



Vascular Access for Apheresis Procedures in Children

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Nothing to disclose

Vascular Access for Apheresis Procedures in Children

Learning Objectives

1. Describe insertion sites and types of central venous access devices (CVAD)
2. Describe the access options for acute and chronic apheresis procedures in pediatrics
3. Describe complications of CVAD
4. Discuss options to prevent and reduce complications of CVAD

Background (1)

Adequate vascular access is a prerequisite for a successful apheresis procedure.

Peripheral IV catheters for Apheresis

- ◆ **Draw:** 16G-20G steel needle with an elongated bevel and a back-eye in an antecubital vein
- ◆ **Return:** \geq 20G (18-20) Flexible needle in peripheral vein of the opposite arm

Background (2)

Challenges with IV Insertion in Children

- ◆ Characteristics of peripheral veins of young children: *small caliber, fragile, not visible, and not perceived by touch*
 - may not accommodate such a large caliber needle
 - may not always technically possible
 - may easily collapse under the negative pressure of the high blood draw for apheresis
- ◆ Central venous access device is required for:
 - young children
 - some adolescents as the number of available venipuncture sites are limited with long-term apheresis

FACTs about Central Venous Access (CVA)

- In US: >5 million CVCs inserted every year¹
- Adverse Events: 15% of patients who receive CVC²
 - Mechanical complications (5 – 19%)
 - Infectious complications (5 – 26%)
 - Thrombotic complications (2 – 26%)
- Increased morbidity, mortality, and healthcare cost, and poor quality of life
- ★ **Prevention and early recognition of complications** are important in reducing morbidity and mortality.

1. Kornbau et al. NIH Int J Crit Illn Inj Sci. 2015

2. McGee and Gould. N Engl J Med 2003

Indications for Central Venous Access

Clinical Indication

- Therapeutic Apheresis
- Donor Apheresis:

Clinical Decision

The risks associated with line placement and maintenance should be weighed against the expected benefits of the apheresis procedures.

Central Venous Access Device (CVAD) Insertion Site

- Most common insertion sites:
 - Subclavian (SC) vein
 - Internal jugular (IJ) vein
 - Femoral (FM) vein
- Pre-Insertion Considerations:
 - Absent of coagulopathy
 - Local or general anesthesia --- NPO?
 - Ultrasound guide ---
cooperativeness of child to ensure
minimal movement

CDC Guidelines for CVC Insertion (2011)

System for categorizing recommendations on the basis of existing scientific data, theoretical rationale, applicability, and economic impact.

Category IA. Strongly recommended for implementation and strongly supported by well-designed experimental, clinical, or epidemiologic studies.

Category IB. Strongly recommended for implementation and supported by some experimental, clinical, or epidemiologic studies and a strong theoretical rationale; or an accepted practice (e.g., aseptic technique) supported by limited evidence.

Category IC. Required by state or federal regulations, rules, or standards.

Category II. Suggested for implementation and supported by suggestive clinical or epidemiologic studies or a theoretical rationale.

CDC Guidelines for CVC Insertion (2011)

- Use **ultrasound guidance** to place CVC to reduce the number of cannulation attempts and mechanical complications (Category 1B)
- Use a CVC with the **minimum number of ports or lumens** essential for the management of the patient (Category IB)
- When adherence to aseptic technique cannot be ensured (i.e catheters inserted during a medical emergency), **replace the catheter as soon as possible**, i.e., within 48 hours (Category IB)
- **Do not administer systemic antimicrobial prophylaxis** routinely before insertion or during use of an intravascular catheter to prevent catheter colonization or CLABSI (Category IB)

Insertion Site for Apheresis Catheter

Temporary catheters (<10 days – 2 weeks) can be placed either through the **internal jugular veins** or the **femoral veins**. In an intensive care unit setting, the femoral approach is easier because the line can be placed at the bedside and without fluoroscopic guidance.

Long-term catheter (>10 days – 2 weeks): Preferred insertion site is **Rt IJ vein**. The Lt IJ vein is not ideal and this vein is used only when necessary.

