ACCESSO INTRAOSSEO
CRITERI DI SCELTA E
RESPONSABILITA'

Bocchio Sandro AATBS

"Sometimes I can't find a vein, even when my life depends on it"
The Clinical Problem

- IVs cannot be started in over 5 million patients
- IVs are extremely difficult to start in over 7 million patients
  - Veins collapse due to shock
  - The more a patient needs an IV, the harder it is to find
- Paramedics & nurses panic - “Holy terror”
- Emergency physicians - “Nightmare”
- Thousands die every year
Current Solutions to IV Failure

- **EMS** - Sub-standard Treatment - (drive faster ?)
  - ET, SQ, IM, Rectal, Oral, Nasal, Inhalation, Sub-lingual, Transdermal
  - None of these are best in emergencies

- **ED** - Central lines - (expensive & high risk)
  - 400,000 patients hospitalized yearly for complications (FDA)
  - More than 10 % mortality
  - Each insertion costs > $2,300 in complications (CDC)

- **Alternative** - Intraosseous Infusions (IO)
  - Standard of care in pediatrics and adults
  - Recommended if no IV can be established rapidly
  - Safety and efficacy proven in thousands of cases
  - Has Saved Hundreds of Lives
History
History

• IO has endured for more than 87 years as a safe and effective alternative to IV

• Over 4,000 adult patients reported during WW II

• Became a lost art for 40 years - Why?

• Re-discovered in 1985 - James Orlowski MD

  • India - saved the lives of hundreds of Cholera patients

  • “My Kingdom for an Intravenous Line”

• Standard of care in Pediatric Advanced Life Support - Since 1986

• Now Standard of Care for adults in difficult vascular access

  • ACLS, NAEMSP, ERC, ILCOR, INS, ENA
Intraosseous (IO)

- Inside the bone is a huge non-collapsible vein
- IO (intraosseous) is just as good as IV (intravenous)
- All drugs reach the circulation the same as IV
- Scientifically sound - proven over 85 years
- Technology was possible in kids because their bones are soft

The Challenge - How to get a needle into adult bones

Ideal IO Devices
Should be Easy, Safe, Fast and Effective
Anatomy of Long Bones

- **Epiphysis**
- **Tibia**
- **Diaphysis**
- **Vein**
- **Medullary cavity**
- **Cancellous bone**
- **Compact bone (thin wall)**
- **Compact bone (thick wall)**
Anatomy of Intraosseous Access

Thousands of small veins lead from the medullary space to the central circulation.
Anatomy of long bones
Anatomy of long bones
Insertion Sites

Proximal Tibia

Distal Tibia

Proximal Humerus

Sternum

Others ? (è stato descritto utilizzo clavicola dx)
Proximal Tibia

- Femur (upper leg bone)
- Patella (knee-cap)
- Patellar Ligament
- Tibial tuberosity (bony thickness below knee-cap)
- Tibia
- Muscle
- Skin
- Anterior (Front view)
- Medial (middle facing)
Anatomical insertion point medial to the tibial tuberosity
Anatomical insertion point medial to the tibial tuberosity

Anatomy
Adult – Right Tibial Epiphysis
Distal Tibia
A closer look at the anatomy
Adult – Right Distal Tibial Epiphysis
Sternum

- Manubrium is upper of sternal structure
- Articulates with body of sternum at the Angle of Louis
Insert Perpendicular

- Note that there are three planes relative to the patient:
  - Surface of ground
  - Surface of body of the sternum
  - Surface of the manubrium

- Perpendicular means at right angles to the surface of the manubrium
Proximal Humerus

Why it is the best site:

- Better flow rate
- Lower pressure
- Less pain
- Easier to anesthetize
- Closer to heart
Proximal Humerus

- Clavicle
- Scapula
- Greater tubercle (insertion site)
- Humerus
Studies conducted at the University of Texas Health Science Center San Antonio, Texas
Adult – Right Proximal Humeral Epiphysis
The Proximal Humerus insertion site is found “slightly anterior to the arms lateral midline”

Note that arm is adducted and internally rotated with the elbow posterior

Right arm
Adult male
Use of Stabilizer in Humerus
Pediatric Insertion Sites
Intraosseous access sites for the pediatric patient

Experience & anatomy suggest that this site is most suitable for patients 5 years of age and older.
Intraosseous anatomy at **distal femur** similar to tibia
Ability to locate accurate site on distal femur
17.9 kg Male, Right Leg

Distal Femur

Skin
Adipose
Muscles
Compact bone
Cancellous bone

22 mm
3.1 kg female, Left Leg / 2 cm distal to the patella – inferior view
3.1 kg female, Left Leg / 2 cm distal to the patella – inferior view
3.1 kg female, Left Leg / 2 cm proximal to the medial malleolus – inferior view
Pediatric IO

1 cm below and 1cm medial to the tibial tuberosity
Identify Landmarks

Patella

Tibial Tuberosity

Insertion site

1 year old patient

Growth Plate
The pediatric growth plate

- Clearly visible tibial growth plate
- Tibia
- Growth Plate
- Insertion site
- Right Leg
- Left Leg
Needle Set Comparative
Photo courtesy of Edward Truemper, MD - Children’s Hospital of Nebraska
Resuscitated in Africa – child arrived obtunded and hypovolemic

