

COMPARISON OF TWO DIFFERENT ANESTHESIA TECHNIQUES FOR TOURNIQUET PAIN WITH THE USE OF FOREARM TOURNIQUET

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ABSTRACT

Purpose

The purpose of this prospective, randomized study was to compare the effectiveness of two different anesthesia techniques for tourniquet pain in minor surgeries of the hand with the use of the forearm tourniquet.

Methods

In group 1, the area under the tourniquet was anesthetized circumferentially using a cream composed of 5% lidocaine and 5% prilocaine (Emla® Astra). In group 2, the area under the tourniquet was anesthetized with a ring-type infiltration of the skin and subcutaneous tissues using 50% diluted Citanest solution using 22 G × 3 1/2" size spinal needle (Sujia®) with three injections.

Results

There were no statistically significant differences between the means of the two groups with respect to both tests (p value = 0.18 [t-test], p = 0.951 [Mann-Whitney test]). Tourniquet related anesthesia technique discomfort was higher in group 2 (p = 0.001).

Conclusions

The tourniquet placed at the distal forearm is an effective, safe, and useful technique for hand surgery. Anesthesia using Emla cream is equally effective and less disturbing than using the injection technique (subcutaneous ring anesthesia).

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INTRODUCTION

A pneumatic tourniquet is usually employed during surgery of the hand to provide a bloodless field. The use of a pneumatic tourniquet is often complicated by the development of tourniquet pain. Various methods have been used to prevent this complication, but most have proved unsatisfactory. The purpose of this prospective, randomized study was to compare the effectiveness of two different anesthesia techniques for tourniquet pain in minor surgeries of the hand with the use of forearm tourniquets.

MATERIALS AND METHODS

The study was performed at Ankara Education and Research Hospital between 02/14/2006 and 05/14/2007. One hundred cases in 92 patients subjected to hand surgery enrolled in this prospective, randomized study (Table 1). They all gave informed consent to participate, and ethical approval from our institution was obtained. For testing the efficiency of the anesthetic agents to the tourniquet pain, a control group was chosen. Twenty-four volunteers accepted to have an inflated tourniquet over their forearm. The volunteers who could not

TABLE 1

Patients' age and sex, the procedures, tourniquet pressure, tourniquet time, HLVAS scores.

Number of cases	100
Number of patients	92
Male/ Female	30/62
Mean age (range) in years	41.5
Mean tourniquet time (range)	13.335 min. (5-29)
Mean tourniquet pressure (range) (mmHg)	226.47 (200-260)
Mean VAS score (range)	3.05 (0-100)
Procedures:	
Carpal tunnel release	29
Tumor excision	16
Ganglion excision	15
Trigger finger release	15
Trigger thumb release	11
Phalanx or metacarp fracture osteosynthesis	8
Foreign object removal	5
Removal of implant	1



Figure 1. The figure is demonstrating the application of the cream (EMLA®). We applied the cream 1 gr per cm² centimeters proximal to the distal wrist crease routinely. The amount of the cream was evaluated as the multiplication of the diameter of the forearm (where the tourniquet would be inflated) and width of the tourniquet (10 centimeters).

tolerate the tourniquet for 13.3 minutes were excluded from the control group. Subjects with a high risk of cardiovascular disease, malignancy, local infection, uncontrolled hypertension, psychotic disorder, local circulation disorder, lactation, coagulation disorder, skin problems or an allergy to local anesthetic agents, systolic arterial pressure more than 160 mmHg, or under 16 years of age were excluded. Before the operations all the patients were tested as if they would take a general anesthesia. Intravenous hydration was performed for all the patients using a 0.9% NaCl solution. For the patients with bilateral pathology, the second hand was operated on after the first operation wound was healed.

TECHNIQUE

Premedication with 10 mg oral diazepam (Diazem®) was performed in all patients 1 hour before surgery. Because of the hypotensive effect of diazepam, this drug was given to the patients whose blood pressures were normal. Before tourniquet inflation the surgical site was anesthetized by local infiltration using diluted 2% prilocain HCl (Citanest®). Median, ulnar, and digital blocks were also used if necessary. Median nerve blocks were applied at the level of the wrist, and ulnar nerve blocks were applied at the level of the elbow (between the tip of the olecranon and the medial epicondyle). Digital blocks were applied at the level of the metacarpophalangeal joint. Using a computer-generated randomization sequence, patients were randomly allocated into two groups. In group 1, the area under the tourniquet was anesthetized circumferentially using a cream composed of 5% lidocaine and 5% prilocaine (Emla® Astra) (Figures 1 and 2). In group 2, the area under the tourniquet was anesthetized with a ring type infiltration of the skin and



Figure 2. The application of the tourniquet over the nylon covering for the cream.

