FOREARM TOURNIQUET IS ADVANTAGEOUS FOR HAND SURGERY UNDER INTRAVENOUS REGIONAL ANESTHESIA

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ABSTRACT

This study was designed to assess the outcome of forearm tourniquet in comparison to upper arm tourniquet during intravenous regional anesthesia (IVRA) for hand surgery, and to evaluate the possibility of reducing the dose of xylocaine used in conjunction with forearm tourniquet. The study included 90 patients allocated into three equal groups: Groups A and B received 30 ml of 0.7 % xylocaine with tourniquet applied at upper arm or at forearm, respectively and Group C received 20 ml of 0.7% xylocaine with forearm tourniquet. Minimum tourniquet time was assigned to be 20 minutes in group A and B and at the end of surgical procedure in group C. Surgical site and tourniquet pain were evaluated using four-point verbal analogue scale (VbAS), dryness and visibility of the operative field using Fromme scale and postoperative pain using visual analogue scale (VAS). Duration of postoperative analgesia was estimated starting at time of tourniquet deflation till first requested for rescue analgesia. Twenty patients had duration of surgery <20 minutes, however tourniquet could be removed only in 8 patients in group C. Time till onset of surgical anesthesia showed a non-significant difference between the three groups despite being shorter in group B. There was a significant reduction of intensity and frequency of tourniquet pain in groups B and C in comparison to group A, with a non-significant decrease in group B. Wetness of the surgical field was reported in only 3 patients with forearm tourniquet but all surgeons were satisfied by the extent of the surgical filed dryness throughout the time of surgery in all cases. IVRA using full dose of xylocaine provided significantly ($p<0.05$) prolonged postoperative analgesia compared to usage of reduced dose irrespective of the site of application of tourniquet. No local or systemic side effects related to the IVRA were observed. It could be concluded that the use of forearm tourniquet during IVRA safely enables to reduce the dose of used local anesthetic and tourniquet time and provide satisfactory bloodless surgical field during hand surgery, but with short duration of postoperative analgesia.

INTRODUCTION

It is well established that most surgeries at the wrist and forearm are performed using a tourniquet to minimize blood loss and are carried upon under either general anesthesia, local infiltration either alone or combined with sedation, IV regional anesthesia or brachial plexus blocks, [1].

Intravenous regional anesthesia is an effective method of providing anesthesia for extremity surgery, with published success rates ranging from 94% to 98%. Although there may be serious complications of local anesthetic toxicity associated with the technique, there are few reports of problems in the literature, [2].

Exsanguinations of the limb prior to tourniquet inflation decreases the amount of blood distal to the cuff and this reduces blood in the surgical field and may limit peak plasma levels of local anesthetic when the cuff is deflated, [3]. Most tourniquet-related morbidity occurs as a result of equipment malfunction. Proximal limb placement (thigh or upper arm) is preferred because larger amounts of tissue and muscle protect nerves from potential trauma.

Placement below the elbow or knee invites a higher risk of complications and is discouraged by some authors. Limited information is available comparing distal to proximal placement and incidence of complications, [4].

However, tourniquet application had certain limitations mainly tourniquet pain that may arise from ischemia of peripheral neurons or nociceptors distal to tourniquet, or from nerve fiber activation directly under it, again because ischemia. Furthermore, mechanical trauma and tissue ischemia under or distal to tourniquet lead to release of inflammatory mediators and thus

initiate, and/or aggravate tourniquet pain, [5].

Moreover, deflation of a tourniquet leads to release of blood with low pH and pO^2 and high lactate and K^+ leading to corresponding changes in systemic values in addition to hemodynamic changes ranging between mild to moderate changes with a transient fall in systemic arterial pressure, [6]. However, these changes could be reduced with short tourniquet time and the use of minimal inflation pressure, [7].

The objectives of this study was to assess the outcome of proximal placement of tourniquet at forearm in comparison to the traditional upper arm tourniquet during IVRA for hand surgery, and to evaluate the possibility of reducing the amount of xylocaine used in conjunction with forearm tourniquet.

PATIENTS & METHODS

This prospective, randomized, comparative study was conducted on 90 patients assigned to undergo minor hand operative procedures under IVRA. Patients with known allergies to local anesthetics, extensive hand trauma or intolerant to tourniquet pain were excluded off the study. All surgeries were performed by the same surgical team.

