2018 AmSECT pediatric
October 4-6, 2018 | Miami, FL

AmSECT experience

GET RID OF THE ½" VENOUS LINE!

Its so 1960's

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2018 AmSECT pediatric October 4-6, 2018 | Miami, FL

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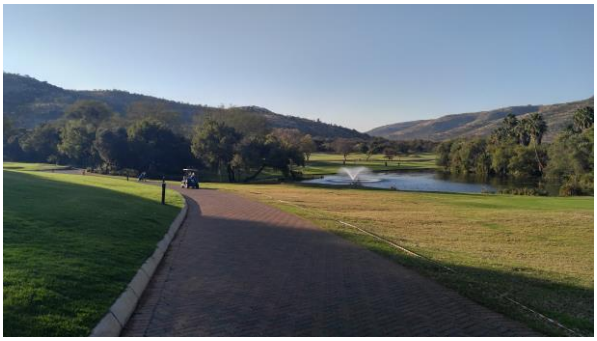
DISCLOSURES

- 1998- Don't get into a strangers car
- 1998- Don't meet people on the internet

- 2018- Summon strangers from the internet to get into their cars!



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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$

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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

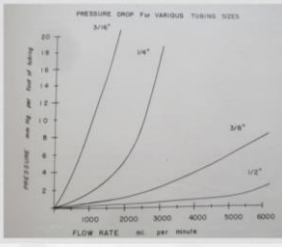
Q	Flow rate
P	Pressure
r	Radius
η	Fluid viscosity
l	Length of tubing

$$Q = \frac{\pi \mathrm{Pr}^4}{8\eta l}$$

Why do we use ½" venous line?

- Galletti P.M., Brecher G.A. Heart-lung bypass, principles & techniques of extracorporeal circulation. 1962
- Recommended 1/2" tubing for venous return

Size of venous lines



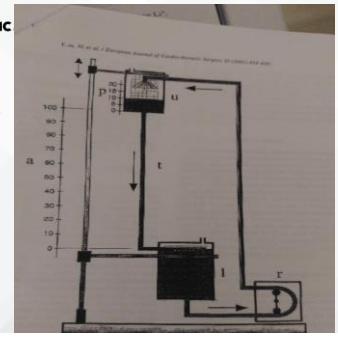
Reed and Clark

Antonio F. Corno. Systemic venous drainage: can we help Newton? EJCTS 31 (2007) 1044—1051

- 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

Ni Y, Leskosek B, Shi L, Chen Y, Qian L, Li R, Tu Z, von Segesser LK. Optimization of venous return tubing diameter for cardiopulmonary bypass. Eur J Cardiothorac Surg 2001;20:614—20.

- 119 Perfusion records retrospectively reviewed from Zurich to obtain clinical relevant Max BF for routine CPB. (mean BSA 1.83, BF 4.62 LPM).
- 19 ped patients & 119 adults.
- Target pump flow for group D was 2.5 l/min/m2
- Actual CPB flow rate was between 4.74 to 5.24 LPM
- D703 oxygenator used with 1/2 " venous line on a SIII HLM
- Length of ven line 2.41 M or 7 ft 10 inches



FLOW PREDICTING EQUATION DEVELOPED

- Evaluate relationship between blood flow rate,tubing cross sectional area, drainage load & tubing length.
- Using multiple regression analysis, Statosoft & 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, CABG 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 1. Fluid dynamic characteristic of different tubing

Tubing diameter [inch]	3/16	1/4	3/8	1/2
Blood flow [mL/min]	650	1335	3679	5551
Reynolds number	1219	1876	3447	5307
Wall shear stress [dynes/cm²]	29.2	38.9	58.4	77.8
Velocity [cm/s]	60.8	70.2	86.0	99.3
Volume [mL]	35.6	63.3	142.5	253.4

Tubing length 200 cm; Height difference 40 cm; Temperature 34°C; Hematocrit 30%

17

Table 2. Fluid dynamic parameters required to obtain a venous drainage of 5000 mL/min

Tubing diameter [inch]	3/8	½
Blood Flow [mL/min]	5000	5000
Pressure difference [mmHg]	68	16
Velocity [cm/s]	117	66
Reynolds number	4686	3514
Wall shear stress [dynes/cm²]	108	34

Tubing length 2 m; Hematocrit 30%; Temperature 34°C

Ni Y, Leskosek B, Shi L, Chen Y, Qian L, Li R, Tu Z, von Segesser LK. Optimization of venous return tubing diameter for cardiopulmonary bypass. Eur J Cardiothorac Surg 2001;20:614—20.

