Gaseous Microemboli and Hemodilution during Cardiopulmonary Bypass?

Potential sources of morbidity and how to reduce them

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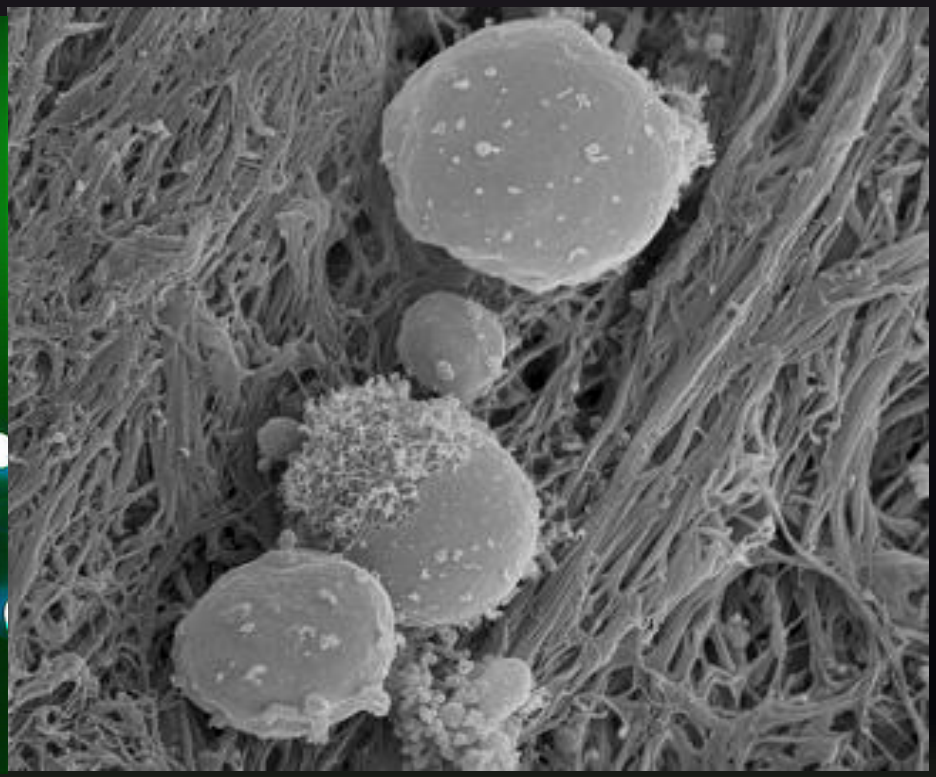
Bubbles in Water

Bubbles in Blood



Martin et al: Stroke 2007; 38(10):2726-32

There is good evidence to demonstrate that smaller micron sizes in venous filters will significantly reduce the amount and size of GME post arterial filter

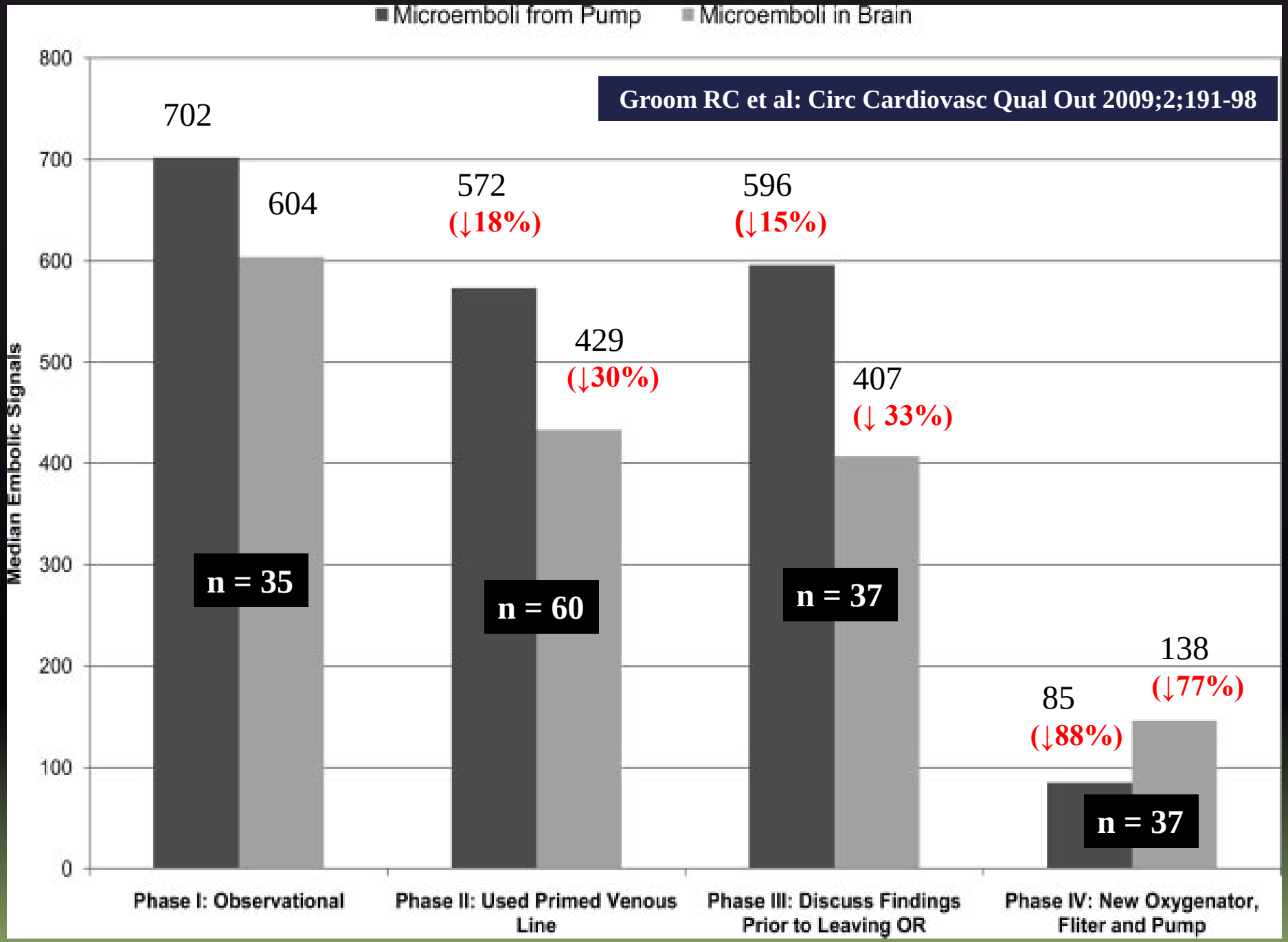
Venous filter sizes vary between manufacturers

