Tourniquet inflation during arthroscopic knee ligament surgery does not increase postoperative pain

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Purpose: A double-blind clinical trial was conducted to determine the effect of inflation of a thigh tourniquet during anterior cruciate ligament repair on arthroscopic visibility, duration of procedure, postoperative pain and opioid consumption.

Methods: Thirty patients were randomly allocated into two groups; Group I had the thigh tourniquet inflated during surgery whereas the tourniquet was not inflated in Group II patients. All patients received standardized general anesthesia and postoperative pain management. Supplemental analgesia was provided with *iv* morphine via a patient-controlled analgesia (PCA) apparatus. Verbal pain rating scores (0-10) were obtained after surgery.

Results: Arthroscopic visibility was impaired in Group II patients ($P < 0.0001$), but this was ameliorated by increased irrigation flow or addition of epinephrine. Duration of surgery was similar in both groups. There was no difference between groups in postoperative morphine consumption (9.8 ± 7.1 mg in Group I *vs* 11.4 ± 10.2 mg in Group II) or in postoperative pain scores between groups.

Conclusion: Inflation of a thigh tourniquet did not result in increased pain or opioid consumption after arthroscopic ACL surgery. Arthroscopic visibility was somewhat impaired in some patients without the use of tourniquet. Finally, the duration of the surgical procedure was not increased in patients where the tourniquet was not inflated during the ACL repair.

Objectif : Un essai clinique en double aveugle a été mené pour déterminer l'effet du gonflement d'un garrot à la cuisse, pendant la réparation du ligament croisé antérieur (LCA), sur la visibilité arthroscopique, la durée de l'intervention, la douleur postopératoire et la prise d'opioïdes.

Méthode : Trente patients ont été répartis au hasard en deux groupes : on a gonflé le garrot à la cuisse dans le groupe I, mais non dans le groupe II. Tous ont reçu une anesthésie générale standard et un traitement pour la douleur postopératoire. L'analgésie supplémentaire a été administrée avec de la morphine *iv* au moyen d'un dispositif d'analgésie contrôlée par le patient (ACP). Les scores verbaux de douleur (0-10) ont été obtenus après l'opération.

Résultats : La visibilité arthroscopique a été altérée chez les patients du groupe II ($P < 0,0001$), mais la situation a été corrigée par l'augmentation du débit d'irrigation ou l'ajout d'épinéphrine. La durée de l'opération a été similaire dans les deux groupes. Il n'y a pas eu de différence intergroupe quant à la consommation de morphine postopératoire (9,8 ± 7,1 mg dans le groupe I *vs* 11,4 ± 10,2 mg dans le groupe II) ou aux scores de douleur postopératoire.

Conclusion : Le gonflement d'un garrot à la cuisse n'a pas provoqué d'augmentation de la douleur postopératoire ou de prise d'opioïdes. La visibilité arthroscopique a été un peu altérée dans le cas de certains patients chez qui le garrot n'était pas gonflé. La durée de l'intervention n'a cependant pas été augmentée pour les patients du groupe II pendant la réparation du LCA.

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ARTHROSCOPIC knee surgery is commonly performed with a thigh tourniquet to decrease bleeding which adversely affects visibility during the procedure. There are reports of nerve and muscle injuries following prolonged tourniquet inflation of the extremities.[1,2] This has led some investigators to advocate that use of a tourniquet is an unnecessary risk when performing knee surgery.[3] Tourniquet pain has also been described in patients undergoing surgery with regional anesthetic blockade[4] and in volunteers.[5] Intraoperative hypertension during surgery with tourniquet and general anesthesia has been associated with increased serum cortisol and norepinephrine concentrations,[6] presumably in response to transmission of pain impulses to the central nervous system from nociceptors affected by inflation of the cuff.[7,8] Persistent noxious input to the central nervous system may result in increased spontaneous activity, increased responsiveness to afferent input and expansion of peripheral receptive fields of dorsal horn neurons.[9] It is, therefore, conceivable that afferent pain impulses from inflation of a thigh tourniquet may increase postoperative pain. In addition, deflation of the tourniquet is associated with hyperemia and increase in limb size.[10] This could also result in increased postoperative pain as a result of compression of peripheral nerves near the surgical site.