The study was conducted at Madienat Zaied Hospital, Abu Dhabi and comprised 65 males (72.2%) and 25 females (27.8%) with mean age of 37.7±10.1; range: 22-55 years. Patients were randomly allocated into three groups (n=30 patients, each):

Group A: comprised 20 (66.7%) male and 10 female (33.3%) patients assigned to receive IVRA using 30 ml of 0.7% xylocaine with tourniquet applied at upper arm above the elbow joint.

Group B: comprised 22 (73.3%) male and 8 female (26.7%) patients assigned to receive IVRA using 30 ml of 0.7% xylocaine with tourniquet applied at forearm.

Group C: comprised 23 (76.7%) male and 7 female (23.3%) patients assigned to receive IVRA using 20 ml of 0.7% xylocaine with tourniquet applied at forearm.

Two intravenous cannula were applied, one in the operative extremity for administration of the study solution and the other in the contralateral extremity for administration of necessary medications or fluids when indicated. When necessary, patients received midazolam, up to 3 mg, for sedation and relief of apprehension; however, no analgesics or opiates were given. After application of routine monitors, a double tourniquet was positioned on the upper operative arm in group A and at forearm in groups B and C.

The operative extremity was exsangunated by maintained elevation and intermittent squeezing for few minutes and the hand and forearm was wrapped with Esmarch bandage. Then, the proximal tourniquet was inflated to 250 torr and Esmarch bandage was removed. Circulatory isolation of the operative site was confirmed by inspection of the hand and absence of radial pulse. Then, IVRA solution assigned for each group was injected intravenously through the cannula applied in the operative extremity.

Four point verbal analogue scale (VbAS): none (=0), mild (=1), moderate (=2), and severe (=3), was used to determine the onset of surgical anesthesia, using pin-brick test every minute and to evaluate the degree of tourniquet pain every 10 min during the operative procedure. After onset of surgical anesthesia, the distal tourniquet was inflated and the proximal was deflated. No treatment for tourniquet pain was offered.

The maximum allowable tourniquet time was either the end of surgery or elapse of 60 minutes; whereas the minimum tourniquet time was 20 minutes in group A and B, but was assigned to be the end of surgical procedure and wound dressing in group C without minimum limit. A two-stage deflation was suggested whereby the cuff is deflated for 10 seconds and reinflated for 1 minute before the final release so as to allow for a more gradual "washout" of local anesthetic, [8].

The dryness and visibility of the operative field was evaluated using Fromme scale, [9] where: 0=no bleeding, 1=slight oozing and gauze use was not necessary, 2=slight bleeding and sometimes blood has to be dried, 3= low bleeding, blood has to be often dried and operative field is visible for some seconds after gauze removal, 4=average bleeding but surgery is hardly possible.

After deflation of tourniquet, postoperative pain was assessed, every 20 min for 1-hour and

every 30 minutes for 2 hours; using visual analogue scale (a 100 mm-scale, with "0" indicating no pain and "100" indicating worst pain ever), if VAS was ≥40, IM injection of declophenac sodium (75 mg/ml; 3 ml ampoule) was given. The duration of postoperative analgesia was estimated starting at time of tourniquet deflation till patient requested for rescue analgesia and number of patients requesting analgesia at each time of determination of VAS were reported.

Data were analyzed using Student *t* test and Chi-square test. Statistical analysis was conducted using the SPSS (Version 10, 2002) for Windows statistical package. P value <0.05 was considered statistically significant.

RESULTS

Patients' characteristics and surgical data were presented in Table (1) and showed a non-significant (p>0.05) difference between both groups. The mean duration till onset of surgical site anesthesia showed a non-significant (p>0.05) difference between the three groups despite being shorter in group B compared to that recorded in groups A and C, (Fig. 1). The mean duration of surgery was 31±8; range: 15-45 minutes with a non-significant (p>0.05) difference between the three groups. Twenty patients (22.2%) had duration of surgery <20 minutes, 5 patients in group A, 7 in group B and 8 patients in group C, however tourniquet could only be removed in group C.