subcutaneous tissues using 50% diluted Citanest solution using 22 G × 3^{1/2}" size spinal needle (Sujia®) with three injections (Figures 3, 4, 5). All local anesthetics were administered by two orthopaedic surgeons. Emla was applied at the tourniquet site for one minute for group 1 and the local anesthetic solution was injected over two minutes for group 2. Before inflation of the tourniquet, we waited 1 hour for group 1 and 30 minutes for group 2 after the application of anesthetics. In all patients, we applied 1gr / cm² Emla or 15 cc 1/1 diluted Citanest under the tourniquet. We limited loss of the Emla cream into the tourniquet wrap by applying a nylon cover over the cream. This improved the skin absorption. A 10 cm wide single-cuff was placed 8 cm proximal to the distal wrist crease. The patients' arterial blood pressures were measured and noted before inflating the tourniquet. The limb was exsanguinated by an Esmarch bandage and the tourniquet was inflated to 100 mmHg above the systolic blood pressure. Total tourniquet time and total operation time were recorded and tourniquet and operative site related discomforts were assessed by visual analogue scale (VAS). All the patients were instructed about the use of the horizontal linear VAS for tourniquet pain. Tourniquet pain was assessed by means of a 100-mm VAS, one end of which represented no pain and the other end the worst pain imaginable. VAS and vital functions were recorded at 5 minute intervals. Mean values of VAS during the operation were calculated and noted. All the patients were reviewed on the second and fourteenth postoperative days for wound inspection and suture removal respectively. For the control group, the tourniquet was placed at the same position as the study patients. Sedative, local or topical anesthetics were not administered to these volunteers for tourniquet pain. The tourniquet was inflated to 100 mmHg above the

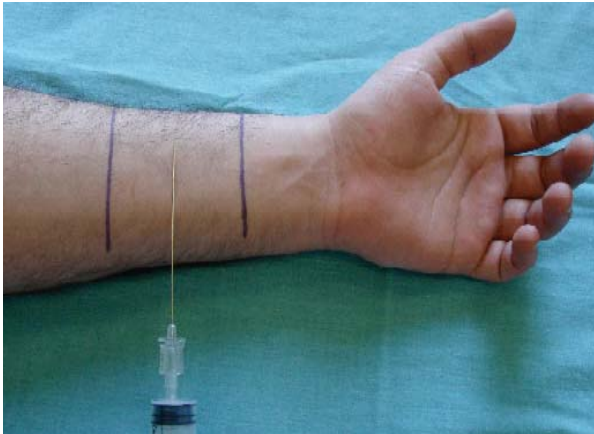


Figure 3. The application of the diluted 2% prilocain solution. We applied the solution under the skin and subcutaneous tissues with three injections. All three injections were applied at the line which passes through the central longitudinal axis of the tourniquet. The first entrance point of the spinal needle was volar at anteromedial corner of the ulna. Second entrance point was the anterolateral corner of the radius and the third entrance point was the dorsal interosseous area of the radius and ulna.

systolic blood pressure, and the tolerability of the tourniquet pain was measured and noted according to VAS in these volunteers. In the control group the tourniquet was inflated for 13.3 minutes (average total mean time of ischemia in patients). These volunteers were seen and assessed for any complication on the second and seventh days after the application of the tourniquet.

RESULTS

The mean patient age was 41.5 (17-60). 62 were female and 30 were male. Surgical procedures performed were: carpal tunnel release 29 cases; tumor excision 16; ganglion excision 15; trigger finger release 15; trigger thumb release 11; metacarpal or phalanx fracture 8; foreign object excision 5; and removal of implant 1. Fifty-eight patients were in group 1 and 42 were in group 2.

The total mean time of ischemia (time when tourniquet was inflated) was 13.3 minutes (5-29 minutes) (number=100) (Standard Deviation=5.229). The average tourniquet time was 13.5 minutes in group 1 (5-24 min.) (n=58) (St. Deviation=5.127) and 13.1 minutes in group 2 (5-29 min.) (n=42) (St.Deviation=5.422). The total mean tourniquet pain according to VAS was 3.0(0-100) (St. Dev.=7.173) (n=100). The average tourniquet pain according to VAS was 3.8(0-100) (St.Dev.=8.80) (n=58) in group 1, and 2.0(0-100) (St.Dev.=3.89) (n=42) in group 2 (Table 2). The average tourniquet pain according to VAS was 41.0(0-100) (St.Dev.=14.65) (n=20) in the control group (Table 3). All the patients except one in group 1 tolerated the procedure well. In this patient, the tourniquet was released and operation was performed without tourniquet. We operated on recurrent carpal



Figure 4. After the entrance of the second point, the needle was progressed up to the lateral side of the radius and then the forearm was pronated. After full pronation, the needle was progressed up to the third entrance point.



