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The effect of using a tourniquet on the intensity of postoperative pain in forearm fractures

A randomized study in 32 surgically treated patients

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Summary. *We have analysed the relationship between the intensity of postoperative pain and the use of a pneumatic tourniquet in procedures for operative fixation of fractures of the forearm. Thirty-two patients were divided randomly into two groups as a control (NT) and tourniquet (T).The pain scores in the NT group were significantly lower. Patients over the age of 30 had notably more pain than those younger after the use of a tourniquet. Avoidance of the tourniquet gave better postoperative analgesia in male patients and in those with comminuted fractures. When a tourniquet was used the best results were obtained if it was kept inflated for less than one hour.*

Résumé. *Le but de ce travail est l'analyse de la relation entre l'application du tourniquet et l'intensité de la douleur post-opératoire des fractures de l'avant-bras. On a divisé 32 malades en deux groupes; les premier est (NT) le groupe de controle, le deuxième (T) étant le groupe du tourniquet. Quand on a comparé les resultats de deux groupes, on a constaté que les résultats du groupe NT sont remarquablement bas. L'âge du malade influence directement les résultats; la douleur causé par l'application du tourniquet est une souffrance importante pour les malades qui sont agés plus de 30 ans. L'évitation de l'application du tourniquet a montré que l'analgésie post-opératoire est plus efficace. Aprés l'application des analgésiques aux malades sévères du sexe masculin, on a constaté une diminution remarquable aux résultats (aux scores de douleur). On a constaté que si la durée l'application du tourniquet est moins d'une heure, le résultats sont meilleurs. En résumé, avant la décision de l'application du tourniquet il faut évaluer individuellement chaque malade et apprécier les avantages et les désavantages bien soigneusement.*

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Introduction

A tourniquet is used regularly when performing an orthopaedic operation on a limb in order to avoid excessive bleeding and to provide a bloodless field. The adverse effects of pneumatic tourniquets have been report as pain, paralysis, tendon rupture, pulmonary embolism, hypertension, tachycardia and increased body temperature during general anaesthesia [7, 15]. Pain at the operation site is common after a procedure and should be controlled to enable optimal recovery [11]. We have analysed the relationship between the intensity of postoperative pain and the use of a pneumatic tourniquet during operations on the upper limb.

Patients and methods

This prospective study was completed within a year and included patients between 15 and 70 years of age with closed fractures of the shafts of the radius and ulna. Those who had major cranial, thoracic or spinal injuries, other fractures or peripheral neuropathy were excluded from this study. Patients were divided into two groups "tourniquet" (T) and "control" (NT).

The patients were randomised in order of their admission into hospital, with the odd numbered patients allocated to the T group and the even numbered to the NT group. Informed consent was obtained from them all.

For statistical analysis we used the t-test for independent samples, the t-test for paired samples, the Mann-Whitney U-test and the Kolmogorov-Smirnov (K-S) test in both groups. The level of significance was set at $P<0.05$.

There were 32 patients (24 male and 8 female). There were 12 male and 4 female patients in each group. The average age

was 27.4±14.9 [15–60] in the NT group and 26.5±15.3 [15–70] in the T group. According to the AO classification [12] there were ten type A fractures, 4 type B and 2 type C in the NT group and 9 type A, 7 type B and 0 type C in the T group. The average period between the time of admission and operation was 4.8±1.9 [2–8] days for the NT group and 5.1±2.1 [2–9] days for the T group. The operations were performed by the same surgical team. Inhalation anaesthesia was used to avoid the risk of tourniquet pain. Premedication was administered with diazepam and atropine 30 min before operations. A standardised anaesthetic was used with thiopental and a muscle relaxant for induction and intubation followed by oxygen, halothane and N_2O for maintenance.

