Ultrasound Guided Central Venous Access in Neonates and Infants

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Ultrasound Guided Central Vascular Access in Neonates, Infants and Children

Mauro Pittiruti*

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Table 1. Central Lines

<table>
<thead>
<tr>
<th>Central Lines</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Umbelical catheters (Umbelical vein)*</td>
</tr>
<tr>
<td>• Epicutaneo-caval catheters (Superficial veins of limbs or scalp)*</td>
</tr>
<tr>
<td>• Central venous catheters: tunneled, non-tunneled, ports (central veins of the neck and of the supra/infra-clavicular region)</td>
</tr>
<tr>
<td>• PICC, Peripherally Inserted Central Catheters (Deep veins of the arm)</td>
</tr>
<tr>
<td>• Inferior Vena Cava catheters (femoral and saphenous vein)</td>
</tr>
</tbody>
</table>

* = only in neonates.
Central lines in neonates, infants and children

Umbelical – DIRECT INSERTION
Epicutaneo-caval caths – NIR TECHNOLOGY
CICC, PICCs, etc. ULTRASOUND GUIDANCE
NIR TECHNOLOGY
NIR TECHNOLOGY

Ideal for detection – puncture – cannulation of superficial veins (< 7mm of depth)

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EDITORIAL II

Difficult peripheral veins: turn on the lights

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ULTRASOUND

Ideal (mandatory !) for detection – puncture – cannulation of deep veins (> 7mm of depth)

International evidence-based recommendations on ultrasound-guided vascular access
US-guided central venous access

Brachio-cephalic, internal jugular, external jugular, subclavian – SUPRACLAVICULAR CVC

Axillary vein at the chest – INFRACLAVICULAR CVC

Axillary vein at the arm, basilica, brachial - PICC

Saphenous, femoral – INFERIOR VENA CAVA CATH.
Axillary vein at the arm, basilica, brachial = PICC
Conventional use of US guided PICC lines in children:

- central lines via arm veins (brachial, basilic, axillary, cephalic)
- small caliber veins (3 mm or >)
- small caliber PICCs (3 Fr or >)
- no age limit: only limit is vein diameter
Not to be confused with other peripherally inserted central lines in neonates

<table>
<thead>
<tr>
<th>Epicutaneo-caval caths</th>
<th>US-guided PICCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neonates</td>
<td>Infants and children</td>
</tr>
<tr>
<td>Direct or NIR insertion</td>
<td>Ultrasound guidance</td>
</tr>
<tr>
<td>Superficial veins of the arm</td>
<td>Deep vein of the arm</td>
</tr>
<tr>
<td>Tip not always central</td>
<td>Tip at CAJ</td>
</tr>
<tr>
<td>Caliber &lt; 3Fr</td>
<td>Caliber 3 Fr or &gt;</td>
</tr>
<tr>
<td>Low flow</td>
<td>High flow (power inject.)</td>
</tr>
<tr>
<td>No blood sampling</td>
<td>Ok for blood sampling</td>
</tr>
</tbody>
</table>
US guided PICCs

Ideal for
- pediatric intensive care unit
- pediatric surgery (perioperative access)
- pediatric parenteral nutrition
- pediatric oncology/haematology

Ideally:
- power injectable polyurethane
Our PICC experience in PICU

107 power injectable, non-valved PICCs:

47  5Fr double lumen
23  4Fr double lumen
19  4Fr single lumen
18  3Fr single lumen
Double lumen 5 Fr power injectable PICC in 13 yr old
Double lumen power injectable PICC in 4 yr old
Conventional PICC in infant
All PICCs are inserted by properly trained nurses or physicians.
Conventional use of PICCs

In pediatric intensive care, PICCs (specially if power injectable and non-valved) can be used as multi-purpose central lines for any i.v. infusion and for hemodynamic monitoring.