Central Venous Catheters (CVC)

- ◆ Non-tunneled central lines:
Short-term use ($\leq 10-14$ days)
- ◆ Tunneled central lines with cuff:
Long-term use ($> 10-14$ days)

Purposes of cuff:

- fibrous tissue ingrowth adheres to the cuff and prevents dislodgment
- a barrier to prevent infection occurring from the skin insertion site

Materials of VADs

- Currently polyurethanes, silicone elastomer, and elastomeric hydrogel are the most frequently used materials in the manufacture of VADs.
- **Polyurethanes** are biocompatible materials that can be made rigid, semirigid, or flexible with good physical strength.
- **Silicone** elastomer is a soft, extremely flexible material. The potential for thrombosis and vessel perforation is reduced.
- Stiffness of catheter material led to thrombosis development, complete vessel erosion, and fluid extravasation into the pleural cavity.

Implantable Ports

- **Vortex® Ports** (AngioDynamics, Latham, NY)
- **Medcomp Dignity Port** (Medical Components, Inc., Harleysville, PA)
- **Norfolk Medical SportPort™** (Norfolk Medical Products, Inc., Skokie, IL)
- **PowerFlow™ Implantable Apheresis IV Port** (Bard Access Systems, Inc., Salt Lake City, UT)

Implantable Ports

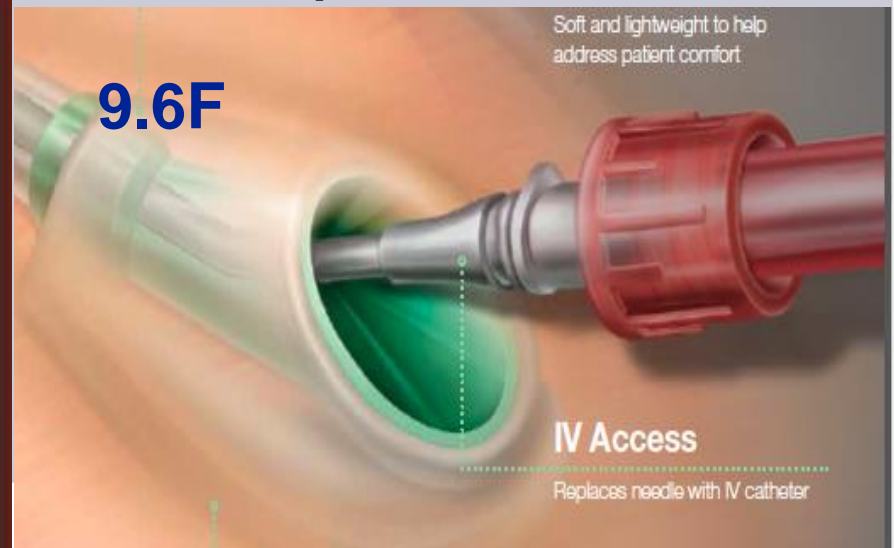
Medcomp Dignity Port

Vortex port



SportPort Systems

Bard Apheresis IV Port



Use of DL Port for RBCx in Adults with SCD

- 29 adults with SCD (318 RBCx)
- 20 had DL-Vortex ports (218 RBCx)
 - 6 removed due to infection
 - 1 removed malfunction

Conclusions:

- DL-Vortex port had more procedural complications and longer duration compared to CVC or peripheral catheter.
- Due to smaller internal diameter and longer catheter of port compared to CVC or peripheral IV.

A. Shrestha, et al. J Clin Apher. 2015

Central Line Complications (Cx) NIH

Immediate Complications:

- Occur at the time of catheter insertion
- Related to technique at the time of procedure
 - number of unsuccessful insertion attempts is the biggest predictor of complications. Ultrasound has significantly reduced the incidence of immediate Cx from 11.8% to 4 - 7%.
- Include vascular, cardiac, pulmonary, and placement complications.

Delayed Complications:

C.Kornbau, et al. Int J Crit Illn Inj Sci. 2015

Immediate Complications

➤ **Vascular complications:**

- Arterial injury (1%): Arterial puncture (4.2–9.3%)
 - femoral > subclavian (*McGee DC, N Engl J Med. 2003*)
- Venous injury: Lacerations, perforation, bleeding/hematoma (4.7%), hemothorax hemomediastinum

➤ **Pulmonary Complications:**

- pneumothorax & pneumomediastinum (1%), chylothorax, tracheal injury, injury to the recurrent laryngeal nerve, and air embolus.

