

Comparing two different lidocaine concentrations in addition to the tourniquet application to incorporate in the Intravenous Regional Anesthesia (IVRA) Method for reducing the total amount of local anesthetic in hand and wrist surgeries: A randomized cohort study

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Abstract

Objective: Modified approaches are emphasized to make the traditional IVRA method more reliable and effective. We aimed to compare two different concentrations used with temporary tourniquet application in addition to the IVRA method for reducing local anesthetics amount in hand and wrist surgeries.

Material and methods: After the approval of Gaziantep University Ethics Committee had been obtained, observation forms of patients with ASA physical score I-II who had undergone elective orthopedic upper extremity surgery were reviewed retrospectively. The patients were divided into two groups according to the concentration of 150 mg of lidocaine in saline. The patients were administered 150 mg lidocaine in 15 ml (Group 15, n:29) and 20 ml (Group 20, n:26) saline. Patients were enrolled into groups in a random and a blind fashion, and after the exclusion criteria were assessed, twenty patients from each group were evaluated. Demographic data, the classification of operation time, the peri-operative follow-up values, the sedoanalgesia consumption needs and the postoperative patient satisfaction scores were compared.

Results: Demographic data were similar in both groups. The tourniquet time was 40.75±14.71 minutes in Group 15 and 38.25±9.77 minutes in Group 20 (p=0.531). Sedation start time was 23.18±9.02 in Group 15 (n=11) and 26.53±6.57 minutes in Group 20 (n=13) (p=0.304). Tourniquet pain time was 46.66±2.88 in group 15 (n=3) and 50.00±7.07 minutes in group 20 (n=2) (p=0.624). No statistically significant difference was found between the all-time classifications, hemodynamic values, peri-operative sedoanalgesia consumptions, and the patient satisfaction scores between the groups (p>0,05). A continuous increase in sedoanalgesic consumption amount with time was observed. None of the patients had signs of local anesthetic toxicity.

Conclusion: We suppose that the plasticity inherent to the IVRA may be optimized by alternative adaptations to be used for decreasing the amount of local anesthetic to safer levels and for reducing the risk of related side effects.

Key words: intravenous regional anesthesia, tourniquet pain, temporary tourniquet, hand and wrist surgeries

Received: 2020-10-02.

Accepted: 2020-12-27



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J Clin Med Kaz 2021; 18(1):64-68

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Introduction

The Intravenous Regional Anesthesia (IVRA) is a method that provides anesthesia due to the elimination of nerve conduction and pain sensation by the administration of venous local anesthetic agent after the application of

pressure over arterial circulation using a tourniquet [1].

The IVRA was first defined in 1908 by Karl August Bier, who administered a local anesthetic solution directed proximally between the two tourniquets placed at each end of the surgical area. In 1931, Morrison modified the Bier-

technique by using a single-cuff tourniquet and percutaneous venous cannula. Currently used IVRA technique was described in 1963 by Holmes, who administered lidocaine by using a double-cuff tourniquet [2].

Recent approaches that combine optimal anesthetic dosage and tourniquet modifications focus on reducing the disadvantages of the IVRA such as tourniquet-associated pain, the risk of local anesthetic toxicity, and insufficient postoperative analgesia [3]. We aimed to compare two different concentrations of lidocaine in addition to tourniquet application as a modified IVRA method to reduce the total amount of local anesthetic in hand and wrist surgeries.

Material and methods

This study was conducted by the approval of Gaziantep University Faculty of Medicine Ethics Committee (Decision no: 2015/350). We retrospectively reviewed the records of the patients who had undergone hand and wrist surgery by using additional tourniquet application in the standard IVRA method and had the forms of "Regional Anesthesia Follow-up" in 2016.

The inclusion criteria consisted of the patients, between the ages of 18-60, classified as class I-II according to American Society of Anesthesiologists (ASA) classification, who underwent elective hand and wrist surgery, and who had routine single-cuff proximal tourniquet for blood-free surgical area. Data recorded from the medical charts included age, gender, the type of surgery, body mass index (BMI), and the ASA classification of the patients. Moreover, routinely monitored heart rate (HR), mean blood pressure (MAP), and peripheral oxygen saturation (SpO₂) values recorded every 5 minutes during the surgery were saved as basal values.