The limb was exsanguinated with an Esmarch bandage and a tourniquet, 9.5 cm wide was used. A pressure of 200 to 250 mm/hg was applied. Internal fixation was undertaken using plates and screws. The average time for operation was 77.8±16.4 [60–120] min for the NT group and 66.9±18.5 [50–105] min for the T group. The tourniquet was deflated after internal fixation was completed and meticulous haemostasis carried out. The patients with a tourniquet were divided into two sub-groups of "less than 60 min" and "60–120 min". The average tourniquet time was 53.3±2.6 [50–55] min in the "less than 60 min group" and 83.0±14.6 [65–110] min in the "60–120 min group". Closed suction drains were used routinely and removed after 48 h. An above elbow cast with the forearm in full supination was applied for the first 48 h. Diclofenac sodium was used as an analgesic in all patients, intramuscularly if desired. The maximum dose was 150 mg/day. Postoperative pain was assessed using a present pain intensity (PPI) scale [10] and the visual analogue scale (VAS) [8]. All the interviews were conducted by the same author (OG), who did not know which group the patient belonged to. The patients were assessed at 24 and 48 h after operation, and asked as to their pain at the operation site before and one hour after receiving analgesic on the first and second postoperative days. The pain was graded as "no pain"=0, "mild pain"=1, "discomfort"=2, "distress"=3, "horrible"=4, "excruciating"=5. The visual pain status was analysed by the subject's marking a 100 mm line where 0 represented no pain and 100 for the worst possible pain.

Results

The average verbal and visual pain scores of the NT group were significantly less than those of the T group both on the first and second days after operation (Table 1). This difference is more evident after receiving the analgesia.

The relationship between the intensity of postoperative pain, sex, the age of the patient and the type of fracture is shown in Table 2. In males there was a significant difference between the average pain scores in the two groups after receiving analgesic, which was most marked on the first day after operation. The use of a tourniquet seemed to cause more severe pain in females and this was most obvious on the second

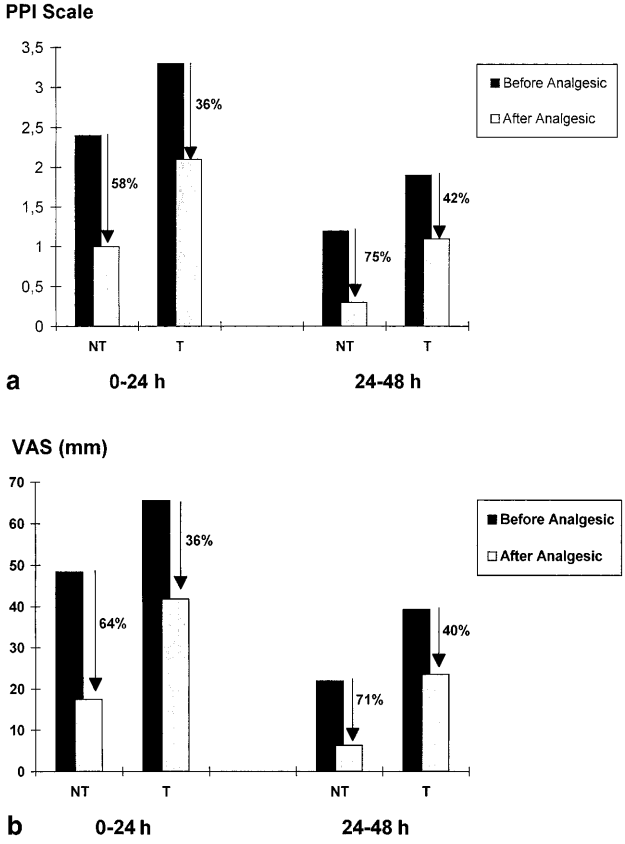

Fig. 1a. Response of postoperative pain to the analgesic in non-tourniquet (*NT*) and tourniquet (*T*) groups: analysis of PPI scale. "↓" indicates the percentage of decrease in pain after application of the analgesic. **b**. Response of postoperative pain to the analgesic in non-tourniquet (*NT*) and tourniquet (*T*) groups: analysis of VAS. "↓" indicates the percentage of decrease in pain after application of the analgesic

Table 1. The average pain intensity scores of all patients and the comparison of the average scores of the T and NT groups

	0–24 h postoperatively				24–48 h postoperatively			
	Before analgesic		After analgesic		Before analgesic		After analgesic	
	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS
NT Group	2.4±0.6 *n*=16	48.4±14.5 *n*=16	1.0±0.8 *n*=16	17.5±16.2 *n*=16	1.2±0.5 *n*=16	21.9±14.3 *n*=16	0.3±0.5 *n*=16	6.4±8.7 *n*=16
T Group	3.3±1.0 *n*=16	65.6±23.7 *n*=16	2.1±1.0 *n*=16	41.9±20.2 *n*=16	1.9±1.1 *n*=16	39.3±24.7 *n*=16	1.1±1.0 *n*=16	23.6±21.1 *n*=16
Statistics (*P* value)	**0.006***	0.05**	**0.002***	**0.001***	**0.03***	**0.02***	**0.005***	**0.003****

