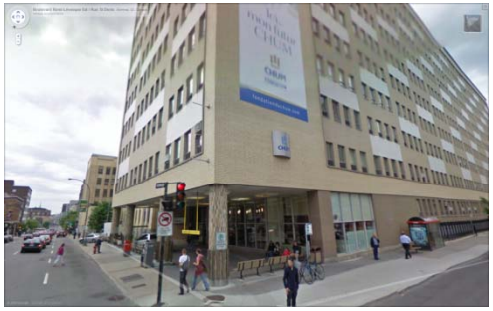


Difficult separation from cardiopulmonary bypass

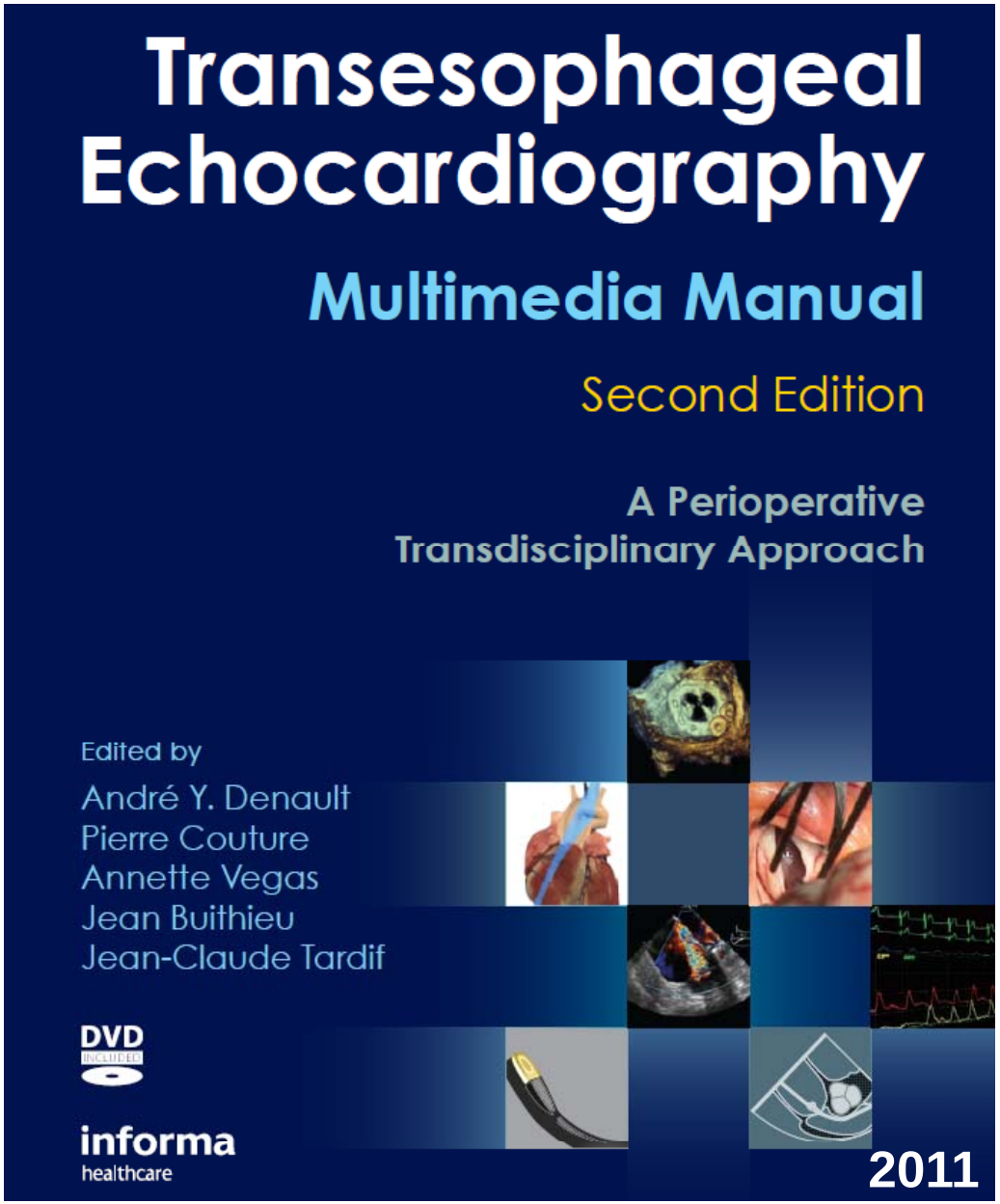
André Denault MD PhD FRCPC,CSPQ, ABIM-CCM, FASE
Professeur agrégé de clinique
Département d'anesthésiologie
Institut de Cardiologie de Montréal
Service des soins intensifs
Centre Hospitalier Universitaire de Montréal