The patients who had cognitive impairment, developmental delay, bleeding-clotting disorders, vascular or neuromuscular diseases, surgeries lasted longer than an hour, and pre-operative pain scores greater than 0 were excluded from the study.

In this study, 150 mg of lidocaine in two different concentrations was administered to the patients. The patients who received lidocaine hydrochloride in a total of 15 ml and 20 ml saline were defined as Group 15 (n=29) and Group 20 (n=26), respectively. After being assessed for the exclusion criteria of the study, randomly selected 20 patients from each group were evaluated further.

The patients were infused with 4-6 ml/kg/h 0.9% NaCl via a 22-gauge cannula inserted at the dorsum of the hand opposite to the operated extremity. Premedication before surgery was provided with 0.03 mg/kg midazolam. Vascular access on the operated extremity was established via a 22-gauge cannula while a single-cuff pneumatic tourniquet was proximally placed. After the extremity was kept above the level of the head for three minutes, Esmarch bandage was wrapped in the direction of distal towards proximal. As a standard procedure, 1mcg/kg fentanyl was administered. The single-cuff proximal tourniquet was inflated to maintain either a value that was 100 mmHg higher than the systolic arterial pressure or a maximum value of 250 mmHg. After unwrapping the Esmarch bandage, arteria radialis and nail bed capillary fillings were controlled to assess the adequacy of the tourniquet pressure.

Additional tourniquet was applied under the elbow after the proximal tourniquet was inflated. Local anesthesia was applied by administering 1 mL solution in 3 seconds. The additional distal tourniquet was kept at a pressure of 100 mmHg above the systolic pressure until 5 minutes after administering the local anesthetic solution. The surgical procedure was started by

removing the additional distal tourniquet after 5 minutes. Peri-operative nausea and vomiting, skin rash, headache, dizziness, tinnitus, metallic taste, and numbness in tongue were questioned in case there was local anesthetic toxicity.

The duration of the operation was determined by certain timings into account. The onset time of surgery was accepted from the starting points of the administration of the local anesthetic solution to the surgical incision. Tourniquet time was taken as the duration from the inflation of the proximal single-cuff tourniquet to its deflation. The period between surgical incision and proximal tourniquet deflation was defined as the surgery time. The duration from proximal single-cuff tourniquet inflation to the generation of tourniquet pain was determined as the tourniquet pain time. The duration from proximal single-cuff tourniquet inflation to the time when sedation started was determined as the sedation starting time.

Visual analog scale (VAS) was used to assess the patients' pain scores. When the patient scored between 0-2, no extra analgesic medication was provided. Patients who scored between 3-5 on VAS scale were administered 1 mcg/kg Fentanyl. When there was no regression of VAS score to 0-2, 3 mg/kg/h propofol and 5 mcg/kg/h remifentanyl, infusion was started considering the intraoperative restlessness due to the tourniquet application. Our standard sedation protocol was applied to the patients monitored with the Bispectral Index (BIS) and had tourniquet pain or a VAS score of 6 or above. A bolus of 0.4 mg/kg Propofol was administered in 3 minutes, and the infusion rate was increased to 0.5 mg/kg/h until the targeted BIS level for two groups (increased from 60 to 75). The infusion rate of propofol was reduced to 0.5 mg/kg/h in 5 minutes when the levels observed were below the target values. The total amount of sedoanalgesic consumptions were noted in the patient surgical records.

After the completion of the operation, the patient satisfaction scores by a scale of 0-2 points (0: bad, 1: medium, 2: good) were noted from the records to evaluate the quality of anesthesia. During the immediate postoperative period, vital signs, toxic symptoms, and pain status were monitored for two hours.

Statistical analysis: The primary outcome of the study was the weight-adjusted analgesic consumption with a specific sedoanalgesia protocol before tourniquet pain. The secondary outcome of the study was the weight-adjusted analgesic consumption with a specific sedoanalgesia protocol after tourniquet pain. This study was planned to compare two groups, where the anticipated difference in MAP values was 20%. Accordingly, the sample size required for an α value of 0.05 and a power of 80% was estimated to be 19 patients in each group in a two-sided design. To compensate for possible dropouts, the sample size was increased to 20 per group.