Stehouwer MC et al: Int J Artif Org 2014; 37(9): 688-96

Liu S et al: J ExtraCorp Techn 2011;43:107–14

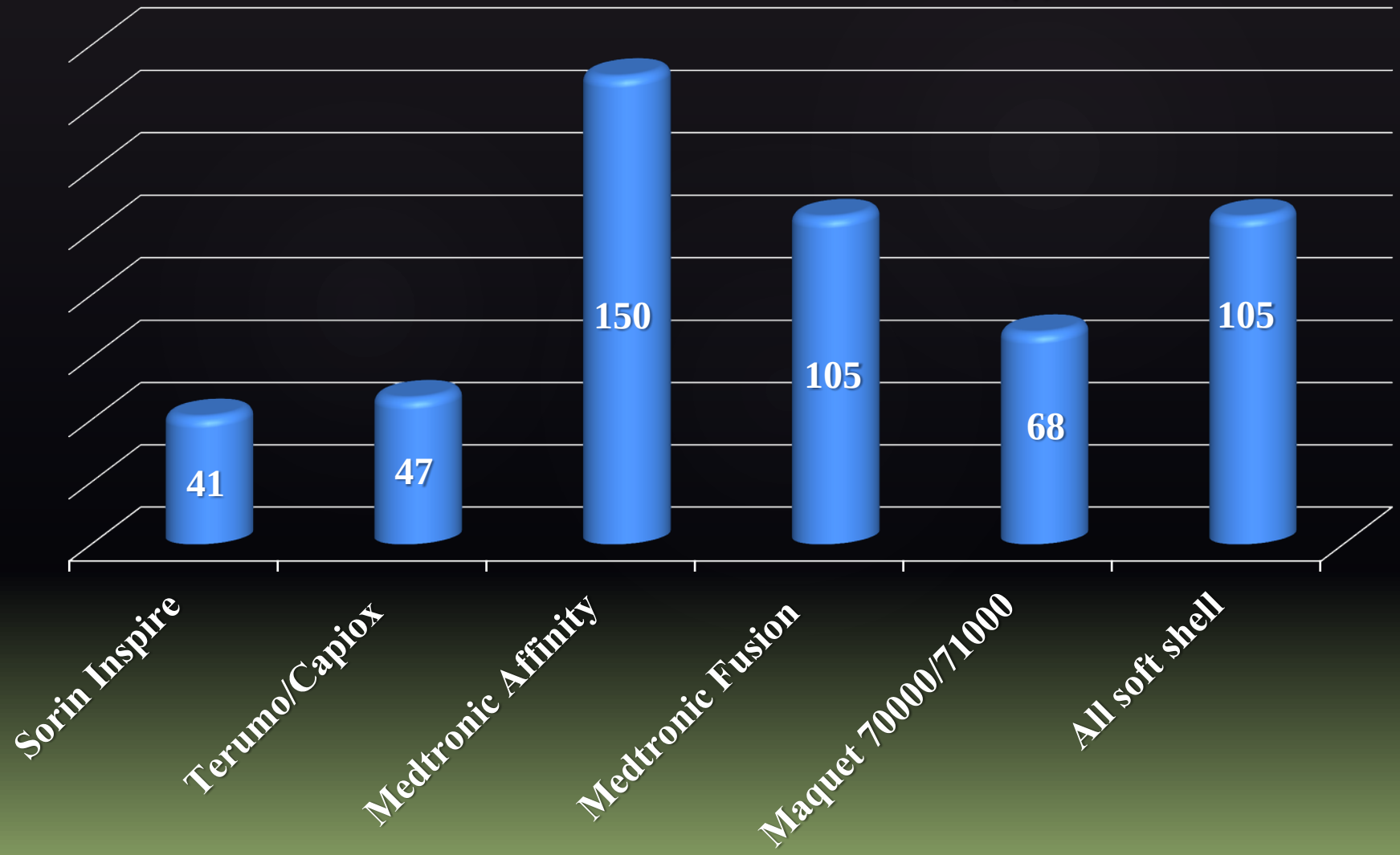
Myers GJ et al: - J ExtraCorp Techn 2009, March;41(1):20-7

