

Simple Arm Tourniquet as an Adjunct to Double-Cuff Tourniquet in Intravenous Regional Anesthesia

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Abstract

Background: Intravenous Regional Anesthesia (IVRA) is a well-known technique for producing analgesia during surgical procedures in the extremities. However, the rapid onset of pain following the deflation of a double-cuff tourniquet during IVRA is a serious disadvantage, leading patient suffering.

Objectives: The aim of this study was to evaluate the clinical effectiveness of a pneumatic arm tourniquet applied 2 cm above the double-cuff tourniquet in controlling the pain that occurs after its deflation.

Patients and Methods: Twenty patients undergoing outpatient hand surgery were operated on under IVRA, using 40 - 50 mL of a solution containing 3 mg/kg of lignocaine. A simple pneumatic tourniquet was applied proximal to the double-cuff tourniquet, 3 min before its deflation, while the procedure was being conducted. The severity of pain on the basis of the Numerical Rating Scale (NRS) was assessed throughout the operation, and continued until an hour after the double-cuff tourniquet was removed.

Results: The mean operation time after the deflation of the double-cuff tourniquet was 20.12 ± 6.1 minutes. Moreover, the mean NRS for the post-deflation time was insignificant (NRS = 2), and only one patient during first 20 minutes received opioids.

Conclusions: This study showed that a pneumatic arm tourniquet as an adjunct to IVRA provides acceptable analgesia following the deflation of the double-cuff tourniquet for relieving surgical pain.

Keywords: Analgesia, Lignocaine, Intravenous Regional Anesthesia (IVRA), Double-cuff Tourniquet, Pneumatic Arm Tourniquet, Numerical Rating Scale (NRS)

1. Background

The German surgeon, August Bier, introduced the Bier Block in 1908; which was later called Intravenous Regional Anesthesia (IVRA). The basic concept behind this block was to provide a painless and bloodless operating field by exsanguinating the extremity, and applying an arterial tourniquet to isolate it from the circulation, finally inducing anesthesia by injecting local anesthetics into the extremity venous system (1).

IVRA is a suitable technique for short elective surgical procedures (< 90 minutes) performed on the distal arm or leg, usually on soft tissue, but it can also be used in the case of an emergency bone fractures even in children. The IVRA is easy to administer, its overall cost is low, it is applicable for all age groups, the onset and recovery of surgical anesthesia is quite rapid, block failure is scarce, it provides muscle relaxation, and it is a safe technique, when done appropriately.

However, the conventional IVRA does have some disadvantages, including the potential for local anesthetic toxicity (cardiac arrests and seizures) (2), emergence of pain following removal of the tourniquet (within 3 - 5 minutes), and lack of postoperative analgesia. Additionally, IVRA lacks postoperative pain relief after tourniquet deflation, due to the rapid washout of the anesthetic solution in the general circulation.

Eastwood et al. demonstrated that the application of a simple Penrose drain used as an adjunct to a pneumatic arm tourniquet increased the speed of the onset of anesthesia (3). This application was theorized to cause a rapid rise in venous pressure, leading to a widening of the space between the endothelial cells and pericytes, and thus, rapid distribution. Davis et al. reported that adding a simple forearm tourniquet to the standard IVRA not only increased the onset of anesthesia, but also improved the density and quality of the block (4, 5).

2. Objectives

The aim of this study was to assess the efficacy of the a simple pneumatic tourniquet with 20 mmHg applied to the proximal arm, 2 cm above the double-cuff tourniquet, as an adjunct to the standard IVRA forin delaying local anesthetic washout, and postoperative pain relief after the double-cuff deflation (6).

3. Patients and Methods

After obtaining approval from by the local research ethics committee, twenty-five consecutive patients with upper extremity problems were enrolled in this study. Five of them did not tolerate awareness and the anesthesiologist had administer general anesthesia. Therefore, 20 patients with ASA physical statuses of I-II were operated on under IVRA, with a simple pneumatic tourniquet applied on the arm, 2 cm above the double-cuff tourniquet, before its deflation. These patients were between 18 and 40 years of age, and undergoing outpatient hand surgery over 9 months in 2013 at the Shafa Yahyaian Orthopedics Hospital. The operations were performed for five different hand problems.