The application of forearm tourniquet reduced the frequency and intensity of tourniquet pain in comparison to upper-arm tourniquet. No patient complained of severe tourniquet pain in all groups and no patient in groups B and C complained of moderate tourniquet pain, while 6 patients in group A had moderate pain. Moreover, up to 30 min tourniquet time, there was a significant reduction in the number of patients with mild pain in groups B (X^2=6.506, p<0.01) and C (X^2=4.581, p<0.05) in comparison to group A with a non-significant (X^2=0.958, p>0.05) difference between groups B and C but in favor of group B. Twelve patients had duration of surgery for ≥40 min; 3 patients in forearm groups still had no tourniquet pain and 4 had mild pain, while in upper arm group, 3 patients had mild and 2 had moderate tourniquet pain, (Table 2).

Wetness of the surgical field was reported in only 3 patients with forearm tourniquet but did not require the use of sponge to dry it; 2 cases in group B and one case in group C, but no case in group A had surgical field witness. All surgeons were satisfied by the extent of the surgical filed dryness throughout the time of surgery in all cases.

. IVRA using full dose of xylocaine (groups A and B) provided significantly (p<0.05) prolonged postoperative analgesia as judged by the duration till request of first rescue postoperative analgesia (VAS≥40) in comparison to group C that received the reduced dose of xylocaine, with a non-significant (p>0.05) prolongation of duration of analgesia in favor of group B, (Table 3, Fig. 2). Only 5 patients (16.7%) in group C requested rescue analgesia (VAS≥40) within the first postoperative hour. At 60 minutes postoperatively, 20 patients (66.7%) in group C, while 5 patients (16.7%) in group A and 3 (10%) in group B requested for rescue analgesia. At 120 minutes postoperatively, all patients in group C, while 26 patients (86.7%) in group A and 19 patients (63.4%) requested rescue analgesia. At 150 minutes postoperatively, 4 patients (13.3%) in group A and 7 patients (23.35%) in group B request rescue analgesia; whereas the remaining 4 patients (13.3%) in group B required analgesia at 180 minutes postoperatively. There was a significant decrease of number of patients requesting rescue analgesia early during postoperative period in group A (X^2= 5.84, p<0.05) and B (X^2=6.7, p<0.05) in comparison to group C with a non-significant difference in favor of group B, (Table 4, Fig. 3). All patients received rescue analgesia only once at time of request. There was no local or systemic side effects related to the IVRA were observed.

Table (1): Patients' characteristics

Parameter		Group A (n=30)	Group B (n=30)	Group C (n=30)
Age (years)		37.5±9.6 (23-55)	41.1±10.2 (23-55)	37.3±10.6 (22-52)
Sex, M:F		20:10	22:8	23:7
Operative procedure	*Carpal T*	14 (46.7%)	13 (43.3%)	11 (36.6%)
	Tenolysis	4 (13.3%)	6 (20%)	5 (16.7%)
	Ganglion	8 (26.7%)	7 (23.4%)	9 (30%)
	Plastic	4 (13.3%)	4 (13.3%)	5 (16.7%)
Onset of surgical anesthesia		3.7±1.2 (2.5-5.5)	3.3±0.9 (2-4.5)	3.8±1.3 (2.5-5.5)
Duration of surgery (min)		30.8±9 (15-45)	31.7±9.2 (15-45)	30.4±8 (15-41)
Number of patients with duration of surgery <20 min		5 (16.7%)	7 (23.3%)	8 (26.7%)

Data are presented as mean±SD, numbers and ratios, ranges & percentages are in parenthesis.

Table (2): Patients' distribution according to intraoperative verbal analogue scale for tourniquet pain

		At 10 min	At 20 min	At 30 min	At ≥40 min
Group A	*No*	25 (83.3%)	19 (63.3%)	7 (23.3%)	0
	Mild	5 (16.7%)	10 (33.3%)	11 (36.7%)	3 (10%)
	Moderate	0	1 (3.4%)	3 (10%)	2 (6.7%)
	T deflated	0	0	9 (30%)	25 (83.3%)
Group B	*No*	28 (93.3%)	23 (76.7%)	17 (56.7%)	2 (6.7%)
	Mild	2 (6.7%)	7 (23.3%)	3 (10%)	1 (3.3%)
	T deflated	0	0	10 (33.3%)	27 (90%)
Group C	*No*	27 (90%)	20 (66.6%)	16 (53.4%)	1 (3.3%)
	Mild	3 (10%)	2 (6.7%)	4 (13.3%)	3 (10%)
	T deflated	0	8 (26.7%)	10 (33.3%)	26 (86.7%)