Groom RC et al: - Circ Cardiovasc Qual Outcomes 2009;2;191-98

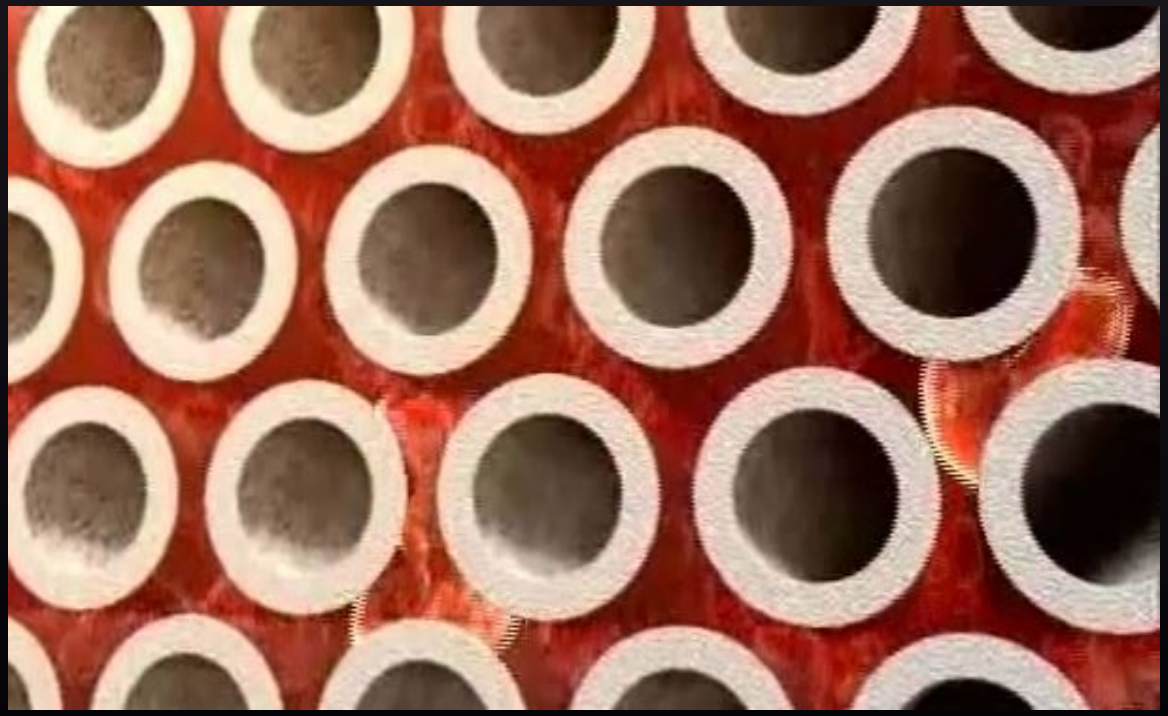

Microemboli from Pump
Microemboli in Brain
Groom RC et al: Circ Cardiovasc Qual Out 2009;2;191-98
Median Embolic Signals
800
700
600
500
400
300
200
100
0
702
604
572
(↓18%)
596
(↓15%)
429
(↓30%)
407
(↓ 33%)
85
(↓88%)
138
(↓77%)
n = 35
n = 60
n = 37
n = 37
Phase I: Observational
Phase II: Used Primed Venous Line
Phase III: Discuss Findings Prior to Leaving OR
Phase IV: New Oxygenator, Fliter and Pump