Demographic data is analyzed as means \pm SD. Shapiro-Wilk test was used to check the consistency of continuous variables. Student's t-test was used to compare normally distributed variables and Mann-Whitney U test was used for non-normally distributed variables. The relationships between categorical variables were tested by the chi-square test. In order to compare the numerical measurements obtained at different times, repeated measurement variance analysis was used for variables with normal distribution and Friedman tests were used for variables that were not normally distributed. For statistical analysis, SPSS (Software Package for Social Sciences) for Windows version 22.0 program was used and $P < 0.05$ was considered statistically significant.

Results

Demographic data and operation times were similar in both groups (Table 1). The number of surgical operations are shown in the Table 2.

Table 1 Demographic data and operation times

Demographic data and operation times	Group 15 (n=20)	Group 20 (n=20)	P
Age	35 ± 17.98	38 ± 18.20	0.738
Gender (m/f)	14/6	10/10	0.197
Weight (kg)	77 ± 12.42	78 ± 15.73	0.825
Height (cm)	171 ± 10.99	169 ± 9.70	0.666
BMI	25 ± 3.78	26 ± 4.55	0.292
ASA (I/II)	11/9	9/11	0.539
Time to start surgery (min)	14.00 ± 3.47	14.75 ± 4.43	0.555
Tourniquet time (min)	40.75 ± 14.71	38.25 ± 9.77	0.531
Surgery time (min)	26.75 ± 13.50	23.50 ± 10.89	0.470
Tourniquet pain time (min)*	46.66 ± 2.88	50.00 ± 7.07	0.624
Sedation start time (min)**	23.18 ± 9.02	26.53 ± 6.57	0.304

*Group 15 (n=3), Group 20 (n=2)

**Group 15 (n=11), Group 20 (n=13)

Table 2 Distribution of the orthopedic surgeries

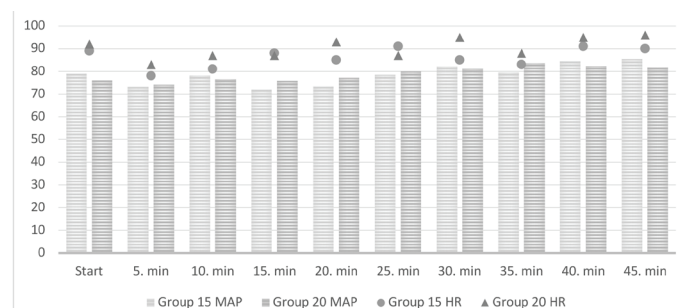
Orthopedic surgeries	Group 15	Group 20
Bening soft-tissue masses (Ganglion cyst, lipoma, osteoid osteoma etc.)	5	4
Tendon or fascia deformity (DeQuervain tendinitis, CTS etc.)	6	7
Orthopedic small bone of the hand fractures (Plate, screw etc.)	1	2
Malleol fractures (Plate, screw etc.)	4	2
Implant remove (Plate, screw etc.)	2	3
Others (Amputation, debridement, foreign object etc.)	2	2
Totally	20	20

The onset time of surgery was 14.00±3.47 minutes in Group 15, and 14.75±4.43 minutes in Group 20 (p=0.555). The tourniquet time was 40.75 ± 14.71 minutes in Group 15 and 38.25±9.77 minutes in Group 20 (p=0.531). Surgery time was 26.75±13.50 minutes in Group 15 and 23.50±10.89 minutes in Group 20 (p=0.470). In Group 15, the operation time was 20 minutes or more for all patients, except for one with 15 minutes. We found that proximal tourniquet was not removed for 20 minutes after local anesthetic solution injection in the patients undergoing IVRA.

The sedation starting time was 23.18±9.02 minutes for 11 patients in Group 15 while it was 26.53±6.57 minutes for 13 patients in Group 20. (p=0.304). Tourniquet pain time in three patients from Group 15 was 46.66±2.88 and 50.00±7.07 minutes in two patients from group 20 (p=0.624). No tourniquet pain earlier than 45 minutes was observed in both groups. There were no statistically significant difference in tourniquet pain and sedation starting time between the groups (p>0.05).