Crucial factors are:

- US guidance
- appropriate protocol of insertion
- appropriate policies for maintenance
100% success at insertion

Consistent adoption of **SIP protocol** as proposed by GAVeCeLT since 2010:

1 – hand washing, maximal barrier protection  
2 – US scan of all veins before starting the procedure  
3 – choice of vein matched with cath diameter (3:1)  
4 – individuation of brachial artery and median nerve  
5 – ultrasound guided venepuncture  
6 – IJV compression while inserting the catheter  
7 – tip verification by intracavitary EKG  
8 – skin securement with ‘sutureless’ device
Though:

Conventional use of PICCs (US-guided venipuncture at midarm) is applicable to children and some infants, but not to neonates.

Limit (regardless of age/weight):

availability of a deep vein at arm (brachial, basilica or axillary) with diameter > 3 mm
Brachio-cephalic, internal jugular, external jugular, subclavian – SUPRACLAVICULAR CVC

Axillary vein at the chest – INFRACLAVICULAR CVC

CICC = centrally inserted central catheters
Non-conventional use of PICCs as CICCs

PICCs = ideal as CICC in neonates and small infants

- optimal micro-introducer
- echogenic 21G needle
- nitinol guidewire
- adjustable length (tunneling, etc.)
- power injectable polyurethane
Ideal choice for neonates/infants

- Best material: power injectable PUR
- Best microintroducer kit
- Best technique: ultrasound
- Best vein available (usually: brachio-cephalic)
‘key points’ for an uneventful insertion…

Ultrasound study of deep veins (RaCeVA)  
US-guided venipuncture and cannulation  
IC-EKG for verification of tip position  
Tunneling  
Securing (glue + sutureless device + transparent dressing)  
Intra/post-procedural controls  
r/o PNX by US  
further verification of tip position by TEE or Rx
‘key points’ for an uneventful insertion…

**Ultrasound study of deep veins (RaCeVA)**

US-guided venipuncture and cannulation

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Table 2. Ultrasound-Guided Venipuncture

<table>
<thead>
<tr>
<th>Location</th>
<th>Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>At neck</td>
<td>Internal jugular vein (out of plane)</td>
</tr>
<tr>
<td>In the supra-clavicular area</td>
<td>Internal and external jugular, subclavian, brachio-cephalic vein (in plane)</td>
</tr>
<tr>
<td>In the infraclavicular area</td>
<td>Axillary, cephalic vein (out of plane/in plane)</td>
</tr>
<tr>
<td>At mid-arm</td>
<td>Basilic vein, brachial veins (out of plane)</td>
</tr>
<tr>
<td>At the groin</td>
<td>Femoral, saphenous vein (out of plane)</td>
</tr>
</tbody>
</table>
• Ultrasound guided venipuncture is rapidly becoming the standard technique for achieving a central line in neonates, infants and children.

• Ultrasound gives the possibility of choosing the most appropriate and safest venous access, as well as performing a 100% safe procedure.
International evidence-based recommendations on ultrasound-guided vascular access
<table>
<thead>
<tr>
<th>Domain code</th>
<th>Suggested definition</th>
<th>Level evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4.SD1.S1–2</td>
<td>Ultrasound guidance should be routinely used for short- and long-term central venous access in children and neonates</td>
<td>A</td>
</tr>
<tr>
<td>D4.SD1.S3</td>
<td>Ultrasound vessel imaging with ultrasound assistance as “a minimum” should be routinely performed before internal jugular vein puncture in neonates</td>
<td>A</td>
</tr>
<tr>
<td>D4.SD1.S4</td>
<td>In neonates, ultrasound screening should be used before subclavian vein puncture. Ultrasound-guided puncture should be considered for catheterization using the supra-clavicular route, but this technique requires experienced operators</td>
<td>C</td>
</tr>
<tr>
<td>D4.SD1.S5</td>
<td>Ultrasound vessel screening should be routinely used before femoral vein puncture. Ultrasound-guided femoral puncture is recommended to decrease inadvertent arterial puncture</td>
<td>B</td>
</tr>
<tr>
<td>D4.SD1.S6</td>
<td>Ultrasound guidance can be considered when difficult peripheral venous access is required in areas such as the antecubital fossa and ankle. Blind deep antecubital fossa puncture should disappear</td>
<td>C</td>
</tr>
<tr>
<td>D4.SD1.S7</td>
<td>Ultrasound-guided arterial catheterization improves first-pass success and should be used routinely in children and neonates</td>
<td>A</td>
</tr>
<tr>
<td>D4.SD1.S8</td>
<td>After central venous catheter placement in paediatric patients including neonates, the ultrasound equipment should remain easily accessible at the patient’s bedside to detect early life-threatening catheter-related complications such as pneumothorax, cardiac tamponade and hemothorax</td>
<td>B</td>
</tr>
<tr>
<td>D4.SD1.S9</td>
<td>There is no ideal site for cannulation in children; the best site should be determined after ultrasound examination</td>
<td>A</td>
</tr>
</tbody>
</table>
• Though much of the initial experience in this field has been carried out with **internal jugular** vein and **subclavian** vein, in neonates and in small children the largest and easiest vein to access is the **brachio-cephalic** vein.
The vein to puncture is chosen after careful ultrasound evaluation of central veins.

