

## ADVANCES

# Safety and effectiveness of intravenous regional anesthesia (Bier block) for outpatient management of forearm trauma

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**ABSTRACT**

**Objective:** To assess the safety and effectiveness of intravenous regional anesthesia (Bier block) in the management of forearm injuries (i.e., forearm, wrist or hand) by primary care physicians at a diagnostic and treatment facility.

**Methods:** A retrospective review was conducted of all patients at a single centre who underwent a Bier block for forearm injuries between September 2000 and March 2005.

**Results:** 1816 Bier blocks were performed on 1804 patients (64% male) during the study period. Patient age ranged from 4–70 (mean 25) years. Wrist fractures requiring reduction were the most common diagnosis. Adverse events were recorded in 9 cases (0.50%, 95% confidence interval 0.23%–0.94%): 1 case of medication error (0.06%); 3 of improper cuff inflation (0.17%); and 5 of inadequate analgesia (0.28%). None of the adverse events resulted in failure to complete the procedure or in serious morbidity or mortality.

**Conclusion:** Bier block anesthesia is a safe, effective and reliable technique in an outpatient primary care setting. This technique is a useful modality for physicians who manage acute upper-extremity injuries.

**Key words:** intravenous regional anesthesia; Bier block; forearm injuries; outpatient management; primary care; diagnostic and treatment facility

**RÉSUMÉ**

**Objectif :** Évaluer la sécurité et l'efficacité d'une anesthésie locale intraveineuse (i.v.) dans le cadre de la prise en charge des blessures à l'avant-bras (c.-à-c., l'avant-bras, le poignet ou la main) par les médecins de premier recours dans un établissement de diagnostic et de traitement.

**Méthodes :** Une revue rétrospective fut menée des dossiers de tous les patients dans un même centre ayant reçu une anesthésie locale i.v. pour des blessures à l'avant-bras entre septembre 2000 et mars 2005.

**Résultats :** Au cours de la période à l'étude, 1 816 anesthésies locales i.v. furent effectués chez 1 804 patients (dont 64 % étaient des hommes). L'âge des patients variait entre 4 et 70 ans (âge moyen 25 ans). Les fractures du poignet nécessitant une réduction représentaient le diagnostic le plus fréquent. Des événements indésirables furent notés dans 9 cas (0,50 %, intervalle de confiance à 95 %, 0,23 %–0,94 %) : un cas d'erreur médicamenteuse (0,06 %) ; 3 cas d'insufflation inadéquate du brassard (0,17 %) ; et 5 cas d'analgésie inadéquate (0,28 %). Aucun des événements

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indésirables n'entraîna l'impossibilité de terminer l'intervention ni de cas de morbidité ou de mortalité grave.

**Conclusion :** L'anesthésie locale i.v. est une technique sûre, efficace et fiable dans un environnement de soins primaires en consultation externe. Cette technique est une modalité utile pour les médecins appelés à prendre en charge des blessures graves à l'avant-bras.

## Introduction

Intravenous (IV) regional anesthesia is a technique involving administration of a local anesthetic into a region where venous return is mechanically impeded.<sup>1</sup> It is easily learned and requires minimal personnel. IV regional anesthesia was introduced in 1908 by the German surgeon August Gustav Bier, hence the more common term “Bier block” for this technique. Although used commonly when it was first introduced, Bier block fell in popularity before being reintroduced by Holmes in 1963.<sup>2</sup> Most experience with Bier block has been in operating rooms, where it is considered a safe and effective alternative to general anesthesia in selected cases involving the upper and lower limbs. Bier block can also be used in the emergency department (ED) to provide rapid and complete anesthesia, as well as muscle relaxation and a bloodless operating field.<sup>3-6</sup>

Fractures and dislocations of the forearm, wrist and hand are commonly managed in EDs and outpatient urgent care settings. Methods of anesthesia and analgesia for upper-extremity injuries requiring reduction include hematoma block, nerve block, Bier block, IV procedural sedation, and general anesthesia. Although Bier block has many advantages and is likely commonly used, there are limited studies describing the ED or outpatient application of this technique. Bier block has been shown to be effective when used by pediatric orthopedic surgeons in the ED management of children's upper-extremity fractures.<sup>3-5</sup> The “mini-dose” Bier block technique (lidocaine (Xylocaine®), 1.5 mg/kg), using a simple blood pressure cuff and cross-clamp tourniquet technique, has been demonstrated to be safe when used by emergency physicians to perform closed reduction of upper-extremity fractures and dislocations.<sup>6</sup> No published studies were identified on PubMed describing the safety or efficacy of Bier block in the outpatient management of forearm (i.e., forearm, wrist or hand) injuries by primary care physicians in a non-hospital urgent care setting. The objective of this study was to review and describe the experience with Bier block over a 5-year period in such a setting.

