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Single-cuff forearm tourniquet in intravenous regional anaesthesia results in less pain and fewer sedation requirements than upper arm tourniquet†

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Editor's key points

- I.V. regional anaesthesia has a role in the management of upper limb surgery.
- The ideal position for tourniquet placement has not been determined in surgical populations.
- This study examined how differing positions of the tourniquet affected the efficacy of the analgesic technique.
- The forearm has advantages over upper limb tourniquet placement with improved analgesia and reduced opioid consumption.

Background. A limitation of Bier's block or i.v. regional anaesthesia (IVRA) is tourniquet pain. We hypothesized that tourniquet placement on the forearm *vs* upper arm during IVRA for distal upper extremity surgery may result in less tourniquet pain, lower the need for analgesic interventions, and decrease post-anaesthesia care unit (PACU) admission.

Methods. Patients for distal upper extremity surgery were randomized into upper or forearm single-cuff tourniquet placement. IVRA was either performed with 15 ml of 2% lidocaine and 20 mg ketorolac in the upper group or 8 ml of 2% lidocaine and 10 mg ketorolac in the forearm group. Vital signs and visual analogue scale (VAS) score were recorded. If VAS score was >4, 50 μg fentanyl was injected. If the patient had VAS scores >6 with fentanyl, deep sedation with propofol was administered.

Results. Twenty-eight subjects were in each group. There were no significant differences in patient characteristics, tourniquet time, or pressure between the groups. Ten patients in the forearm *vs* 27 in the upper arm group had a VAS score >4. The mean fentanyl use was 30 μg in the forearm group *vs* 104 μg in the upper arm group. One patient in the forearm group required propofol *vs* 22 in the upper arm group. PACU bypass to phase 2 recovery occurred 19 times in the forearm group *vs* zero times in the upper arm group ($P<0.0001$).

Conclusions. Our results indicate that the placement of the tourniquet on the forearm resulted in less discomfort, fewer sedation interventions, and greater likelihood of bypassing the PACU when compared with upper arm tourniquet.

Keywords: Bier block; regional anaesthesia

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I.V. regional anaesthesia (IVRA) or Bier's block provides effective anaesthesia of the distal extremity of short duration and is particularly useful for ambulatory surgery procedures. IVRA requires the use of tourniquets that are applied to the extremity to sequester the local anaesthetic and to create a bloodless surgical field.[1] However, ischaemic pain due to tourniquet compression can occur.[2] As a result, IVRA may require sedation or additional parentally administered analgesia, which may impact postoperative cognitive function, nausea, vomiting, and time to discharge from the hospital. Although studies exist examining forearm tourniquets for IVRA, it has not been clearly demonstrated that pain is less than upper arm tourniquets. It also has not been studied in a surgical setting where parenteral sedative interventions were utilized. A few studies have reported success with forearm tourniquet for IVRA, but did not compare this group with an upper arm tourniquet.[3 4] Additional studies compared upper arm and forearm tourniquet groups. While some results showed no difference in pain scores,[5–7] others showed lower pain scores in the forearm group,[8 9] but did not have patients who were undergoing surgery. This left a knowledge gap that our study attempts to examine.

Our study not only compares two tourniquet locations, but also has patients undergoing surgery with i.v. sedation which more closely resembles clinical practice. We hypothesized that single-cuff tourniquet placement on the forearm *vs* upper arm during IVRA for distal upper extremity surgery may result in less tourniquet pain, lower the need for i.v. adjuvants (fentanyl and propofol), and decrease post-anaesthesia care unit (PACU) admission for patients undergoing distal upper extremity surgery.

†Post-Graduate Assembly in Anesthesiology 2011—awarded second place in the Current Research by New Investigators competition.

Methods

Patients having distal upper extremity surgery under IVRA were enrolled in the study which was approved by the IRB. Written informed consent was obtained. Patients were eligible to participate in the study if between age 18 and 70 and of ASA status I–III with normal preoperative diagnostic studies. Patients with allergy to local anaesthetics, local infections, open wounds of the surgical hand, seizure disorder, severe coagulopathy, peripheral vascular disease, chronic opioid use, extremes of body weight, or pregnancy were excluded from the study.