RaCeVa = Rapid Central Vein Assessment

Linear probe
10-14 Mhz
‘hockey stick’
RaCeVA in 4 mo. old in PICU
The choice: BCV
Axillary vein at the chest

- Atypical (CICC or PICC ?)
- Rare (ma possible) in neonates
- Most likely to be feasible in infants and children
‘key points’ for an uneventful insertion...

Ultrasound study of deep veins (RaCeVA)
**US-guided venipuncture and cannulation**
IC-EKG for verification of tip position
Tunneling
Securing (glue + sutureless device + transparent dressing)
Intra/post-procedural controls
  r/o PNX by US
  further verification of tip position by TEE or Rx
• Different PICCs can be used (silicon, polyurethane, power injectable polyurethane), single and double lumen
• The calibre - 3Fr or 4Fr or 5Fr - is chosen considering the diameter of the vein (vein mm = or > cath Fr)
Key point

Check the diameter of the vein!
Kits for micro-introduction:
- 21 G echogenic needles
- soft straight tip 0.018” guide-wire
- 3.5 or 4.5 Fr micro-introducer-dilator
• All catheters are inserted by real time ultrasound guidance, by the ‘in-plane’ approach.
US guided venipuncture

Always keep an eye on the tip of the needle
Easy puncture...
Easy puncture...
Not so easy!
(800 gr)
Ultrasound is constantly used to assess the direction of the guidewire, soon after its insertion in the needle.

Wrong direction!
guidewire
‘key points’ for an uneventful insertion…

Ultrasound study of deep veins (RaCeVA)
US-guided venipuncture and cannulation

**IC-EKG for verification of tip position**

Tunneling

Securing (glue + sutureless device + transparent dressing)

Intra/post-procedural controls

  r/o PNX by US

  further verification of tip position by TEE or Rx
Whenever possible, the correct position of the tip is verified during the procedure via the intracavitary ECG method.
IC-EKG method

- Intracavitary ECG (lead II)
- The intracavitary electrode is the tip of the catheter
- Based on changes of P wave during the progression of the catheter into the central veins
- CAVO-ATRIAL JUNCTION: maximal peak of the P wave (Stas, Yeon, Schummer, Pittiruti/La Greca, etc.)
  \(=\) CRISTA TERMINALIS

P increasing

Maximal P

P decreasing and/or diphasic
IC-EKG in children/neonates?