➤ **Cardiac Complications:**

- Arrhythmia, supraventricular tachycardia, and cardiac arrest

Delayed Complications

more gradual in onset and can occur in the weeks to years after CVC placement

➤ **Device dysfunction:**

- Fibrin sheath formation with occlusion of the distal openings resulting in inability to withdraw blood
- Fracture (SC>IJ) with pinch-off syndrome
- Venous thrombosis (FM>IJ>SC), superior vena cava synd
- Central venous stenosis
- Site of catheter placement, duration of catheterization, and underlying patient comorbidities all affect the rate of device dysfunction.

➤ **Infection:**

- Leads to sepsis, shock, and death

Risk of CLABSI* by Insertion Site

Objectives

Systematic review of the literature to determine the risk of CLABSI with nontunneled CVC inserted in FM, SC, and IJ vein

Methods

Meta-analytic techniques were used to summarize the data from

- 2 RCT (1006 catheters) and 8 cohort (16,370 catheters) studies.
- Total catheter days: 113,652

****CLABSI: Central line associated bloodstream infection***

PE Marik, et al. Crit Care Med. 2012

Risk of CLABSI by Insertion Site (Cont'd)

Results:

- Average CLABSI rate: 2.5/1,000 catheter days (0.6-7.2)
- No significant difference in the risk of CLABSI between the FM and SC/IJ sites
- No difference in the risk of deep venous thrombosis when the FM site was compared to the SC and IJ sites combined.
- A significant interaction between the risk of infection and the year of publication ($p=.01$), with the femoral site demonstrating a higher risk of infection in the earlier studies.

Conclusions:

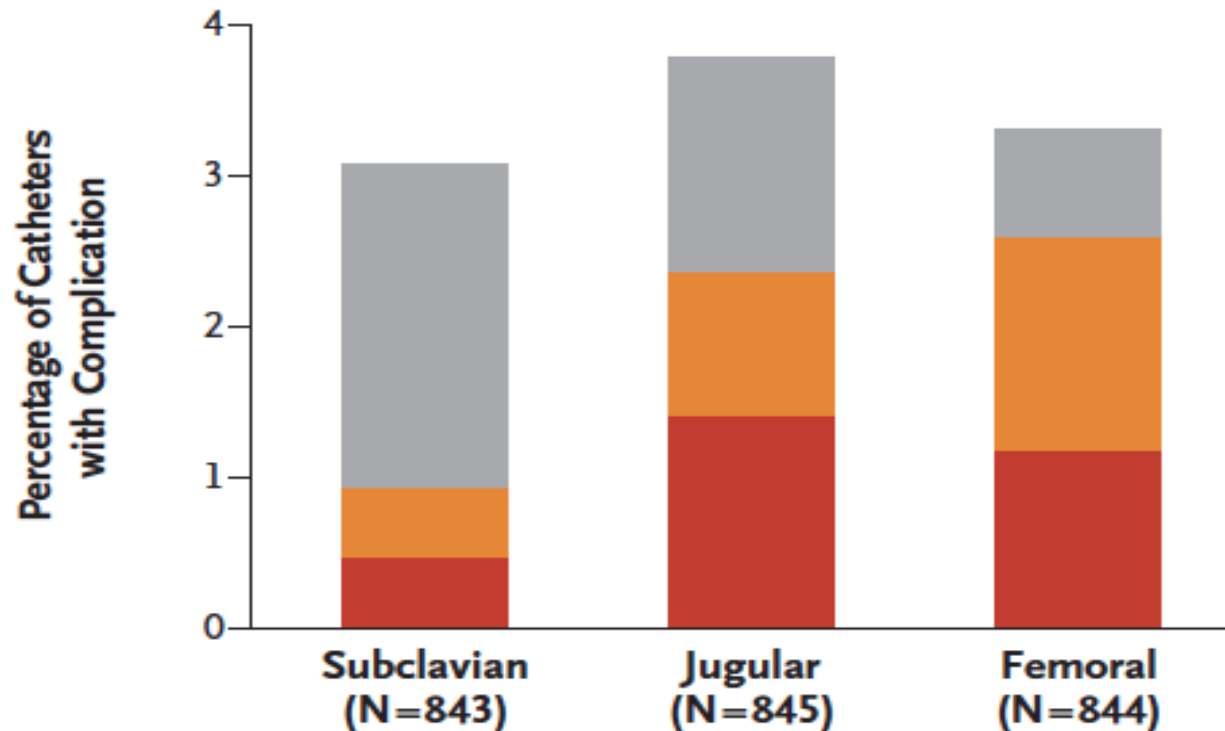
Although earlier studies showed a lower risk of CLABSI when the IJ was compared to the FM site, recent studies show no difference in the rate of CLABSI between the 3 sites.

