Minimising microbubble delivery in CPB

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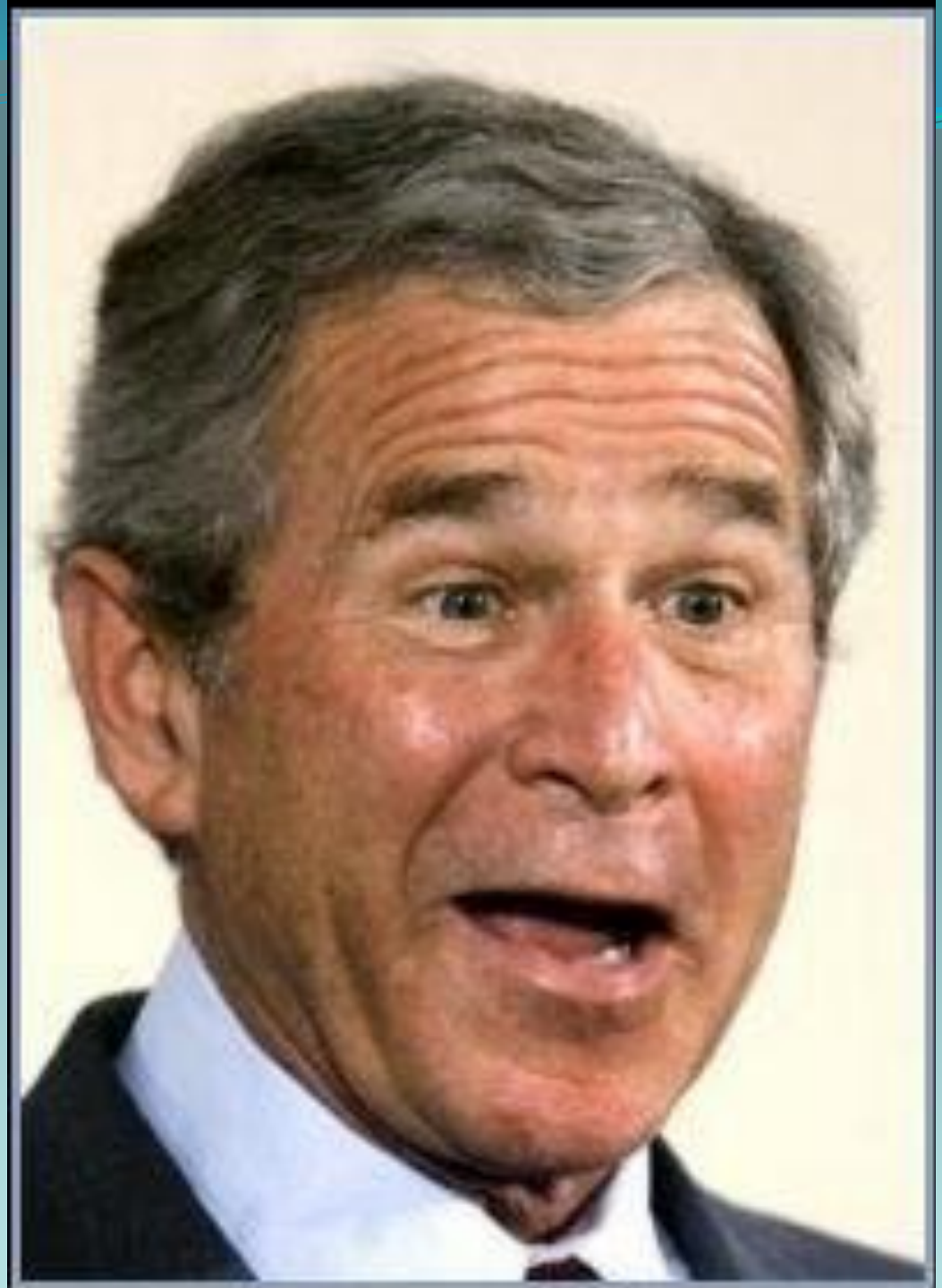


- Pathophysiology of microbubbles
- Etiology
- Minimizing, practical guidelines

Pathophysiology

Neurological impairment in adult cardiac surgery:

50-70% one week postOp

30-40% three months postOp

Attention, concentration, short term memory and hand-eye coordination (Pugsley et. al 1994)

Pathophysiology

Activation:

- Coagulation
- Complement
- Immune

- Platelets & leucocytes (Philp et.al. 1972)
- Platelets (Thorsen et.al. 1987)
- Complement (Pekna et.al. 1993)

Pathophyiology

- Ischemia

With no obstruction, still inflamation and oedema, decreased cerebral blood flow

Decreased cerebral blood flow progressively up to 90 min after exposure.