Values of the NT and T groups are mean±standard deviation
* Independent *t*-test
** Mann-Whitney U-test
Bold *P* values are significant

Table 2. Relationship between sex, age of the patient, type of fracture and the intensity of postoperative pain in T and NT groups

	0–24 h postoperatively								24–48 h postoperatively							
	Before analgesic				After analgesic				Before analgesic				After analgesic			
	Female		Male		Female		Male		Female		Male		Female		Male	
	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS
NT Gr.	2.8±1.0 *n*=4	50.0±12.8 *n*=4	2.3±0.5 *n*=12	47.9±15.5 *n*=12	1.0±0.0 *n*=4	16.3±4.5 *n*=4	1.0±0.9 *n*=12	17.9±18.8 *n*=12	0.8±0.5 *n*=4	18.0±13.3 *n*=4	1.3±0.5 *n*=12	23.3±14.9 *n*=12	0.0±0.0 *n*=4	1.5±3.0 *n*=4	0.4±0.5 *n*=12	7.3±8.8 *n*=12
T Gr.	3.5±1.0 *n*=4	71.8±24.0 *n*=4	3.2±1.0 *n*=12	63.5±24.3 *n*=12	2.0±1.4 *n*=4	45.0±27.6 *n*=4	2.2±0.9 *n*=12	40.8±18.5 *n*=12	2.5±1.0 *n*=4	53.0±25.9 *n*=4	1.7±1.1 *n*=12	34.7±23.6 *n*=12	1.8±1.5 *n*=4	34.3±34.0 *n*=4	0.9±0.7 *n*=12	20.0±15 .5 *n*=12
P	0.3**	0.3**	**0.01***	0.08*	0.3**	**0.03****	**0.006***	**0.006***	**0.03****	0.06**	0.3*	0.2*	**0.03****	**0.03****	0.05*	**0.03****
	≤30 years		>30 years		≤30 years		>30 years		≤30 years		>30 years		≤30 years		>30 years	
	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS
NT	2.5±0.7 *n*=11	51.7±16.3 *n*=11	2.2±0.5 *n*=5	41.2±5.8 *n*=5	1.2±0.9 *n*=11	19.4±17.5 *n*=11	0.6±0.6 *n*=5	10.2±10.0 *n*=5	1.3±0.7 *n*=11	21.8±16.5 *n*=11	1.0±0.0 *n*=5	22.2±9.2 *n*=5	0.4±0.5 *n*=11	6.1±8.2 *n*=11	0.2±0.4 *n*=5	5.2±8.7 *n*=5
T Gr.	2.9±1.0 *n*=10	56.3±23.1 *n*=10	3.8±0.8 *n*=6	81.0±16.4 *n*=6	1.7±0.7 *n*=10	31.4±10.7 *n*=10	2.7±1.2 *n*=6	56.0±22.1 *n*=6	1.6±1.2 *n*=10	32.1±24.6 *n*=10	2.3±0.8 *n*=6	51.2±21.6 *n*=6	0.9±0.7 *n*=10	17.6±15.1 *n*=10	1.5±1.2 *n*=6	33.5±27 .2 *n*=6
P	0.3**	0.8**	**0.009****	**0.004****	0.2**	**0.03****	**0.009****	**0.004** **	0.5**	0.6**	**0.004****	**0.02****	0.1**	0.06**	**0.02****	**0.02****
	Type A		Type B&C		Type A		Type B&C		Type A		Type B&C		Type A		Type B&C	
	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS
NT Gr.	2.5±0.7 *n*=10	54.4±14.7 *n*=10	2.2±0.4 *n*=6	38.5±7.3 *n*=6	1.2±0.9 *n*=10	21.0±18.7 *n*=10	0.7±0.5 *n*=6	11.7±9.7 *n*=6	1.3±0.7 *n*=10	24.7±17.5 *n*=10	1.0±0.0 *n*=6	17.3±4.6 *n*=6	0.5±0.5 *n*=10	8.8±8.9 *n*=10	0.0±0.0 *n*=6	0.8±2.1 *n*=6
T Gr.	3.1±0.8 *n*=9	64.0±22.6 *n*=9	3.4±1.3 *n*=7	67.6±26.7 *n*=7	2.1±1.3 *n*=9	41.7±24.8 *n*=9	2.1±0.7 *n*=7	42.1±14.0 *n*=7	2.0±1.4 *n*=9	43.0±30.3 *n*=9	1.7±0.5 *n*=7	34.4±15.9 *n*=7	1.3±1.2 *n*=9	26.9±26.5 *n*=9	0.9±0.4 *n*=7	19.3±12 .0 *n*=7
P	0.1**	0.3**	0.07**	0.07**	0.1**	0.05**	**0.005****	**0.001 ****	0.2**	0.2**	**0.03****	0.1**	0.1**	0.09**	**0.008****	**0.002****

