Tourniquet Deflation Prior to 20 Minutes in Upper Extremity Intravenous Regional Anesthesia

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Abstract

Background: Bier blocks, or intravenous regional anesthesia (IVRA), are a method of anesthesia for upper extremity surgeries. This study reports our experience with tourniquet deflation prior to 20 minutes with upper extremity IVRA. **Methods:** This study was designed as a retrospective cohort analysis. Records, including intraoperative and immediate postoperative anesthesia notes, of 430 patients who underwent IVRA with an upper extremity Bier block and a corresponding tourniquet time of less than 20 minutes were reviewed. Patient demographics, procedure(s) performed, American Society of Anesthesiologists scores, volume of lidocaine used in Bier block, tourniquet time, and any complications were recorded. **Results:** This cohort consisted of 127 males and 303 females. The 3 most common procedures performed were carpal tunnel release (315), trigger finger release (47), and excision of masses (34). The average tourniquet time for this cohort was 16 minutes (range, 9–19 minutes), and the average volume of lidocaine (0.5% plain) injected was 44 mL (range, 30–70 mL). A tourniquet time of 17 minutes or less was observed in 339 patients, and 170 patients had tourniquet times of 15 minutes or less. Five complications were recorded: intraoperative vomiting, mild postoperative nausea/vomiting, severe postoperative nausea and vomiting, and transient postoperative hypotension that responded to a fluid bolus. **Conclusions:** No major complications were observed in our cohort of upper extremity IVRA and tourniquet times of less than 20 minutes. Several variables play a role in the safety of upper extremity IVRA.

Keywords: intravenous regional anesthesia, Bier blocks, tourniquet time, upper extremity

Introduction

Bier blocks, or intravenous regional anesthesia (IVRA), are a method of anesthesia for upper extremity surgeries. IVRA was first described by August Bier in 1908, and after a period of latency, it began to gain widespread use after Holmes reemphasized its use in 1963.^{3,8} Bier blocks are technically easy to perform, and the rates for successful anesthesia approach 98%.^{4,12} Furthermore, when compared with brachial plexus blocks for outpatient hand and upper extremity surgery, IVRA may realize lower costs and faster postanesthesia recovery.⁵

Although a reliable source of anesthesia, IVRA has been associated with some disadvantages. Some patients cannot tolerate the tourniquet-mediated arm pain, and there are also reports of neurologic injury and compartment syndrome caused by the tourniquet.^{3,9} Perhaps the most dreaded complications associated with IVRA relate to the potential systemic toxicity of the local anesthetics used. If the local anesthetic gains access to a patient's systemic circulation,

the central nervous system (CNS) and cardiovascular system can be affected. The CNS is usually affected first, with symptoms including dizziness, tinnitus, perioral paresthesia, and seizures. Anesthetic-induced toxicity of the cardiovascular system may manifest as hypotension, bradycardia, arrhythmias, or cardiac arrest.^{1,4,9,12}

Historically, the tourniquet used in IVRA is left inflated for a minimum of 20 minutes.² Theoretically, this allows time for the local anesthetic to bind to the tissues and, consequently, prevent a large bolus of drug from entering the systemic circulation. However, this tourniquet time appears to be arbitrary, and no safe time interval between

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anesthetic drug injection and tourniquet deflation has been established.^{2,8}

Our institution has utilized various tourniquet times for cases using IVRA, with many cases having tourniquet times that are less than 20 minutes. The purpose of this study was to report our experience with tourniquet deflation prior to 20 minutes in the setting of upper extremity IVRA.

Materials and Methods

After obtaining approval from our institutional review board, we performed a retrospective review of the surgical and anesthesia records of 430 patients who underwent elective upper extremity surgery from January 2013 to December 2014. All of these patients received surgery at an outpatient surgery center and had IVRA with a tourniquet time of less than 20 minutes. All 430 patients were included for review in this study. Patient demographics were documented, including age, sex, height, weight, type of procedure(s) performed, American Society of Anesthesiologists (ASA) score, and any pertinent past medical history.

A member of the anesthesia team performed each Bier block in the same sequence, and all Bier blocks were performed in the operating room and on the operating table. First, an intravenous cannula was placed into a dorsal hand or wrist vein on the operative side. A well-padded single-lumen tourniquet was also placed proximal to the cannulated vein, either on the forearm or the arm. The limb was then elevated and exsanguinated with an Esmarch bandage. The tourniquet was then inflated to 250 mm Hg (for forearm tourniquets). One surgeon preferred the use of arm tourniquets, and these were inflated to 300 mm Hg (also per their preference). The Esmarch bandage was removed, and 0.5% lidocaine (the volume of which was determined by the anesthesia team and the patient's weight) was injected into the cannulated vein over 90 seconds. The lidocaine was dosed to fall below the recommended maximum of 3 mg/kg, and Bier blocks using an arm or a forearm cuff were dosed in the same manner. The limb was then lowered, and the intravenous catheter was removed. The surgeon would then scrub, return to the operating room, and gown in the usual sterile fashion. Adjunct medications, or a combination thereof, were also administered during the surgery at the discretion of the anesthesia team; these included propofol (Diprivan) alone ($n = 75$), propofol and midazolam (Versed; $n = 222$), propofol and fentanyl ($n = 87$), or propofol, midazolam, and fentanyl ($n = 43$). Adequate anesthesia was tested with a sharp instrument, and the procedure was begun. The tourniquet was deflated after closure of the wound and application of the dressing.

