Difficult Vascular Access in Children
Vascular Access in children

• Interest for VA - books & courses - is still limited compared to Nerve Blocks for example.

• VA is mandatory for every case (at least a PVA, sometimes a CVA); NB not.

• Difficult Access:
  • peripheral: predictable (skin)
  • central: surprises (under the skin)
  • skills - Tips - Tricks & devices
Inhalational Anesthesia

• Often the first choice

• not finding a iv

• Laryngospasm without iv!
Algorithm?

Peripheral Access failure after inhalational anesthesia

Anesthesia

Stable

controlled

HD difficulties

Airway difficulties

highly unstable

call for help

PA with device

Age

(< 6 m

Trans.illum

NIR)

> 6 m

USG

saphenous arm

EJV

Trend position

Keep head and neck free

IO access

tibial

other

CVA

SCV → IJV → FV

> 5 days

< 5 days

No

Need for postop CVA?

(+ expertise)

denudation

Wake the child up

or Proceed without iv

Pirotte - Van Regemorter submitted
Intraosseous Access

• Should be available in every Operating Theater
• Large education and information
• ...to never have to use it

Demystification
• easy
• complications = rare

Storage?
Known by everybody

in 3 years time: 12 needles used
...all for workshops
Intraosseous Access

• Should be available in every Operating Theater
• Large education and information
• ... to never have to use it

Storage?
Known by everybody

- extravasation: 4-12% (in OR?)
- compartment syndrome: 0.6%
- osteomyelitis: 0.5%
- fracture
- lesion of the growth plate
- fat embolism

- previous attempt same bone
- local infection
- osteogenesis imperfecta
- R-L intracardiac shunt

Demystification

• easy
• complications = rare

in 3 years time: 12 needles used
... all for workshops
Indications IO Access

- NO iv access + highly unstable child:
  - cardiac arrest
  - unstable trauma (only access possible with all the veins flat/empty)
  - major events after inhalational anesthesia

- Prevention:
  - device ready at induction if combination:
    - known DIVA + potential difficult airway
  - especially in remote locations

- child with a cold
- obesity
- Pierre-Robin,...
- 3 years old
  - strabismus surgery
  - complete AV block
  - inhalational induction
  - easy and rapid iv
  - IO access not needed

- 8 months - 11kg
  - MRI (remote location)
  - Cushing syndrome - Adrenal gl.
  - awake iv impossible
  - inhalational induction
  - iv inner wrist
  - 2d iv : USG saphenous
  - IO access not needed
Site

Flat aspect of the tibia
Infants: 1 cm

Growth Plate
Needle

15 mm  3-39 kg

25 mm  > 3 kg

45 mm  > 40 kg, soft tissue +++
Flush
5 to 10 ml
Peripheral Access
Peripheral Access

- Difficulties are predictable: clinical examination & history

- chronic illness
- black skin
- happy mommy’s child
Peripheral Access

**DIVA score (Yen - 2008)**

<table>
<thead>
<tr>
<th></th>
<th>0 point</th>
<th>1 point</th>
<th>2 points</th>
<th>3 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>visibility of the vein</td>
<td>visible</td>
<td></td>
<td>not visible</td>
<td></td>
</tr>
<tr>
<td>palpation of the vein</td>
<td>palpation</td>
<td></td>
<td>no palpation</td>
<td></td>
</tr>
<tr>
<td>age</td>
<td>&gt; 3 years</td>
<td>1-2 years</td>
<td></td>
<td>&lt; 1 year</td>
</tr>
<tr>
<td>history of prematurity</td>
<td>term</td>
<td></td>
<td></td>
<td>preterm</td>
</tr>
</tbody>
</table>

(chronic illness, obesity, previous DIVA ,...)

**DIVA**

≥ 4  
= !!

• In the OR:
  • first attempt success = 70-80%
  • impossible = 0,3% (ward = up to 5%)
  • & experience (years of practice, nb / week)
• **Tips & Tricks?**

• wet a black skin (often dry)
• take EMLA off 5 min. before
• warm up the hand of foot *(water, glove, B.Hugger)*
• push the needle with the thumb («clic»)
  • wait for back flow in neonates *(up to 2”)*
  • or fill the needle with saline *(«swimming RBC»)*
• use only half of the needle length to find the vein
• 2d half should be catheterized *(reduce postop extravasation)*
Devices for PVA?

