Intravenous Regional Anesthesia with Drug Combinations of Lidocaine, Ketamine, and Atracurium

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Abstract

Background: The aim of the study was to show that a combination of lidocaine, ketamine, and atracurium provides better intravenous regional anesthesia (IVRA) and to examine the possible clinical advantages of using muscle relaxants (i.e., atracurium) with intravenous regional anesthesia.
Materials and Methods: In a prospective, double-blind, randomized, sequential allocated study, 60 patients of physical status ASA-1 in the 20–50-year age group were divided into three groups of 20 patients each. Group I received 0.5% lidocaine (150 mg), group II received 0.5% lidocaine (75 mg) and 0.1% ketamine (30 mg), and group III received 0.25% lidocaine (75 mg), 0.1% ketamine (30 mg), and atracurium (2 mg).
Results and Conclusion: The addition of 0.1% ketamine to 0.25% lidocaine resulted in rapid onset of sensory block, motor block, and lower visual analogue scale scores for pain compared with the group that received lidocaine only. The addition of atracurium to the combination of lidocaine and ketamine resulted in improved operating conditions and rapid onset of both sensory and motor blocks with less pain during surgery.

INTRODUCTION

Intravenous regional anesthesia (Bier's Block) is a method of producing analgesia in the distal part of a limb by intravenous injection of a local analgesic solution into the vein of the same limb, while circulation to the limb is occluded by the application of tourniquet. This method of peripheral block was discovered by August Bier in 1902 [1]. This technique fell into disrepute for many years after Holmes [2] in 1963 revived the technique by substituting lidocaine for procaine. This technique is most useful for surgery on arms but can be used for legs as well. Intravenous regional anesthesia (IVRA) is safe and problems are few [3]; the advantages of the technique, if correctly performed, are high indices of reliability and success rates in addition to the avoidance of certain risk factors that are inherent to general anesthesia, particularly those of airway obstruction and pulmonary aspiration. No specific anatomic knowledge is required; intravenous regional anesthesia requires only that the anesthesiologists insert a needle or cannulla into a suitable vein. The onset of analgesia is rapid so that surgery or manipulation may begin within 5–10 minutes and muscular relaxation is good.

The disadvantages of the technique include the application of a tourniquet, which must be inflated continuously; it is not possible to release it to enable bleeding vessels to be identified unless additional anesthetic is injected after the tourniquet is re-inflated [4]. The duration of surgery is limited by the time during which the arterial tourniquet is safe.

The most important complications occur due to the toxicity of the local anesthetic agents and if the tourniquet deflates accidentally soon after the local anesthetic agent has been injected. The complications range from dizziness and tinnitus to muscle twitching and loss of consciousness. Serious cardiac effects are rare and can occur if convulsions are inadequately treated or if bupivacaine is administered.

Different agents have been used for IVRA, including local anesthetic agents, phencyclidines, non-steriodal anti inflammatory drugs, opioids, and muscle relaxants. In the recent past, ketamine hydrochloride found a place in the field of IVRA with encouraging results [5]. Ketamine is an effective, local anesthetic agent for IVRA and is capable of providing complete sympathetic, sensory, and motor blockade at concentrations between 0.3% and 0.5% [6]

Various neuromuscular blocking agents have been used to

improve the operating conditions and reduce the local anesthetic dose and possible systemic toxicity ([7]). The use of atracurium as an adjuvant in intravenous regional anesthesia is because of its effect on muscle spindles; it reduces central input from these structures, which results in loss of muscle tone and control of voluntary movements with a decrease in nervous inputs to the brain ([8]). In addition, blockade of muscle spindles induced by atracurium may alleviate muscle spasms and reduce pain both during and after surgery ([9]).

MATERIALS AND METHODS

This prospective study was conducted in the Department of Anesthesiology and Critical

Medicine, SK Institute of Medical Sciences, Soura, Srinagar, Kashmir. After approval of the hospital ethical and research committee, the anesthetic procedure was explained to the participants of this study and informed consent was obtained.

The patients were of physical status ASA-1, aged 25–50 years. Most of the surgeries were on the distal regions of the upper limbs and included dupuytrens contracture release, release of post-burn contractures of the hand, and tendon repairs of hand. Patients with a history of allergic reaction to lidocaine, and/or significant cardiovascular disease, peripheral vascular disease, and neurological diseases were excluded from the study. At the pre-operative visit, on the evening before surgery, the visual analogue scale (VAS) scoring system was explained to all patients. Patients were assigned randomly and blindly to three groups of 20 patients each. Each patient received thirty milliliters of test solution.

Group I: patients received 0.5% lidocaine (150 mg). Group II: patients received 0.5% lidocaine (75 mg) and 0.1% ketamine (30 mg). Group III: patients received 0.25% lidocaine (75 mg), 0.1% ketamine (30 mg), and atracurium (2 mg).

