia and analgesia [6]. As the effect of anaesthetic drugs are limited to the part of the body to be operated on, effects like pulmonary complications and venous thromboembolism, which are associated problems with general anaesthesia, are usually very less with regional anaesthesia. It is useful as an outpatient anaesthesia procedure [7]. It is associated with less risk in patients with full stomach requiring emergency surgery and also for poor risk patients. IVRA is easy and provides reliable surgical anaesthesia but has a drawback of tourniquet pain and no post operative analgesia.

Hoyle solved the problem of tourniquet pain by using double cuff pneumatic tourniquet [8]. This technique is particularly advantageous to use in critically ill patients having intercurrent systemic diseases, associated head and neck injury, patients who are not fit for general anaesthesia and also in patients with full stomach requiring emergency surgery. These are all advantages inherent to regional anaesthesia [9]. IVRA has some added advantages over nerve blocks, i.e. it is easy to perform, does not require special training. It has rapid

onset of anaesthesia and failure rate is almost nil. It is cost effective, so especially good for developing countries. It is an effective alternative in place where facilities for general anaesthesia are not available, useful for outpatient and provides bloodless field for surgery. There are certain disadvantages associated with IVRA, like sometimes less effective blockade, poor muscle relaxation, tourniquet discomfort, leakage of local anaesthetic, toxic reaction to local anaesthetic during injection and just after deflation of tourniquet, rarely associated with nerve injury, gangrenous changes in finger following prolonged tourniquet application, cardiac asystole within 15 seconds to tourniquet release [10, 11]. Various modifications are made to prevent these complications like proper exsanguinations of limb, use of double cuff pneumatic tourniquet, frequent changing of pressure in cuff, slow injection rate, avoid deflation of tourniquet within 20 minutes of injection, intermittent deflation and inflation technique at the end of procedure to avoid peak plasma level of local anaesthetic.

Many adjuncts can be added to local anaesthetics for IVRA [12]. Agents like opiods (fentanyl, meperidine) [13]. clonidine, dexmedetomidine, muscle relaxants (atracurium, pancurium), tramadol, NSAIDS, ketamine [14] have been used. Prippenac G found in his study that addition of small amount of muscle relaxant provides good relaxation [15]. Similar report was given by study of Elhakin M and Sadek RA. They also found that addition of 2 mg atracurium provided better operative condition, effective anaesthesia and slight postoperative analgesia [16].

Still the use of muscle relaxants are limited in IVRA because of residual neuromuscular blockade, after deflation of tourniquet [17]. To avoid this problem, relaxant used should have shorter duration of action than the duration of cuff inflation. As atracurium undergoes Hoffmann elimination under normal physiological temperature and pH (37^0C and 7.4 pH) and should decay spontaneously in the isolated arm.

Sappan P found that duration of action of atracurium increased in presence of lower and upper limb tourniquet possibly because of blockade of circulation and inhibition of Hoffman elimination, secondarily to metabolic acidosis and decrease in temperature of the ischemic limb [18].

In view of these contradictory reports regarding use of muscle relaxant in IVRA [19], it was decided to study the effect of addition of muscle relaxant (atracurium) with lignocaine for IVRA in patients undergoing upper limb surgery in our institution.

Method

The study was carried out in the Department of Anaesthesiology, M.G.M. Medical College, Indore (M.P.). It was a prospective, randomized comparative study done over a definite period of time over 75 patients posted for upper extremity surgeries (lasting for not more than 1 hour). The study included 75 patients of age 18 to 65 years of ASA I & II. Exclusion criteria included Patients with history of known hypersensitivity to local anaesthetic agents, severe peripheral vascular and neurological disease where use of tourniquet is undesirable, hemolytic diseases, cardiovascular disease, hypertension, obese, epilepsy and deranged renal function.

Grading of sensory block

After permission from ethics committee and proper written informed consent from the patient, randomization was done by computer generated numbers.

