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“Failure to drain” – Inadequate Venous Drainage

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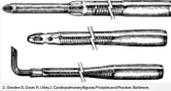
- No disclosures

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Pediatric Venous Cannula selection

- Important considerations¹
 - Anatomy of patient
 - Size of patient
 - Anticipated blood volume
 - Cannulation site
 - Vessel sizes
 - Vessel/structural abnormalities
 - Proposed procedure
 - Defect to be repaired
 - Previous surgical procedures



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Potential Effects of Inadequate Venous Return

- Failure to establish cardiopulmonary bypass (CPB)
- Increased central venous pressure
 - Heart distention
- Hypotension
 - Due to inability to maintain adequate flow
- If prolonged – venous congestion

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Potential Causes – Non-Anatomical³

- Air-lock in venous line
- Manual lifting of the heart
- Too small of venous cannulae
- Kinked venous line
- Misplaced vena caval tourniquet

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Potential Causes – Non-Anatomical³

- Misplaced or entrapped cannula
- SVC cannula misplaced in azygos vein
- IVC cannula misplaced in hepatic vein(s)
- Cannula manufacturing defect⁴

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Potential Causes –Anatomical⁵

- Undiagnosed:
 - Left SVC
 - Anomalous venous return
 - Interrupted IVC with azygous extension
 - Hepatic veins entering right/left atrium directly
 - Arterial to venous shunt
 - PDA



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Potential Causes –Anatomical⁵

- Uncontrolled systemic to pulmonary shunts
- Persistent LSVC to coronary sinus without innominate vein
- LSVC to left atrium with innominate but hypoplastic right SVC
- Left atrial isomerism with interrupted IVC and azygous continuation
- Left atrial isomerism with abdominal situs inversus

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Preventative Measures^{3,5}

- Thorough Trans-esophageal ECHO (TEE) prior to surgery and/or cath if necessary
- Monitor CVP to detect potential build-up once cannula(e) placed
- Utilize vacuum assisted venous drainage to augment return if appropriate
- Monitor cerebral oximetry

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Preventative Measures^{3,5}

- Train all sterile field personnel to scan for venous line obstruction
- Utilize venous line flow probe
- Construct plan ahead of time for best drainage if complex anatomy is known

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Unknown Anatomical Abnormality

- Before bypass:
 - Construct a plan to cannulate based on new knowledge
 - Plan to cool further to allow for potential need for lower flows

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Unknown Anatomical Abnormality

- Bypass established
 - Institute VAVD and determine any improvement
 - Reassess cannula size for vessels
 - If caval cannulation is inadequate, re-establish CPB with atrial cannulation

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Unknown Anatomical Abnormality

- Bypass established
 - Add additional cannulae and connectors as situation warrants
 - If still no resolve – open atrium and establish sucker bypass
 - Last resort
 - Cool to lower temperature to allow for lower flows
 - Doesn't fix problem necessarily

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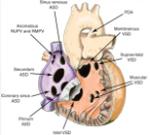
Case Report



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Patient Profile

- 1 month old male born at 33 weeks with failure to wean respiratory support
- 2.73 kg
- 45.5 cm
- 0.18 m²
- NKDA
- Diagnosis:
 - Secundum ASD
 - Perimembranous VSD
 - Pulmonary venous stenosis



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Prebypass Labs and Vitals

- pH: 7.488
- pCO₂: 37.9 mmHg
- PO₂: 79.2 mmHg
- Hct: 38.7 %
- Lac: 0.9
- All electrolytes and other lab values were normal
- HR: 140-160s
- MAP: 40-60s

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Surgical Plan

- Aorta and Bi-caval cannulation
- Cool to 26°C
- X-clamp – give Del-Nido cardioplegia
- Caval snares
- Right atriotomy
 - Vent through ASD
 - Pulmonary vein repair
 - VSD repair
 - ASD
- De-air through aortic root
- X-clamp off and rewarm
- Close right atrium
- Wean bypass
- MUF

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Cannulation Plan

- Aorta – 8 Fr Maquet arterial cannula
- SVC – 10 Fr Edwards plastic right angle
- IVC – 12 Fr Medtronic metal right angle