Figure 5. During the infiltration of the solution, we attempted to get a 1 cm expansion below the skin.

tunnel syndrome in one patient. Four volunteers could not tolerate the tourniquet for 13.3 minutes, so they were excluded from the control group. To compare the difference between the two groups with respect to average tourniquet pain (tourniquet VAS), both independent samples t-test and Mann-Whitney tests are used. There were no statistically significant differences between the means of the two groups with respect to both tests (p value=0.18 [t-test], $p=0.951$ [Mann-Whitney test]). There was no correlation between tourniquet time and tourniquet-VAS in both groups ($p=0.86$ in group 1 and $p=0.85$ in group 2). To compare the effect of Emla or Citanest on tourniquet pain, the Kruskal Wallis test was used. There were statistically significant differences between the means of two groups (Group 1-control group or group 2-control group) with respect to this test ($p<0.01$). Tourniquet related anesthesia technique discomfort was more in group 2 ($p=0.001$). A bloodless field was achieved in all cases except one. There were no serious complications during surgery or at follow-up.

	n (Number of Patients)	Mean of tourniquet pain-St. Dv. VAS		Mean of tourniquet time-St. Dv. (MIN.)	
Group 1	58	3.8	8.801	13.5	5.127
Group 2	42	2.0	3.894	13,1	5.422

DISCUSSION

The mechanism of tourniquet pain is still poorly understood but is probably multifactorial. Cole suggested that tourniquet pain had both a superficial and a deep component and may be caused by compression or possibly ischemia of large nerves.¹ Cole believed it was autonomic in origin and of sufficient intensity to penetrate a spinal block. The role of the autonomic system is disputed by Farah and Thomas who demonstrated the occurrence of tourniquet pain during IV regional analgesia (IVRA) of the upper limb despite stellate ganglion block.² Rousso et al. and Lowrie et al. proposed that tourniquet pain has a significant cutaneous component.^{3,4} Yu-Chuan et al. found in their study that Emla and subcutaneous ring anesthesia provided predominantly superficial analgesia, and both provided only limited analgesia, suggesting that skin compression is one component of tourniquet pain.⁵ Subcutaneous ring anesthesia was reported by Rousso et al. to be an excellent analgesic technique for tourniquets. However, Yu-C.Tsai et al. found that subcutaneous ring anesthesia only provided similar analgesia to Emla. It is possible that both lidocaine and prilocaine may affect the pain threshold by a central effect. Ohlsen et al. measured the plasma concentrations of lidocaine and prilocaine in 106 patients after application of Emla for split-skin grafting,⁶ and Lowrie et al. found it unlikely that sufficient lidocaine or prilocaine was absorbed to exert a central analgesic effect, even if absorption was altered by the inflation of the tourniquet.

When we look at the literature, there is no study like ours that compares the effects of two local anesthetic agents (Emla and Citanest) on forearm tourniquet pain.

In this study, our aim was to determine whether there is a superiority between Emla or Citanest on forearm tourniquet pain. We found that one is not superior to the other. Both techniques were found to be equally effective. We did find, however, that using Emla cream is less disturbing than injection. For testing the effectiveness of anesthetic agents against tourniquet pain, we chose a control group of 24 volunteers and compared them with groups 1 and 2. In the control group, VASs were dramatically higher than in the patients in groups 1 and 2 (>10 times).

There are a few studies about forearm tourniquet pain tolerance, and most authors believe that the forearm tourniquet can be tolerated for up to 20-30 minutes without any anesthesia.⁷ But in our study, the mean time of tourniquet duration was 13.3 minutes. Contrary to the literature, we found that short tourniquet time produces enough pain to require anesthesia for forearm tourniquet pain.

Yousif et al. also found that the forearm tourniquet is well tolerated without anesthesia.⁸ Like Douglas et al., they found these results in patients who did not undergo surgical procedures.

The Edwards et al. study was undertaken to compare the use of forearm and upper arm tourniquets for local anesthetic procedures on the hand.⁹ They did not use any anesthesia for tourniquet pain. They found that the use of a forearm tourniquet was well tolerated and was not associated with an increase in complications. The study results were similar to ours. Operation time was always less than 20 minutes. The mean forearm tourniquet duration was 8.5 (3-20) minutes and the pain score was 3.7 (0.5-9) according to VAS (0-10). 3.7/10 VAS score

	Cream (EMLA) (Tourniquet Vas-St. Dev.)	2% Prilocaine solution (CITANEST) (Tourniquet Vas-St. Dev.)	Control (Tourniquet Vas-St. Dev.)	p*
Tourniquet	3.8-8.80	2.0-3.83†	41.0-14.65†	<0.001

*Kruskal Wallis test

†Difference between control group was statistically significant (p<0.001).

was similar to the result that we found in our control group (41/100). We feel that this study supports ours. The difference in our study was that we used anesthesia for the tourniquet pain and compared two techniques.

No other studies used preoperative sedation with oral diazepam. Also, we compared two different anesthetic techniques in the patients who are operated on with local anesthesia so that we protected the patients from the complications of high dose anesthetics. Edwards et al.⁷ found that the forearm tourniquet could be used quite safely in patients undergoing surgical procedures with local anesthesia. However, no significant improvement in pain relief was noted when compared to the group with the above-elbow tourniquet. Using the forearm tourniquet with Emla or Citanest for anesthesia, there was no increase in the rate of significant complications associated with the use of the forearm tourniquet, and we had no particular problem with hemostasis. Complications were minimal in the short and long term. Only two mild hypertensive crises and two mild vagal reactions were noted, which resolved without treatment. Regarding long term complications, we found no problems due to the cuff or the punctures. In conclusion, the tourniquet placed at the distal forearm is an effective, safe and useful technique for hand surgery. Anesthesia using Emla cream is equally effective and less disturbing than the injection technique (subcutaneous ring anesthesia).

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