The anesthesia records for each patient were used to identify the location of the tourniquet used for the Bier block, the volume and dose of 0.5% lidocaine injected, the

Table 1. Patient Demographics (N = 430).

Characteristic	Mean	Range
Age (y)	57	19-91
Height (cm)	166	135-196
Weight (kg)	86	36-204
ASA classification	2	1-4
Volume of 0.5% lidocaine injected (mL)	43	30-70
Lidocaine dose (mg/kg)	2.70	1.23-6.94

Note. ASA = American Society of Anesthesiologists.

time of tourniquet inflation and deflation, and the presence of any intraoperative or immediate (prior to discharge) postoperative complications related to lidocaine toxicity, including tinnitus, perioral numbness, dizziness/lightheadedness, seizures, neurovascular complications, metallic taste, and so forth. The postoperative recovery unit records were also reviewed for any postoperative complications prior to the patient's discharge. Complications were then divided into those involving the CNS system and those affecting the cardiovascular system.

Results

Four hundred thirty patients were included in this study. This cohort consisted of 127 males and 303 females with an average age of 57 years. The patient demographics and lidocaine doses are shown in Table 1. The 3 most frequently performed procedures were carpal tunnel release ($n = 315$), trigger finger release ($n = 47$), and excision of masses ($n = 34$). All Bier blocks in the cohort were performed with a tourniquet placed on either the arm or the forearm with 0.5% lidocaine used as the local anesthetic. The volume of 0.5% lidocaine injected was not recorded in 77 of the patients.

The tourniquet times, listed by frequency (or number of patients per recorded tourniquet time), are shown in Figure 1.

The average tourniquet time for this cohort was 16 minutes (range, 9-19 minutes). A tourniquet time of 17 minutes or less was used in 339 patients, and 170 patients had tourniquet times of 15 minutes or less. An arm tourniquet was used in 79 patients, and a forearm tourniquet was used in 351 patients.

The recorded complications are shown in Table 2. None of the patients experienced any signs of CNS or cardiovascular compromise, and no tourniquet-related complications were recorded. Five patients experienced complications; however, all of these resolved prior to their discharge home. Although the sedative agents used were not recorded in all patients, we did evaluate the dosage for the patients who had complications. We were unable to identify any dose associations with the complications that did occur. Two of the 4 patients with nausea/vomiting had a previous history of postoperative nausea/vomiting, and the patient with

Figure 1. Number of IVRA procedures by tourniquet time.

Note. IVRA = intravenous regional anesthesia.

Table 2. Complications.

Patient information	Age (y)	Sex	ASA class	Lidocaine dose (mg/kg)	Tourniquet time (min)	Complication	Comments/outcome
Patient 1	52	F	2	3.40	15	Post-op nausea/vomiting	History of post-op nausea/vomiting; resolved in PACU
Patient 2	55	F	1	3.57	17	Post-op nausea/vomiting	Resolved
Patient 3	71	M	2	1.98	15	Intra-op vomiting	Resolved, no other complications
Patient 4	46	F	2	2.32	16	Severe post-op nausea/vomiting	History of post-op nausea/vomiting; resolved in PACU
Patient 5	79	M	2	2.46	17	Post-op hypotension in PACU	Patient on beta blocker; transient hypotension resolved with fluid bolus

Note. ASA = American Society of Anesthesiologists; PACU= Post-Anesthesia Care Unit.

postoperative hypotension had a history of hypertension as they were on beta blockers.

Discussion

The use of a tourniquet in IVRA allows isolation of the local anesthetic to the exsanguinated limb. However, a minimum time until tourniquet deflation has yet to be established for upper extremity IVRA, and there is a paucity of data pertaining to Bier blocks with tourniquet times of less than 20 minutes. The aim of this study was to report on our institution's experience with IVRA and tourniquet deflation prior to 20 minutes, and to evaluate for any acute systemic (drug-related) complications in an outpatient surgery center setting.