There are no reports of a possible association between tourniquet inflation and postoperative pain after arthroscopic knee ligament surgery. The principal aim of our randomized, double-blind clinical trial was to determine whether tourniquet inflation during arthroscopic anterior cruciate ligament (ACL) reconstruction increased postoperative pain and analgesic requirements. Also, we determined the duration of surgery and arthroscopic visibility in these patients undergoing out-patient ACL repair with and without a tourniquet.

Methods

The study protocol was approved by the institutional Research Ethics Committee. Informed written consent was obtained from 30 ASA I or II day surgery patients scheduled for elective anterior cruciate ligament reconstruction using semitendinosus tendon graft. Exclusion criteria included age <18 yr, allergy to any of the study medications, history of substance abuse or neuropathy in the distribution of the femoral nerve.

The patients were assigned according to a computer generated series of random numbers into one of two study groups. A pneumatic tourniquet was applied to the thigh in both groups, and covered with sterile drapes after skin preparation. A second tourniquet cuff was applied to a sand bag which was out of view to the surgical team. The two cuffs were connected to an ATS™ 1500 Tourniquet System (Zimmer). In Group I, the pneumatic tourniquet around the patient's thigh was inflated and the tourniquet around the sand bag was also inflated. Conversely, in Group II, the tourniquet around the patient's thigh was not inflated and the tourniquet around the sand bag was inflated. The pneumatic tourniquet was inflated to 300 mmHg. Thus, the surgical team was unaware whether the thigh tourniquet was inflated before start of surgery. No pre-medication was administered. Anesthesia was induced with 40 $\mu g \cdot kg^{-1}$ midazolam, 1 $\mu g \cdot kg^{-1}$ fentanyl, and 2-5 $mg \cdot kg^{-1}$ propofol. A laryngeal mask was inserted after loss of consciousness. General anesthesia with spontaneous ventilation was maintained with nitrous oxide, isoflurane, and 1 $\mu g \cdot kg^{-1} \cdot hr^{-1}$ fentanyl infusion. Intraoperative monitoring included pulse oximetry, ECG and automated non-invasive blood pressure monitoring. Surgical technique was identical in all patients, and the operation was performed by the same orthopedic surgeon (DJ). The tourniquet cuff(s) was deflated following completion of surgery and skin closure.

All study patients received multi-modal analgesia with intra-articular injection of 20 ml ropivacaine 0.25% with epinephrine 1:200,000 and 2 mg morphine, 30 mg ketorolac *iv* and a femoral nerve block with 20 ml ropivacaine 0.25%. A peripheral nerve stimulator was used to locate the femoral nerve. The analgesic regimen was administered immediately after skin closure and deflation of the tourniquet, prior to awakening from general anesthesia. The surgeon was asked to describe the arthroscopic visibility (intra-articular bleeding) at the completion of the operative procedure. Patients in both study groups received local cold therapy using an AIRCAST cryo/cuff ® and the lower extremity was positioned in a continuous passive motion (CPM) machine. Postoperative pain management was similar in both groups. A patient controlled analgesia (PCA) apparatus was connected to the *iv* infusion tubing immediately on arrival to the postanesthetic care unit (PACU). The PCA unit was programmed to deliver a 1.5 mg bolus of morphine with a five minute lock-out without a background morphine infusion. The PCA was connected for at least five hours after arrival to PACU. After the five hour period the nurse was instructed to discontinue the *iv* PCA morphine apparatus, provided the morphine consumption was $\leq$ 6 $mg \cdot hr^{-1}$. Four hours after surgery 600 mg acetaminophen with 60 mg codeine and 10 mg ketorolac *po* were administered. Verbal pain scores were assessed using a self-rating pain scoring method (0=no pain, 10=worst possible pain). Pain scoring by the patient was

TABLE I Demographic data and duration of surgery.

