Tiny Veins, Big Problems: Vascular Access in Children

Tim Horeczko, MD, MSCR, FACEP, FAAP
Department of Emergency Medicine
Harbor-UCLA Medical Center
Torrance, CA
<table>
<thead>
<tr>
<th>Signs</th>
<th>Mild  &lt; 3% Body Weight Lost</th>
<th>Moderate 3-9% Body Weight Lost</th>
<th>Severe &gt; 9% Body Weight Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental Status</td>
<td>Normal</td>
<td>Fatigued, Irritable</td>
<td>Lethargic, Unconscious</td>
</tr>
<tr>
<td>Breathing</td>
<td>Normal</td>
<td>Increased</td>
<td>Tachypnea</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Moist</td>
<td>Dry</td>
<td>Parched</td>
</tr>
<tr>
<td>Tears</td>
<td>Normal</td>
<td>Decreased</td>
<td>Absent</td>
</tr>
<tr>
<td>Capillary refill</td>
<td>&lt; 2 seconds</td>
<td>Prolonged</td>
<td>Minimal</td>
</tr>
<tr>
<td>Clinical Sign</td>
<td>LR + [95% CI]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------------</td>
<td>---------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Two or more of following 4 signs:</td>
<td>6.1 [3.8 to 9.8]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Capillary refill time</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Dry mucous membranes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Absence of tears</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>● Abnormal overall appearance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

No Tears

Appearance

too gnarly

Refill

Lips
Mild Volume Depletion

• **Control** nausea

• **Break** ketosis

• **Replace** volume by mouth over time
Mild Volume Depletion: management

- **Control Nausea**
  - Ondansetron (Zofran) 0.15 mg/kg
  - Alternative PO dosing (Freedman, 2006)
    - 8-15 kg: 2 mg/dose once
    - 15-30 kg: 4 mg/dose once
    - 30+ kg: 8 mg/dose once

- **Break ketosis**

- **Oral rehydrating solution**
Rally the Parents!

• **Acknowledge** frustration

• **Build confidence** by starting PO hydration in ED

• Guide them how **to continue at home**

Rally the Parents!

**Goal**: 50 mL/kg over 4 hours

- **1 mL/kg** of oral rehydration solution *every 5 minutes* for 4 hours

- **3 mL/kg** of oral rehydration solution *every 15 minutes* for 4 hours
Rally the Parents

• One teaspoon = **5 mL**

• Write clearly type of solution in teaspoons

_E.g._:

• **10 kg infant**, 50 mL/kg over 4 hours = 500 mL over 4 hours

• 500 mL/5 mL = 100 teaspoons

• 100 teaspoons/4 hours = **6 tsp every 15 min**
15 minute trial: 3 mL/kg
Moderate Volume Depletion

- Continue PO if possible
- Stable child?
- Try: hypodermoclysis
- Parenteral fluids given into subcutaneous space
Hypodermoclysis

- Place EMLA

- Inject **hyaluronidase** 150 U into subcutaneous space

- Insert angiocatheter into **subcutaneous space**

- Infusion by gravity or pump

Hypodermoclysis
Hypodermoclysis
We’re gonna need an IV...

• General Principles
• Adjuncts
• Topical anesthetics (EMLA, vapocoolant)
• Needleless anesthetic injector (J-tip)
• Near-infrared light (AccuVein, VeinFinder)
We’re gonna need an IV...

• Optimize your attempts

Pain

Environment

Visualization and Mechanics
We’re gonna need an IV...

Neonate – 1 g
Infant – 2 g
Child – up to 10 g
Adolescent/Adult – 10 – 16 g
We’re gonna need an IV...

- J-Tip
- Needle-free injection of local anesthetic
We’re gonna need an IV...