The exclusion criteria were vascular and neurological pathologies at the tourniquet site, surgery at different sites, allergy to local anesthetics, history of epilepsy or head trauma, hypotension, sickle cell anemia, liver disease, renal dysfunction, cardiac conduction abnormalities, a history of chronic pain, and patient dissent.

After describing of the research to the patients and having them sign consent forms, one annula was inserted into a vein in the dorsum of the non-operated hand for the infusion of a crystalloid solution. A second cannula was inserted into a vein on the dorsum of the operated hand. All of the patients were taught how to use of the numerical rating scale (NRS) for the tourniquet pain. The NRS is a printed graduated scale, from 0 to 10, with equal increments (0 for absence of pain and 10 for the worst pain imaginable). All of the patients were operated on in an outpatient setting, and monitored via ECG, blood pressure, and pulse oximetry. In addition, all of the patients received midazolam (0.03 mg/kg) intravenously, 3 min before the cuff inflation. Pre or intraoperative opioids or other analgesics were not administered.

A double-cuff tourniquet was placed on the proximal arm, and the patient's blood pressure was measured before the inflation of the tourniquet. After exsanguination with an esmarch bandage, the cuff was inflated to a pressure 150 mmHg above the systolic blood pressure. Then, 0.5% lidocaine was slowly injected over period of 180 sec for anesthesia. The calculated dose was approximately 3 mL/kg up to

40 mL of the lidocaine volume. The same anesthesiologist administered all of the local anesthetics.

The cannula was removed, and after five minutes, the operation was initiated. If the patient complained of tourniquet pain (which usually happens before 30 minutes of exsanguination), the distal tourniquet, placed on anaesthetized skin, was inflated, and the proximal one carefully deflated. Keeping the tourniquet inflated for at least 20 - 25 minutes after the injection of the local anesthetic was mandatory, even if the surgical procedure was much shorter. In order to maintain of hemostasis, the double-cuff tourniquet should be deflated at the end of the main course of the operation (mean double-cuff tourniquet time \approx 41.75 minutes), but 3 minutes before, a simple pneumatic tourniquet was applied at 2 cm proximal to the double-cuff tourniquet, and inflated with a pressure of 20 mmHg, for as long as the procedure continued (pneumatic tourniquet time \approx 15 minutes). During the operation, the pain at the surgical site was assessed one minutes before and after the double-cuff deflation, as well as every 5 minutes after the double-cuff deflation, for one hour.

If the NRS was three or more, fentanyl (2 μ g/Kg) and, in the condition of severe restlessness, another dose of midazolam (0.015 mg/Kg) were administered via IV access on the non-operated hand. Data describing the age, sex, type of problem and operation, time of surgery, time of the surgery after the tourniquet deflation, severity of pain (NRS) at the surgical field, and the number of patients who needed extra analgesics during the operation were recorded in a prepared form. All data are summarized in [Table 1](#).

4. Results

Overall, 20 patients participated in the study. During the operations, all of the patients were hemodynamically stable; therefore, hemorrhage was insignificant. The severity of pain on the basis of the NRS was assessed throughout the operation, and until one hour after the tourniquet was removed-off. Before the double-cuff tourniquet was removed, the mean NRS was 0; after that it was 1.25.

Later, in spite of the fact that the procedure was going on (mean = 19.75 minutes), then NRS score of 2 was reported in two patients. Postoperatively, 11 patients received opioids due to their NRS scores of 3 ([Table 2](#)). Among them, two of the patients received opioids twice, while one received them three times. Two of the patients required midazolam to reduce restlessness. In summary, after the double-tourniquet- was removed; eleven patients had received opioids (55%), while the others (45% of patients) did not, because of their NRS scores of \leq 2.

Table 1. Data of Patients Enrolled in the Study

Parameters	Values
Number of Patients	20
Gender	
Male	13
Female	7
Type of problem	
Fracture of distal radius	5
Fracture of distal ulnar	1
Metacarpal fracture	8
Digital fracture	4
Digital neuroma	1
Extensor tendon rupture	1
Type of operation	
Open Reduction & Internal Fixation	18
Digital Neuroma Excision	1
Extensor Tendon Repair	1
Mean operation time (until the end of dressing)	56.75
Mean double cuff tourniquet time	41.75
Mean Post-tourniquet deflation procedure time (≈pneumatic tourniquet time)	15
Patients received opium	11
Mean age in years (range)	29.75
Mean numerical rating scale (NRS)	1.25

5. Discussion

The importance of IVRA in surgeries in the upper limb is well known. This technique involves administering intravenous local anesthetic substances in a region where the venous drainage is mechanically impeded by a tourniquet.