	Group I n=14	*Group II n=15*
Age (yr)	35.3 ± 7.8	35.7 ± 6.6
Weight (kg)	70.8 ± 15.5	77.9 ± 14.4
Height (cm)	167 ± 7.7	174 ± 9.3
Male/female	5/9	10/5
Duration of surgery (min)	60.8 ± 9.6	65.3 ± 15.5

Values represent mean ± SD.

TABLE II Assessment of arthroscopic visibility.

	Group I n=14	*Group II n=15*
Clear, no bleeding	11	0
Somewhat impaired visualization; increase in irrigation flow	3	5
Impaired visualization; addition of epinephrine into irrigation solution	0	10
Markedly impaired visualization; requires tourniquet inflation	0	0

$P < 0.0001$ Group II *vs* Group I

done every 30 min after arrival to PACU for two hours; thereafter pain scores were obtained every hour. The presence of the femoral nerve block (sensory block) was assessed by pin-prick using a 27 gauge blunt needle one hour after arrival to PACU. Prior to discharge, patients in both groups were asked to indicate the degree of overall satisfaction with post-operative pain management on a four point satisfaction scale: (0=unsatisfied/poor, 1=somewhat satisfactory /adequate, 2=satisfactory/adequate, 3=very good, 4=excellent).

We predicted a 30% increase in total *iv* PCA morphine consumption in the tourniquet group (Group I) *vs* Group II patients over the study period. Assuming an α of 0.05 and a (1-ß) of 0.8, a total of 30 patients (15 per group) were required at the stated level of statistical confidence. Demographic data, total *iv* morphine consumption and duration of surgery were analysed using Student's t test. Pain scores and postoperative morphine consumption over time were analysed using repeated measures analysis of variance (ANOVA). Arthroscopic visibility was analysed using a Mann-Whitney U-test on ranks. Patient satisfaction was analysed using a contingency table (chi square). $P < 0.05$ was considered statistically significant.

Results

Thirty patients were enrolled in the study. One patient was lost to analysis due to absence of femoral nerve block. Therefore, a total of 29 patients were available for analysis; 14 patients had the thigh tourniquet inflated during surgery (Group I) and 15 patients did not (Group II).

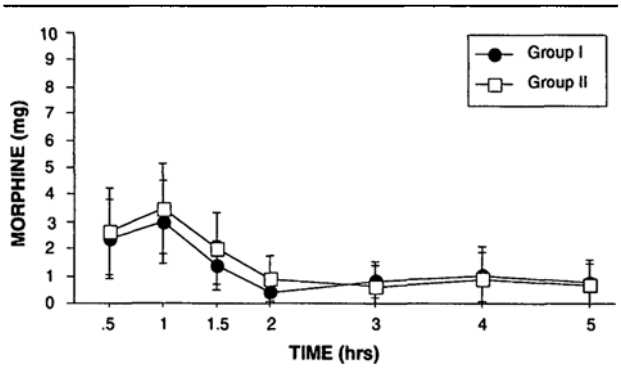

FIGURE 1 Postoperative intravenous morphine consumption in Group I and Group II. No significant difference was observed between groups over time. Values indicate mean ± 95% confidence limits.

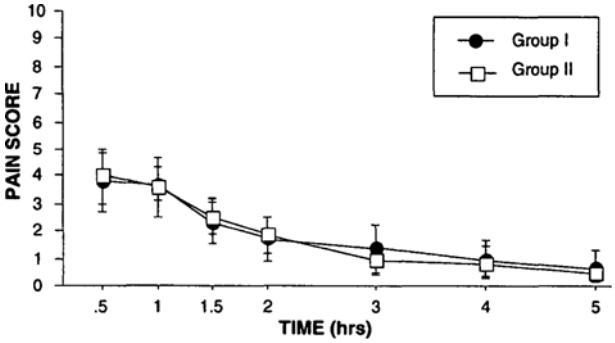

FIGURE 2 Graphical representation of verbal rating scores for pain in both Group I and Group II. No significant difference was observed between groups. Values indicate mean ± 95% confidence limits.