Before administration of IVRA, resuscitation equipment and drugs were made available to meet any untoward complications. No medications were given to any of the patients. Prior to administration of IVRA, an infusion of 5% dextrose in 0.5 N saline was begun in the normal limb.

A 20-ga IV cannula was inserted into distal vein of the extremity that was to be studied; webril was applied to the arm to protect the skin. Two tourniquets were placed over the webril. The arm was exsanguinated by using an esmarch bandage. A proximal tourniquet was inflated to 250 mm Hg.

The absence of radial artery pulsations was assured. Thirty milliliters of test solution was injected slowly over 90 seconds. Ten minutes after administration of drug, the distal tourniquet was inflated and the proximal tourniquet was deflated. Five milligrams of diazepam were given to all patients intraoperatively.

After the injection of different study solutions, the onset of sensory block was determined by the pin prick method just distal to the tourniquet at 1-minute intervals. The onset of motor block was recorded at 1-minute intervals when the patient could not produce any movement of the fingers.

The patients were questioned about pain during surgery and at 5 and 15 minutes after deflation of the tourniquet. The pain was measured using a 0–10 cm VAS where 0 indicates no pain and 10 indicates the worst level of pain.

Electrocardiograms were monitored throughout the operation and up to 1 hour after tourniquet deflation. Both systolic and diastolic blood pressures were measured by an automatic oscillotonometry (NIBP) monitor every 10 minutes during the operation and 2, 5, 10, 15, 30, 45, and 60 minutes after deflation of the tourniquet during the post-operative period.

Patients were also observed for complications over a period of one hour after deflation of the tourniquet.

The parameters were expressed as the mean ± SD and the results thus obtained were statistically evaluated using student's t test. A p value less than 0.05 was considered significant.

OBSERVATIONS AND RESULTS

The patients' demographic data were observed for heart rate, blood pressure, duration of surgery, and complications. Mean age, sex, weight, duration of surgery, and both intra-operative and post-operative heart rates and blood pressures were comparable in all the three groups and there were no statistically significant differences.

Figure 1

Table 1: Comparison of age, sex, and duration of surgery.

Study groups	Age (years) (mean ± SD)	Sex (M:F)	Duration Of Surgery (min)	Remarks
I	46.25 ± 5.15	11:9	51.5 ± 4.27	Not significant
II	43.10 ± 6.98	10:10	52.45 ± 5.07	Not significant
III	42.10 ± 8.45	9:11	51.7 ± 4.64	Not significant

Figure 2

Table 2: Comparison of onset of sensory block

Study group	I	II	III
Onset of Sensory block (mean ± SD, min)	5.35 ± 1.18	4.05 ± 1.28	3.50 ± 0.89
T value	I vs. II 3.32	II vs. III 1.58	I vs. III 5.60
p value	$p < 0.01$	$p > 0.05$	$p < 0.001$
Remarks	Significant	Not significant	Significant

Figure 3

Table 3: Comparison of onset of motor block

Study group	I	II	III
Onset of Motor block (mean ± SD, min)	7.55 ± 1.36	5.50 ± 1.54	4.85 ± 0.93
T value	I vs. II 4.38	II vs. III 1.62	I vs. III 7.30
p value	$p < 0.001$	$p > 0.05$	$p < 0.001$
Remarks	Significant	Not significant	Significant

Figure 4

Table 4: Comparison of mean visual analogue scale (VAS) score for pain during surgery and 5 and 15 minutes after deflation of tourniquet in groups I, II, and III.

VAS Score (Mean ± SD)	Group I	Group II	Group III
During surgery	2.20 ± 0.83	1.10 ± 0.72	0.95 ± 0.83
5 minutes after deflation of tourniquet	1.45 ± 0.61	0.65 ± 0.49	0.50 ± 0.51
15 minutes after deflation of tourniquet	2.4 ± 0.94	1.15 ± 0.67	1.05 ± 0.83

Figure 5

Table 5: Incidence of adverse effects during the peri-operative period in groups I, II, and III.

Adverse effects	Group I No (%)	Group II No (%)	Group III No (%)
Loss of consciousness	–	–	–
Restlessness	2 (10)	–	–
Dizziness	–	1 (5)	1 (5)
Bradycardia	2 (10)	–	–
Muscle fasciculation's	–	1 (5)	–
Nausea	–	–	–
Vomiting	–	–	–
Bronchospasm	–	–	–
Other	–	–	–
Total (%)	4 (20)	2 (10)	1 (5)

DISCUSSION

Intravenous regional anesthesia (IVRA) is a simple and effective method for producing analgesia of an extremity by intravenous injection of local anesthetic while the circulation is interrupted by the application of a tourniquet. The technique of IVRA fell into disrepute because of side effects associated with the agents used for the technique. With the introduction of lidocaine hydrochloride, the technique was described as safe and reliable ([10]).