Standard half inch tubing cross sectional area 1.27 cm2

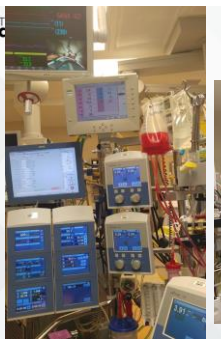
1 Cm2 is adequate for venous return & has a reduction of 27 ml/foot

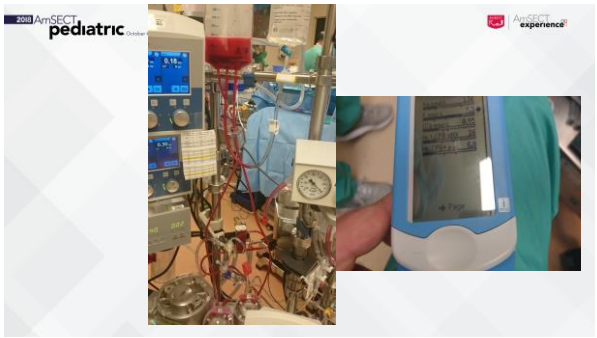
- A: determine max BF with conventional tubing “in vitro” test with Bovine Blood (HCT 35%, Temp 32)
- 4 tubing sizes (1/4, 5/16, 3/8, 1/2”), 3 different lengths (1-3 Meters)
- 3 different drainage loads (50-80 cmH20)
- C: EqnB validated using 66kg bovine with 2 tubing sizes (1/2”, 3/8”) with 3 different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

Table 1
Theoretical blood flow of tubing with 1.0-cm² cross-sectional area

Tubing length (m)	Drainage load (cmH_2O)			
	50	60	70	80
1.00	7.2	7.7	8.2	8.7
1.25	6.9	7.4	7.9	8.4
1.50	6.6	7.1	7.6	8.1
1.75	6.3	6.8	7.3	7.8
2.00	6.0	6.5	7.0	7.5
2.25	5.7	6.2	6.7	7.2
2.50	5.4	5.9	6.4	6.9

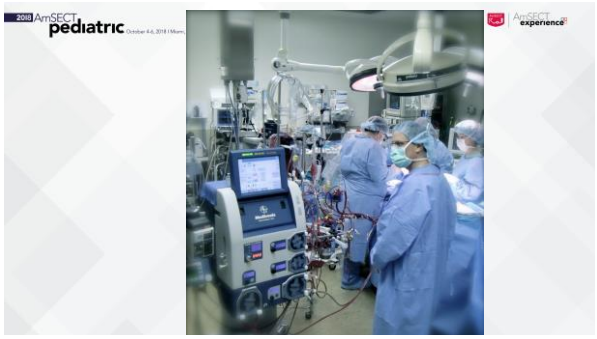
	INCHES	CENTIMETERS
1/2	½ x 3/32 = 0.5 x 0.09375	1.27 x 0.238125
3/8	3/8 x 1/16 = 0.375 x 0.0625	0.9525 x 0.15875
3/8	3/8 x 3/32 = 0.375 x 0.09375	0.9525 x 0.238125
1/4	¼ x 1/16 = 0.25 x 0.0625	0.635 x 0.15875
1/4	¼ x 3/32 = 0.25 x 0.09375	0.635 x 0.238125





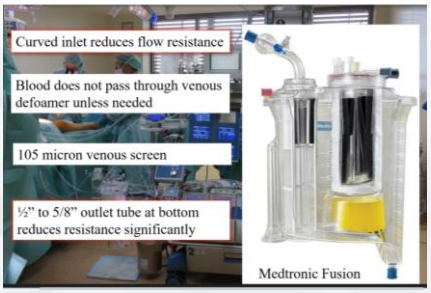

82
178
59/48 (52)
59/50 (53)
(7)
100
C 80
R 83


pH 7.35
PCO2 45
PO2 291
Temp 32.4
HCO3 25
BE 0
SO2 100
HCT 30
Hgb 10.3
SO2 100
K+ 3.5
Q 4.3