Patients were randomly assigned using a computer-based random number generator to one of the two study groups, either the upper arm tourniquet or forearm tourniquet placement. Sealed envelopes were opened before block placement. Before block placement, subjects were also educated in reporting the pain score using the visual analogue scale (VAS) score from 0 to 10; 0 representing no pain and 10 for the worst pain. A peripheral i.v. line was placed on the non-operative arm in the holding area. In the operating theatre, standard monitoring included electrocardiography, oxygen saturation, end-tidal carbon dioxide, and non-invasive arterial pressure. A 22 G i.v. cannula was placed in the distal vein of the surgical hand and saline locked. The single-cuff pneumatic pressure tourniquet was placed immediately above or below the elbow crease and on the top of a circumferentially placed cotton cast padding before inflation. The patient's extremity to be operated on was then exsanguinated with an Esmarch bandage. The radial artery pulse was checked before and after the tourniquet inflation to ensure arterial occlusion. Next, we slowly injected medication into the i.v. cannula of the surgical hand. We used a dose of local anaesthetic for upper arm Bier block: 15 ml of 2% lidocaine as described by the New York School of Regional Anesthesia (NYSORA) and supplemented this with 20 mg ketorolac.[10 11] In the forearm group, we used 8 ml of 2% lidocaine supplemented with 10 mg ketorolac. Since, ketorolac has been shown to have beneficial effects in IVRA, it was added to the local anaesthetic solution at 20 mg for the upper arm group and 10 mg for the forearm group.[2] The adequacy of analgesia was then tested before surgery by the surgeon who tested sensation in the radial, median, and ulnar distributions.

Thereafter, the patient's surgical arm was covered with a drape concealing the site of the tourniquet. The patients were constantly monitored and decisions made by an anaesthesiologist who was unaware of patient allocation, and was instructed by the protocol to only administer medications according to the VAS score by a predetermined schedule of administration. The patient's VAS score was assessed every 5 min until the tourniquet cuff was released. If the VAS score was >4, 50 μg fentanyl was injected i.v. Additional fentanyl was subsequently given if VAS score remained higher than four unless respiratory rate was <10 bpm, or reached a maximum allowable dose by protocol of 3 μg kg^{-1} of fentanyl. If the patient had VAS scores >6 under the treatment regimen of fentanyl, deep sedation with propofol was administered and VAS score was no longer recorded. After the procedure was finished, the tourniquet was deflated. Patients bypassed the PACU to phase 2 recovery, which refers to a step-down recovery unit of post-anaesthesia care with lower acuity and less monitoring, if they did not receive either propofol or fentanyl. All other patients went to the PACU.

Statistical analyses were performed using the following methods. For an effect size of $>30\%$ on pain ratings per group, power analysis for 90%, and α set to 0.05, 54 patients were required. We considered VAS scores as ordinal. Data analysis for all pain ratings was by the Mann–Whitney '*U*'. Group analysis was by parametric analysis for continuous variables and χ^2 for categorical variables. $P<0.05$ was considered significant.

Results

Fifty-nine patients were enrolled in the study. Surgeries in each group were similar and were completed without complications. Surgeries included ganglion cyst excision, mass excision, digital nerve repair, metacarpal and digital fracture pinning, and ORIF, ruptured tendon repair, and palmar fasciotomy. Anaesthesia was satisfactory in all patients at the start of surgery. Patient characteristics in the upper and forearm groups did not differ significantly (Fig. 1; Table 1). However, there were significant differences between the groups in VAS scores, fentanyl and propofol requirements, and PACU admission frequency (Table 2). Patients who had the tourniquet placed on the forearm had lower pain scores than those who had the tourniquet placed on the upper arm. VAS score was >4 in 10 patients in the forearm group *vs* 27 patients in the upper arm group (Table 2). The mean VAS score was lower in the forearm group at all time intervals (Fig. 2). Accordingly, the use of analgesic interventions was lower in the forearm group when compared with the upper arm group (Table 2). For instance, three to four times more fentanyl was required in patients having an upper arm when compared with a forearm tourniquet, 104 μg when compared with 30 μg, respectively. In addition, 19 patients having a forearm tourniquet were able to bypass the PACU when compared with zero in the upper arm group. Moreover, propofol was required for only one patient in the forearm group compared with 22 patients in the upper arm group. No signs of local anaesthetic toxicity were noted in any study patients.

Discussion

Our data indicate that placement of the tourniquet on the forearm rather than upper arm during IVRA for distal upper extremity surgery results in a greater proportion of patients with less tourniquet pain and as a by-product, less use of supplementary analgesia. This study is unique in that it compares two tourniquet locations in the surgical setting with supplementary sedation while demonstrating that the