There were no differences between groups with respect to demographic data and duration of surgery (Table I). There was no difference between groups in consumption of *iv* PCA morphine at each time interval during the five hour period after surgery. (Figure 1) Also, there was no difference between groups in total postoperative *iv* PCA morphine consumption (9.8 ± 7.1 mg in Group I *vs* 11.4 ± 10.2 mg in Group II). Verbal rating scores for pain are shown in Figure 2. No differences between groups were found. There was no difference between groups in satisfaction with pain management.

Both groups rated their postoperative pain management as either excellent or very good. Arthroscopic visibility as assessed by the surgeon, was significantly impaired in Group II *vs* Group I ($P < 0.0001$, Table II). The mean duration of inflation of the pneumatic tourniquet in Group I patients was 62.4 ± 9.4 min.

Discussion

Our results indicate that inflation of a thigh tourniquet during arthroscopic ACL surgery is not associated with increased postoperative pain or increased demand for supplemental opioid analgesics. The arthroscopic visibility was impaired in some of the patients where a tourniquet was not used. However, increased flow of irrigation fluid or addition of epinephrine to the irrigation solution resulted in satisfactory optic conditions in all patients in this group, and similar duration of the surgical procedure compared to patients who were operated on with an inflated tourniquet.

The advantage of using a tourniquet during extremity surgery is minimal bleeding in the surgical field, thus facilitating expedient completion of the surgical procedure. However, the use of a tourniquet is associated with several potential complications; nerve and muscle injuries,[11–13] limb swelling,[10] hypercoagulability,[14] deep venous thrombosis,[15] hyperthermia,[16] intraoperative tourniquet pain with regional anesthesia,[4] as well as acidosis after deflation of the cuff with reports of ensuing pulmonary edema[17] and cardiac arrest.[18] The etiology of tourniquet pain is somewhat unclear, but may be related to activation of small, nonmyelinated C-fibres.[7,8] Intense nociceptive input to the spinal cord results in hyperalgesia and increased receptive fields of dorsal horn neurons.[9] Thus, pain impulses resulting from tourniquet inflation might result in increased postoperative pain. A randomized trial of tourniquet use during total knee arthroplasty found less postoperative pain and use of analgesics in patients in whom the tourniquet was not used.[19] Similarly, postoperative pain was increased after surgically treated malleolar fractures with use of tourniquet in a subset of patients who were male and older than 30 yr of age in a prospective, non-randomized study.[20] In contrast, we did not find any difference in pain scores or opioid consumption after ACL reconstruction with or without tourniquet inflation during surgery. This may, in part, be related to the relatively short duration of tourniquet inflation in our study (62.4 ± 9.4 min). Also, our standard multi-modal analgesic protocol for same-day knee ligament surgery includes administration of a femoral nerve block, intra-articular injection of a local anesthetic/morphine/epinephrine mixture and *iv* ketorolac. Femoral nerve blockade,[21] parenteral administration of non-steroidal anti-inflammatory drugs (NSAID)[22] and intra-articular injection of morphine/bupivacaine[23] may reduce the intensity of pain after knee surgery. The use of a Cryo-cuff may also have decreased postoperative discomfort in these patients.[24]

In conclusion, inflation of a thigh tourniquet did not result in increased pain or opioid consumption after arthroscopic ACL surgery when a multi-modal analgesic combination including femoral nerve blockade, intra-articular morphine/ropivacaine/epinephrine and *iv* ketorolac is administered perioperatively. Although arthroscopic visibility was somewhat impaired in some patients without the use of tourniquet, this was effectively remedied by increased irrigation flow or by the addition of epinephrine to the irrigation solution. Finally, the duration of the surgical procedure was not increased in patients where the tourniquet was not inflated during the ACL repair.

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