## Methods

### *Setting and patients*

Whistler Health Care Centre (WHCC) is a diagnostic and treatment facility located in Whistler, a resort town of 9000 residents 100 km north of Vancouver, BC, Canada. WHCC treats 23 000 patients annually, including many with significant orthopedic trauma. As a diagnostic and treatment facility, WHCC functions like an ED without a hospital or in-patient beds. There is no surgical capability or on-site specialist support beyond radiology. WHCC is staffed by 8 primary care (family) physicians, 2 of whom have additional emergency medicine (CCFP-EM) certification. Patients were eligible for the study if their medical record indicated that they underwent Bier block anesthesia for a forearm (i.e., forearm, wrist or hand) injury between September 2000 and March 2005.

### *Bier block procedure*

Prior to the procedure, patients were given written information on the procedure, and informed consent was obtained. The technique of Bier block used at the WHCC is identical to that described in the emergency medicine literature,<sup>1</sup> with the exception that the injured arm is simply elevated for 2 minutes before cuff inflation rather than exsanguinated. The insertion of an IV line in the unaffected arm was discretionary. The upper arm was wrapped with cast felt padding before the application of the pneumatic cuff, to reduce the risk of pinching or bruising. A 0.5% solution of lidocaine in a dose of 1.5–3 mg/kg was used, according to physician preference. Local anesthetic was slowly injected through an indwelling cannula and the patient was advised that the arm would tingle and feel warm (or cold) and that the skin would become mottled. The cannula was removed immediately after injection of the anesthetic, and bleeding was prevented by using a small (22-gauge or smaller) catheter and by holding pressure on the site for several minutes after the cannula was removed. The risk of cuff leak was minimized by using an anesthetic injection site at least 10 cm distal to the cuff and inflating the cuff to at least 250 mm Hg, regardless of patient age. A second (distal) cuff was available, and was usually only employed if the procedure took longer than anticipated, resulting in discomfort at the proximal cuff

site. The arm was typically anesthetized and appropriate for reduction at 15–20 minutes post injection. The Bier block and reduction were performed by the attending primary care physician. Bier block guidelines at WHCC stipulate that the pneumatic cuff must be inflated to at least 100 mm Hg above the patient's systolic pressure for a minimum of 30 minutes and no longer than 90 minutes. The cuff was deflated using a "deflation/re-inflation" technique to reduce the risk of a significant IV bolus of lidocaine reaching the central circulation, whereby for 3 cycles the cuff is deflated for 5 seconds and then re-inflated for 1 minute. In 2004 a mini-C-Arm (General Electric OEC) was obtained by WHCC. Post-reduction radiographs were routinely obtained, either before or after cuff deflation at the attending primary care physician's discretion (depending on the confidence of reduction success).

### Patient identification

Eligible patients were identified by searching the WHCC computer database for all upper-extremity post-reduction radiographs performed between September 2000 and March 2005. Charts were obtained and reviewed for all patients with injuries distal to the elbow joint. Patients were excluded if there were any charting irregularities that failed to confirm that a Bier block was performed, or if important information was not interpretable.

### Data collection

A procedure monitoring summary was completed in real-time by the nurse for every patient enduring Bier block during the study period. This form captured data on vital signs, limb circulation status, cuff size, bladder type (double or single), IV type and size, cuff inflation pressure and dura-

tion, anesthetic dose, cast or splint type, and after-care instructions. All patient records were reviewed, including the Bier block procedure monitoring summary form, physician notes and nursing notes. Information on the following variables was obtained: patient age, gender, diagnosis, mini-C-Arm use, unilateral or bilateral Bier block procedure, medication errors, cuff inflation problems, evidence of inadequate anesthesia, side effects, procedural difficulties or errors, and any adverse effects or complications.

### Outcomes and statistical considerations

This was a descriptive study without a specific study hypothesis. Predefined outcomes included adequacy of analgesia, seizures, any documented central nervous system adverse effect, hypotension, persistence of limb ischemia after the procedure, procedural errors, adverse events requiring hospitalization, and mortality. Adequacy of analgesia was evaluated by documenting any cases that required rescue anesthesia or where nursing notes documented any pain during the procedure. Raw numbers and proportions (with 95% confidence intervals [CIs] when indicated, calculated using Stata Ver. 5.0, MacIntosh) are reported.

### Results

A total of 1816 Bier blocks were performed during the study period. Table 1 provides demographics and injury information, and shows that patients undergoing a Bier block were young, predominantly male, and overwhelmingly had wrist injuries. Patient age ranged from 4–70 (mean 25) years. No patients met exclusion criteria.