Photo courtesy of Nicole St. Clare – Children's Hospital, Harvard
Physiology
Pressure and Flow Rates

- With a pressure bag or infusion pump, IO flow rates are similar to IV
  - Tibia – is similar to a 21 gauge catheter
  - Humerus & Sternum – are similar to a 16 gauge catheter
- Syringe bolus infusions - completed in seconds
- Initial rapid 10 cc syringe bolus dramatically increases IO flow rates

NO FLUSH = NO FLOW
Intrinsic IO Pressure

Arterial Pressure
120/80 mm Hg

Venous Pressure
0 to 10 mm Hg

Intraosseous Pressure
35/25 mm Hg
## IO Infusion Rates - Pigs

Compare IO flow rates using high pressure delivery systems

<table>
<thead>
<tr>
<th>Site</th>
<th>Average Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humerus - Pressure Bag (600 mmHg)</td>
<td>113 ml/min (6,780 ml/hr)</td>
</tr>
<tr>
<td>Humerus – FMS 2000 (300 mmHg)</td>
<td>77 ml/min (4,608 ml/hr)</td>
</tr>
<tr>
<td>Tibia - Pressure Bag (600 mmHg)</td>
<td>81 ml/min (4,808 ml/hr)</td>
</tr>
</tbody>
</table>

Lariat et al. Dynamics of Flow IO Study. 59th Research Wing USAF
Infusion Flow Rates – Humans (mL/hr)

At Different Infusion Pressures (mmHg)

Note: For tibial IO, not enough cases at 100 and 150mmHg to calculate means.
Infusion of Medication

Which Drugs can be given?

- Any medications that can be safely injected into a peripheral IV can likewise be safely injected IO
- Caution with long-term infusions of cytotoxic drugs ie. hypertonic saline

What Dose?

- IO and IV doses are identical

Lab Testing:

- 4 cc of blood can be aspirated from an IO device and placed into a heparin-coated syringe for standard laboratory testing
- Discard first 2 cc of marrow first
Medication Infused

- Epinephrine
- Atropine
- Lidocaine
- Sodium Bicarbonate
- Amiodarone
- Fentanyl
- Rocuronium
- Dextrose 50 %
- Narcan
- Normal Saline
- Mivacron
- Insulin
- Manitol
- Magnesium

- Ringers Lactate
- Dopamine
- Levophed
  - Lasix
- Etomidate
- Succinylcholine
- Promethazine
  - Blood
- Thiamine
- Vasopresin
- Aminophyllin
  - Norcuron
- Cordorone
  - Calcium
IO Lab Analysis

Compared lab results between IO and IV in human volunteers

The following lab values were nearly identical:

- Glucose, BUN, Creatinine, Sodium, Potassium, Chloride, Calcium, Hematocrit, Hemoglobin, Cardiac Enzymes

- WBC was higher indicating residual marrow

- Blood gases – IO values were between arterial and venous
Blood Gases:

**pO₂**

- Mean IO value = 53.3% of mean arterial value
- Normal range arterial: 75 to 90mmHg
- Normal range venous: 30 to 50mmHg

**O₂ Saturation**

- Mean IO value = 86.9% of mean arterial value
- Normal range arterial: 94 to 97%
- Normal range venous: 60 to 85%
Complications
Potential Complications

- Extravasation
- Compartment syndrome
- Dislodgement
- Fracture
- Failure (device or user)
- Infections (osteomieliti)
  - From 1940 - 1984 the rate of infection & osteomyelitis was < 0.6%
  - From 2004 - 2009 the rate of infection & osteomyelitis in the was < 0.004 % (2 in 600,000) (ez-io data)

Mortality from above complications - Miniscule

Not:
- Fat embolism
- Epiphyseal plate injury
Pain
85% of IO patients will be unconscious
  • For them, pain is not an issue

For the conscious patient - pain is an issue
  • Pain related to insertion of needle - Minimal
    • May numb the skin and periosteum with local xylocain
  • Pain related to infusion of meds/fluids - Significant
    • Numb the vessels by injecting xylocain IO
    • Psychological pain - “You are going to do what?”
      • Talk to your patient
Two Kinds of Pain

Pain Sensors
Skin and Periosteum
(somatic pain)

Pain Sensors
Blood vessels
(visceral pain)
IO Pain Mitigation Study
40 Healthy Volunteers - IRB approved study

### Proximal Humerus
- Able to give good flush after 40 mg lidocaine (*pain tolerable*)
- Pain increased slightly after flush (opened new paths)
- Pain essentially eliminated after additional 20mg lidocaine
- Flow rate averaged > 5,000 ml / hr
- Anesthesia lasted > 90 minutes
- All tibial volunteers stated that the humerus was far less painful

