GET RID OF THE ½" VENOUS LINE!
It's so 1960's
Bharat Datt, Msc, CCP, CPC, FPP
Chief Perfusionist
Arnold Palmer Hospital for Children

DISCLOSURES
- 1998- Don't get into a stranger's car
- 1998- Don't meet people on the internet
- 2018- Summon strangers from the internet to get into their cars!
Why are we talking about adults?
- 85% of babies born with CHD survive
- Moodie et al., <1 million adults with CHD living in US
- Number expected to grow 8% annually
- Costs for adults living with CHD amount to 1.9 billion US$

Venous drainage
- Volume of blood in the systemic venous system:
  - venous tone, central venous pressure
  - Height differential (hydrostatic column) 40-60 cms between patient and the fluid level in the venous Res
- Resistance in the venous line: length of venous line
  - size and type of cannula(s)
  - placement of the cannulas
  -*** type of Venous Reservoir
Physics of venous return

- Art Circulation, high pressure low compliance system
- Ven circulation, low pressure high compliance system
- Ven return dependent on ven cannula, ven tubing diameter & length
- Viscosity of blood (temp, HCT) and CVP (Fullness of patient)
- F De Somer Venous drainage - gravity or assisted? Perfusion 2011 26: 15-Phy

Poiseuille's Law

\[ Q = \frac{\pi Pr^4}{8\eta l} \]

Why do we use \( \frac{1}{2}" \) venous line?

- Galletti P.M., Brecher G.A. Heart-lung bypass, principles & techniques of extracorporeal circulation. 1962
- Recommended 1/2" tubing for venous return
LV vents not only decompress the heart but also assist in venous drainage.

30 cms height differential gets you -20 to 25 mmhg.

40 cms get you -38 mmhg.

FLOW PREDICTING EQUATION DEVELOPED

Evaluate relationship between blood flow rate, tubing cross sectional area, drainage load & tubing length.

Using multiple regression analysis, Statsoft & Graphpad.

\[ F = 3.59544 + 0.0416D - 2.3100L \]

for 3/8” venous line.

F: Optimized venous tubing evaluated in China on 312 patients (mean BF 4.93 Lpm, range (3.9 to 7 Lpm).

Ex-vivo eval done.

256 valves. ASD/VSD 26, CAGB 11 Bentall 11, CPB HCT of 0.21.

Mean CPB time of 79.8±34.7 minutes. Prime of 1500 ml.
F De Somer Venous drainage - gravity or assisted? *Perfusion* 2011 26: 15

<table>
<thead>
<tr>
<th>Tubing diameter [inch]</th>
<th>Flow [mL/min]</th>
<th>Reynolds number</th>
<th>Wall shear stress [dynes/cm²]</th>
<th>Volume [cm³]</th>
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</thead>
<tbody>
<tr>
<td>3/16</td>
<td>650</td>
<td>384</td>
<td>60.8</td>
<td>0.73</td>
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<td>1/4</td>
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<td>86.5</td>
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<td>3/8</td>
<td>1974</td>
<td>79.4</td>
<td>98.1</td>
<td>2.79</td>
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</tbody>
</table>

Table 1. Fluid dynamic characteristics of different tubing

**Ni Y, Leskosek B, Shi L, Chen Y, Qian L, Li R, Tu Z, von Segesser LK.**


- A: determine max BF with conventional tubing “in vitro” test with Bovine Blood (HCT 35%, Temp 32)
- 4 tubing sizes (1/4, 5/16, 3/8, 1/2”), 3 different lengths (1-3 Meters)
- 3 different drainage loads (50-80 cmH20)
- C: EqnB validated using 66kg bovine with 2 tubing sizes (1/2”, 3/8”) with 3 different lengths, 2 different drainage loads
- E: optimal venous diameter validated from EqnB

Standard half inch tubing cross sectional area 1.27 cm²

1 cm² is adequate for venous return & has a reduction of 27 ml/foot

<table>
<thead>
<tr>
<th>Tubing diameter [inch]</th>
<th>Flow [mL/min]</th>
<th>Pressure difference [mmHg]</th>
<th>Velocity [cm/s]</th>
<th>Reynolds number</th>
<th>Wall shear stress [dynes/cm²]</th>
<th>Tubing length [cm]</th>
<th>Drainage load [mmHg]</th>
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<tbody>
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<td>5000</td>
<td>150</td>
<td>311</td>
<td>117</td>
<td>108</td>
<td>2</td>
<td>60</td>
</tr>
<tr>
<td>3/8</td>
<td>5000</td>
<td>125</td>
<td>286</td>
<td>80</td>
<td>117</td>
<td>2</td>
<td>60</td>
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</table>

Table 2. Fluid dynamic parameters required to obtain a venous drainage of 5000 mL/min
<table>
<thead>
<tr>
<th>INCHES</th>
<th>CENTIMETERS</th>
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</thead>
<tbody>
<tr>
<td>1/2</td>
<td>0.09375</td>
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<tr>
<td>3/8</td>
<td>0.375</td>
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<tr>
<td>3/16</td>
<td>0.1875</td>
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<tr>
<td>1/4</td>
<td>0.25</td>
</tr>
<tr>
<td>1/8</td>
<td>0.375</td>
</tr>
</tbody>
</table>

1.27 x 0.238125
0.9525 x 0.15875
0.9525 x 0.238125
0.635 x 0.15875
0.635 x 0.238125
Clinical data from Schoen Clinic Vogtareuth - Germany

Low Resistance to Venous Flow

- Curved inlet reduces flow resistance
- Blood does not pass through venous defuser unless needed
- 105 micron venous screen
- 5/16” to 5/8” outlet tube at bottom reduces resistance significantly

1/8” venous line up to 2.1 m²

- 3/8”
- 1/2”
Conclusion of Schoen clinic presented at EU conf 2015

- Up to 2.1 BSA
- 5.2 to 5.5 Lpm without vacuum if cannulated properly
- Cannula choice is extremely important
- 2-stage 36/48 consistent drainage with both the 1/2" and 3/8" venous lines.
- 32/36 limited flow regardless of venous line size
- Favorable impact on clinical practice using a low resistance reservoir
Lactate trend in Roller with Gravity

mg/dl

VENOUS SATURATIONS RG

Update on pediatric perfusion practice in North America- 2005, Groom et al

- 53 respondents pediatric heart surgery
- 32 respondents operated adult/pediatric hearts
- 21 centers only pediatric heart
- 46% centers used VAVD
- Slow innovation- 20 yrs for 74% centers to use coated tubing.

International pediatric perfusion practice 2011 survey results. Harvey B et al.

- 64% centers used VAVD
- 23% used integrated art filters
- 54% centers used washed red cells in prime
- MUF 71% (62% AV)
- 85% centers used coated circuits
- 32% used Del Nido cardioplegia
- Innovation was slow
FINAL COMMENTS

- Re-evaluate the use of ½ inch venous line?
- 3/8th inch line has been successfully used upto 90 kgs with the FX series of oxygenators
- Possibility of using the 3/8th inch venous line up-to 115 kgs with the Medtronic Fusion oxygenator.
- VAVD always an option.
- Reduce prime, hemodilution and homologous blood utilization
- IMPROVE OUTCOMES