Mild Hypothermic Arch Reconstruction Using Dual Cannulation in Neonates: The Children's Hospital of Wisconsin Experience

Kevin Daley, MSP, CCP, LP
George Hoffman, Viktor Hraska, Caleb Varner

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Disclosures

- none

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Background

- Cerebral and visceral perfusion during aortic arch surgeries is extremely important
  - we are presented with hurdles while trying to achieve adequate oxygen delivery
- Deep Hypothermic Circulatory Arrest (DHCA) has been widely accepted as a strategy to decrease oxygen demand and thereby allow for a safe drop in oxygen delivery.
  - Regional Cerebral Perfusion is a widely accepted strategy used to ensure continuous oxygen delivery to the brain during DHCA.
  - Somatic hypoperfusion during DHCA can lead to organ and tissue damage
  - Additionally, cold-induced enzyme dysfunction can exacerbate bleeding issues following bypass.
- I am presenting Children's Hospital of Wisconsin's experience with a goal-directed, dual cannulation, mild-hypothermic perfusion strategy to overcome some of the deleterious effects of DHCA and hypo-perfusion for Aortic Arch surgery in neonates.
  - The vast majority of our experience with this technique is for Stage 1 Palliation of Hypoplastic Left Heart Syndrome

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Background

- Stage one surgical palliation (S1P) of hypoplastic left heart syndrome (HLHS) requires complex reconstruction of the aortic arch with regional or complete interruption of blood flow
- Varying strategies of DHCA and antegrade cerebral perfusion (ACP) have been employed to permit surgical repair and to minimize organ injury
- Recent approaches to limit ischemic injury with ACP without deep hypothermia
  - Dual aortic cannulation techniques of minimally-hypothermic CPB have been used in adults to avoid regional ischemia during arch reconstruction
  - Rojagopal (2010): 'regional abdominal perfusion' via 3Fr femoral artery monitoring catheter at 26C, total flow 80-100 ml/kg/min ->lower incidence of AKI
  - Karavas (2011): ACP, DAC, and coronary perfusion strategy at 32C; somatic ischemia remained
  - Hammel (2013): ACP+DAC (descending aortic cannulation) via supradiaphragmatic access at 30-32C: shorter support time, less AKI, same ECMO, ICULOS, mortality
  - Raess (2017): distal arch catheter; 60/40 flow ratio; less AKI, no change in clinical outcomes

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Methods

- Cannulation
  - Arterial
    - 8 fr via 3.5 mm graft on innominate
    - 3-4 fr Percutaneous introducer femoral artery sheath
  - Venous
    - Bicaval cannulation: 12fr. Right Angle, 14fr. Straight venous

Methods

- Circuit Setup
  - Arterial Line y'd distal to oxygenator
  - Transonic flow probe on both lines
  - C-clamp on "head" line

Targets

- **rSO2C** >50% <85%
- **rSO2S**>60%
- Right radial pressure <50mmHg

Perfusion Conduct

- Full body perfusion and cooling to 32°C using innominate artery cannula
- Regional Femoral Perfusion (RFP) initiation
- Aortic arch occlusion (patent Left Carotid)
- Head flow stopped
- Cardioplegia via "head" arterial cannula
- Antegrade Cerebral Perfusion (ACP) initiation:
  - 50-80mL/kg/min (<50mmHg)
  - RFP: 150-180ml/min
- Following arch repair: aortic arch occlusion (patent left carotid), ACP stopped, neo ascending aorta cannulated with 8fr. Arterial cannula.
- Whole body perfusion and rewarming.

Results

variable	Mean ± sd	Median (iqr)	Min - Max
Birth Weight (kg)	3.22 ± 0.47	3.15 (0.78)	2.53 – 4.32
Gest Age (wk)	38.9 ± 0.71	39.1 (0.2)	37.1 – 39.6
Age S1P (days)	5.89 ± 1.78	6 (1)	4 – 11
Wt S1P (kg)	3.32 ± 0.52	3.17 (0.63)	2.55 – 4.46
BSA (m2)	0.22 ± 0.02	0.21 (0.02)	0.19 – 0.26
aAo Diam (mm)	2.5 ± 0.7	2.0 (1.0)	2.0 – 4.0
Gender (female)	10/18 (56%)		
Genetic Syndrome	4/18 (22%)		

Results

Epoch	Mean ±sd	Median (iqr)
CPB cooling time	35 ±17	33 (16)
ACP time	64 ±34	49 (33)
RFP time	59 ±39	49 (19)
Clamp Time	61 ±32	51 (28)
Low Flow time	1 ±2	0 (1)
Dual Aortic Perfusion Time	58 ±26	46 (22)
CPB warming time	46 ±3	34 (22)
CPB total support time	145 ±71	117 (45)
Surgical time	326 ±106	290 (130)
Anesthesia time	469 ±110	443 (75)

Results

Variable	Mean ± sd	Median (iqr)
Qacp (ml/kg/min)	63 ±12	70 (25)
Qrfp (ml/m2/min)	47 ±7	48 (10)
MAP Rrad (mmHg)	49 ±6	49 (5)
MAP UAC (mmHg)	36 ±8	34 (13)
ΔMAP (RR-UAC)	13 ±9	15 (15)
rSO2 Cerebral (%)	83 ±8	84 (17)
rSO2 Renal (%)	88 ±8	92 (20)
Δa-rSO2 Cerebral (%)	22 ±15	16 (17)
Δa-rSO2 Renal (%)	17 ±14	12 (20)
Temp (C)	31 ±1	32 (2)

Discussion

- Flow distribution measured and adjusted
- Concerns about leg ischemia are overcome by continuous NIRS monitoring of both legs.

Outcomes

- AKI – 0 (18)
- NEC – 0 (18)
- Leg ischemia – 0 (18)
- ECMO – 2 (18)
- Mortality – 1 (18) (POD 1 on ECMO)

Looking forward

- Regional perfusion and dual cannulation is not a new strategy for providing full body perfusion during arch repairs, however our method of cannulating the patient's femoral artery to provide distal perfusion offers a significant advantage over other methods by removing a cannula and tubing from the direct surgical field.

Conclusion

- Modified dual arterial perfusion strategy with percutaneous femoral artery access *pre-CPB* permits *flexible intraoperative perfusion strategy* to avoid circulatory arrest with minimal periods of low flow and short total support time
- No limb ischemic events or early complications from percutaneous femoral access
- Mid and longer term outcomes need to be determined

Thanks!