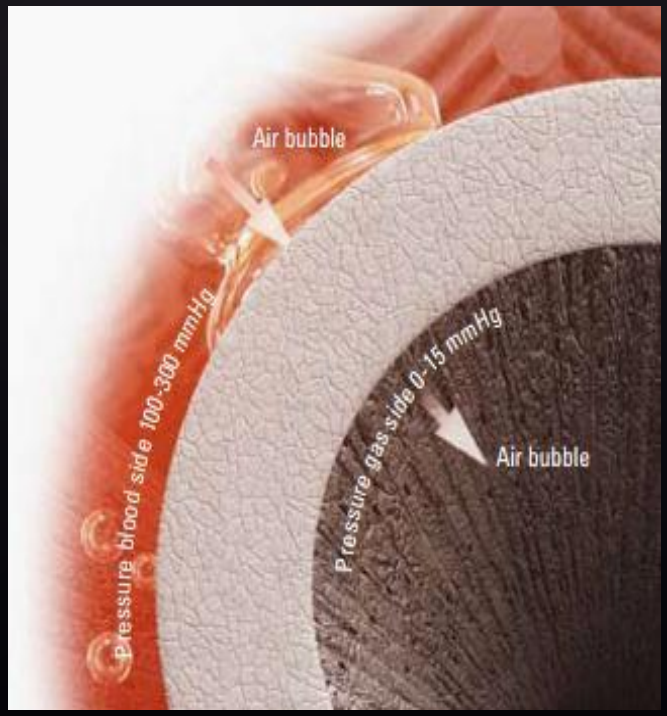
Venous Reservoir

Venous Filter Sizes (μ)

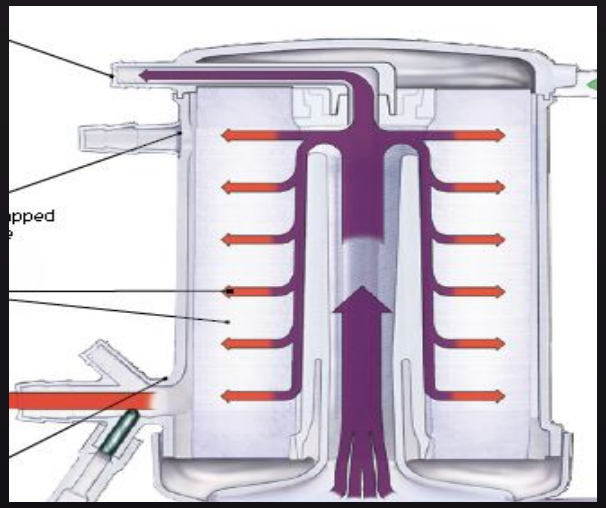


Hollow fiber membrane bundles are the largest GME ‘filters’ in our CPB circuit

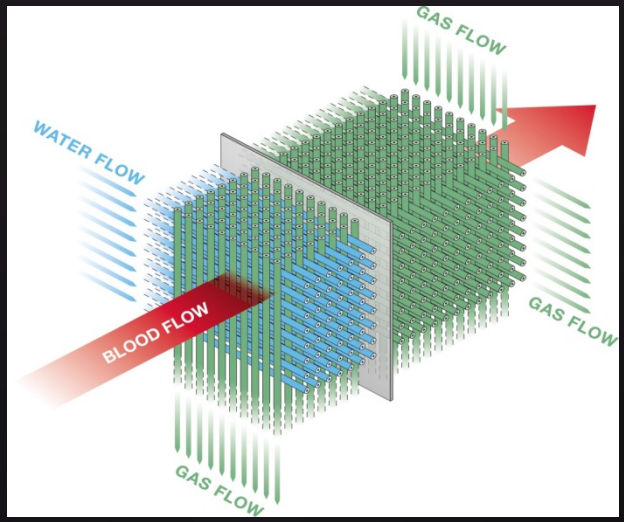




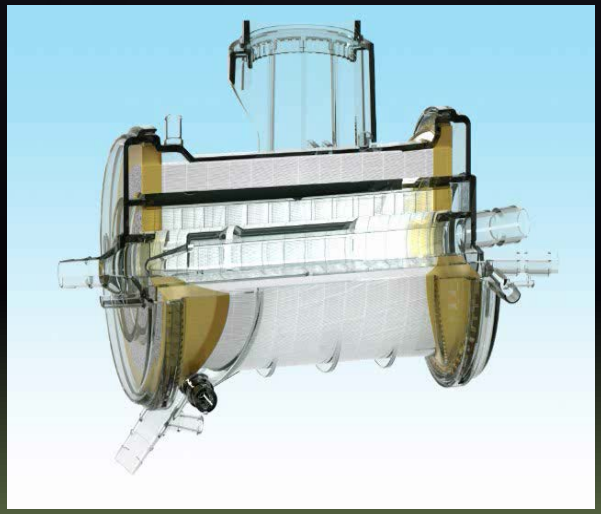
However, the absorption of microbubbles by the membrane oxygenator bundle can vary dramatically between devices