- Vein Entry Indicator Device (VEID)
  - acoustic pressure monitoring
  - some benefit when difficult
    (no vein visible & slow blood entry)

- Transillumination (VeinLite)
  - increase success when < 2 years old
  - some benefit when difficult (slow blood entry)
  - experience / dark environment !, no depth!

www.AliExpress.com

www.alibaba.com
• **NIR technology**
  - controversial efficacy: better visibility - same success rate
  - screening (dark skin, hematoma)?
  - bifurcation - flushing ok
  - no depth

Devices for PVA?
• NIR technology

Near-infrared light to aid peripheral intravenous cannulation in children: a cluster randomised clinical trial of three devices*

J. C. de Graaff,¹ N. J. Cuper,² R. A. A. Mungra,³ K. Vlaardingerbroek,⁴ S. C. Numan⁴ and C. J. Kalkman⁵

Anaesthesia 2013, 68, 835–845

doi:10.1111/anae.12294
Devices for PVA?

- **Ultrasound Guidance** (> Transillum., > NIR)
  - increase success rate and reduce time in case of difficult PVA
  - could reduce need for CVC or IO
  - recommended by several societies
  - ankle, antecubital fossa, arm (picc-, mid-lines)
  - asleep >> awake (!!)

- Internat EB reco (2012): Int Care Medicine
Devices for PVA?

- USG - ! deep veins - USG puncture ok - insufficient cannulation ....
Long IV cannula or Mid-Line

- 22-20-18 ga / 8 or 10cm
- quick insertion
Central Venous Access

• Difficult situations in children?:
  - need to proceed under GA
  - as for adults: problems often unknown
  - the young child - infants & neonates
    - the equipment
    - the puncture
Lowering the age limit to proceed under LA

• think : « Picc Line »

Medical indications:
- neuromuscular pathologies
- severe chronic pulmonary infections
- ...
- ex: 5 y old healthy / 18 months old sick +++
Picc Lines

- under GA
- LA alone
- Hypnosis + LA
- N2O + LA
- Midazolam + LA
• technically not always easier than classic CVC

• our limit = 10kg / 1 year (picc 3 fr)

• ! vein puncture without success = vein lost
Central Venous Access

• Difficult situations in children?:

  • need to proceed under GA
  
  • as for adults: problems often unknown

• the young child - infants & neonates
  • the equipment
  • the puncture

under the skin
ULTRASOUND = huge benefit
CVA: the problem is often unknown

« detecting the difficult puncture BEFORE it gets difficult »

abnormal vein position
CVA: the problem is often unknown

« detecting the difficult puncture BEFORE it gets difficult »

abnormal patency
Benefits of USG

avoid inadvertent arterial puncture
optimize the vein puncture & catheterization
Overall Goal of USG in children:

- reducing the **Number of Attempts**

  - Chance to success
    - \(-25\%\) success chance / attempt

  - Incidence of complication
    - High if > 3 attempts

- Risk of HD instability, hypothermia, ...

  - Procedure time = anesthesia time
Other benefits of US

confirm correct GW migration before dilatation
detect possible early complication
Recommendations

2002: **Nice** (National Institute for Clinical excellence) - **UK**

   www.nice.org.uk

2012: **ASA** Task force on central venous access - **USA**

   Anesthesiology 2012;116:539-73

2012: **AS** of Echocardiography & **SC**ardioVx Anesth - **USA**

   Anesth Analg 2012;114:46-72

2012: **International** EB recomm. on Vascular access - **Int.**

   Int Care Medecine 2012; 38:1105-17

2014: **SFAR** Guidelines use of USG for vascular access - **France**

   Anaesth Crit Care Med 2015; 34: 65-69
Recommendations

1) Prescreening - choosing the site of insertion
2) US guidance
3) Screening of the GW before dilation
4) US available to detect early complications

- IJV
- FV
- (SCV)
- Picc Lines
- PVA (if difficult)
- AL (if difficult)
Central Venous Access

- Difficult situations in children:
  - need to proceed under GA
  - as for adults: problems often unknown
  - the young child - infants & neonates
    - the equipment
    - the puncture
Size: child vs probe size

* Having an adapted probe is mandatory

* Screening is better than nothing
  - position - patency - diameter
  - vein track vs arteries & lung