Table (3): Postoperative duration of analgesia (minutes) till first request of rescue analgesia

Group	Mean±SD (range)	Significance
Group A	107±25.3 (60-150)	P_1=0.003
		P_2>0.05
Group B	120.8±27.6 (60-180)	P_1=0.001
Group C	61.4±17.6 (35-95)	

Data are presented as mean±SD, ranges are in parenthesis
P_1: significance versus group C P_2: significance versus group B

Table (4): Postoperative pain visual analogue scale

Time	Group A	Group B	Group C
40 min	0	0	5 (16.7%)
60 min	5 (16.7%)	3 (10%)	15 (50%)
90 min	15 (50%)	7 (23.35%)	9 (30%)
120 min	6 (20%)	9 (30%)	1 (3.3%)
150 min	4 (13.3%)	7 (23.35%)	0
180 min	0	4 (13.3%)	0

Data are presented as numbers, percentage are in parenthesis

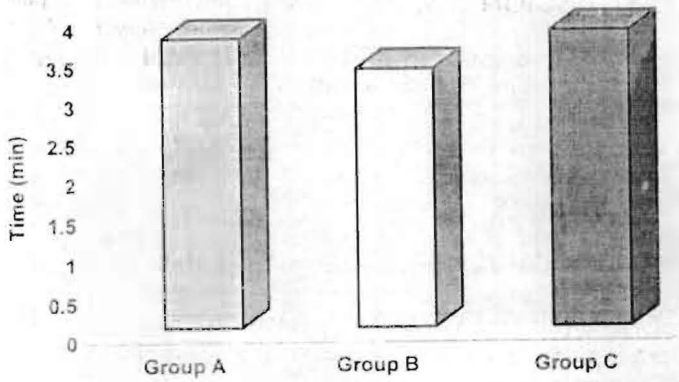

Fig. (1): Mean onset of anesthesia after xylocaine injection in the studied groups

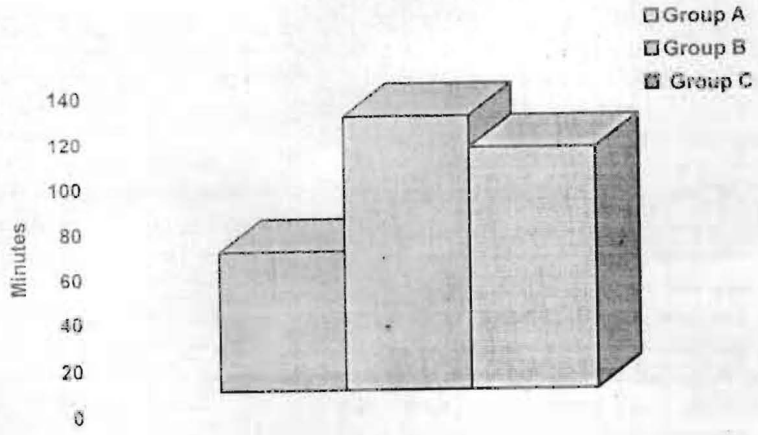

Fig. (2): Mean duration till first request of rescue postoperative analgesia in the studied groups

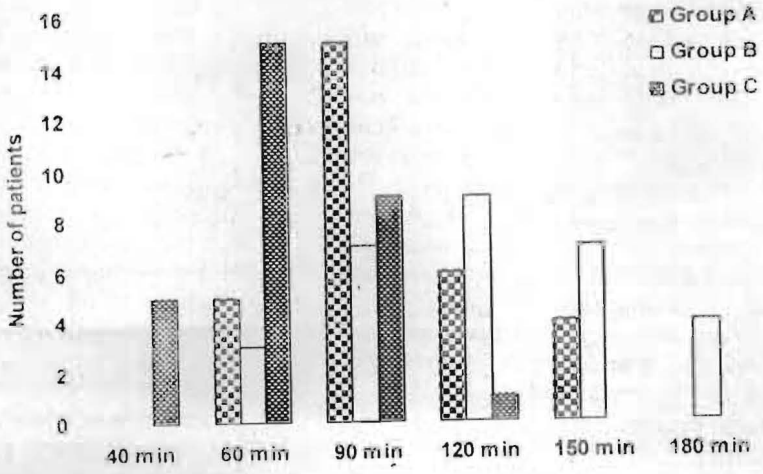

Fig. (3): Patients distribution according to time of request of postoperative rescue analgesia

DISCUSSION

The resultant anesthesia after IVRA is produced by direct diffusion of the local anesthetic from the vessels into the nearby nerves. IVRA is best used for brief minor surgery (up to 1 hour) of the hand and forearm. Its use for longer surgical procedures is precluded by the appearance of the discomfort from the tourniquet, which limits the indications for its use. The main advantages of this technique are its simplicity and reliability. Its drawback is the lack of postoperative analgesia because the block quickly resolves after release of the tourniquet, [10].