- Yes, it works

**Rationale:**
- Surface landmark = unreliable in children
- Chest X-Ray = more difficult to interpretate
- Repositioning because of malposition = more expensive

**Critical issues:**
- Never use IC-EKG with guidewire technique (risky)
- P changes are faster and occur in shorter space
- X-Ray criteria for CAJ are unclear
The intracavitary ECG method for positioning the tip of central venous access devices in pediatric patients: results of an Italian multicenter study

Francesca Rossetti¹, Mauro Pittiruti², Massimo Lamperti³, Ugo Graziano⁴, Davide Celentano⁵, Giuseppe Capozzoli⁶

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⁵ Pediatric Intensive Care Unit, Catholic University Hospital, Roma - Italy
⁶ Department of Anesthesia and Intensive Care, Ospedale Civile di Bolzano, Bolzano - Italy
Applicability

99.4 %

- In 2 children out of 309, the P wave was not identified on the surface ECG, so that IC-ECG was not performed
  - One child 2 mo. old
  - One child 5 yr old
Feasibility

99.4 %

– In 2 cases out of 307 no elevation of the P wave could be identified:
  • One child 1 mo. old
  • One child 2 yr old
Accuracy

95.8%

- Gr. A 96.2%
- Gr. B 95%
- Gr. C 96.8%

In all cases of mismatch but one, tip position as estimated with IC-EKG was too low as estimated by radiological criteria (from +1cm to +5cm).

In the 95 cases performed with a dedicated ECG monitor (Nautilus) accuracy was 98.8%
Safety

100%

• No complication directly or indirectly related to the IC-EKG method
• In the pediatric population, the IC-EKG method is applicable and feasible in almost all patients (> 99%)
• As compared with the radiological methods, the accuracy of the IC-EKG method is very high 95.8%, and even higher if performed with a dedicated monitor such as Nautilus (98.8%)
• The IC-EKG method is 100% safe also in children
What about IC-EKG in neonates?

- Preliminary personal experience (47 cases, not included in the multicenter study)
  - Saline technique
  - Caths >3Fr, central insertion, US-guidance
  - Age 3hrs – 29 days; weight > 950 gr

RESULTS
- Applicability 100%
- Feasibility: 45 cases out of 47 (96%)
- Accuracy: 100% (check by x-ray and/or echocardiography)
Annals of Internal Medicine

The Top Patient Safety Strategies That Can Be Encouraged for Adoption Now

Paul G. Shekelle, MD, PhD; Peter J. Pronovost, MD, PhD; Robert M. Wachter, MD; Kathryn M. McDonald, MM; Karen Schoelles, MD, SM; Sydney M. Dy, MD, MSc; Kaveh Shojania, MD; James T. Reston, PhD, MPH; Alyce S. Adams, PhD; Peter B. Angood, MD; David W. Bates, MD, MSc; Leonard Bickman, PhD; Pascale Carayon, PhD; Sir Liam Donaldson, MBChB, MSc, MD; Naihua Duan, PhD; Donna O. Farley, PhD, MPH; Trisha Greenhalgh, BM BCH; John L. Haughom, MD; Eileen Lake, PhD, RN; Richard Lilford, PhD; Kathleen N. Lohr, PhD, MA, MPhil; Gregg S. Meyer, MD, MSc; Marlene R. Miller, MD, MSc; Duncan V. Neuhauser, PhD, MBA, MHA; Gery Ryan, PhD; Sanjay Saint, MD, MPH; Stephen M. Shortell, PhD, MPH, MBA; David P. Stevens, MD; and Kieran Walshe, PhD
Table 2. Patient Safety Strategies Ready for Adoption Now

**Strongly encouraged**
- Preoperative checklists and anesthesia checklists to prevent operative and postoperative events
- Bundles that include checklists to prevent central line–associated bloodstream infections
- Interventions to reduce urinary catheter use, including catheter reminders, stop orders, or nurse-initiated removal protocols
- Bundles that include head-of-bed elevation, sedation vacations, oral care with chlorhexidine, and subglottic suctioning endotracheal tubes to prevent ventilator-associated pneumonia
- Hand hygiene
- The do-not-use list for hazardous abbreviations
- Multicomponent interventions to reduce pressure ulcers
- Barrier precautions to prevent health care–associated infections
- **Use of real-time ultrasonography for central line placement**
- Interventions to improve prophylaxis for venous thromboembolisms
Encouraged