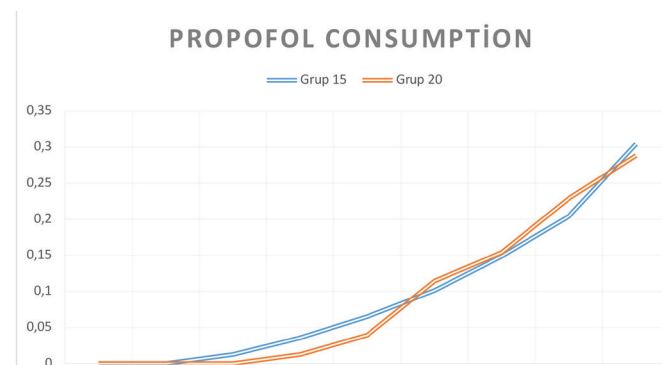
There was no statistically significant difference between the two groups in terms of MAP and HR values for all the investigated time periods in this study (Figure 1). Although we did not find any statistically significant difference in the amount of propofol consumption between the groups, the amount of propofol needed in both groups showed a significant linear increase from the start (p<0.05) (Figure 2). The distribution of the propofol amount needed among the time periods was shown in Table 3.

Figure 1 - Distribution of the MAP and HR averages



Noted: We did not evaluate the propofol amounts after 45 minutes due to two observations; first, bolus doses were required initially as the tourniquet pain developed; secondly, the number of patients that decreased to 10 or below was statistically irrelevant in terms of analysis.

Figure 2 - The increase of the propofol consumption (mg/kg)



Noted: We did not evaluate the propofol amounts after 45 minutes due to two observations; first, bolus doses were required initially as the tourniquet pain developed; secondly, the number of patients that decreased to 10 or below was statistically irrelevant in terms of analysis.

Table 3 The distribution of the propofol consumption

Propofol consumption (mg/kg)	Grup 15	n	Grup 20	n	P
5 min.	-	20	-	20	-
10 min.	-	20	-	20	-
15 min.	0.01 ± 0.05	20	-	20	0.330
20 min.	0.03 ± 0.08	20	0.01 ± 0.05	20	0.327
25 min.	0.06 ± 0.10	18	0.03 ± 0.09	19	0.450
30 min.	0.10 ± 0.11	16	0.11 ± 0.13	18	0.763
35 min.	0.14 ± 0.12	13	0.15 ± 0.13	15	0.911
40 min.	0.20 ± 0.13	12	0.22 ± 0.13	9	0.684
45 min.	0.30 ± 0.05	7	0.28 ± 0.06	6	0.659
50 min.	0.46 ± 0.23	7	0.46 ± 0.24	3	0.975
55 min.	0.45 ± 0.16	6	0.31 ± 0.00	2	0.305
60 min.	0.43 ± 0.04	5	0.79	1	0.002*

When the postoperative patient satisfaction scores were classified as good, middle, and bad in Group 15 and Group

Table 4 Patient satisfaction scores

Patient satisfaction score	Group 15 (n=20)	Group 20 (n=20)	P
Bad	1	2	0.472
Medium	6	3	
Good	13	15	

20, distribution of patients was determined as (13-15), (6-3) and (1-2), respectively (Table 4). There was no statistically significant difference in the satisfaction scores of the patients between the groups ($p=0,472$). Postoperative additional fentanyl administration was not required in both patient groups, and no patient developed a sign of toxicity against local anesthetic.

Discussion

The anesthetic methods used in orthopedic hand and wrist surgeries involve local anesthesia, sedoanalgesia, peripheral nerve block and general anesthesia. The choice of the appropriate anesthetic method depends on the type and the duration of the surgery. Although ultrasound-guided peripheral blocks for upper extremity surgeries are more commonly preferred, the IVRA, with its inherent properties such as easy application, early recovery, and low-risk adverse effects, can be considered as an alternative for high-risk patients [4].

The IVRA method has been numerously modified; at the present, double-cuff strategy is generally performed for the surgery of the upper extremity. As the surgical procedure is limited regionally to the extremity, the modifications that aim to minimize the dose and the location are attempted for the purpose of controlling central adverse effects. Although the modification of the tourniquet is in the first-out mentality of the IVRA, the concern about the toxicity of the intraosseous passage has made this approach not preferable. The use of a forearm tourniquet has been reported to be as safe as a proximal tourniquet and has been re-introduced in surgical practice [5].

Modified IVRA techniques with additional or temporary forearm tourniquets in the upper extremity increased the IVRA initial rate and improved the quality of anesthesia by decreasing the anesthetic dose to non-toxic levels [6]. Moreover, the forearm tourniquet position might even allow motor functions of the tendons to be maintained that could be critical in some surgical procedures [7]. On the other hand, forearm tourniquet, especially in procedures close to the wrist, can be problematic due to the possibility of blocking the surgical area to some extent [8,9]. Therefore, the studies related to temporary forearm tourniquet methods have recently gained priority. In this study, we aimed to compare two different high concentrations of lidocaine accompanying a temporary forearm tourniquet that limits the area compared to the conventional method that requires more local anesthetics in the whole extremity.