* if the probe is too large, OOP is easier

* using a part of the probe is possible
Size: vein vs needle & catheter

<table>
<thead>
<tr>
<th>Age</th>
<th>vein</th>
<th>needle</th>
<th>1 lumen</th>
<th>2 lumens</th>
</tr>
</thead>
<tbody>
<tr>
<td>preterm</td>
<td>&lt;1–2 mm</td>
<td>0,72 mm</td>
<td>0,64 mm</td>
<td>1,40 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>35 – 100%</td>
<td>30 – 65%</td>
<td>70 – 100%</td>
</tr>
<tr>
<td>term</td>
<td>2–4 mm</td>
<td>0,72–0,81</td>
<td>0,81 mm</td>
<td>1,40 mm</td>
</tr>
<tr>
<td>5 years</td>
<td>3–7 mm</td>
<td>0,81–1,02</td>
<td>1,02 mm</td>
<td>1,70 mm</td>
</tr>
<tr>
<td>10 years</td>
<td>5–10 mm</td>
<td>0,81–1,02</td>
<td>1,29 mm</td>
<td>1,70 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8 – 20%</td>
<td>12 – 25%</td>
<td>15 – 35%</td>
</tr>
</tbody>
</table>

(Arrow)
### Catheters

<table>
<thead>
<tr>
<th></th>
<th>&lt; 1.5 kg</th>
<th>newborn</th>
<th>6 m - 4 y</th>
<th>4 - 10 y</th>
<th>&gt; 10 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single lumen CVC</td>
<td>2 F (22 ga)</td>
<td>3 F (20 ga)</td>
<td>3 F (20 ga)</td>
<td>4 F (18 ga)</td>
<td>5 F (16 ga)</td>
</tr>
<tr>
<td>Double lumen CVC</td>
<td>/</td>
<td>4 F</td>
<td>4 F</td>
<td>5 F</td>
<td>7 F</td>
</tr>
<tr>
<td>PICC</td>
<td>1 F (28 ga)</td>
<td>2 F (23 ga)</td>
<td>3 F (vein &gt; 3 mm)</td>
<td>4 F (vein &gt; 4 mm)</td>
<td>5 F (vein &gt; 5 mm)</td>
</tr>
<tr>
<td>Umbilical catheters</td>
<td>3.5 F</td>
<td>5 F</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
</tbody>
</table>
Guidewires

5 mm vein

2 mm vein
Dilation

From 'damaged' introducer to 'kinked' guidewire

- gentle pressure
- in the same track as the needle
- in/out movement detect guidewire kinking
- progressive dilatation with peripheral cannula’s
Central Venous Access

• Difficult situations in children?
  • need to proceed under GA
  • as for adults: problems often unknown
  • the young child - infants & neonates
    • the equipment
    • the puncture
Access to the Femoral Vein
the Femoral Vein

- low US image quality *
- optimal leg position (arterial overlap)
- check ilio-femoral patency
the Femoral Vein

- frequent transfixion
- reduce arterial puncture
- track guidewire before dilation
Access to the **Internal jugular Vein**

- small children have no neck
- the vein is small and highly mobile
- the needle is big, the J-shaped GW is huge in neonates

22ga 0.18” J guidewire Morita M. Anesth Analg 2009
• Subclavian vessels are « extrathoracique »
  • accidental arterial puncture : not always the CA (SClav A)

• Lung top protrudes above the clavicle
  • pneumothorax & anterior approach IJV
Guidewire insertion
Guidewire insertion
« Peri-clavicular » Accesses

<table>
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<tr>
<th>Approach - Targeted vein</th>
<th>Guidance</th>
<th>Age categories</th>
<th>USG Technique</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supraclavicular - Brachiocephalic vein</td>
<td>US</td>
<td>all</td>
<td>LAX - IP</td>
<td>- large &amp; open vein - easy puncture</td>
<td>- central approach - exit site - I brachial plexus</td>
</tr>
<tr>
<td>Infraclavicular - Subclavian vein</td>
<td>US / LM</td>
<td>all *</td>
<td>LAX - IP LAX - OOP *</td>
<td>- open vein - safe progression - exit site</td>
<td>- shadow clavicle - orientation children/ adolescents *</td>
</tr>
<tr>
<td>Transpectoral - Axillary vein</td>
<td>US</td>
<td>(children) adolescents</td>
<td>SAX - OOP LAX - IP</td>
<td>- exit site - comfort</td>
<td>- depth - compressibility vein - proximity pleura</td>
</tr>
</tbody>
</table>