No significant morbidity or mortality was identified related to a Bier block during the study period. Specifically,

**Table 1. Characteristics of patients who were administered intravenous regional anesthesia (Bier block) for repair of forearm (i.e., forearm, wrist or hand) injuries**

| Variable              | Time frame, no. of patients* |      |      |      |      |                 | Totals |
|-----------------------|------------------------------|------|------|------|------|-----------------|--------|
|                       | Sept–Dec<br>2000             | 2001 | 2002 | 2003 | 2004 | Jan–Mar<br>2005 |        |
| No. of patients       | 54                           | 293  | 322  | 415  | 416  | 204             | 1804   |
| Male                  | 34                           | 250  | 234  | 230  | 274  | 149             | 1171   |
| Female                | 20                           | 143  | 88   | 185  | 142  | 55              | 633    |
| Mean age, yr          | 24                           | 26   | 25   | 26   | 24   | 25              |        |
| Location of injury    |                              |      |      |      |      |                 |        |
| Wrist                 | 51                           | 377  | 316  | 412  | 416  | 196             | 1768   |
| Hand                  | 0                            | 12   | 4    | 7    | 5    | 10              | 38     |
| Forearm               | 3                            | 4    | 2    | 0    | 1    | 0               | 10     |
| Total no. of injuries | 54                           | 393  | 322  | 419  | 422  | 206             | 1816   |
| Bilateral Bier block  | 0                            | 0    | 0    | 4    | 6    | 3               | 12     |

\*Unless otherwise specified.

there were no cases of mortality, complications requiring hospitalization, seizures, hypotension, or limb ischemia after completion of the procedure. Adverse events were recorded in 9 cases (0.50%, 95% CI 0.23%–0.94%): 1 case of medication error (0.06%); 3 of improper cuff inflation (0.17%); and 5 of inadequate analgesia (0.28%). None of the adverse events resulted in failure to complete the procedure. The mini-C-Arm was used to confirm reductions at the bedside in 81% of Bier blocks in 2004 and 92% in 2005.

## Discussion

In this large series, we found Bier block is an extremely safe and effective technique for the management of forearm injuries by primary care physicians in an outpatient diagnostic and treatment facility. Over a 5-year period we found no cases of mortality or serious morbidity attributable to the Bier block procedure. Most complications were secondary to the effects of IV lidocaine and attributable to cuff leaks. We found only 4 cases where adverse effects were recorded. These were due to medication error and improper cuff use, and necessitated only patient observation. The single medication error involved using 0.5% bupivacaine (Marcaine®) instead of lidocaine. The error was recognized after injection, the cuff was left inflated for 90 minutes and, other than some discomfort related to the relatively prolonged cuff inflation time, there was no adverse effect. The 3 cases of improper cuff inflation resulted in direct IV injection of lidocaine into the central circulation. The patients complained of dizziness and tinnitus, the injection was stopped, and the procedure was re-commenced and successfully completed after a 30-minute monitoring period.

Procedural and post-procedure discomfort was minimized in many cases by the prior administration of oral or occasional parenteral analgesia. We identified only 5 cases where Bier block was associated with suboptimal analgesia. These were managed either by the addition of IV procedural sedation (fentanyl/midazolam), hematoma block, IV morphine, oral midazolam, or patient tolerance of some procedural pain.

Bier block is very useful for procedures lasting less than 60 minutes involving the extremities. It avoids the need for general anesthesia or procedural sedation in patients with full stomachs or complex medical problems. Bier block can be used to reduce fractures or dislocations, remove foreign bodies, incise and drain abscesses, and débride burns. However, the use of IV procedural sedation is preferred at the WHCC for elbow fractures and dislocations because of the immediacy of analgesic onset and lack of pneumatic cuff interference with reduction and splinting.

Contraindications to Bier block include lidocaine allergy, uncontrolled hypertension, homozygous sickle cell disease, severe crush injury, severe Raynaud's disease, and the inability of the patient to cooperate. Complications include dizziness, lethargy, headache, blurred vision, tinnitus, vasovagal reaction, bradycardia, hypotension, thrombophlebitis and seizures. Complications are extremely rare and can be minimized by checking equipment and by strict adherence to proper technique. It is important to check medication dosage, cuff size, inflation and pressure, and to use the "deflation/re-inflation" technique when deflating the cuff after the minimum 30-minute inflation time. There have been no reported fatalities directly attributed to the use of a Bier block.<sup>1</sup>

## Limitations

This study has limitations related to its retrospective design. Patient care records may not identify all adverse events, nor are they ideal for assessing anesthetic adequacy and procedural pain.

## Conclusion

In this review of 1816 forearm injuries over a 5-year period, the Bier block was found to be safe, reliable and extremely effective. This technique is a useful modality for physicians who manage acute forearm arm injuries.

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**Competing interests:** None declared.

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