(Helps SC et.al. 1990)

Earlier studies suggested only microbubbles >35 µm was associated with increased morbidity.

Pathophysiology

- **Size**
- **Volume, numbers**
- **Composition**

Pathophysiology

Size:

<10 µm all passes the capillary bed.

10- 15 µm generally passes the capillary bed,
1/3 showed transient blockage.

>15 µm blockage of the capillary bed.

(Feinstein et.al.1984)

Pathophysiology

Numbers:

Direct correlation between GME numbers and change in accuracy of memory (Stump, et. al. 1996, Fearn et..al. 2001)

HITS count during CPB	No. of patients	No. with deficit	% with deficit
<200	58	5	8.6
201-500	13	3	23.1
501-1000	16	5	31.3
>1000	7	3	43

(Pugsley et.al.1994)

Many small bubbles as bad as a few large.

Pathophysiology

Composition:

Solubility:

CO_2 , O_2 , N

2-32 minutes for oxygen:nitrogen ratio 1:1

(Dexter et.al. 1998)

Foam like bubbles increases absorbtion time

Etiology

Venous air
Fluid addition
Drug administration
Blood sampling
Vent & suction
Residue from priming
Rollerpump cavitation
Temperature gradients
Low level venous reservoir
Oxygenator bubble migration
Etc.....

Etiology

Venous air

Fluid addition

Drug administration

Blood sampling

Oxygenator bubble migration

Etiology

Venous air:

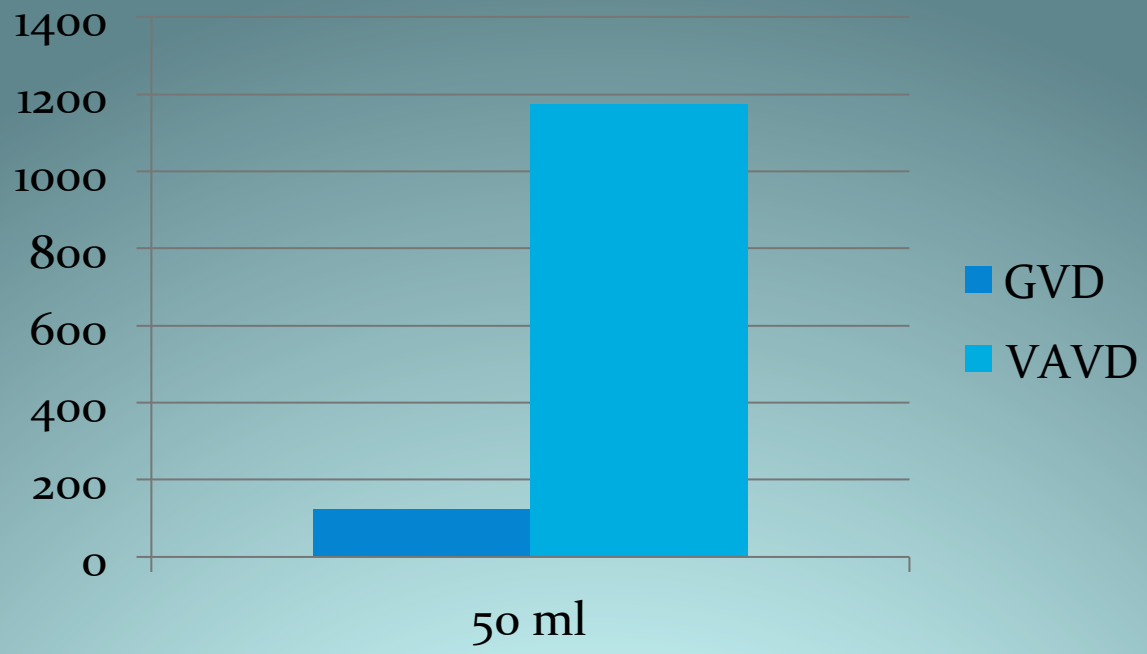
Major source of GME in the arterial line

Not completely de-aired venous line, pre- bypass
incl. unprimed venous line to reduce volume

Air from around the purse string sutures .
From right atrium during surgery.

