Evolving Techniques in Pediatric Vascular And Endovascular Trauma Surgery: What Special Precautions Are Needed? How to Deal with Arterial Spasm? When and How Can Endovascular Grafts be Used?

Michael C. Dalsing, MD MBA
Professor Emeritus
Indiana University School of Medicine
Division of Vascular Surgery

I have no Pertinent Conflicts

Special Precautions Are Needed in the infant and young child

- Based on Immature Anatomy
  - Unique neonate/infant arteries
    - Undeveloped tunica media
    - **Prone to intense spasm**
- Based on Immature Hemostasis
  - Low antithrombin levels
  - Larger plasma volume of distribution
    - Faster UFH/LMWH clearance
  - **Higher heparin doses for similar Rx**
- Based on Arterial Size
  - Conduit for open repair
  - Technical Challenges
    - Open
    - **Endovascular**
      - **Access**
      - **Device**

Intense Spasm – Prevention

Learn from Colleagues: Femoral Access

- Age and Size Limitations based upon artery diameter

[[artery (mm) - catheter (mm)]/artery (mm)]* 100 ≥60%

No clinical/radiologic vasospasm occurred

Franken, et al. AJR Am J Roentgenol 1982; 138:295-8.

AGE	Estimated CFA diameter (mm)	Fr	ID (mm)	Radial Sheath OD (mm)	Standard Sheath OD (mm)
Birth	2.25	4	1.56-1.57	1.78	1.96
6 months	3	4	1.56-1.57	1.78	1.96
1 year	3.5	4	1.56-1.57	1.78	1.96
2 years	4	4	1.56-1.57	1.78	1.96
5 years	5 .25	5	1.89-1.9	2.13	2.29
8 years	6 .25	6	2.22-2.24	2.44-2.46	2.95
11 years	7	7	2.55-2.57	2.77-2.79	3.32
15 years	8	8	2.92 +/-		3.48+/-

Sun LR, et al. J NeuroIntervent Surg 2021;13:794–798.

Intense Vasospasm (Infant) – Prevention

8 Infants (16 cases): 6.6-12.8 kg & 4.4-27.6 months old

- **Prevent Pain**
  - General Anesthesia
  - Lidocaine-soft tissue injection @ access site
  - (1% maximum of 4 mg/kg (range 0.5 to 0.6 ml))
- **Minimize Local Trauma**
  - Ultrasound guided access of CFA
    - 21 G needle & 0.018-inch wire into the artery
    - 4F sheath/introducer with Y-hemostatic valve
- **Prevent arterial spasm**
  - **Nitroglycerin Protocol:**
    - Nitroglycerin (1 ug/kg) ultrasound guided subcutaneous injection above CFA at 10, 12, 2 o'clock

  - Wait 5 minutes – Access artery
  - Intra-arterial nitroglycerin bolus
    - dose of 1-2 µg/kg
  - Heparinized saline flush

Colasurdo M, Santdasani S, Chen H, Garcia R, Nesbit G. Subcutaneous and intra-arterial nitroglycerin administration to facilitate femoral artery access for neuro-endovascular procedures on infants and toddlers. Journal of Vascular and Interventional Radiology (2024), doi: https://doi.org/10.1016/j.jvir.2024.05.010.

Intense Vasospasm (child) – Prevention/Treat

23 Patients (27 Procedures): 8.4+/-6.3 y/o
< 15 kg (n=9) mean age 1.7+/- 0.5 yrs
> 15 kg (n=18) mean age 11.7 +/- 4.9 yrs

- Minimize Local Trauma
  - Ultrasound guidance for access
  - Femoral artery diameter determined by ultrasound
- Pharmacologic Prevention **Not Routine** but if spasm noted
  - **Nitroglycerin- 3 ug/kg, maximum of 200 ug**
  - Heparin bolus 75-100U/kg IS ROUTINE
- Arterial Spasm during procedure:
  - **Verapamil- 0.5 mg/mL (1-mL infants or 2-mL small children)**
    - If not working, remove the sheath

Dymtriw et al. Long Vascular Sheath for Transfemoral Neuroendovascular Procedures in Children. Neurointervention 2021;16:149-157

Pediatric Vascular Injuries: Statistical Trends in Large Databases

- National Trauma Data Bank
  - > 2.5 million pts
  - 1.4% arterial injury (35,771)
  - 0.14% (3,637)   < 16 y/o (10.5+/- 4.8)
    - Endo vs Open (263/2255 pts)
      - > older, blunt trauma, higher ISS
      - Increasing over time (p<.001)
        - 2007 – 7.8%
        - 2014 – 12.9%
      - Results equivalent to open
        - Branco, et al. J Vasc Surg 2017;66:1175-83.
- Most Common Endo By # children
  - angioembolization of Internal iliac artery (33.4%)
  - thoracic aortic endograft (22.9%)