Intravascular Complications of Central Venous Catheterization by Insertion Site

- Multicenter trial
- Randomly assigned nontunneled CVCS in adult patients to the subclavian, jugular, or femoral vein
- A total of 3471 catheters were inserted in 3027 patients.
- The primary outcome measure was a composite of CLABSI rate and symptomatic deep-vein thrombosis.

J Parienti et al. N Engl J Med. 2015

Complications in the Three-Choice Comparison According to Insertion-Site Group (Cont'd 1)



■ Mechanical (grade ≥3)	18 (2.1%)	12 (1.4%)	6 (0.7%)
■ Symptomatic deep-vein thrombosis	4 (0.5%)	8 (0.9%)	12 (1.4%)
■ Bloodstream infection	4 (0.5%)	12 (1.4%)	10 (1.2%)

Comparison of infections and complications in 3 vascular access devices (VAD) in adults with solid tumours

- Non-ports: 13/28 (46%) had complications
 - 10/19 tunnelled catheters had complications including 3 displacements and 7 removed for infection.
- Ports: 1/30 ports (3%) had complications
 - No reports of line-related sepsis in the port including PICC.
 - Almost complication-free

K Coady, et al. J Vasc Access. 2015

Complications of CVAD in Pediatrics

Meta-analysis of Observational Studies

- 74 cohort studies (24 prospective and 50 retrospective studies)
- Ages: 0 - 18 yo
- 31,933 CVADs (2005-2015)
- International health care community (Europe, North America, Asia, and South America)

*As context, from the 82 US hospitals reporting to the National Healthcare Safety Network in 2013, **2.7 million CVAD catheter days** in the pediatric and neonatal population were registered.*

*AJ Ullman, et al. Pediatrics. 2015
School of Nursing and Midwifery, Griffith Univ. Queensland, Australia*

Complications of CVAD in Pediatrics – Cont'd 1

Type of Complications	Overall Incidence (%)	Rate/1000 catheter days
Failure - All	25%	1.97
- Nontunneled	16.7	-
- Hemodialysis	46.4	1.57
- Tunneled	29.2	0.86
- Implanted	15.8	0.15
BSInfection - All	10.3%	1.63
- Nontunneled	8.7	5.86
- Hemodialysis	10.4	0.41
- Tunneled	19.9	1.13
- Implanted	15.9	0.28
Thrombosis - All	1.7%	0.08
- Nontunneled	3.7	9.06
- Hemodialysis	2.9	0.07
- Tunneled	0.6	0.04
- Implanted	1.9	0.06

Complications of CVAD in Pediatrics – Cont'd 2

Type of complications	Overall Incidence (%)	Rate per 1000 catheter days
Occlusion/blockage - All	7.4%	1.06
- Nontunneled	8.0	-
- Hemodialysis	11.1	0.26
- Tunneled	12.1	0.85
- Totally mplanted	5.0	0.30
Dislodgement/Migration - All	4.7%	0.43
- Nontunneled	3.5	-
- Hemodialysis	8.8	0.10
- Tunneled	7.0	0.24
- Totally mplanted	2.0	0.02
Breakage/Rupture - All	1.6%	0.14
- Nontunneled	8.8	-
- Hemodialysis	0.5	0.00
- Tunneled	1.1	0.08
- Totally mplanted	0.0	0.01