Values of the NT and T groups are mean±standard deviation; * Independent *t*-test; ** Mann-Whitney U-test; Bold *P* values are significant

Table 3. Relationship between tourniquet time and the intensity of postoperative pain

	0–24 h postoperatively				24–48 h postoperatively			
	Before analgesic		After analgesic		Before analgesic		After analgesic	
	PPI	VAS	PPI	VAS	PPI	VAS	PPI	VAS
<60 min	3.2±1.2 *n*=6	59.0±26.8 *n*=6	1.8±0.7 *n*=6	30.8±13.3 *n*=6	1.2±1.0 *n*=6	26.5±22.8 *n*=6	0.8±0.7 *n*=6	18.3±17.4 *n*=6
60–120 min	3.3±0.9 *n*=10	69.5±22.2 *n*=10	2.3±1.2 *n*=10	48.5±21.2 *n*=10	2.3±0.9 *n*=10	46.9±23.5 *n*=10	1.3±1.1 *n*=10	26.7±23.4 *n*=10
Statistics (*P* value)	0.8	0.4	0.5	0.2	0.09	0.3	0.5	0.4

Values of the NT and T groups are mean±standard deviation; Statistical test: Mann-Whitney U-test

postoperative day. When patients were divided into those under 30 years of age and those over, no significant difference was found between the NT and T groups in the younger patients, but there was a significant difference in those who were older. The fractures were grouped as "mild" (type A) and severe (types B and C). After receiving analgesia there was a significant difference between the average scores of the NT and T groups than those with B and C fractures, on the first and second postoperative days.

The length of use of the tourniquet was not found to be an important factor in the intensity of postoperative pain [Table 3]. However, the pain scores in the "less than 60 min" group were slightly less than in the "60–120 min" group.

The use of analgesics significantly lessened the pain in both groups on the first and second postoperative days, and better relief was obtained in the NT group (Fig. 1).

In two patients mild tourniquet paralysis was observed but both settled completely within two months. Both had tourniquets of more than one hour. The first was a 30-year-old woman who had a tourniquet applied for 105 min. She had severe pain, even after analgesic, during the first two days after operation. The second was a 19-year-old male who had a tourniquet inflated for 90 min. His pain scores were similar to the average for his group.

Discussion

We have demonstrated a strong relationship between the severity of pain after operation and the use of a tourniquet after surgical treatment of fractures of the forearm. Ischaemia may produce acute inflammation, degeneration and necrosis of muscle fibres, followed by phagocytosis and regeneration. A 15–90 min period of tourniquet induced ischaemia may produce harmful effects on the ultrastructure of skeletal muscles. Pathological changes include accumulation of lipid droplets, intrafibrillary and interfibrillary oedema and thickening of the basement membrane of the epithelium. The severity of these changes depends on the period of ischaemia [1, 13]. We found slightly lower pain scores in those with shorter tourniquet times. The use of a nonsteroidal analgesic anti-inflammatory drug may have helped combat the inflammation and oedema following use of the tourniquet. Even a non-narcotic analgesic will provide nearly complete analgesia in those who have not had tourniquets. The use of an Esmarch bandage may cause additional damage.