Radial Flow
Short Blood Flow Path

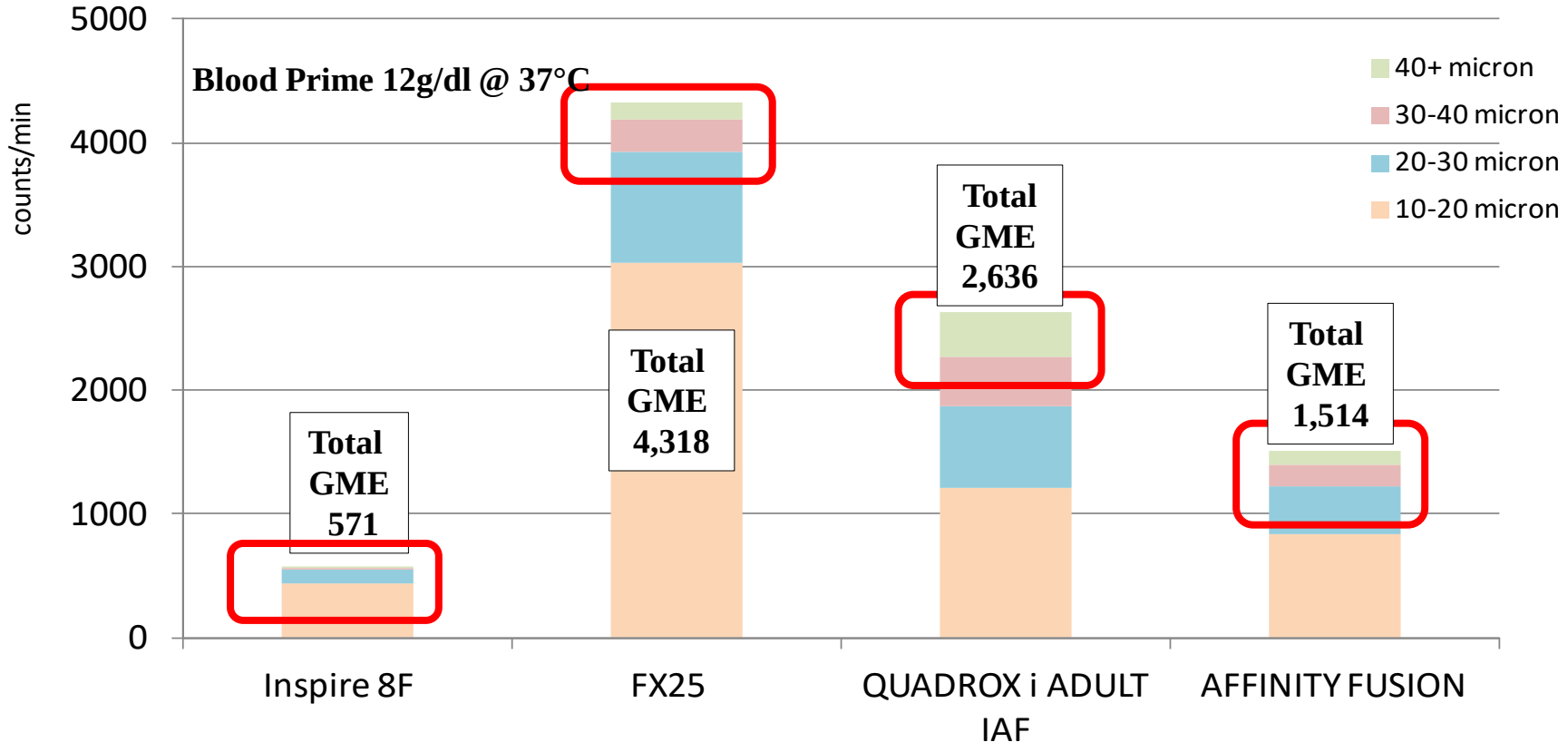


Cross Flow
Short Blood Flow Path



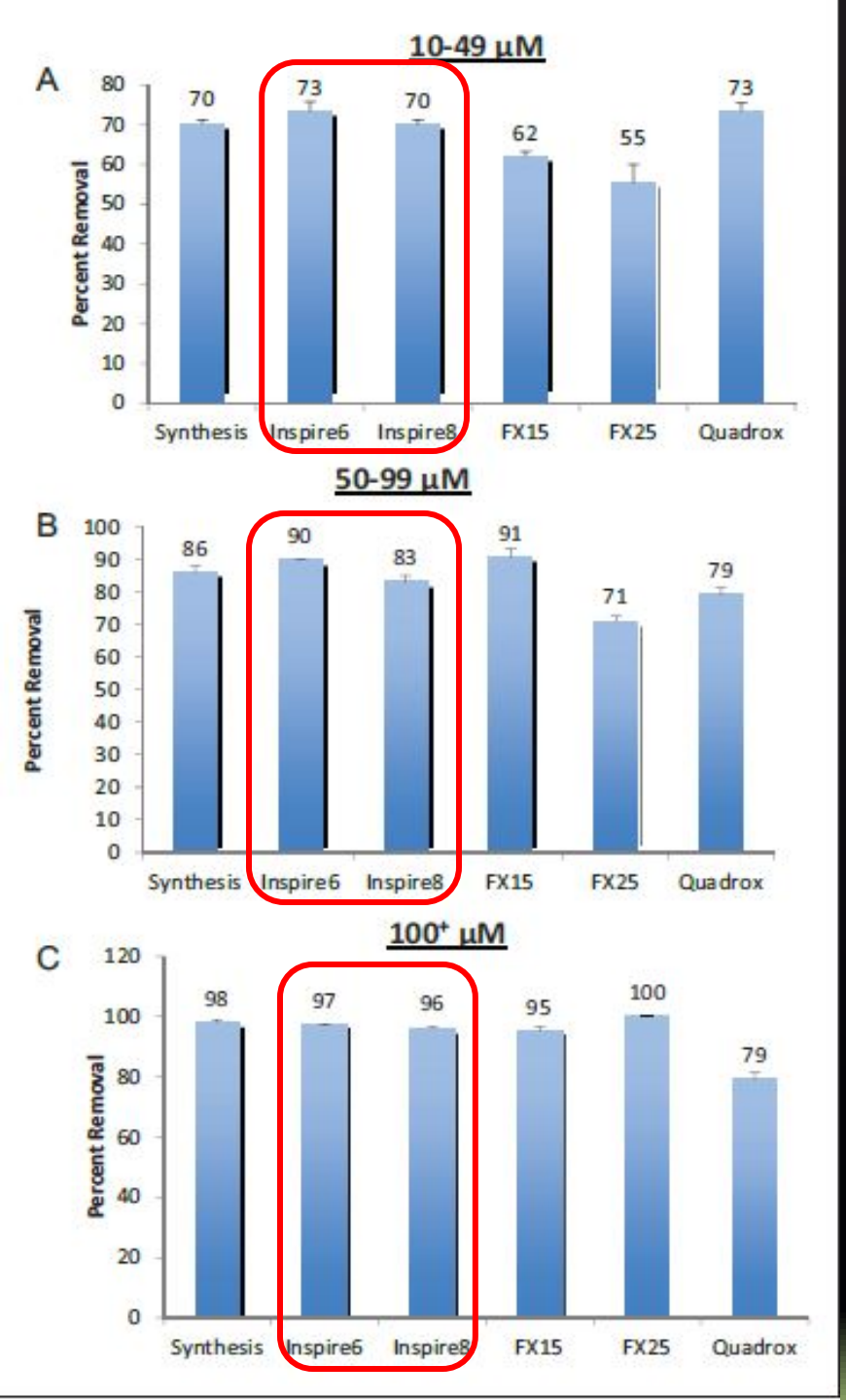
Axial Flow
Long Blood Flow Path

INSPIRE 8 F vs. ADULT OXYGENATORS IAF
Post Filter average bubble count
@ 6LPM - 100 ml/min cont. air injection



Polyester Arterial Filter	38µ	32µ	40µ	No AF

Petree L et al: Sorin Group, Arvada CO – 2013



Stanzel R & Henderson M:
Perfusion 2015; 1-7

In vitro study of GME using EDAC Quantifier with blood prime (HCT 30%)
Oxygenators evaluated were;
Synthesis … Inspire 6 … Inspire 8
FX15 … FX25 … Quadrox i

Inspire 6 and Inspire 8
(no arterial filters)
were better than or equal to the GME removal of 4 other adult oxygenators
(integrated arterial filters)

Non-randomized, prospective clinical trial for GME in 5 different adult oxygenators

(Medtronic Fusion, Terumo FX25,

Inspire 6, Inspire 6F, Avant 903)

Inspire 6 with 20 µ stand alone arterial filter was significantly better in GME removal than all oxygenators tested ($p<0.006$)

and

Inspire 6F with 38 µ integrated arterial filter was significantly better in GME removal than Fusion oxygenators ($p=0.0101$)

