BIER BLOCKS FOR FRACTURE REDUCTION IN THE PEDIATRIC EMERGENCY DEPARTMENT

Adam Bretholz, MD, FRCPC
OUTLINE

- Introduction
- Video demonstration
- Advantages/Disadvantages
- Evidence
  - Discussion of implementation
  - Educational Course
- Summary
FOREARM FRACTURES

- Common in children
  - 45% of all fractures in childhood
  - 62% of upper limb fractures

- 81% in children older than 5 years
  - Peak incidence:
    - 12 to 14 in boys
    - 10 to 12 in girls

ONE SIZE FITS ALL?

- Ketamine for all procedural sedations
- Procedural sedations for most reductions
- Alternatives?
BIER BLOCK

August Bier - 1906

Adam Bretholz - 2012
BIER BLOCK

- 1906 by a German surgeon - August Karl Gustav Bier
- Anesthetic injected through IV in the affected limb with inflated proximal tourniquet
- Analgesia is produced by diffusion of anesthetic from the vessels into the nearby nerves
BIER BLOCK

- Reintroduced by Holmes in 1963 (Lancet)
- Intravenous regional anesthesia is one of the most commonly used regional anesthesia techniques in the US
- Best used for minor surgery of the hand and forearm
VIDEO DEMONSTRATION
PADDING AND CUFF SET-UP
DRAINING OUT BLOOD
LIDOCAINE INFUSION
D/C IV AND PREPARE FOR REDUCTION
REDUCTION
CUFF DEFLATION
C’EST FINI
BIER BLOCK: ADVANTAGES

- Quick onset of action (10 minutes)
- Short duration – allows proper neurovascular assessment after reduction
- Avoids the need for sedation and the risks of respiratory depression
- Reliable analgesia
- Easy to administer
- Provides muscle relaxation
BIER BLOCK: DISADVANTAGES

- Fear of systemic effects of lidocaine
  - Cardiac
  - Seizures
- Need to place an IV and have a cooperative patient
- Generally reserved for slightly older patients
- Rare tourniquet pain
CONTRAINDICATIONS

- Complex Medical Conditions
- Pathologic Hypertention
- Compromised circulation (Reynaud’s disease, compartment syndrome)
- Open fracture
- Blood dyscrasias (ex. sickle cell disease)
- Infection to the limb
- Unreliable or inadequate tourniquets
LET'S TALK LITERATURE....
Predictors of Airway and Respiratory Adverse Events With Ketamine Sedation in the Emergency Department: An Individual-Patient Data Meta-analysis of 8,282 Children

Steven M. Green, MD
Mark G. Roback, MD
Baruch Krauss, MD, EdM
Lance Brown, MD, MPH
Ray G. McGlone, FCEM
Dewesh Agrawal, MD
Michele McKee, MD, MS
Markus Weiss, MD
Raymond D. Pitetti, MD, MPH
Mark A. Hostetler, MD, MPH
Joe E. Wathen, MD
Greg Treston, MBBS
Barbara M. Garcia Pena, MD
Andreas C. Gerber, MD
Joseph D. Losek, MD
For the Emergency Department
Ketamine Meta-Analysis
Study Group*

From the Department of Emergency Medicine, Loma Linda University Medical Center and Children’s Hospital, Loma Linda, CA (Green, Brown); the Department of Pediatrics, University of Minnesota, Minneapolis, MN (Roback); the Division of Emergency Medicine, Children’s Hospital and Harvard Medical School, Boston, MA (Krauss); the Royal Lancaster Infirmary, Lancaster, UK (McGlone); the Division of Emergency Medicine, Children’s National Medical Center, Washington, DC (Agrawal); the Division of Emergency Medicine, Boston Medical Center, Boston, MA (McKee); the Department of Anaesthesia, University Children’s Hospital, Zurich, Switzerland (Weiss, Gerber); the Division of Pediatric Emergency Medicine, Children’s Hospital of Pittsburgh, Pittsburgh, PA (Pitetti); the Department of Pediatrics, University of Chicago, Chicago, IL (Hostetler); the Department of Pediatrics, University of Colorado Health Sciences Center, Denver, CO (Wathen); Emergency Department, Royal Darwin Hospital, Darwin, Northern Territory, Australia (Treston); the Division of Emergency Medicine, Miami Children's Hospital, Miami, FL (Garcia Pena); and the Department of Pediatrics, Medical University of South Carolina, Charleston, SC (Losek)
KETAMINE META-ANALYSIS