The present study was aimed to evaluate the effects of drug combinations of different dosages of lidocaine and reduction in its potential toxicity and to compare the onset of sensory and motor blockade with individual drugs and drug combinations.

In our study, we used 0.5% lidocaine (150 mg) in group-I patients, 0.25% lidocaine (75 mg) with 0.1% ketamine in group-II patients, and 0.25% lidocaine (75 mg), 0.1% ketamine (30 mg), and atracurium (2 mg) in group-III patients. We found that the extent of analgesia was excellent, the onset of motor block was rapid, and the incidence of complications was low because of lower concentrations of drugs used in our study.

Lidocaine in maximum doses [i.e., 350 mg was used for IVRA by Keneddy et al. ([11])] yields an extent of analgesia that it excellent; however, the only drawback of such a high dose of lidocaine is the high incidence of toxicity. The onset of sensory block in the 0.5% lidocaine group was 5.35 ± 1.18 minutes in our study. Also, the VAS score for pain in the post-cuff deflation period at 15 minutes was 2.4 ± 0.94. This finding confirms the study conducted by Brown et al. ([12]) who used 0.5% lidocaine and observed that the onset of sensory block was within 3–5 minutes and no toxic reactions were observed.

In our study, the onset of sensory block and motor block was faster (4.05 ±1.18 and 5.05 ±1.54 minutes, respectively) in the group that received 0.1% ketamine hydrochloride compared with the group that received lidocaine only (5.35 ±1.18 and 7.55 ±1.38 minutes, respectively). Roy and Deshpande ([13]) used ketamine in concentrations of 0.25%, 0.37%, and observed that the 0.5% concentration of the drug was effective and that analgesia was good in 90% and moderate in 10% of subjects. The onset of action was 13.05 ± 4.26 minutes. However, this concentration of the drug was associated with a higher incidence of complications. The reason for the rapidity in onset of sensory block and motor block and lower incidence of complications in our study

compared with the above-mentioned study is that we used lower concentrations of ketamine in combination with 0.25% lidocaine, which confirms the findings of Kulkarni et al. [14]. Tomar et al. [15] also observed that patients who received a mixture of local anesthetic agents for IVRA had more profound analgesia and successful block compared with patients who received individual drugs only; they also observed a low incidence of complications in patients who received a combination of drugs, which confirms our study.

The VAS score for pain 15 minutes after deflation of the tourniquet in the lidocaine plus ketamine group was 1.15 ± 0.67 compared with 2.4 ± 0.94 in the group in which lidocaine was used (p value < 0.001). Better analgesia obtained in patients in which ketamine hydrochloride was used because of the local anesthetic action of ketamine [16].

The addition of atracurium to lidocaine improves operating conditions during IVRA with less pain during surgery. In our study, patients allocated to group III had a faster the onset of motor blockade (4.85 ±0.93) compared with the group I where the onset of motor block was 7.55 ± 1.38 minutes; the differences between the two were statistically significant (p < 0.001). Additionally, the VAS scores for pain during surgery (0.85 ± 0.83) and at 15 minutes after deflation of the tourniquet (0.50 ± 0.51) were lower in the atracurium group compared with the lidocaine only group (2.20 ±0.83 and 1.45 ±0.61, respectively). These results confirm the findings of Sadek and Elhakim [17] who observed that the group of patients that received a combination of lidocaine and atracurium had a significantly greater degree of muscle relaxation and more rapid onset of motor block compared with patients who received lidocaine only. They also observed that the patients who received atracurium had less pain during surgery. The effectiveness of the addition of a muscle relaxant to IVRA was also studied by Abdullah and Fadhil [18] who observed that the analgesic effect was more profound in the group that received lidocaine and pancuronium compared with the group that received lidocaine alone. Besides the well-known effect of atracurium on the sensory nerve endings and nerve trunks, atracurium has an effect on the muscle spindles, reducing the central input from these structures [19,20,21].

Various adverse effects that occurred in our study subjects were bradycardia, restlessness, dizziness, and muscle fasciculations. The incidence of adverse effects in our study was only 11.6%. Merrifield and Carter [22] used lidocaine for IVRA and observed a complication rate of 28% with intermittent release and re-inflation of the tourniquet. Ware [23] observed a complication rate of 23.5%. The lower incidence of complications in our study compared with the above-mentioned studies was because of the lower concentrations and dose of lidocaine used in patients belonging to groups II and III. Kulkarni et al. [24] also observed that by using combinations of various drugs, they were able to reduce the dose of lidocaine to be used for IVRA and hence its potential toxicity.

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