Five complications were recognized. However, no patients developed seizures, arrhythmias, or cardiac arrest. Two of the patients that had complications (nausea/vomiting) experienced these same complications with previous surgeries. An episode of hypotension was also observed;

however, no signs of cardiovascular collapse were observed, and this patient's hypotension responded appropriately to a small fluid bolus. Two of the patients who experienced complications (patients 1 and 2) were given a lidocaine dose that exceeded the 3 mg/kg recommendation (3.40 and 3.57 mg/kg, respectively). Furthermore, all 5 patients with complications were given adjunct medications, including propofol (all 5 patients), midazolam (patients 1 and 4), and fentanyl (patient 5). All 5 complications did occur in patients whose tourniquet time was between 15 and 17 minutes. This is likely due to the fact that 61% (256) of the patients in this study fell into this time frame.

Several factors play a role in limiting systemic toxicity in the setting of IVRA. One of these factors is the pharmacokinetics of the chosen local anesthetic. Presently, lidocaine is the most commonly used agent in North America and was used in each of the Bier blocks in our cohort.⁷ Lidocaine is biexponentially eliminated from the arm after tourniquet deflation, with 30% of the lidocaine dose

entering the circulation after initial tourniquet release and the remaining amount entering the general circulation in the following 45 minutes.^{2,18,19,22} Peak arterial levels of lidocaine are reached within 1 minute of tourniquet deflation and may correlate with systemic toxicity. However, a correlation between peak arterial levels, tourniquet time, and clinical symptoms has yet to be established.^{10,20-22} However, lidocaine has inherent properties (rapid dissociation from sodium channels present in CNS and cardiovascular tissue) that prevent toxic accumulation of the drug and major CNS or cardiovascular complications.^{2,6} This is contrast to bupivacaine, which does not rapidly dissociate from the sodium channels and has been implicated in 7 deaths, all stemming from cardiovascular collapse.^{1,11,17}

The dosing of the local anesthetic in IVRA and the manner in which it is injected also factor into systemic toxicity. Currently, the recommended maximum dose of lidocaine for upper extremity IVRA is 3 mg/kg.¹⁶ Guay⁹ reported on complications associated with IVRA; in this systematic review, the majority of the complications in upper extremity IVRA using 0.5% lidocaine were those in which the 3 mg/kg dose was exceeded. In our cohort, our average dose of 2.70 mg/kg of 0.5% lidocaine fell below this maximum dose.

Proper technique in the setting of IVRA plays a prominent role in reducing systemic risk. Adequate patient monitoring and the assurance that the equipment (including the tourniquet) is functional are paramount.¹¹ The rate of local anesthetic injection into the exsanguinated limb is also important. Lawes et al¹⁴ recorded venous pressures in forearm veins during simulated Bier blocks and found that these pressures were often equivalent to or greater than the tourniquet cuff pressure. These findings suggest that increased venous pressure may mitigate the effect of the tourniquet, and highlight the importance of abstaining from a rapid rate of injection of the local anesthetic. Bier blocks performed at our institution abide by these principles.

This study had several strengths. The patient cohort was heterogeneous, recognizing a spectrum of patient demographics, ASA scores, and procedures performed. Also, we included Bier blocks that used arm or forearm tourniquets. Regardless of the tourniquet placement, the lidocaine dose and volume was calculated in the same manner (by weight), and was not adjusted based on the location of the tourniquet. A wide range of tourniquet times was observed, all of which were below 20 minutes. There is a paucity of literature regarding upper extremity IVRA and tourniquet deflation prior to 20 minutes; thus, we are unaware of other studies that have examined the specific aims of our study or have studied a cohort as large as ours.

One of the weaknesses of this study is its retrospective nature. Certain symptoms of local anesthetic toxicity, such as dysphoria, dizziness, or mild CNS excitability, can be subtle. Thus, some of these symptoms may have not been

recorded in the medical record during the perioperative period and not included in our study. Also, almost all patients were given propofol, and a segment of the cohort was also given midazolam or fentanyl. This may have affected the ability to observe any symptoms of toxicity and also may have effectively raised the threshold for local anesthetic toxicity. Both propofol and midazolam have also been reported to confer anticonvulsive properties, and the presence of these medications may have acted as confounding variables in this study.^{13,15,23} Furthermore, major complications from upper extremity IVRA are reported as rare, and although our cohort was large, it may still be of insufficient size to conclude that IVRA with short tourniquet times is without these complications.^{2,9}

Future directions for this subject area should include studies in which the data are collected prospectively. This would help to ensure that all complications, both major and minor, would be captured. Also, the location of the tourniquet and the dose of lidocaine used could be standardized.

Authors' Note

All data presented in this study can be accessed via confidential data sheets (Microsoft Excel). These data sheets are encrypted to protect patient privacy. However, if needed, these data sheets are easily accessible by members of our research team.

Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5).

Statement of Informed Consent

Requirement of informed consent was waived by our institutional review board for all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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