A thorough preanaesthetic checkup was done prior to the procedure. Thorough history, clinical examination and routine investigations and haemodynamic parameters were noted. The technique was explained to all the patients. The patients were asked to undergo a preoperative fasting of 6 hours and xylocaine sensitivity was done.

The patients were allocated randomly into three groups (A, B and C) (25 patients in each group) by computer generated numbers. Group A patients received only lignocaine 0.5% 40 ml. preservative free (Xylocard) and served as a control group. Whereas Group B and C patients apart from lignocaine 0.5% 40 ml. received injection atracurium 2 mg and 4 mg respectively.

The patient was reassessed preoperatively. Pulse and B.P. were recorded. Grip strength of both the hands was tested. Intravenous line was placed in the opposite arm.

A padded double cuff tourniquet was positioned around the upper arm, on the side, to be operated. A 22 gauge butterfly scalp vein was placed in a suitable peripheral vein in the forearms. It was properly fixed and connected to slow normal saline drip to keep the needle patent. For exsanguinations the limb was either elevated to 90^0 for 5 minutes or the rubber bandage (Esmarch) is wound spirally up from hand to reach tourniquet or then the proximal tourniquet was inflated to 50 mm Hg above the systolic pressure. Then the previously prepared calculated dose of 0.5% lignocaine 40 ml. was injected through butterfly needle in group A patients, 0.5% lignocaine 40 ml. and 2 mg atracurium in group B patients, 0.5% lignocaine 40 ml. and 4 mg atracurium in group C patients. Blood pressure and pulse were recorded just after injection of the drug and thereafter every 5-10 minutes.

The effectiveness of the sensory block (by pin prick), degree of motor block or muscle relaxation (by finger movement and grip strength) was assessed at 1^{st}, 3^{rd}, 5^{th}, 10^{th}, 15^{th}, and 30^{th} minutes. After development of complete analgesia, degree of muscle relaxation was further assessed using single twitch and tetanic with peripheral nerve stimulator [20].

After establishment of complete analgesia, distal cuff was inflated to 50 mm Hg above systolic pressure to avoid tourniquet discomfort and proximal cuff was then deflated. Throughout the procedure tourniquet pressure was monitored whenever fall in tourniquet pressure was found, it was again inflated t o avoid leakage of drug.

During cuff deflation and 30 minutes thereafter patients were closely observed for any sign of untoward reaction, like disturbed pattern of respiration, decreased tidal volume, diplopia, blurred vision, light headness, dizziness, perioral numbness, tinnitus, altered hearing and slurred speech. Patients were also assessed for recovery of sensory and motor blockade. After that total tourniquet time, time of sensory and motor recovery following release of tourniquet was noted.

At the end of the procedure, every patient who underwent this procedure was instructed to come for follow-up if any signs of nerve injury or ischemia (like parasthesia, paresis or paralysis and gangrene) would develop in that extremity.

Sensory assessment done by pin prick.

Table 1

a.	Excellent	Complete anaesthesia (Lack of any sensation to pin prick).
b.	Good	Complete anaesthesia (touch sensation may be retained, but no pain to pin prick).
c.	Fair	Adequate analgesia with slight discomfort but tolerate without any supplementation.
d.	Poor	Inadequate analgesia requiring supplementation; either sedative, systemic analgesics or general anaesthesia.

Motor assessment was done by movement of fingers, grip strength and response to nerve stimulator.

Grading of Motor block

Table 2

a.	Excellent	Completely limp, absent single twitch response and absent tetanic response to 30 Hz.
b.	Good	Minor movements of digits; response to single twitch weakly present but absent tetanic response at 30 Hz.
c.	Fair	Weak grip possible; response to single twitch present but weak response to tetanic stimulation at 30 Hz.
d.	Poor	Good grip strength and movements of the fingers with good response to single and tetanic stimulation.

Monitoring of Haemodynamic Parameters (Pulse Rate, SBP, DBP, RR) was done preoperatively, after injection of the drug, intraoperatively every 10 minutes and just after release of tourniquet and every 10 minutes for 30 minutes thereafter.