Jabur G et al: – Perfusion 2016; 31(5): 409-17

We now know that Excessive Hemodilution leads/contributes to …

Peripheral and organ edema

Acute kidney injury

Increased post operative bleeding

Increased need for banked blood/products

Increased incidence of stroke

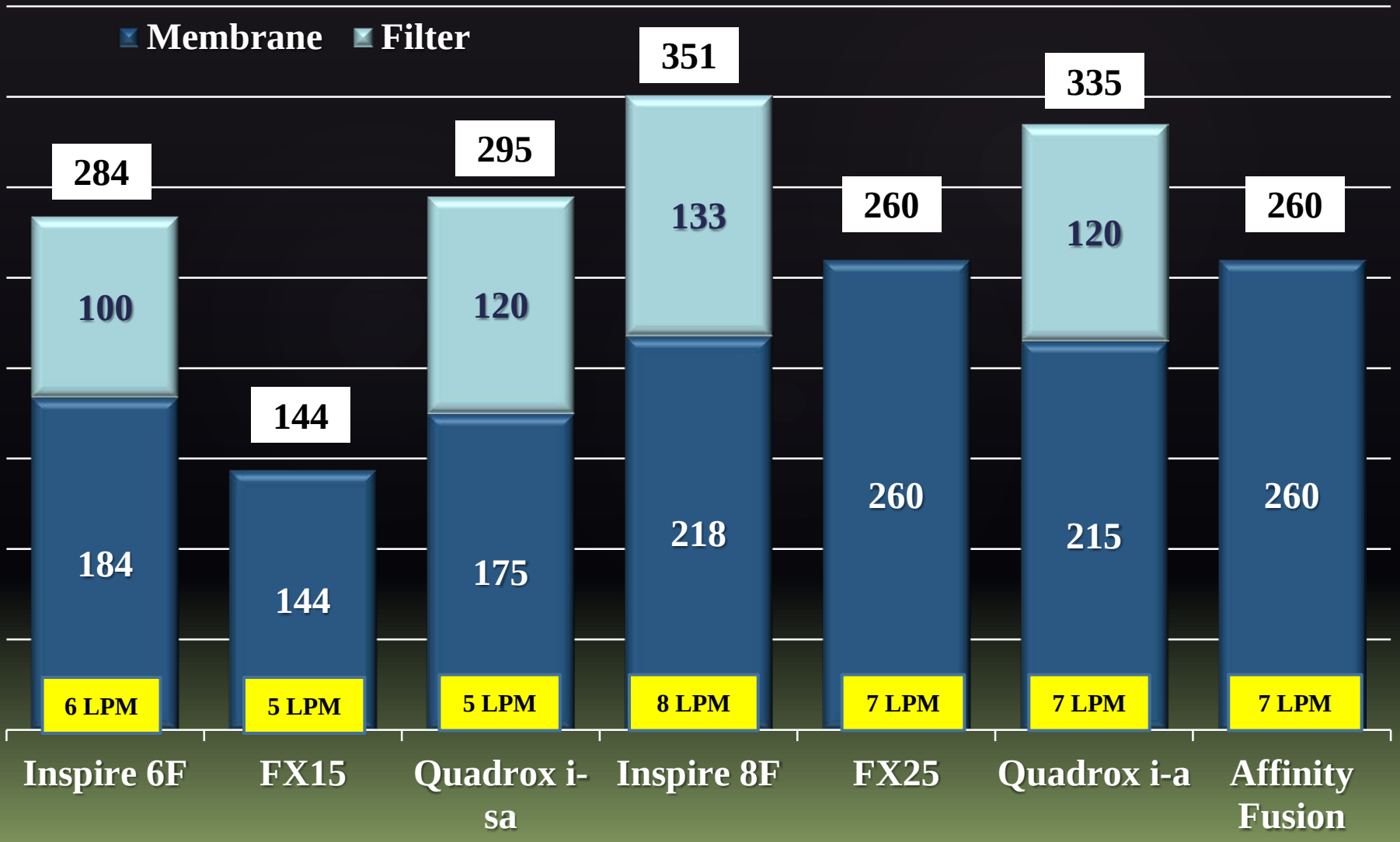
Poor patient outcomes

Ranucci M: Ann Thorac Surg 2015; 100(1): 95-100

Karkouti K et al: J Thorac Cardiovasc Surg 2005; Feb;129(2):391-400

Habib RH et al: J Thorac Cardiovasc Surg 2003 Jun;125(6):1438-50

Traditional way perfusionists compare device prime volumes



Dynamic Operating Volume

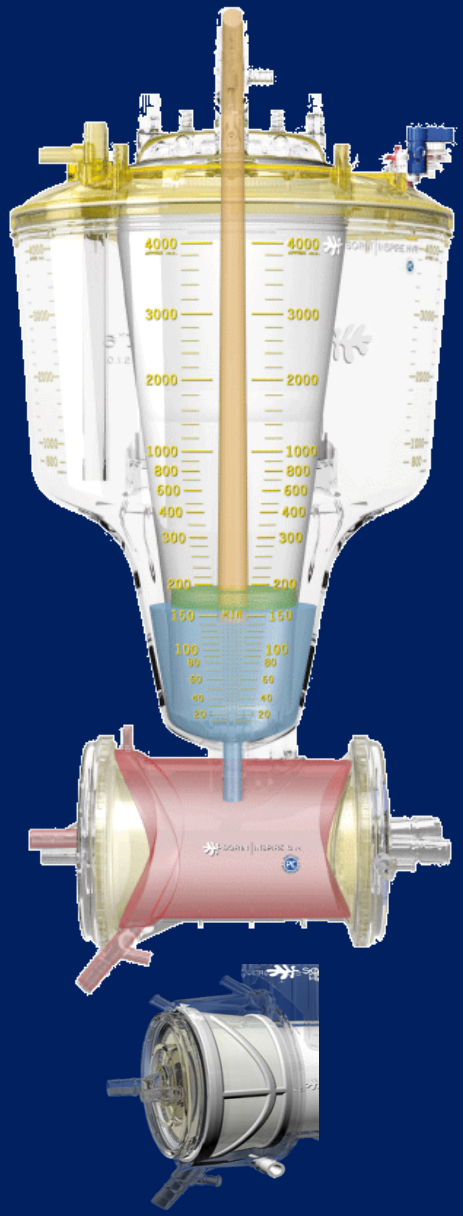
Venous collector priming volume