Multicomponent interventions to reduce falls
Use of clinical pharmacists to reduce adverse drug events
Documentation of patient preferences for life-sustaining treatment
Obtaining informed consent to improve patients’ understanding of the potential risks of procedures
Team training
Medication reconciliation

Practices to reduce radiation exposure from fluoroscopy and CT

The use of surgical outcome measurements and report cards, such as those from ACS NSQIP
Rapid-response systems
Use of complementary methods for detecting adverse events or medical errors to monitor for patient safety problems
Computerized provider order entry
Use of simulation exercises in patient safety efforts
‘key points’ for an uneventful insertion…

Ultrasound study of deep veins (RaCeVA) US-guided venipuncture and cannulation IC-EKG for verification of tip position

**Tunneling**

Securing (glue + sutureless device + transparent dressing)

Intra/post-procedural controls

  r/o PNX by US

  further verification of tip position by TEE or Rx
• In most cases, the catheter is tunneled to the infra-clavicular area, so to achieve a more favourable exit site.
Femoral line, tunneled
How to tunnel?
Please, avoid exit site at the neck ....!
Please, avoid exit site at the neck ....!
‘key points’ for an uneventful insertion…

Ultrasound study of deep veins (RaCeVA) US-guided venipuncture and cannulation IC-EKG for verification of tip position Tunneling

Securing (glue + sutureless device + transparent dressing)

Intra/post-procedural controls
r/o PNX by US
further verification of tip position by TEE or Rx
• All catheters are secured by sutureless devices; the puncture site and the exit site are sealed with cyano-acrylate glue and covered with transparent dressing.
Glue + sutureless device + transparent dressing
Glue !!!!
In selected cases
Please, avoid sutures....
Please, avoid sutures....
‘key points’ for an uneventful insertion…

Ultrasound study of deep veins (RaCeVA)
US-guided venipuncture and cannulation
IC-EKG for verification of tip position
Tunneling
Securing (glue + sutureless device + transparent dressing)

Intra/post-procedural controls
r/o PNX by US
further verification of tip position by TEE or Rx
• At the end of the procedure, the possible presence of pneumothorax or other pleura-pulmonary damage is excluded by ultrasound scan of the intercostal spaces.
• After the procedure, the correct position of the tip is also verified by chest x-ray or echocardiography.
TTE = best choice in neonates
Insertion of a tunneled central venous catheter in a neonate
(3Fr power injectable polyurethane)
Take-home message

Critical factors for a ‘uneventful’ insertion were:

Well-trained operator
US examination of all veins before the procedure
Rational, common-sense based choice of the most appropriate vein
‘In plane’ puncture
Appropriate material for venepuncture (micro-introducer, non-j wire, etc.)
Intra-procedural tip verification (IC-EKG)
Tunneling
Glue + sutureless securement
Final comments
Comments

A careful **ultrasound** assessment of the child before CVC insertion allows a rationale choice of the vein apparently most appropriate in terms of caliber, depth and potential risk of pleural or arterial damage.
In our experience, in the vast majority of patients < 6 years, the **brachiocephalic vein** is the vein with the largest caliber and the easiest to puncture.
US guided puncture of the brachio-cephalic vein

In neonates/infants > 800 g
(our experience)
In neonates/infants > 450 g
(J.Bennett, Birmingham)
Tunnelling of central lines is a simple technique that allows us to achieve simultaneously:

- **an optimal site for venepuncture** (which minimizes the risk of puncture-related complications)

- **and an optimal exit site** (which reduces the risk of late complications).
Tip position must be verified during the procedure with IC-EKG and/or echocardiography.

These methods are easier, safer, faster and more accurate than fluoroscopy.
Glue is a simple, safe, inexpensive tool for closing the skin at the puncture site and sealing the skin around the catheter at the exit site.

- Stops extraluminal contamination
- Stops bleeding/oozing at the exit site
- Secures the catheter for 7-10 days
CONCLUSION
Who is the ‘expert’?
Who is the expert?