TABLE 5: Comparison between three different peri-clavicular approaches for CVC placement in children. US: ultrasound, LM: landmark. *: the US-guided infraclavicular approach of the subclavian can be more difficult in older children (visualization of the vein, 3-D orientation, initial OOP approach).
« Peri-clavicular » Accesses

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</table>
« Peri-clavicular » Accesses

SCV & BCV are « open » & « fixed »
• infra & supra- clavicular approaches described
• nice in-plane approach

• easier guide wire insertion
• Supraclavicular access of the BCV
• Infraclavicular access of the SCV
More and more used in low weight infants as alternative for IJVs
example of SCV access

Guidewire insertion facilitated by placing the needle tip into the BCV
the vein do not collapse ...
• VA in Children

• remains challenging
• plan B to get a first access should be available for stable and urgent situations
• ultrasonography & IO devices are useful
• technological progresses will help us
• ... but manual skills remains important
respiration, and they may contain valves. Arteries are pulsatile and more difficult to compress.

US needle guidance can be performed with two different needle-to-probe alignments or “approaches”: the out-of-plane approach or OOP when the needle is inserted perpendicular to the US beam and is seen as a hyperechoic (white) dot and the in-plane approach or IP when the needle is inserted strictly into and parallel to the US beam and is seen as a hyperechoic (white) line.

With OOP approaches, the vessel is placed in the middle of the screen to lie under the middle part of the probe. The needle is inserted at a distance corresponding to the vessel depth with a flat angle (\(<45^\circ\)) to appear in the soft tissues above the vessel (Fig. 19.7). The needle tip is followed by sliding or tilting movements of the probe (Fig. 19.8). Sliding movements, requiring gel on the skin, are used if the site offers enough room for movement. Tilting movements are used if room for probe movement is limited (more frequently in infants and neonates). Probe movements should always precede needle movements because the appearance of the hyper-echoic needle tip on the screen is the most obvious pattern recognized by our eyes.

With IP approaches, the probe remains in a stable imobile position while the needle is inserted exactly parallel and under the length of the probe (Fig. 19.9). Perfectly inserted, the needle is seen as a bright hyperechoic line. If the needle
2016

**Fig. 19.10** Different gel models used for pediatric vascular access training sessions. (a) “Head and torso,” (b) “pediatric vessels,” and (c) “PICC insertion arm” from Blue Phantom® and (d) “vascular access child” from Simulab®

**Fig. 19.11** Sterility and ergonomy. (a) Long sterile drape and probe covers ensure maximal barrier precautions. (b) Hands and US screen are aligned in front of the operator to facilitate handling.

**Fig. 19.38** Insertion of a peripherally inserted central catheter on the left arm of a child. (a) Sterile dressing and positioning during a USG puncture at mid-arm level (SAX-OOP technique). (b) Insertion of the dilator and introducer over the guide wire. (c) Insertion of the PICC in the peel-away introducer. (d) Fixation by a suture-free StatLock® above the antecubital fossa

### 19.4.2.5 Catheter Tip Positioning

A non-central placement of the PICC increases the risk of mechanical and thrombotic complications. It is therefore advised to avoid blind insertions and to use either ECG guidance or fluoroscopy. The ideal position is the cavo-atrial junction when the arm is in adduction with the elbow slightly flexed. Fluoroscopy seems to be the easiest and most reliable and versatile tool because it shows the cavo-atrial junction with precision but also helps to direct the PICC from the arm (using phlebography) to the SVC (Fig. 19.39). Irradiation should however be reduced as much as possible in children by using adapted doses and short pulsed emission of X-ray and by closing the diaphragm.

### 19.4.3 Fixation and Maintenance

PICCs are fixed by a suture-free securing device (StatLock®, BARD) and covered by a transparent dressing. To increase comfort, the fixation should not reach the antecubital fossa and can therefore be placed above the insertion point (Fig. 19.38d). The dressing has to be changed every week and the catheter flushed with 10 ml of
Intraosseous Access Courses

Clinical Education Resources
ARROW® EZ-IO® Intraosseous Vascular Access System

Online Education – Clinical Principles, Quiz and Certificate - View
View the most comprehensive online resource for ARROW® EZ-IO® Vascular Access education, complete a brief quiz and receive a certificate for successful completion.