TEVAR for Pediatric Injury: Statistical Trends in Large Databases

- National Trauma Data Base - 2007 -2019
  - 2,110,194 pediatric pts (TAI – 3755 (0.2%)

Pts (% total) Survived ER	AGE y/o	NOM	TEFAR	OAR
134 (5.5%)	1-11	126	4	4
733 (30.2%)	12-17	498	185	95
1564 (64.3%)	18-21	640	456	50

- TEVAR trend Increasing over time:
  - Youngest child TEVAR – 7 y/o
  - TEVAR has a lower in-hospital mortality
    - Raulli, et al. Ann Vasc Surg 2023; 89: 190–199

Thoracic aorta (mean diameter)

Age in years	Aortic Arch (mm)	Proximal Descending Aorta (mm)	Aorta at Diaphragmatic Hiatus (mm)
0-2	9.0	7.1	6.7
3-5	12.7	10.2	9.6
6-9	15.2	12.0	11.5
10-14	18.3	14.4	14.0
15 - 18	20.1	16.4	16.0

Kale & Alam. Indian J Rad Imaging. 2020, 30(2): 170-176

Case reports in the literature: 23
Youngest 16 months – unique BESG
22 cases – 7-17 y/o
Access usually CFA cutdown
Cuffs, limbs, available endografts
good early results, poor follow-up

Abdominal Aortoiliac Pediatric Injury Endovascular Repair

- Infradiaphragmatic Abdominal aorta/ CIA: (*mean – max SD to mean + max SD)

Location	1- 3 y/o	> 3 to 7 y/o	>7 to 11 y/o	> 11 to 15 y/o	> 15 to 17 y/o
Prox aorta	7.2 – 10.7 mm	8.7 – 11.6 mm	11.3 – 13.3 mm	12.1 – 15.9 mm	14.4 – 18.9 mm
Distal aorta	5.5 -7.8 mm	6.6 – 9.8 mm	9.7 – 12.3 mm	9.8 – 14.3 mm	12.7 – 15.5 mm
RCLA	3.6 – 5.5 mm	4.2 – 6.5 mm	6.4 – 8.0 mm	6.9 – 9.2 mm	8.3 – 10.9 mm
LCIA	3.6 – 5.5 mm	4.3 – 6.7 mm	6.4 – 8.0 mm	6.9 – 9.2 mm	8.3 – 10.9 mm

Akturk & Gunes. Pediatrics International (2018) 60, 455–460. Turkey

Author/Date	# pts	Age	Lesion	Aorta (mm)	Access Cutdown CFA	Stent Graft DM BE or SE Stent grafts	Alive	F/U Poor F/U
Papazoglou et al. Ann Vasc Surg 2015; 29: 365.e11	1	9 y/o	Aorta/RCIA dissection	?	Cutdown LCFA, 6F	12x24mm, 8x60 mm bare metal self expanding	yes	12 mo
Aidinian et al. *Vasc Endovasc Surg*. 2006;40(3): 239. Sakran JV, et al. *Vasc Endovasc Surg*. 2009;43(6):597.	1	10 y/o	Transection at IMA	?	Cutdown RCFA,	16 x 5mm BESG	yes	4 yrs
Lee et al. J Vasc Surg Cases Innov Tech 2023;9:1.	1	10 y/o	Pseudo after open repair	10.5	Cutdowns CFAs, 12 F, 8F	Bilateral 8 mm stent grafts to bifurcation, bilateral 10mm stent grafts bridge to aorta	yes	6 mo CT
Nicholas et al. Br J Radiol 2020;93:(1106):20190017.	1	11 y/o	Grade 3 with pseudo	14	RCFA,	BESG 24 to 14 mm	?	None reported
Reyes, Montoya. Eur J Vasc Endovasc Surg. 2017;53:558	1	13 y/o	PseudoA	9.5	?	10x 37 stent graft	?	None reported
Kim, et al. J Vasc Surg 2022;75:1570.	1	17 y/o	PseudoA	?	?	16x14x7 bifurcated aortic graft	yes	3 mo

Conclusions: Pediatric Vascular Injury

- Pediatric Vasospasm during arterial intervention
  - Prevented/treated by
    - Preventing pain
    - Minimizing vascular trauma during the intervention
    - Providing antispasmodic agents
- Endovascular for emergency care in older severely injured child
  - Unknown, performance of a covered stent graft in a growing aorta

Thank You For Your Time and Attention

I hope you find this information Useful in Your Busy Practice