To have ‘experience’ is not enough

The expert is the one who knows when/how to use the most appropriate materials and the most appropriate methodology.
Il tema del IX PICC Day e del IX Congresso GAVeCeLT sarà La Scienza dell’Accesso Venoso.

Nelle tre giornate del convegno si svolgeranno sessioni scientifiche mirate ad una rifondazione della pratica clinica dell’accesso venoso basta sulle evidenze scientifiche, unico approccio possibile per garantire la sicurezza e la cost-efficacia dei nostri interventi.

Coordinamento Scientifico
Sergio Bertoglio
Roberto Biffi
Mauro Pittiruti

Segreteria Organizzativa
Manuela Tartagni
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Per ulteriori informazioni, contattare la Segreteria Scientifica:
mauro.pittiruti@rm.unicatt.it

Informazioni e aggiornamenti sul convegno saranno anche disponibili sul sito web del GAVeCeLT:
www.gavecelt.info

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SEDE DEL CONVEGNO
Tutte le sessioni scientifiche e didattiche del GA VeCeLT 2015 si svolgeranno presso il Centro Congressi Atahotel Executive (via Don Luigi Sturzo 45, Milano).

SEGRETERIA ORGANIZZATIVA
La Segreteria Organizzativa del GAVeCeLT 2015 sarà curata dalla Millennium Events
Via K. Adenauer 18 - 00061 Anguillara Sabazia (RM)
Tel 06 01902533 - Fax 06 3221853
info@millenniumevents.it

ISCRIZIONI
E’ prevista la possibilità di iscriversi soltanto al IX PICC Day o soltanto al IX Congresso GAVeCeLT o ad entrambi gli eventi cumulativamente. La iscrizione ai singoli corsi è comunque separata dalla iscrizione congressuale. Per quanto riguarda i costi e le modalità di iscrizione ai corsi e al congresso, si rimanda alla scheda di iscrizione, ottenibile tramite la Segreteria Organizzativa e/o tramite il sito www.gavecelt.info.

PRENOTAZIONI ALBERGHIERE
Per prenotazioni alberghiere presso in hotel vicini alla sede congressuale, contattare la Segreteria Organizzativa.

CALL FOR ABSTRACTS
Sia nell’ambito del PICC Day che nell’ambito del Congresso GAVeCeLT sono previste sessioni di presentazione di posters. Chi è interessato a portare il proprio contributo scientifico e clinico nell’ambito degli accessi venosi, è pregato di inviarci un abstract in formato carattere Arial 12 punti, così strutturato: titolo (tutto maiuscolo), completo di nome e cognome degli Autori, istituzione o centro clinico di provenienza; testo dell’abstract (max. 600 parole: introduzione/metodo/risultati/commento). L’abstract dovrà essere inviato entro il 31 ottobre 2015, esclusivamente tramite email, a Mauro Pittiruti (mauro.pittiruti@rm.unicatt.it)

TRADUZIONE SIMULTANEA
E’ prevista la traduzione simultanea inglese/italiano e italiano/inglese in tutte le sessioni scientifiche del IX PICC Day e del IX Congresso GAVeCeLT.

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IX PICC Day
IX Congresso GAVeCeLT

Milano
1 - 3 dicembre 2015
Centro Congressi Atahotel Executive

Convegno internazionale organizzato da GAVeCeLT
Gruppo Aperto ‘Gli Accessi Venosi Centrali a Lungo Termine’
WoCoVA will organize the 4th world Congress in June 2016. The theme of this congress is: Excellence in Vascular Access

Topics to be discussed in the program:
- Controversies
- Innovations in materials and procedures
- Implementation of guidelines
- Worldwide Networking
- Education

Reasons to attend the 4th WoCoVA:
- International multi disciplinary networking
- Learning through participation
- High profile speakers
- Global guidelines
- Certification programs

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Thank you for your attention

mauro.pittiruti@rm.unicatt.it