Therefore, following the deflation of the double-cuff tourniquet, the majority of the entrapped local anesthetic is rapidly diffused throughout the circulation, and so there is a risk of postoperative pain insurgence, seizure, and even cardiac arrest.

Actually, this technique has undergone technical modifications since it was first introduced. These modifications have focused on three limitations of the IVRA: relatively slow onset time, tourniquet pain, and postoperative analgesia. Over time, some technical adjustments, such as a distal i.v. cannula, slow injection, use of double-cuff tourniquets, appropriate inflation pressure, careful deflation procedure, and use of warm anesthetic solutions (37°C) have improved the efficiency and safety of the IVRA.

Parallel developments of using drugs to produce local anesthesia and/or act as adjuvants have played important roles in these improvements. It has been proven that some pharmacological adjuvants, such as neostigmine (7), ketamine (8, 9), clonidine (10), and ketorolac (11, 12), ameliorate the tourniquet pain, while adding certain drugs, such as clonidine, ketorolac, meperidine (13, 14), and neostigmine, as an adjuvants alleviates postoperative pain (15). In addition, alkalinized anesthetic solutions can reduce the anesthetic onset time.

Based on previous clinical studies, which have evaluated the safety and efficacy of the forearm tourniquet, the forearm IVRA has been found to be safer than the conventional IVRA, because a larger bolus of drug recirculates after the tourniquet is removed in the upper arm IVRA. Therefore, the forearm tourniquet increases the safety margin of the technique (16, 17). Rawal et al. showed re-exsanguination with an esmarch's bandage, following the institution of the IVRA, with a brief deflation and reinflation of the tourniquet; they called this procedure re-IVRA, a technique that would result in minimal leakage of the local anesthetic (18).

In this study, we focused on the abrupt ending of local anesthetic from the limb, after the tourniquet was removed, as a primary reason for postoperative pain and, perhaps, seizure or arrest. This concept triggered a new question "Is it feasible to reduce the pace of recirculation by creating a partial obstruction on the venous flow?" After reviewing the resources, we were unable to find a minimal standard pressure that exclusively impeded the venous drainage. Finally, on the basis of experts' opinions, we applied a simple arm tourniquet on the proximal side of the double-cuff tourniquet, with 20 mmHg pressure, before the tourniquet was removed. Therefore, during the arterial blood flow, while the surgeon was able to check hemostasis, the abrupt recirculation of the local anesthetic was slowed down. This delay could postpone the initiation of postoperative pain, and reduce the risk of systemic intoxication.

Although these data are not statistically valuable, but they shows that a limited number of patients suffer from pain for one hour after the tourniquet is removed.

Therefore, we believe that a clinical trial study, which compares the efficiency of this application to the control group, would be valuable. To the best of our knowledge, the clinical usage of a pneumatic arm tourniquet as an adjunct to ameliorate postoperative pain has not been previously reported.

Table 2. Summary of Pain Scores one Minute Before Through one Hour After the Double-Cuff Tourniquet Removal for the Patients Undergoing Hand Surgery Under IVRB Using the New Technique

Time Related to Double-Cuff Tourniquet Off	1' Before	1' After	5' After	10' After	15' After	20' After	25' After	30' After	35' After	40' After	45' After	50' After	55' After	60' After
Severity of pain numerical rating scale (NRS)														
0	20	19	17	12	11	16	11	8	9	7	8	9	10	3
1	0	1	1	6	7	1	4	6	6	6	8	1	1	9
2	0	0	2	2	2	2	2	4	4	7	4	9	7	6
3	0	0	0	1	0	1	3	2	1	0	0	1	2	2
4-10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean NRS	0	0	1	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Footnote

Authors' Contribution: Ali Akbar Jafarian developed the original idea and protocol, and exhibited great efforts in the research process; Farnad Imani helped us and supervised the research; Farid Najd Mazaher took part in the data gathering; Fatemeh Moini analyzed the gathered data; Reza Salehi wrote the article and is the corresponding author.

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