• Ultrasound-guided peripheral venous access
Ultrasound-assisted peripheral vascular access in a paediatric ED

Ed Oakley¹,² and Ai-Ming Wong³
¹Department of Emergency Medicine, Monash Medical Centre, ²Murdoch Children’s Research Institute and ³Department of Medicine, University of Melbourne, Melbourne, Victoria, Australia

- Prospective, observational; landmark v. US-guided techniques
- 84 patients enrolled
- 61 line placement episodes in the landmark group (with 253 attempts)
- 38 in the US group (with 90 attempts)
• Prospective; US group (USG-PIVA) v. B group (blind)
• 1° outcome: time to cannulation
• 2° outcomes: success rate at 1st puncture, number of punctures, and diameter of the catheters
• US recorded **slightly higher success** per attempt overall
  (42% vs 38%, *P* = 0.08)

• **US performed better** in the **patients with difficult access**
  (success 35% vs 18%, *P* = 0.003)

• **US attempts took longer** than landmark attempts
  (2 min 15 s vs 4 min, *P* < 0.001)
Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: a prospective randomized study

Mehdi Benkhadra¹, Mathieu Collignon¹, Isabelle Fournel², Christian Oeuvrard¹, Patricia Rollin¹, Murielle Perrin¹, François Volot¹ & Claude Girard¹

• 20 children, no group difference in for sex, age, and BMI.
• **USG-PIVA was considerably faster** (63.5 s vs 420.5)
• **Less** punctures (1 vs 2.5)
• **Better success rate** at 1st cannulation (85% vs 35%)
• Overall success rate did not differ (90% vs 85%) faster; recommend in children with difficult venous access
Tip: Use a longer angiocatheter
Tip: Use **angiocath** from central line kit
Tip: Use **arterial catheter** and **Seldinger technique**
We’re gonna need an IV...

0.9% Normal Saline
• 20 mL/kg, may repeat

D5NS
• 20 mL/kg, may repeat

Plan for/overlap with PO challenge

Feel the need, the need for speed

• **PALS**: “Limit the time spent attempting to establish peripheral venous access in a critically ill or injured child.”

• PIV attempts x 2 → IO

• **Directly to IO** if cardiac arrest

Intraosseous Needles: Contraindications

• **Infection** or **burn** at entry site
• Ipsilateral **fracture** of the extremity
• Osteogenesis imperfecta, osteopenia, etc
• **Previous ortho** procedures near site
  • Prostheses, hardware, etc

• **Relative contraindications**
  • **Previous attempt** on same bone
  • Unable to locate landmarks
IO Failure to Place

• Incorrect **landmarks**

• **Bent** needle

• Needle **obstruction**: marrow, clot, or bone spicules
  - Flushing or continuous infusion

• Penetration of **both cortices**
  - Excess force

• Subcutaneous/periosteal **infiltration**
  - Incomplete placement/dislodgement
Post-placement complications

• Cellulitis, osteomyelitis
  • < 0.6% in lit review of 4000 cases over 35 years;
    < 3% in another large review
• Compartment syndrome - fluid extravasation
• Pain
• Hematoma
• Growth plate injuries
• Fat embolus (adults: sternal and ileum IO)
A Bone to Pick...

- Proximal Tibia
- Distal Tibia
- Distal Femur
- Proximal Humerus

\[
\text{Adults and Children} \quad \text{Adults}
\]

- Sternum
- Iliac Crest
I FIND THIS HUMERUS
Bone Marrow Aspirate as an Accessible and Reliable Source for Critical Laboratory Studies

Study objective: To determine whether laboratory studies performed on bone marrow aspirate can be used to predict values in the peripheral blood of human beings.

Design: Prospective correlative study.

Setting: Tertiary care pediatric hospital.

Type of participants: Fifteen patients from the hematology-oncology division of Children’s Hospital, Oakland, California, were studied during routine diagnostic bone marrow aspirations.

Interventions: Aliquots of serum and bone marrow obtained as part of routine diagnostic studies were analyzed.

Measurements and main results: Venous and bone marrow samples were analyzed for blood gas values, hemoglobin, and serum chemistries. Bone marrow specimens were found to reliably predict venous values of pH, bicarbonate, base excess, Pco₂, hematocrit, sodium, chloride, and glucose. Bone marrow was not predictive of blood oxygenation, potassium, or ionized calcium.