- 3.9% overall incidence of adverse airway and respiratory events
  - 0.3% laryngospasm
  - 0.8% apnea
- Significant independent predictors:
  - Under 2 and over 13 yrs
  - High dosing (>2.5mg/kg)
  - Co-administration of anticholinergic
  - Co-administration of benzodiazepines
The Use of Local Anesthetic Techniques for Closed Forearm Fracture Reduction in Children

A Survey of Academic Pediatric Emergency Departments

Erika Constantine, MD,* Dale W. Steele, MD,* Craig Eberson, MD,† Kathy Boutis, MD,‡ Siraj Amanullah, MD, MPH,* and James G. Linakis, PhD, MD*
### TABLE 2. Survey Responses (Combined and by Specialty)

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Combined Response (%)</th>
<th>OS Group (%)</th>
<th>PEM Group (%)</th>
<th>P</th>
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<td>Frequency of local anesthetic use for forearm fracture reductions</td>
<td>Never</td>
<td>22</td>
<td>37</td>
<td>10</td>
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<td>(n = 35 OS, 42 PEM)</td>
<td>Rarely</td>
<td>43</td>
<td>17</td>
<td>64</td>
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<tr>
<td></td>
<td>Sometimes</td>
<td>22</td>
<td>34</td>
<td>12</td>
<td></td>
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<tr>
<td></td>
<td>Frequently</td>
<td>13</td>
<td>11</td>
<td>14</td>
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<tr>
<td></td>
<td>Always</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Characteristics of patient population chosen for local anesthetic use</td>
<td>Comorbidities precluding</td>
<td>29</td>
<td>32</td>
<td>27</td>
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<tr>
<td>(n = 22 OS, 37 PEM)</td>
<td>sedation</td>
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<tr>
<td></td>
<td>Inadequate fasting</td>
<td>20</td>
<td>27</td>
<td>16</td>
<td>0.33</td>
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<td></td>
<td>Older age</td>
<td>59</td>
<td>82</td>
<td>46</td>
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<td>Encouraged in all patients</td>
<td>10</td>
<td>5</td>
<td>14</td>
<td>0.27</td>
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<tr>
<td></td>
<td>Other</td>
<td>12</td>
<td>0</td>
<td>19</td>
<td>0.04</td>
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<td>Types of local anesthetic techniques used (n = 22 OS, 37 PEM)</td>
<td>Hematoma block</td>
<td>92</td>
<td>91</td>
<td>92</td>
<td>1</td>
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<td></td>
<td>Bier block</td>
<td>20</td>
<td>23</td>
<td>19</td>
<td>0.74</td>
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<td>Axillary nerve block</td>
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<td>0</td>
<td>0</td>
<td>—</td>
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<td>Cubital nerve block</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
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<tr>
<td></td>
<td>Other</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>—</td>
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<tr>
<td>Reasons for not using local anesthetic techniques (n = 13 OS, 4 PEM)</td>
<td>Inadequate training</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>1</td>
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<tr>
<td></td>
<td>Ineffective</td>
<td>35</td>
<td>38</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Unnecessary</td>
<td>100</td>
<td>100</td>
<td>100</td>
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<tr>
<td></td>
<td>Risk of complications</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>1</td>
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<td></td>
<td>Time consuming</td>
<td>6</td>
<td>8</td>
<td>0</td>
<td>1</td>
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<td></td>
<td>Other</td>
<td>18</td>
<td>15</td>
<td>25</td>
<td>1</td>
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</tbody>
</table>
Adverse events associated with intravenous regional anesthesia (Bier block): a systematic review of complications

Joanne Guay MD, FRCPC (Clinical Associate Professor)*

Department of Anesthesia, Maisonneuve-Rosemont Hospital, University of Montreal, Montreal, Quebec, Canada H1T 2M4

- Literature review 1950 – 2007
- Only three pediatric cases involve lidocaine:
  - Two seizures related to overdose: 7 yr F (1965) and 13 yr M (1966) 4.6mg/Kg and 20mg/Kg respectively
  - One tourniquet induced sensory and motor deficit in 16 yr F (1987) - permanent slight weakness of wrist
- Safe technique with low incidence of complications
INTRAVENOUS REGIONAL ANAESTHESIA IN CHILDREN

B. FitzGerald

- 50 children, 0.5% Lidocaine 10-30 ml based on patient’s age
- Longest tourniquet time was 18 minutes
- No complications

Br. J. Anaesth. (1976), 48, 485
Outpatient Treatment of Upper Extremity Injuries in Childhood Using Intravenous Regional Anaesthesia


Departments of Orthopaedics and Anaesthesia, Royal Children's Hospital, Melbourne, Australia