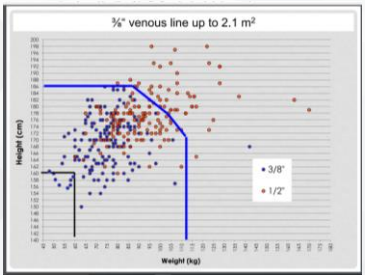


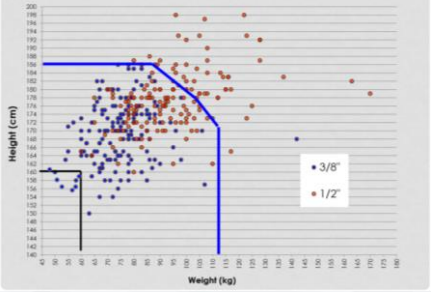
LOW RESISTANCE TO VENOUS FLOW

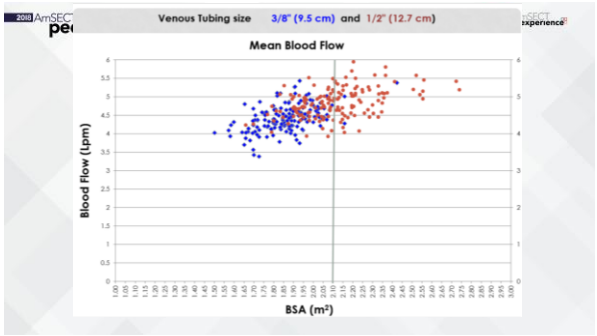
- Curved inlet reduces flow resistance
- Blood does not pass through venous defoamer unless needed
- 105 micron venous screen
- ½" to 5/8" outlet tube at bottom reduces resistance significantly



Clinical data from Schoen Clinic Vogtareuth -Germany

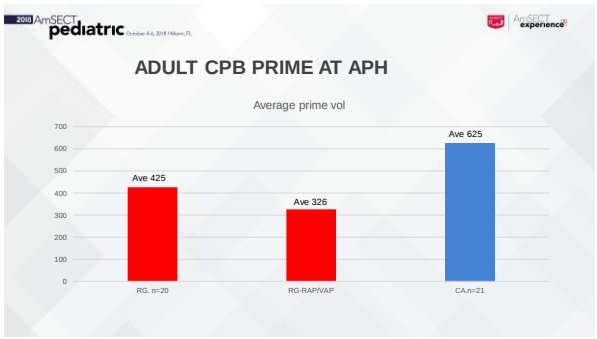


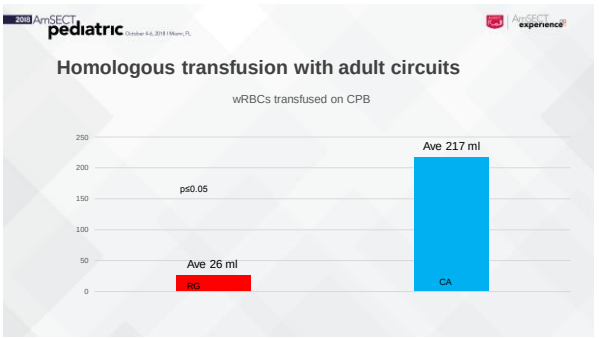


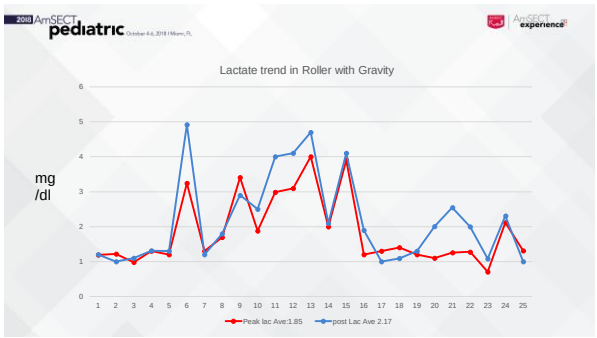


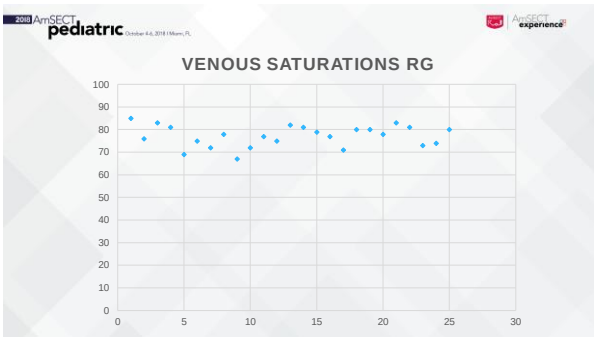
Conclusion of Schoen clinic presented at EU conf 2015

- 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







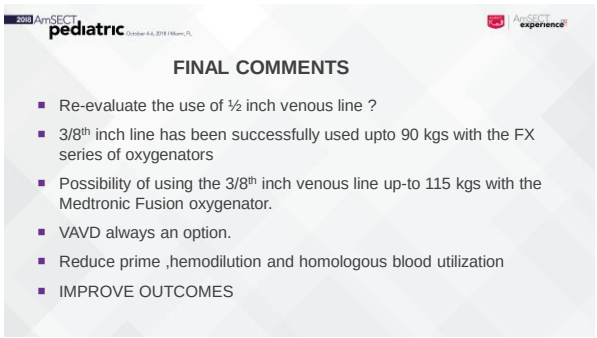


Update on -pediatric perfusion practice in North America- 2005,Groom et al

- 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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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