Conclusion: This study demonstrates in human beings what has previously been shown in animals – that the bone marrow is an alternative source of blood for a variety of laboratory studies. (Grisham J, Hastings C: Bone marrow aspirate as an accessible and reliable source for critical laboratory studies. Ann Emerg Med October 1991;20:1121-1124.)

Jonathan Grisham, MD*
Caroline Hastings, MD†
Oakland, California

From the Departments of Emergency Medicine* and Hematology† Children’s Hospital, Oakland, California.

Received for publication January 8, 1991
Revision received May 6, 1991. Accepted for publication June 10, 1991.

Financial support for this study was provided in part by Cock Critical Care, Inc.

Address for reprints: Jonathan Grisham, MD, Department of Emergency Medicine, Children’s Hospital, Oakland, 747 52nd Street, Oakland, California 94609.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>$r$</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>.86</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>$P_{co_2}$</td>
<td>.78</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>$P_{o_2}$</td>
<td>.35</td>
<td>NS</td>
</tr>
<tr>
<td>$HCO_3^-$</td>
<td>.76</td>
<td>&lt; .05</td>
</tr>
<tr>
<td>Base excess</td>
<td>.90</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>$%O_2$ saturation</td>
<td>.52</td>
<td>NS</td>
</tr>
<tr>
<td>Hematocrit</td>
<td>.87</td>
<td>&lt; .005</td>
</tr>
<tr>
<td>Sodium</td>
<td>.73</td>
<td>&lt; .005</td>
</tr>
<tr>
<td>Potassium</td>
<td>.09</td>
<td>NS</td>
</tr>
<tr>
<td>Chloride</td>
<td>.79</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Calcium</td>
<td>.24</td>
<td>NS</td>
</tr>
<tr>
<td>Glucose</td>
<td>.96</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

**IO and IV good correlation:**
- Albumin
- BUN
- Chloride
- Creatinine
- Glucose
- Hematocrit
- Hemoglobin
- Total protein

**IO may be lower than IV:**
- CO2 level
- Platelet count

**IO may be higher than IV:**
- WBC count
• IV + IO samples from 20 children (HD normal; routine BMB) run through i-STAT
• Differences were “clinically acceptable for pH, base excess, sodium, ionised calcium and glucose”
• Coefficient of variance of intraosseous samples was smaller than for venous samples
• Conclusion: Analysis of intraosseous samples with a bedside, single-use cartridge-based analyser is feasible; may be a useful guide to treatment
Glucose

The diagram shows a scatter plot comparing intrasosseous sodium (mmol/l) against venous sodium (mmol/l). The data points are distributed across the graph, with a tendency to cluster near the 45-degree line, indicating a positive correlation between the two measurements.
$\text{intraosseous pH}$ vs. $\text{venous pH}$

The data points are scattered around the 45-degree line, indicating a positive correlation between intraosseous and venous pH.
Intraosseous medications

*Caveat:* Adenosine

Aim toward

Sternal head and clavicular head of sternocleidomastoid muscle

30°
Vein with catheter inserted

Note umbilical tape for hemostasis
Summary

Rally: Mild Volume Depletion
PO

Replete: Moderate Volume Depletion
PO, SC, and/or IV

Resuscitate: Severe Volume Depletion
IV, IO
Summary

• Try PO for mild and moderate volume depletion

• Make liberal use of adjuncts

• To resuscitate: use the push-pull technique: 30 mL syringe, 3-way stop-cock
Thank You!

@EMtogether
A curated, up-to-date syllabus is maintained for you at:

PEMplaybook.org/lectures/
References


• Benkhadra M et al. Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: a prospective randomized study. *Paediatr Anaesth.* 2012 May;22(5):449-54


• Eslami P. Intraosseous Access. *eMedicine.* 2010
References


• Hostetler MA et al., Recombinant Human Hyaluronidase-Enabled Subcutaneous Pediatric Rehydration. *Pediatrics.* 2009;124;e858
References


References