It has been previously noted that postoperative pain is higher in older patients [11]. We found that avoidance of the tourniquet improved analgesia in both older patients and males, and if used it was best to apply for less than an hour.

Although a bloodless field for operating may be useful in severely comminuted fractures of the diaphyses, it is not always necessary for other procedures. Careful haemostasis during the operation may slightly prolong the operative time, and we found that operations were completed approximately 10 min quicker when a tourniquet was used.

Tourniquet pain which is a severe, dull, aching sensation at the site of the tourniquet or in the limb may be refractory to treatment despite satisfactory anaesthesia. It occurs particularly during spinal or epidural anaesthesia in the leg and regional anaesthesia in the upper limb. Its cause is not certain [2, 4, 6], but it is directly related to the time for which the tourniquet is used and technique of anaesthesia [14, 15].

Excessive or insufficient pressure, prolonged use and application without careful consideration of the local anatomy may lead to tourniquet paralysis [3]. We encountered this complication twice, both with a tourniquet which was used for a long period. We recommend that a tourniquet be used for less than an hour or if it is required longer than this it should be deflated for ten minutes and then reinflated [3].

A significant increase in both systolic and diastolic blood pressure has been observed in volunteers who received neither medication or anaesthesia after application of a tourniquet to their arms [5, 9]. This is though to be due to an increase in serum cortisol and plasma norepinephrine [6].

A wide tourniquet should be used in order to lessen the possibility of complication and the level of inflation should be kept as low as possible [3, 7].

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References

1. Appell HJ, Glöser S, Duarte JAR, Zellner A, Soares JMC (1993) Skeletal muscle damage during tourniquet-induced ischaemia: the initial step towards atrophy after orthopaedic surgery? Eur J Appl Physiol 67:342–347
2. Chabel C, Russell LC, Lee R (1990) Tourniquet-induced limb ischemia: a neurophysiological animal model. Anesthesiology 72:1038–1044
3. Crenshaw AH (1992) Surgical techniques. In: Crenshaw AH (ed) Campbell's Operative Orthopaedics. Mosby Year Book, St Louis Baltimore Boston
4. Crews JC, Cahall M, Behbehani MM (1994) The neurophysiologic mechanisms of tourniquet pain: the activity of neurons in the rostroventral medulla in the rat. Anesthesiology 81:730–736
5. Crews JC, Hilgenhurst C, Leavitt B, Denson DD, Bridenbaugh PO, Stuebing RC (1991) Tourniquet pain: the response to the maintenance of tourniquet inflation on the upper extremity of volunteers. Reg Anesth 16:314–317
6. Crews JC, Sehlhorst CS (1991) Response to maintenance of tourniquet inflation in a primate model. Reg Anesth 16:195–198
7. Hagenouw RRPM, Bridenbaugh PO, van Egmond J, Stuebing R (1986) Tourniquet pain: a volunteer study. Anesth Analg 65:1175–1180
8. Huskisson EC (1983) Visual analogue scales. In: Melzack R (ed) Pain measurement and assessment. Raven Press, New York
9. Hutchinson DT, McClinton MA (1993) Upper extremity tourniquet tolerance. J Hand Surg [Am] 18:206–210
10. Melzack R (1987) The short-form McGill pain questionnaire. Pain 30:191–197
11. Melzack R, Abbott FV, Zackon W, Mulder DS, Davis MWL (1987) Pain on a surgical ward: a survey of the duration and intensity of pain and the effectiveness of medication. Pain 29:67–72
12. Müller ME, Allgöwer M, Schneider R, Willenegger H (1991) Manual of internal fixation. Springer, Berlin Heidelberg New York
13. Ömeroğlu H, Erdoğan D, Ömeroğlu S, Günel U, Biçimoğlu A (1997) Ultrastructural analysis of the alterations in skeletal muscle during tourniquet application on extremities. Acta Orthop Traumatol Turc 31:323–326
14. Tetzlaff JE, Walsh M, Yoon HJ (1993) PH adjustment of mepivacaine decreases the incidence of tourniquet pain during axillary brachial plexus anaesthesia. Can J Anaesth 40:133–136
15. Tetzlaff JE, Yoon HJ, Walsh M (1993) Regional anaesthetic technique and the incidence of tourniquet pain. Can J Anaesth 40:591–595