Through the present study, time till complete surgical anesthesia showed a non-significant difference between the three groups despite the use of reduced dose of xylocaine in group C.

These results agreed with Marsch et al., [11], who compared IVRA using 40 ml of chloroprocaine 0.5% and 1% and reported that the use of 1% non-significantly had earlier time of onset of anesthesia but this beneficial effect should be weighed against a fourfold increase of systemic local anesthetic toxicity.

The observed non-significant difference between patients received reduced dose and those received full-dose goes in hand with Reuben et al., [12], who reported that the use of a forearm cuff for IVRA is a technique that provides effective surgical anesthesia with a local anesthetic dose reduction of up to 30%

Patients with forearm tourniquet had less pain scores compared to those had upper arm tourniquet with the difference being significant ($p<0.05$) only in patients who had tourniquet inflated for $\geq$30 min and was non-significant ($p>0.05$) at 10 and 20 min after start of IVRA. These results go in hand with Davis et al., [13] who reported that application of forearm tourniquet during IVRA provides a more rapid onset of anesthesia and may improve the density and quality of the block. Also, Perlas et al., [14] reported that a forearm cuff is better tolerated than an arm tourniquet during IVRA and is also associated with lower pain scores.

Moreover, the obtained results coincided with that observed by Delgado-Martinez et al., [15] and Karalezli et al., [16] who evaluated the results of IVRA with distal forearm tourniquet and reported that it provides safe, rapid and effective anesthesia for patients undergoing outpatient hand surgery. Bloodless surgical field was reported in 87 patients; only slight oozing was reported in only 3 patients with forearm tourniquet but did not require the use of sponge to dry it; furthermore, all surgeons were satisfied by the extent of the surgical filed dryness throughout the time of surgery in all cases. These results agreed with that reported with the use of forearm tourniquet by Perlas et al., [14], Delgado-Martinez et al., [15], and Karalezli et al., [16].

Duration of postoperative analgesia showed a significant ($p<0.05$) prolongation in groups A and B compared to group C with a non-significant prolongation in group B compared to group A. These results signified that the postoperative analgesia provided by a full-dose of xylocaine was superior to that provided by the reduced dose of xylocaine irrespective of the type of tourniquet used and agreed with Sinha et al., [17], who reported that dissipation of anesthetic effect of IVRA is expected soon after tourniquet deflation but postoperative analgesia is dose dependent. Moreover, obtained results are in accordance with Marsch et al., [11] who compared IVRA using 40 ml of chloroprocaine 0.5% and 1% and reported that the use of full dose provided significant reduction of postoperative pain.

Despite 20 patients had duration of surgery <20 minutes, tourniquet could only be removed in 8 patients in group C prior to the previously determined minimum tourniquet duration (20 minutes). These results agreed with Sinha et al., [17] who reported limiting the maximum intravenous bolus dose and keeping the minimum cuff deflation time to 15 min enables to safely administer IVRA.

No systemic or local toxicity was reported in all patients either during surgical procedure or after deflation of tourniquet despite the reduction of cuff-deflation time in group C. The safety of forearm tourniquet agreed with data obtained by Coleman et al., [18] who evaluated local anesthetic leakage under the forearm tourniquet, through interosseous vessels that was initially questioned and reported that it quantified to be similar for both forearm and conventional upper arm cuff placement. Furthermore, through the present study sequential deflation was applied so as to broaden the safety spectrum through slowing the time to peak systemic local

anesthetic level during the washout period. It could be concluded that the use of forearm tourniquet during IVRA safely enables to reduce the dose of used local anesthetic and tourniquet time and provide satisfactory bloodless surgical field during hand surgery, but with short duration of postoperative analgesia.

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