Statistical Method

Continuous variables were described as Mean± S.D. and the difference between the three groups were analysed using one–way ANOVA followed by postHoc tukey test. Intragroup comparison of perioperative values were analysed using paired 't' test. Categorised variables were described as frequency and analysed by Pearson's-chi-square test. p value < 0.05 was considered significant. All the analysis was performed using SPSS software.

Results

The age and weight wise distribution of cases in all the three groups are almost identical and the difference was found to be statistically insignificant (p > 0.05).

Table 3: Variation in Pulse Rate

Group	Statistical Analysis	Preoperative (Per min.)	After injection of drug (per min.)	Intraoperative (per min.)	After release of tourniquet (per min.)
A	Mean± S.D. P Value Result	87.84±7.25	87.68±7.43 >0.05 N.S.	89.12±7.05 >0.05 N.S.	88.24±6.94 >0.05 N.S.
B	Mean± S.D. P Value Result	86.24±10.46	85.76±10.33 >0.05 N.S.	85.52±10.89 >0.05 N.S.	84.92±9.78 >0.05 N.S.
C	Mean± S.D. P Value Result	87.68±6.65	86.64±6.47 <0.05 Significant	86.40±7.46 <0.05 Significant	84.72±8.02 <0.05 Significant

Table 4: Variation in systolic blood pressure

Group	Statistical Analysis	Preoperative (Per min.)	After injection of drug (per min.)	Intraoperative (per min.)	After release of tourniquet (per min.)
A	Mean± S.D. P Value Result	121.52±8.07	122.72±9.86 >0.05 N.S.	124.56±10.73 >0.05 N.S.	123.52±9.61>0.05 N.S.
B	Mean± S.D. P Value Result	126.64±14.68	126.8±14.12 >0.05 N.S.	126.24±12.55 >0.05 N.S.	126.20±13.75 >0.05 N.S.
C	Mean± S.D. P Value Result	122.88±10.39	122.64±10.75 >0.05 N.S.	121.84±10.41 >0.05 Significant	120.72±10.75 >0.05 Significant

Table 5: Variation in diastolic blood pressure

Group	Statistical Analysis	Preoperative (per min.)	After injection of drug (per min.)	Intraoperative (per min.)	After release of tourniquet (per min.)
A	Mean± S.D. P Value Result	79.2±5.97	79.2±5.97 >0.05 N.S.	80.08±6.62 >0.05 N.S.	78.56±5.39 >0.05 N.S.
B	Mean± S.D. P Value Result	81.12±5.48	81.28±5.41 >0.05 N.S.	80.8±6.11 >0.05 N.S.	81.52±5.51 >0.05 N.S.
C	Mean± S.D.P Value Result	80.16±4.39	80.08±4.41 >0.05 N.S.	79.84±4.12, >0.05 N.S.	79.28±4.46>0.05 Significant

From Table No. 3, 4 & 5 the mean pulse rate, systolic blood pressure and the diastolic blood pressure preoperatively, after the injection of drug, intraoperatively and after release of tourniquet were found to be statistically insignificant (p>0.05) in group A & B. However, the parameters were found to be reducing significantly in group C.

The tourniquet time (duration from inflation of tourniquet to deflation of tourniquet at the end of the surgery) was also monitored. The mean tourniquet time was 45.52±11.37 minutes, 64.4±8.05 minutes and 52.4±11.39 minutes in group A, B and C respectively.

Table 6: Statistical Comparison of Onset of Sensory Block

Statistical Analysis	A ↔ B	B ↔ C	A ↔ C
Mean±S.D.	7.04±1.59↔5.52±1.9	5.52±1.19↔4.64±1.29	7.04±1.59↔4.64±1.29
P Value	<0.05	>0.05	<0.05
Result	Significant	Not Significant	Significant

It was observed that there was statistically significant difference of onset of sensory block between the study group (B and C) and control group (A) and the onset of sensory block was early in study group as compared to control group.