- 400 Children, all in ED
  - only 9 (2.3%) needed further OR due to poor reductions
- Minimum tourniquet time 20 min.
- One patient required admission overnight due to mild clonic muscle twitching 30 min. after cuff deflation

J Pediatr Orthop, Vol. 8, No. 5, 1988
Intravenous Regional Anesthesia in the Treatment of Forearm and Wrist Fractures and Dislocations in Children

Wayne A. Colizza, MD, CM; Edward Said, MD, FRCSC

- 139 patients over 6 years for wrist and forearm fracture reduction
- Meperidine and promethazine followed by 0.5% Lidocaine (3mg/Kg)
- Tourniquet pain in 7%
- No toxicity even with one tourniquet failure minutes after inflation
Intravenous regional anesthesia for management of children’s extremity fractures in the emergency department

R. DALE BLASIER, MD, ROSALIND WHITE, RN

- 470 patients, 2 - 19 yrs over a 5 yr period in Arkansas
- No adverse events (no hypotension, tachycardia, seizures or arrhythmias)
  - 1 patient complained of metallic taste after tourniquet release
  - 2 patients complained of significant tourniquet pain (not precluding reduction)
  - 1 patient complained of tingling in the face w/out EKG changes
ONE SIZE FITS ALL?

- Should we have a different analgesia option for “older”, more co-operative patients?
Safety and effectiveness of intravenous regional anesthesia (Bier block) for outpatient management of forearm trauma

Bruce Mohr, MD

- 1,816 Bier blocks between September 2000 and March 2005, patients from 4-70 yrs.
- No serious morbidity or mortality. Adverse events were recorded in 9 cases:
  - 1 case of medication error (0.06%);
  - 3 cases of improper cuff inflation (0.17%);
  - 5 cases of inadequate analgesia (0.28%).

BIER BLOCK: SCOTTISH RITE CHILDREN’S HOSPITAL ATLANTA

- Has been used for forearm fractures since at least 1985
- No problems noted – but no hard data
- New retrospective review put forth recently for publication
- Acknowledgements and thanks to Dr. Chad Aarons
HYPOTHESES

- First: Bier blocks are at least as safe and more cost-effective than procedural sedation.
- Second: Cast application could be utilized following acute closed reduction without risking serious complications.
METHODS AND MATERIALS: 
PATIENT SELECTION

- Electronic data base search - all upper extremity fractures requiring reduction from 2008-2010
- Both bone forearm fracture, Monteggia, Galeazzi, nightstick or distal radius fracture included
- Hand fractures were eliminated – separate hand team
- Elbow fractures and dislocations were eliminated – too close to the cuff
METHODS AND MATERIALS

Charts were retrospectively reviewed:
- Diagnosis
- Triage time and date
- Procedure start time
- Discharge time and date
- Discharge versus admission status
- Returns to the ED with chief complaint

Calculated length of time from initiation of the procedure to discharge and time from discharge to return to ED
BIER BLOCK PROTOCOL

- Informed consent obtained
- IV line in the involved upper extremity
- Brachial tourniquet was applied and inflated to 250 mm/hg
- 0.5% Lidocaine administered slowly at a weight-dependent dosing of 1mL/kg (3.33mg/kg)
BIER BLOCK PROTOCOL

- IV then removed
- Patients monitored during the procedure including casting and reduction
- Tourniquet was inflate for a minimum of 20 minutes
SEDATION PROTOCOL

- Sedation performed by a “sedation physician” in the PED
- Sedation procedures were not standardized, however a general protocol was followed
- This included induction with Ketamine dosed at 1-2 mg/kg with the additional use of Propofol at 1mg/kg and reassessed every 10 minutes
- Patient monitored for blood pressure, heart rate and oxygen saturation
DEFINITION OF COMPLICATIONS

**Anesthesia**
- **Major complication:** Any life threatening cardiovascular event or seizure that required hospitalization or pharmacological intervention.
- **Minor complication:** Not included in this study

**Cast Application**
- **Major complication:** Development of compartment syndrome.
- **Minor complication:** Return to the emergency room for univalving, bivalving or need to change the cast.
RESULTS: DEMOGRAPHICS

- Average age in the Bier block group 10.4 y/o
- Average age in the sedation group 6.7 y/o
  - Expected a difference as it requires a “cooperative” patient who is generally older
RESULTS: SEDATION VS. BIER BLOCK

- 1245 patients
  - 600 Bier block, 645 procedural sedation
- Average time to discharge from initiation of procedural sedation:
  - 1 hour and 42 minutes
- Average time to discharge from initiation of Bier block:
  - 47 minutes
- (p<.0001)
- No episodes of cardiac, respiratory, or seizure events that necessitated either pharmacologic intervention or admission in either group.
RESULTS: AVERAGE COST

- Procedural sedation: $6313
- Bier block: $4956
RESULTS: CASTING

- No episodes of compartment syndrome in either group
- 31 patients in the procedural sedation group returned to the PED within two weeks
  - 28 needed some intervention to their cast because of tightness. (4.34%)
- 23 patients in the Bier block group returned to the PED within two weeks
  - 13 necessitated cast intervention for tightness. (2.16%)
- p=0.0382
RESULTS: CASTING

- Other complaints:
  - wet casts, minor swelling of fingers, prescription problems, falls, foreign objects in casts, pruritis, and two patients who missed follow-up appointment to check maintenance of reduction.