### Proximal Tibia
- Able to give good flush after 80 mg lidocaine (*pain intolerable*)
- Pain increased after flush (opened new paths)
- Pain essentially eliminated after additional 40mg lidocaine
- Flow rate averaged <1,000 ml / hr
- Anesthesia lasted < 30 minutes
VAS Pain Scores
IO Insertion and Removal

- **INSERTION**
  - Tibia: 2.8
  - Humerus: 3

- **REMOVAL**
  - Tibia: 3.3
  - Humerus: 1.2
Note: Any pain above 5 is considered intolerable by most subjects.
IO Pain Mitigation Study

40 Healthy Volunteers - IRB approved study

- 2% (preservative free) Lidocaine given IO provided effective local anesthesia in all volunteers
- Primed the EZ-Connect® with 2% Lidocaine
- Optimal dosage was 40 mg IO (2cc)
- Infused Lidocaine slowly (0.2cc increments)
- Allowed 15 seconds for anesthetic effect
-Flushed hard to get flow (caused brief pain)
- Repeated 20 mg after the flush

Some tibial volunteers required repeated administration to achieve desired effect
Indications & Contraindications
When you need meds or fluids immediately

- Cardiac arrest
- Status epilepticus
- Shock Trauma
- Arrhythmia
- Dehydration
- Burns
- Drug overdose
- DKA (diabetic)
- Stroke
- Myocardial infarction

- Coma
- Head Injury
- Anaphylaxis
- Congestive heart failure
- Emphysema
- Respiratory arrest
- Hemophiliac crisis
- Pediatric shock
- Chest pain

Rapid IV access is often difficult or impossible in these situations

- IV cannot find in 2 attempts or 90 sec
- GCS < 12  RTS 11
**IO Indications – Emergency**

- **CRITERI DINAMICI**
  - Precipitato > 5 mt
  - Altri deceduti
  - Incastrati
  - Estricazioni prolungate
  - Sbalzato-proiettato

- **CRITERI AMBIENTALI**
  - Scarsa o nulla visibilità
  - Situazioni meteo severe
  - Pz visibile parzialmente
  - Pz grave obeso
  - Pz con vestiari tecnici (es. tute protezioni Hazmat)
  - Ambiente impervio e/o ostile
Contraindications

- Local Infection
- Osteogenesis imperfecta
- Fractures - major trauma to extremity or sternum
- Prosthesis (knee, shoulder, sternotomy)
- Absence of Anatomical Landmarks (morbid obesity)
- Recent (24 hours) previous IO
FDA (CE) Approved IO Devices

- Jamshidi / Illinois Sternal / Cook (Manually Pushed In)
  - Mostly used for pediatrics
- F.A.S.T. 1, - Pyng (Bed of Nails)
  - Designed for adult sternum
  - Manually inserts 10 probes and one IO needle at once
- B.I.G. - Bone Injection Gun (Nail Gun)
  - Shoots a needle into adult tibia and other bones
- EZ-IO (Battery Powered Drill)
  - Powers a hollow drill (Catheter) into the medullary space
Verificare posizione -
verificare che la tacca
corrisponda alla
localizzazione sternale e che la Target Zone si trova sopra il manubrio
Premere l' introduttore nella zona bersaglio aumentare la forza , fino a quando in modo distinto si sente la foratura dell'osso ..
Collegare la siringa e aspirare per verificare l'esatto posizionamento
The Bone Injection Gun (BIG)™

- Cleared for use in proximal tibia and proximal humerus

- Pediatric B.I.G - 18G
- Adult B.I.G - 15G
Technique of Insertion
The Vidacare G-3 Driver
Lighter, smaller, stronger and technologically advanced

Seamlessly integrated with EZ-IO Needle Sets
Battery life indicator
Sealed lithium batteries

Designed for 1000 human insertions
3 Lengths for 3 Sizes

Length & color are the only differences between these Catheters
Select the Right Length Needle Set
Consider soft tissue thickness prior to EZ-IO insertion

25 mm Needle Set

45 mm Needle Set

Note that the 5 mm mark is NOT visible above the skin
Insert needle set into appropriate site

Position the EZ-IO Driver at a 90 degree angle to the bone
Don’t Push Too Hard

Lightly holding the EZ-IO driver will improve success

Don’t force the needle set into position - “allow the driver to do the work”
Control position of needle tip

Beware of Recoil -
Take your finger off the trigger when you enter the bone

User induced recoil may lead to needle dislodgement or extravasation

STOP WHEN YOU FEEL THE POP
Syringe FLUSH Catheter

No Flush = No Flow

Some patients may require multiple syringe flushes

Alert patients require 2% preservative free Lidocaine Intraosseously PRIOR to flush

Syringe FLUSH catheter with 10 ml of a sterile solution
La possibilità di ottenere un accesso vascolare sicuro ed in brevi tempi è spesso determinante per l'outcome del paziente. L'infermiere del sistema di emergenza e urgenza deve e può posizionare una un ago per infusione intraosseo.

Gli equipaggi sanitari con competenze avanzate dovrebbero essere dotati di kit per l'accesso intraossea.

Importante creare e manterere una formazione per i nuovi infermieri, garantire un retraining, permettere la divulgazione di nuove ricerche e nuove evidenze.