Download the most comprehensive and detailed document describing virtually every practical aspect of intraosseous (IO) access: IO anatomy and physiology, basic and clinical science supporting IO access, insertion sites and techniques, indications, contraindications and warnings, complications, frequently-asked questions...and so much more.

Intraosseous Vascular Access Bibliography - View
Download a comprehensive bibliography of articles describing intraosseous access (regardless of device type or brand name), organized in categories including pharmacokinetics, clinical studies, case studies, guidelines, intraosseous devices, pediatrics and complications.

Clinical and Medical Affairs Procedural Lab Programs - Europe, Middle East and Africa
Pediatric Vascular Access Courses

Friday 2 June 2017
Geneva

Euroanaesthesia GENEVA 03-05 JUNE 2017
THE EUROPEAN ANAESTHESIOLOGY CONGRESS

Ultrasound guided central venous access in neonates, infants and children

**IMPORTANT NOTICE: access is limited to pre-registered delegates**

Pre-registration is required and attendance is limited to 48 participants.

This course will provide an update on new technologies, devices and techniques for achieving a successful vascular access in children. Participants will learn how to use ultrasound to improve success rates and patient care, preventing or treating short and long term complications, when central, peripheral, and peripherally inserted central lines catheters, arterial lines and intraosseum needles are inserted.

By the end of this course attendees will be able to:

- properly operate a ultrasound machine and make adjustments to obtain adequate image quality,
- acquire ultrasound images for examination of the vascular structures,
- adequately apply the use of ultrasound to facilitate the intravascular placement of catheters
- acquire the decision-making process for the correct choice of device and procedure for neonates and children.

Tutors will cover the basics of ultrasound and ultrasound-guided line placements, with specific focus on paediatric anatomy, dedicated devices and procedures for children. Areas covered will include jugular, femoral, subclavian venous access and arm vein access. An overview on the immediate and long term management on children with vascular catheter will be provided. The course will also include hands-on practice on phantoms and human models.

The pre-congress course is designed for physicians, nurses and healthcare professionals interested in the field of vascular access placement and management in children.

This pre-congress course is organised by the ESA Scientific Subcommittee on Paediatric Anaesthesia.

Hour session: 09:00 – 18:00
Pediatric Vascular Access Courses

ULTRASOUND TRAINING COURSES

PAEDIATRIC ULTRASOUND GUIDED VENOUS ACCESS
A One-Day Practical Course for physicians and nurses
Pending 6 RCR Category 1 CME Credits

COURSE DIRECTOR
Dr Thierry Pirotte
Consultant Anaesthetist
Université Catholique de Louvain
Belgium

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>08.30</td>
<td>Registration and coffee</td>
</tr>
<tr>
<td>09.00</td>
<td>Lecture: Ultrasound physics and knobology applied to (very) small vessels</td>
</tr>
<tr>
<td>09.20</td>
<td>Lecture: US-guided vascular punctures in children</td>
</tr>
<tr>
<td>09.50</td>
<td>Practical: Machine knobology and needling towards small (2mm) in vitro vessels.</td>
</tr>
<tr>
<td>10.30</td>
<td>MORNING BREAK</td>
</tr>
<tr>
<td>10.50</td>
<td>Lecture: US anatomy and puncture of the internal jugular vein in children</td>
</tr>
<tr>
<td>11.10</td>
<td>Lecture: US anatomy and puncture of the femoral vessels in children</td>
</tr>
<tr>
<td>11.20</td>
<td>Lecture: US anatomy and puncture of the «subclavian» vein in children</td>
</tr>
<tr>
<td>11.45</td>
<td>Practical: Scanning the neck and the supra &amp; infraclavicular area on live paediatric models</td>
</tr>
<tr>
<td>13.00</td>
<td>LUNCH</td>
</tr>
<tr>
<td>13.45</td>
<td>Lecture: Ultrasound-guided PICC Line insertion in children</td>
</tr>
<tr>
<td>14.05</td>
<td>Lecture: Arterial and venous peripheral access in children</td>
</tr>
<tr>
<td>14.15</td>
<td>Practical: Scanning the arm and forearm area in live paediatric models + review different approaches and needling techniques</td>
</tr>
<tr>
<td>15.45</td>
<td>AFTERNOON BREAK</td>
</tr>
<tr>
<td>16.00</td>
<td>Summary &amp; Question time</td>
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Monday 27 July 2017
Luton - UK