- Average time from discharge to triage on return:
  - Sedation group: 36 hours and 8 minutes
  - Bier block group: 32 hours and 35 minutes
STRENGTHS

- Large number of patients (1245 – including 600 Bier blocks)

- Good follow up – able to access records from the only two pediatric centers in the city
WEAKNESSES

- Retrospective chart review
  - Not randomized controlled
  - Not blinded
CONCLUSIONS

- Bier blocks are safe – no major complications
- Bier blocks are fast – almost 1 hr less time needed
- Bier blocks are cost effective – almost $1400 less expensive
- Casting can be applied immediately without risk
IMPLEMENTATION: THE DOMINO EFFECT
IMPLEMENTATION

- Presentation at half-day
- Meetings with PED management committee
- Protocol development and approval
- Funding from capital fund +/- foundation
- Course
  - Online pre-course material
  - Half-day course: lectures, standardized patients and simulation based scenarios
  - Educational research study
What is a Bier Block?

Bier Block is a technique of limb anesthesia which does not require systemic medication. An IV is placed in the patient’s arm (broken limb) then the arm is elevated for two minutes. Following elevation, a blood pressure cuff is placed, with soft-roll underneath for comfort, and inflated to pressures well above systolic to occlude blood flow to the arm. The picture below shows the Bier Block set-up.

Once the limb blood flow has been occluded, lidocaine is injected into the arm through the IV. This IV is then removed prior to fracture reduction. Within 10 or 15 minutes, the limb is anesthetized allowing closed reduction of the fracture.
Prevention and Precautions:

The following recommendations are suggested to decrease the risk of complications with Bier Blocks:

Resuscitation Equipment and Medications:
The potential for respiratory depression, seizures and even cardiac arrest necessitates full monitoring. Resuscitation equipment, medications, anticonvulsants and 20% intralipid should be immediately available.

Note: Attention to the ECG may be the difference between a toxic and lethal dose.

Figure 2: Profound ST elevation and increased T-wave amplitude 15 seconds after an intravenous injection with bupivacaine with epinephrine followed by decreased heart rate and rapid resolution of ST-T changes after stopping the injection [13].
HELPFUL MNEMONIC

- **B** - Brief (drug effects are shorter)
- **O** - Old technique (since the 1900s)
- **N** - NPO not needed
- **E** - Experience of >5000 from Whistler
- **S** - Simple/safe
HELPFUL MNEMONIC

- L  Lethargy
- I  Intracranial effects: seizures
- D  Dizziness
- O  Ocular effects: blurred vision
- C  Cardiac effects: bradycardia/hypotension
- A  Achy head (headache)
- I  Inflammation of the vein (thrombophlebitis)
- N  Numbness of the tongue
- E  Ears ringing
SCENARIOS
Lillian questioning if she should have another at the swim up bar in Mexico
SUMMARY

- Safe and Efficient
  - Good alternative in cooperative children
  - Potential to significantly impact patient flow
THANK YOU!
REFERENCES


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<tr>
<th></th>
<th>Reduction with Bier Block</th>
<th>Reduction with Sedation</th>
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<tbody>
<tr>
<td>Radiology films</td>
<td>$230 pre and post; $460 total</td>
<td>Radiology films</td>
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<tr>
<td>Radiology reading</td>
<td>$72 total for pre and post</td>
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<tr>
<td>ED Facility level: Level 5, Extensive resources</td>
<td>$2779</td>
<td>ED Facility level: Level 5, Extensive resources</td>
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<tr>
<td>ED Procedure: Fracture Reduction</td>
<td>$874</td>
<td>ED Procedure: Fracture Reduction</td>
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<td>ED Supplies; splint/cast</td>
<td>$300-400</td>
<td>ED Supplies; splint/cast</td>
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<td>ED E &amp; M level</td>
<td>$235-443</td>
<td>ED E &amp; M level</td>
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<td>Sedation: By Sedation Services: Anesthesia codes</td>
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