Venous filter hold-up volume

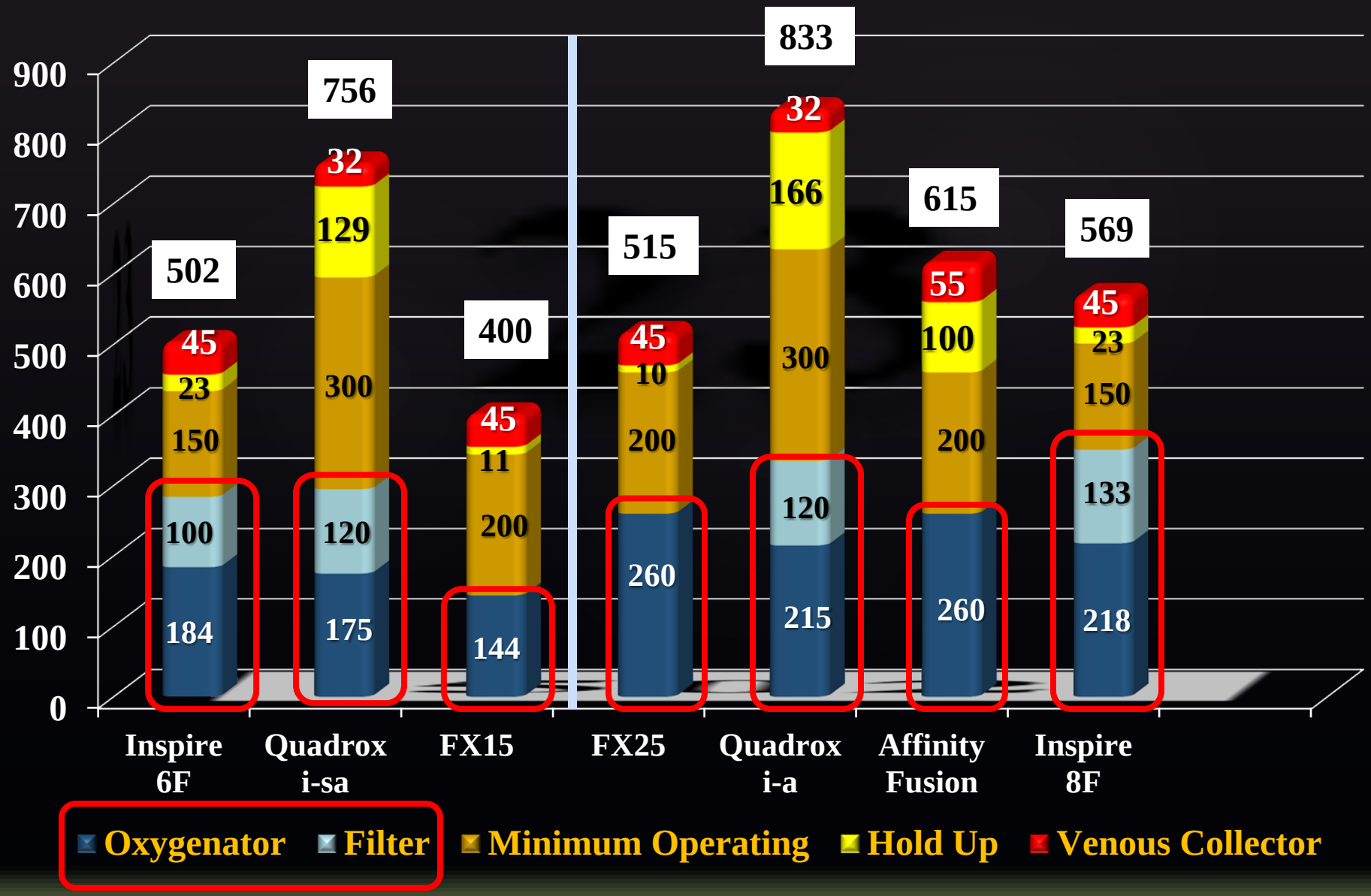
Minimum operating level

Oxy module priming volume

Arterial Filter Priming Volume



Dynamic Operating Volume



Use realistic approach to Address Excessive Hemodilution

Recognize/treat preoperative anemia

Eliminate prebypass anaesthesia volume loading

RAP and/or VAP all on pump cases

Use autotransfusion device (chest opening to chest closure)

Use Hemoconcentrator (but do not overuse)

Smaller (1.0 ml) syringes/less sampling for lab work

Recognize that Cardioplegia is a hemodilution factor

1 L Crystalloid 1 L 4:1 Blood = 200 Crystalloid 1 L 16:1 Blood = 58 Crystalloid