Conclusions

- **Overall**, 10.3% of 31,933 pediatric CVADs developed a CLABSI, with an IR of 1.63 per 1000 catheter days
- **Tunneled CVADs** had the highest pooled proportion of
 - CLABSI (19.9% of 1992 CVADs)
 - Occlusion or blockage (12.1% of 1485 CVADs)
 - Local infection or phlebitis (4.8% of 1827 catheter days)
- **Totally implanted devices** had
 - Lowest proportion and rate of dislodgement per 1000 catheter days (2.0% of 1902 CVADs ; 0.02 per 256 962 catheter days)
 - Lowest proportion of breakage/rupture (0.0%, 2179 CVADs)

CLABSI --- Micro-organisms

The organisms are usually the normal resident flora of the skin at the insertion site, which may lead to colonization of the catheter. This is often observed in the ICU practice and can be the source of bacteremia and sepsis with multi-organ failure.

- Bacterial Infection (*Parameswaran et al. 2011*):
Gram-positive (64%) and Gram-negative (36%)
- Most common pathogens: *S. aureus* 40%, *Pseudomonas aeruginosa* 16%, coagulase negative staphylococci 8%, *E. coli* 8%, *Klebsiella pneumoniae* 8%, and *Acinetobacter baumannii* 4%.
- Fungal infection: *Candida sp* 16%
- Viral and parasitic infection: no study has shown any viral or parasitic cause of CLABSI

CDC Guidelines for the Prevention of Intravascular Catheter-Related Infections (2011)

Evidence-based recommendations for preventing intravascular catheter-related infections.

- 1) educating and training healthcare personnel who insert and maintain catheters
- 2) using maximal sterile barrier precautions during central venous catheter insertion
- 3) using a $> 0.5\%$ chlorhexidine skin preparation with alcohol for antisepsis
- 4) avoiding routine replacement of central venous catheters as a strategy to prevent infection
- 5) using antiseptic/antibiotic impregnated short-term central venous catheters and chlorhexidine impregnated sponge dressings if the rate of infection is not decreasing despite adherence to above strategies.

Maintenance of CVA (CDC)

Antibiotic Lock Prophylaxis, Antimicrobial Catheter Flush and Catheter Lock Prophylaxis

Use prophylactic antimicrobial lock solution in patients with long term catheters who have a history of multiple CLABSI despite optimal maximal adherence to aseptic technique (Category II)

Anticoagulants

Do not routinely use anticoagulant therapy to reduce the risk of catheter-related infection in general patient populations (Category II)

Line Management

Flushing And Locking

Flushing – after medication or blood transfusions, CVC or the port should be flushed with normal saline

Locking – anticoagulant

- CVC: Heparin, Sodium Citrate,
Positive pressure clamping to minimize reflux of blood into the catheter
- Implantable Port: Heparin, tPA,
Positive pressure clamping
- If port is not being used, a “heparin lock” should be administered once a week – once a month

The catheter length should be estimated in advance and the final position confirmed by X-ray.

Risk Factors for Thrombus Formation

- Length of catheter
- Increased catheter-to-vessel size (small diameter of vessel compared to the size of catheter), thus higher risk of thrombosis in small children
- Location of the tip of the catheter: Increased risk with the tip located in brachiocephalic vein vs. upper vena cava or Rt atrium
- Longer indwelling time
- Underlying disease
- Pareneteral nutrition

Types and Size of CVA in Pediatric Patients

Factors determining the choice of CVC type and caliber:

- Age
- Weight
- Length

Guidelines for CVC Size by Weight at CHOP

	Short –term (≤14 days)	Chronic (>14 days)	
Patient Weight (Kg)	Catheter* (French)	Catheter* (French)	Port** (French)
10 - 20	DL-7F	DL-8F	
21 - 30	DL-8F	DL-8F	SL-7.5F
31 - 40	DL-9F	DL-8F	SL-7.5F
41 - 50	DL-11.5F	DL-10F	SL-9.6F DL-11.4F
>50	DL-11.5 -13.5F	DL-10F	DL-11.4F

*Medcomp catheter

** Vortex port

Future Directions

- ◆ Improve practice to prevent complications with insertion and maintenance, including dressing and securement, access devices, appropriate locking and flushing procedures
- ◆ Clinical trials to determine the appropriate type and size of CVAD and locking of CVSD in children
- ◆ Development by Manufacturer of innovative, safe, and effective CVADs to prevent CVAD-associated complications in pediatric patients

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