Augmented by VAVD. GME increases x 10 in the arterial line
(Willcox et. al. 2002)

Etiology



Arterial line counts post arterial filter (Willcox et. al. 1999)

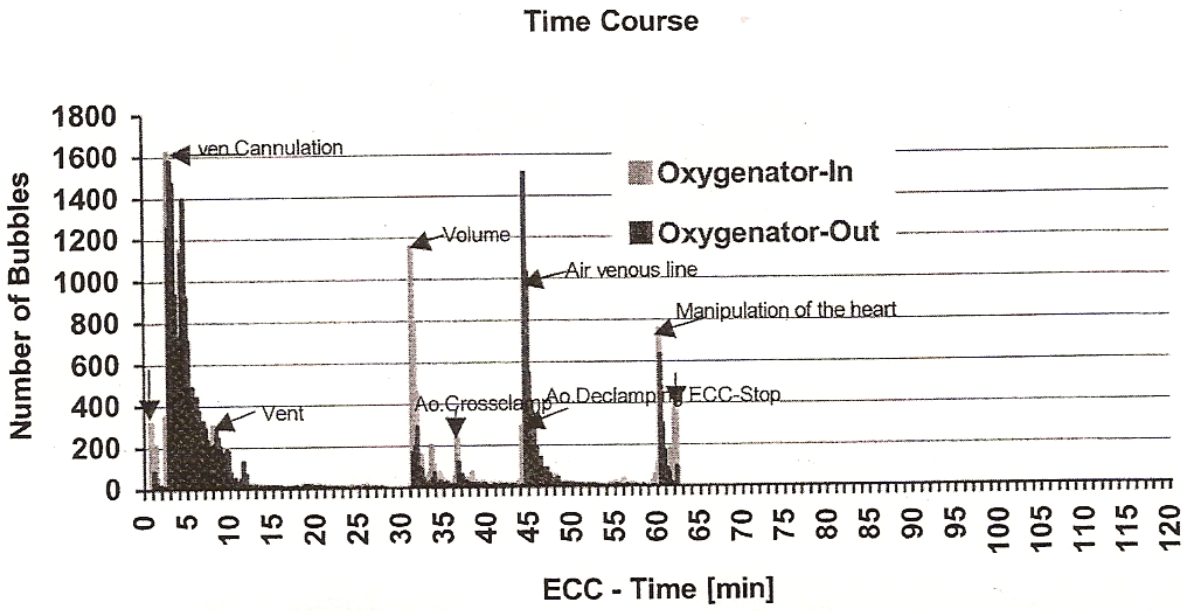


Figure 7. Time course of CABG procedure. Every peak is related with manipulation, which generates bubbles. Bubble activity can be observed in front and behind the oxygenator.

Etiology

Fluid addition

Drug administration

Blood sampling

Small bubbles of air is introduced through the

sampling manifold along with drugs or

purging of the sampling manifold during

blood sampling.

(Borger et. al. 2002)

Etiology

- Perfusion interventions

Up to 75% of GME correlates with perfusionist intervention.

(Taylor et.al.1999, Borger et.al. 2002)

Etiology

- *The more interventions, the higher degree of neuropsycological impairment.*

More versus less : 10 interventions showed increased impairment.

(Borger et. al. 2002)

Practical guidelines

Venous air:

Level in venous hardshell reservoir

250 ml as stated by the manufacturer are safe.
Lowering level from 1000 to 250 ml, increased bubblevol.
by 12,4 % after reservoir and 40,2% after arterial filter.

(Nielsen et.al.2008)

Reduce vacuum to a minimum.

Reduce surgical source, **make noise!!!**

Practical guidelines

Fluid addition

Drugs administration

Blood sampling

De-air syringes prior to drug administration

Limit purging to a minimun, discard syringes.

Etiology

Oxygenator bubble migration:

Negative pressure in the oxygenator causes bubbles to migrate across the microporous hollowfiber membrane.

(Jegger et. al. 2003)

Master thesis

Hypothesis:

- The use of vacuum assisted venous drainage with a roller pump in between the venous reservoir and the oxygenator cannot lead to damaging micro bubbles being transported across the membrane of the oxygenator to the arterial line during CPB, following a no-flow situation.