Table 7: Statistical comparison of onset of motor block

Statistical Analysis	A ↔ B	B ↔ C	A ↔ C
Mean±S.D.	13.84±2.13↔6.92±1.26	6.92±1.26↔5.88±1.62	13.84±2.13↔5.88±1.62
P Value	<0.01	>0.05	<0.01
Result	Highly Significant	Not Significant	Highly Significant

It was observed that the difference of onset of motor block was statistically highly significant between control group and study group, and was not significant between the two study groups.

Onset of motor block was shorten in patients who received atracurium besylate.

Table 8: Showing grading of motor block

Motor grading	Total number of cases					
	Group A		Group B		Group C	
	No.	%	No.	%	No.	%
Excellent	10	40	21	84	22	88
Good	13	52	4	16	3	12
Fair	2	8	0	0	0	0
Poor	0	0	0	0	0	0

Motor block was excellent in 10 patients in group A, 21 in group B and 22 in group C. It was good in 13 cases, 4 cases and 3 cases in group A, B and C respectively. Fair in 2 cases of group A. Poor blockade was not found in the study.

Table 9: Statistical Comparison of sensory recovery

Statistical Analysis	A ↔ B	B ↔ C	A ↔ C
Mean±S.D.	6.88±0.98↔8.0±1.20	8.0±1.20↔10.44±2.10	6.88±0.98↔10.44±2.10
P Value	<0.05	<0.05	<0.01
Result	Significant	Significant	Highly Significant

Group B and C had markedly longer sensory recovery time as compared to group A. These differences were found to be statistically significant ($p<0.05$).

Table 10: Statistical Comparison of motor recovery

Statistical Analysis	A ↔ B	B ↔ C	A ↔ C
Mean±S.D.	3.28±0.61↔14.2±2.55	14.2±2.55↔17.08±1.35	3.28±0.61↔17.08±1.35
P Value	<0.01	<0.05	<0.01
Result	Highly Significant	Significant	Highly Significant

Group B and C had markedly longer motor recovery time as compared to group A and was statistically highly significant.

It was observed that quality of sensory block was excellent in 15 patients in Group A as compared to 18 patients in Group B and 19 patients in Group C. it was good in 5 patients each in all the groups. It was fair in 3 in Group A, 2 cases in Group B and 1 case in Group C. It was poor in 2 in Group A and required intravenous ketamine.

All the patients were closely monitored throughout the procedure and upto 30 minutes following release of tourniquet. No untoward reactions were seen in any case in this study. All the patients were also followed for a period of 24 hours in the postoperative period. None of the patients had any complication in the postoperative period also.

Discussion

The study was carried out in 75 patients of ASA grade I & II of either sex, posted for various surgical procedures involving upper extremities, in routine or emergency hours. All patients were comparable in regards to their demographic profile – age, sex and weight.

Exsanguinations of the extremity was done either by Esmarch bandage or by elevating limb for 5 minutes. Proper exsanguinations is important for achieving efficient analgesia, as exsanguinations prevents the dilution of the local anaesthetics (so higher concentration is available for its effect) and on release of tourniquet, there is no chance of dumping a large volume of blood containing local anaesthetics into the general circulation (thus preventing toxicity). The distribution of drug is also better in collapsed veins. This was suggested

by Holmes [6]; Colbern *et al* [2]; El-Hassan *et al* [21]. Esmarch's bandage is not a good method of exsanguinations in painful and infected conditions. Holmes [6]. Cox JMR [3]. Torrance *et al* [22] preferred gravitational drainage by simple elevating the limb and found it to be as effective as exsanguinations by Esmarch's bandage, especially in painful and infected conditions [23].

A double cuffed pneumatic tourniquet was used in all cases. After the onset of sensory analgesia the distal cuff was inflated and proximal one deflated, thus avoiding tourniquet discomfort. Torrance *et al* [22] used double cuffed pneumatic tourniquet and found it to be extremely effective. The pneumatic tourniquet was inflated upto 50 mm Hg above systolic blood pressure. Ware RJ [5] have recommended inflation of tourniquet upto this pressure.