Temporary forearm tourniquets are designed with an unstable pressure to slow the upward passage of the local anesthetic solution. It has been found that a forearm tourniquet added to the traditional IVRA method for 8 minutes at an unstable pressure started the sensory block an earlier onset time [10]. Studies have shown that dilute solutions could be used with the help of forearm tourniquet at an unstable pressure in the traditional IVRA method. It was stated that slowing down the upward movement of 10 mL 0.5% lidocaine solution could be used for the remaining 30 mL 0.25% lidocaine solution.

Additionally, sensory and motor block onset time was reported to be earlier [11]. In our study, we preferred to obtain a pressure higher than the systolic pressure to prevent intraosseous passage, and more concentrated solutions were used and maintained for five minutes to increase tissue penetration.

The studies have revealed that 2% lidocaine solutions led to shorter motor and sensory block onset time as well as longer motor and sensory block regression time. Since the use of additional tourniquet reduces the amount of volume used, it contributes to minimize the risk in case of possible leakage. It was stated that concentration levels did not make any difference on tourniquet pain [12]. While high concentrations have been reported to help save time, it should not be overlooked that high concentrations pose an increased risk of endothelial damage [13]. In our study, the concentrations of 0.75% and 1% lidocaine were used.

Tourniquet pain, which is a common complication, occurs in more than half of the patients within the first hour after the tourniquet is inflated. It has been reported that there is no difference in pain up to 40 minutes between the use of a single-cuff tourniquet or a double-cuff tourniquet [14]. Ischemia plays an important role in the total conduction block after 15 to 45 minutes when saline is injected instead of local anesthetics under the conditions similar to those of clinical IVRA, leading to a complete sensory blockade of the limb and skin [15]. It has been stated that tourniquet pain increases linearly with hypertensive tendency and occurs within an hour [16]. In our study, it was observed that the required amount of sedoanalgesic consumption increased with time. None of the patients from the two groups in our study developed tourniquet pain before 45 minutes, and only three patients in Group 15 and two patients in Group 20 had tourniquet pain. Sedation onset time occurred at 11 patients in Group 15 and 13 patients in Group 20. No sedoanalgesic need was observed before 15 minutes. No statistically significant difference in tourniquet pain was found between the two study groups.

Chiao et al. have shown that forearm tourniquet created less discomfort, reduced sedoanalgesic consumption and shortened the length of stay in PACU. They reported that the addition of a simple forearm tourniquet to the conventional IVRA method not only shortened the onset time of anesthesia but also improved the density and quality of the block [17]. In our study, one patient in Group 15 and two patients in group 20 reported the postoperative satisfaction score as "bad". The remaining patients reported either "middle" or "good" scores of postoperative satisfaction. No statistical significance was found in the postoperative satisfaction scores between two groups of patients. In this study, we observed that the tourniquet did not open before the 20th minute, and no toxic symptoms were present in the postoperative period.

In our study, no statistically significant difference was observed between the groups in terms of surgical times, the follow-up parameters, and the patient satisfaction scores. The amount of sedoanalgesic consumption had a continuous increase with time.

Limitations

In this study, only two different concentrations that were routinely used in our clinics were compared. Variations in concentrations should better be tried to find the optimal amount of anesthetic. Moreover, no control group was present in this study, so that the investigated parameters could not be compared between the patients and the healthy subjects.

Conclusion

Consequently, we suggest that the method explained in the current study may be an alternative local anesthesia procedure in short-term hand and wrist surgeries as it has the capacity to limit adverse effects due to an adjustable concentration of local anesthetic in addition to the temporary tourniquet application incorporated in the standard IVRA method. Instead of the traditional IVRA method that would increase local anesthetic requirement, low dose sedoanalgesia could be used with the modified IVRA method in tourniquet discomfort management, which might occur until the development of actual tourniquet

pain. We believe that further studies are needed to determine the optimal amount and the concentration of local anesthetic to be added to the temporary forearm tourniquet in the traditional IVRA method.

Disclosures: There is no conflict of interest for all authors.

Acknowledgement: None

Funding: None.

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