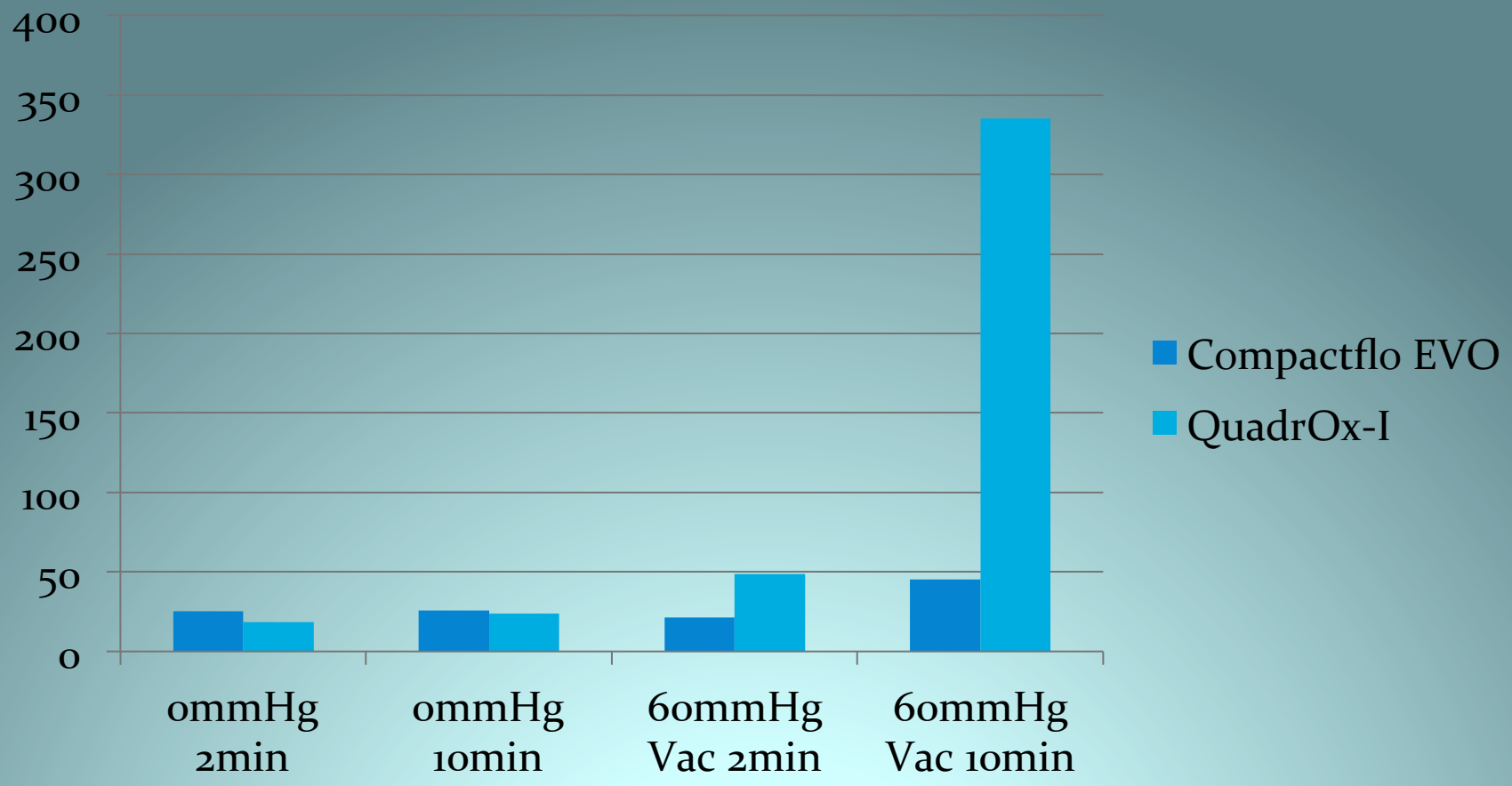
- There is no difference in bubble migration for the two commercial available oxygenators after a period of no-flow with vacuum.