In this study, lignocaine hydrochloride 0.5% was chosen because this drug has been widely employed and most thoroughly studied, in respect to its action, sensory and motor analgesia, duration, side effects and toxicity [24]. All the newer, local anaesthetic agents introduced subsequently were compared to lignocaine hydrochloride, taking it as a standard, the volume of lignocaine was also fixed (40 ml) for all cases included in this study. As most of the earlier workers Elhakin *et al* [25] used 0.5% lignocaine 40 ml for IVRA on upper limb, because it would cause better venous filling and hence would diffuse out into the tissues it a greater amount.

Colbern *et al* [2] favoured lignocaine as a drug of choice because of wide margin of safety. Atracurium, a muscle relaxant was used in this study. As it has shorter duration of action and undergoes Hoffman elimination at normal temperature and pH, so there is no or less risk of residual neuromuscular block after release of tourniquet [26, 27].

Mean tourniquet time was 45.52±11.37 minutes in group A, 64.4±8.05 minutes in group B and 52.4±11.39 minutes in group C. None of the operations took more than 60 minutes. No surgery was over before 20 minutes. Many workers strongly advocated that the release of tourniquet should never be attempted earlier than 20-30 minutes after injection of the local anaesthetic drug [6].

The mean time for the onset of complete analgesia was longer in group A as compared to group B and C who received atracurium besylate along with lignocaine hydrochloride G Mir, ANaqeeb, T Waani also noted similar findings [27].

It is evident that addition of atracurium with lignocaine hydrochloride for IVRA definitely lowers the mean onset time for complete analgesia. However not much benefit is achieved by increasing the dose of atracurium from 2 mg to 4 mg as has been studied (Group B and C) [26, 28].

Comparison of onset of motor block in group A with groups B and C. it was found that onset time of motor blockade was statistically highly significant ($p<0.01$). When both the study groups B and C were compared, again the difference was statistically significant ($p < 0.05$). Other workers (Elhakeim *et al* [25] and Unal *et al* [19], Gupta S [26].) have reported a shorter mean time for onset of motor blockade, when they used atracurium with lignacaine as compared to lignocaine alone. Our results are well comparable with their findings.

The mean time for sensory recovery was 6.88±0.98 minutes in group A as compared to 8±1.2 minutes in group B and 10.44±2.10 minutes in group C patients. When the sensory recovery time in both the study group (B and C) was compared, it was statistically found to be just significant ($p < 0.05$). Similar results seen by Prasad DB, Anjan T [16].

The probable explanation for an increase in the recovery time for sensation in the study group patients have been given by Elhakim M and Sadek RA [25], that it was the effect of atracurium on muscle spindles, reducing the central input from these structures. Muscle spindles are sensory end organs of the skeletal muscles and their principle function is to signal the exact length of muscle fibres. Probably atracurium interferes with the muscle spindles activity, resulting in loss of muscle tone control of voluntary movement with a decrease in nervous input to the brain.

The group B and C patients markedly took longer time for motor recovery as compared to group A patients and the difference in the motor recovery time was found to be highly significant ($p < 0.01$)

McGlone *et al* [29] reported mean recovery time of motor blockade as 25.8 minutes, when they used 2 mg atracurium along with 0.5% prilocaine. Elhakim *et al* [25] also reported a mean recovery time of 22 minutes, when they used atracurium 2 mg along with 0.5% lignocaine 40 ml. in the present series, the mean recovery time is shorter as compared to the findings of above workers.

All the patients were closely monitored throughout the procedure and upto 30 minutes following release of tourniquet. No untoward reactions were seen in any case in this study.

Conclusion

The simplicity of block, cost effectiveness and relative safety makes it an attractive alternative to brachial plexus block for upper extremity surgeries. 0.5% lignocaine produces good sensory and motor block during IVRA. Addition of atracurium shortens the onset of sensory and motor block and improves the degree of motor block. However, it increases the recovery time of sensory and motor block. Increasing the dose of atracurium did not show added benefit. Hence, it can be concluded that addition of atracurium to local anaesthetics increases the onset of sensory and motor block and gives good muscle relaxation.

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