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Perfusion Plan

- Alpha-stat blood gas management
- On bypass Hct of 28 %
- Off bypass post MUF Hct of >30 %
- DUF entire case
- Target Flow 420 ml/min (2.4 Cl)

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TEE Findings

- TEE confirmed diagnosis of:
 - Secundum ASD
 - Perimembranous VSD
 - Right upper and lower pulmonary vein stenosis
 - Flow acceleration as they enter left atrium
 - Mean gradient of 6-7 mmHg
 - No mention of hepatic veins into RA or IVC issues

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Bypass Sequence Of Events

- Initiated bypass with SVC cannula in SVC and IVC cannula placed in right atrium
- Bypass initiated without issue and drainage was appropriate
- Began DUF
- Began cooling to 26°C
- PDA snared

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Bypass Sequence Of Events

- Surgeon attempted to flip IVC cannula into IVC
 - Immediately lost significant venous drainage
 - Pulled back on cannula while perfusion applied VAVD (-24 mmHg)
 - No significant aid to drainage
 - Put back in RA for a moment

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Bypass Sequence Of Events

- Re-checked to make sure IVC cannula was appropriate
 - Even though cannula was appropriately sized it was decided to down size to a 10 Fr
- Stopped cooling – was 33°C at this point
 - Low flow while removing IVC cannula from RA and replacing with new cannula
 - Off bypass for few seconds to disconnect old cannula and connect new IVC cannula

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Bypass Sequence Of Events

- Re-initiated bypass with IVC cannula (now 10Fr Right angle) again in RA
 - Once full flow tried to manipulate IVC cannula into IVC but would not go without losing almost all venous drainage.
 - Again attempted to apply VAVD (~ -25 mmHg)

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Bypass Sequence Of Events

- Surgeon could not manipulate IVC cannula to allow for adequate venous drainage without being in RA
- Surgeon requested to cool to 18°C for possible circulatory arrest
 - Began pH-stat blood gas management
 - Ice placed on patient head

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Bypass Sequence Of Events

- 21°C – X-clamp and cardioplegia
- 18°C - attempted low flow bypass with RA open to try to place IVC cannula under direct vision into IVC

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Bypass Sequence Of Events

- Noticed 3 very small hepatic veins draining directly into RA with no true IVC
 - None of which were large enough to cannulate.
- Surgeon requested circulatory arrest and performed entire repair
- ASD, VSD, and pulmonary vein stenosis repaired under circulatory arrest

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Bypass Sequence Of Events

- After 74 min circulatory arrest, bypass resumed and X-clamp removed
- Rewarmed to 36°C
- Weaned bypass
- MUF
- TEE confirmation of good repair

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Post-bypass Labs and Vitals

- pH: 7.36
- pCO₂: 45.3 mmHg
- PO₂: 213 mmHg
- Hct: 34.2 %
- Lac: 5.5
- Base: 0.1 mmol/L
- All electrolytes and other lab values were normal
- HR: 150s
- MAP: 50s

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Bypass times

- CPB: 86 min
- X-Clamp: 85 min
- Circ Arrest: 74 min

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Post-operative period

- Uneventful ICU stay
- Extubated 3 days post-operatively
- Discharged home 3 weeks after surgery
 - Feeding issues was main hurdle

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Readmission

- Readmitted 4 months after initial surgery due to recurrent right pulmonary vein stenosis
- Repaired on bypass but had a plan for known (now) issue
 - Went on with single atrial cannula and planned for circulatory arrest.
 - Uneventful CPB run
 - 55 min circulatory arrest period
- Extubated 3 days later
- Discharged home after 7 days

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Outcome and Improvement

- Outcome resulted in patient doing well and being discharged home without issue
- TEE and/or pre-operative cath procedure are the only ways anatomy could have presented itself
 - Surgeon said on the outside it looked like a single vessel but inside had 3 separate hepatic vein lumens

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Outcome and Improvement

- Knowing the anatomy would not have changed the overall need for circulatory arrest or our eventual plan
 - Would have allowed for a plan pre-operatively
 - Maybe would have done ACP knowing the entire repair would need to be done under circ-arrest
 - Would have shortened the first CPB run
 - Due to all the time spent on manipulating cannulas and making a plan on the fly

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Thank you

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 - Braley Millin, CCP
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References

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