Master thesis

Master thesis

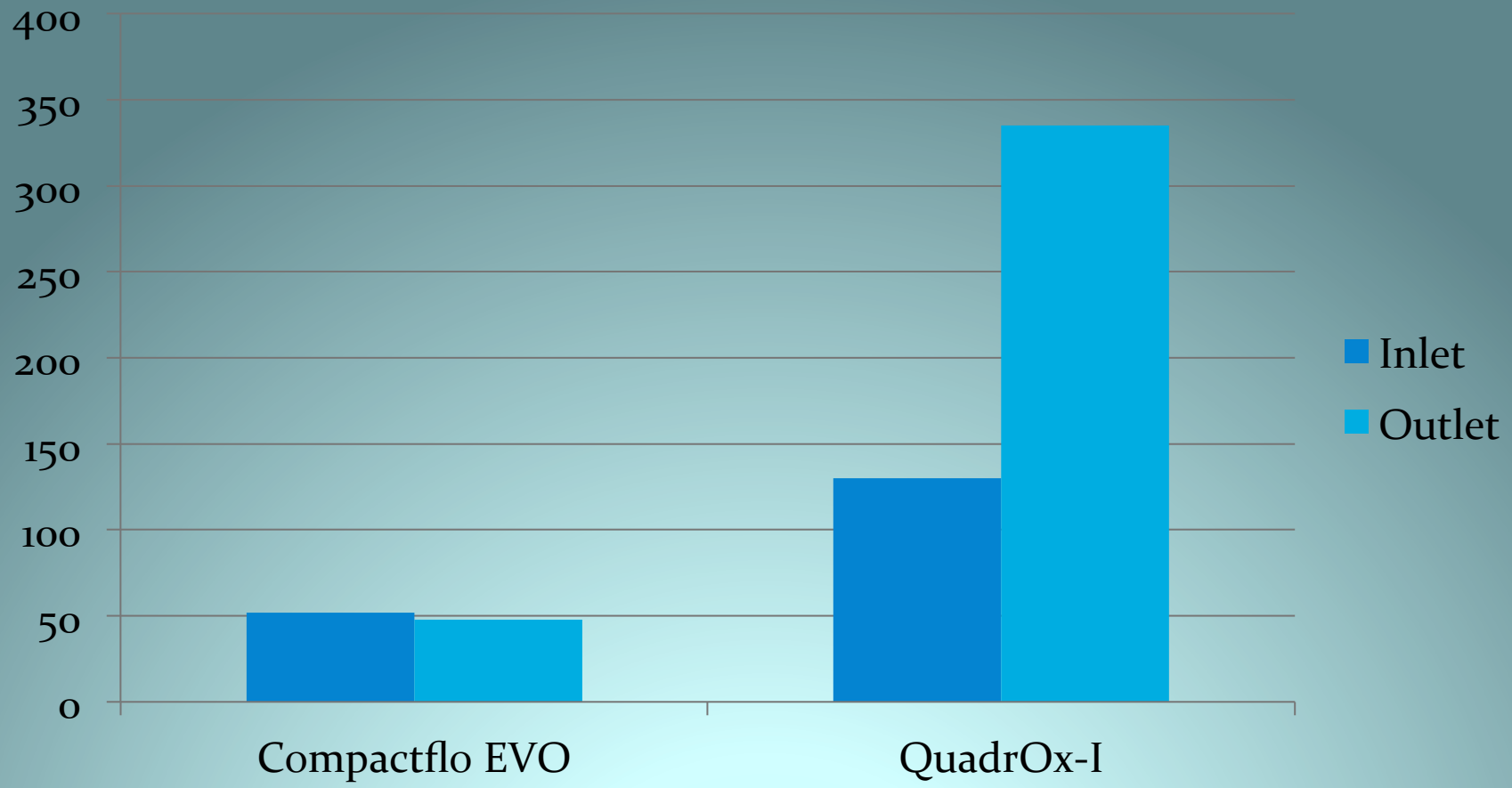
- 2 oxygenators
- High vacuum vs. no vacuum
- 2 or 10 minutes no-flow
- Soft occlusion of rollerpump.

Master thesis



Master thesis

Mean air volume nL no-flow for 10 min. with vacuum



Master thesis

- It is possible to migrate air across the membrane
- Increased air with increased time (2 min vs.10 min)
- Measured on volume alone: significant difference

  Comp vs. Quadr ($p<0.001$)
- Measured on ratio: no significant difference

  Comp vs. Quadr ($p=0.129$)
- 2 of 28 measurements higher than venous air, but for a shorter period of time and pre-arterial filter.

Summary

Avoid GME!!!

Limit venous air
De-air syringes

OR….