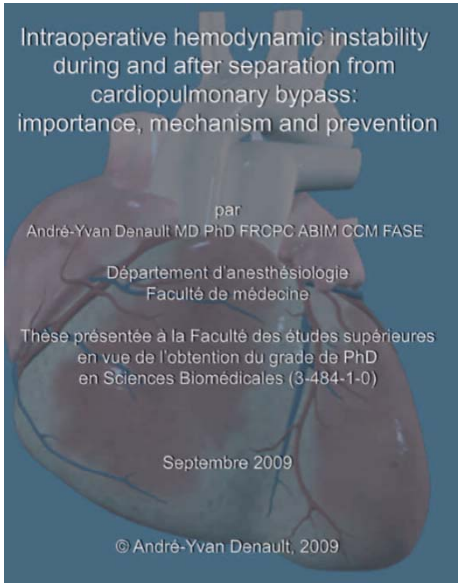
ICM

3rd LATIN AMERICAN COURSE ON
PERIOPERATIVE ECHOCARDIOGRAPHY AND ULTRASOUND
Bogota 2012

CHUM

Université de Montréal

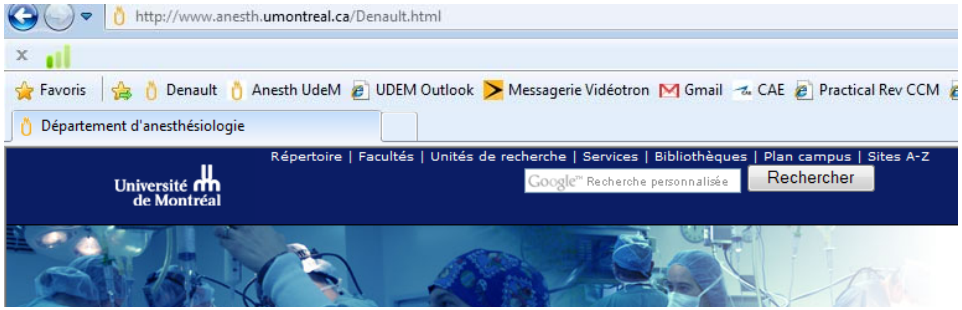




andre.denault@umontreal.ca

Ressources

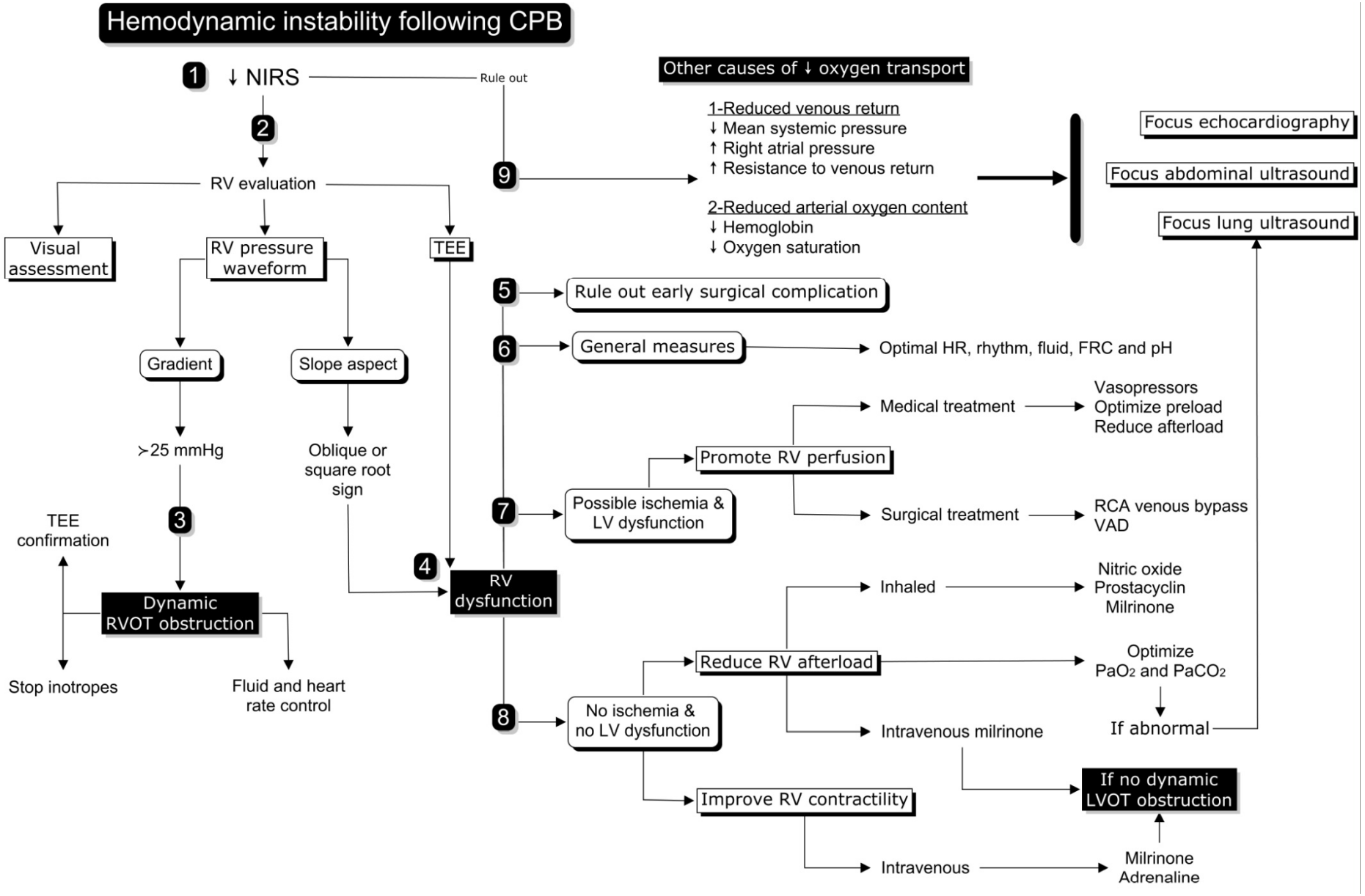
www.anesth.umontreal.ca/Denault.html



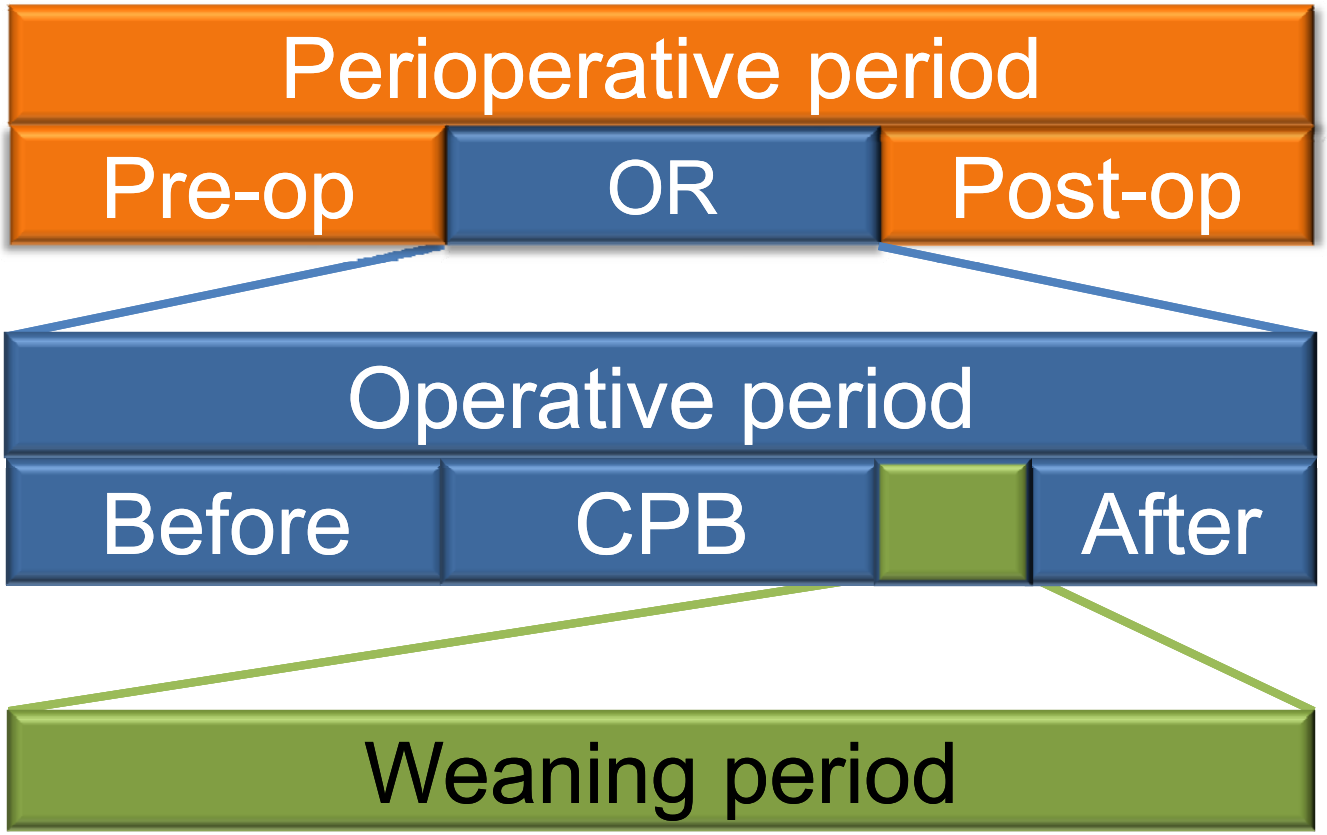
2012 Septembre
3rd Latin American course on Perioperative Echocardiography and Ultrasound
(Bogota, Columbia)

Key points

- Difficult separation from CPB is the most important factor associated with post-operative complications and mortality
- Difficult separation from CPB leads to brain and systemic desaturation
- Right ventricular failure is the common denominator in difficult separation from CPB
- Proposed strategy to approach difficult weaning from CPB



Denault et al. Current Opinion in Anesthesiology 2013


Perioperative period
Pre-op
OR
Post-op
Operative period
Before
CPB
After
Weaning period

May 25th1961

"..sending a man to the moon and bring him back safe before the end of this decade."

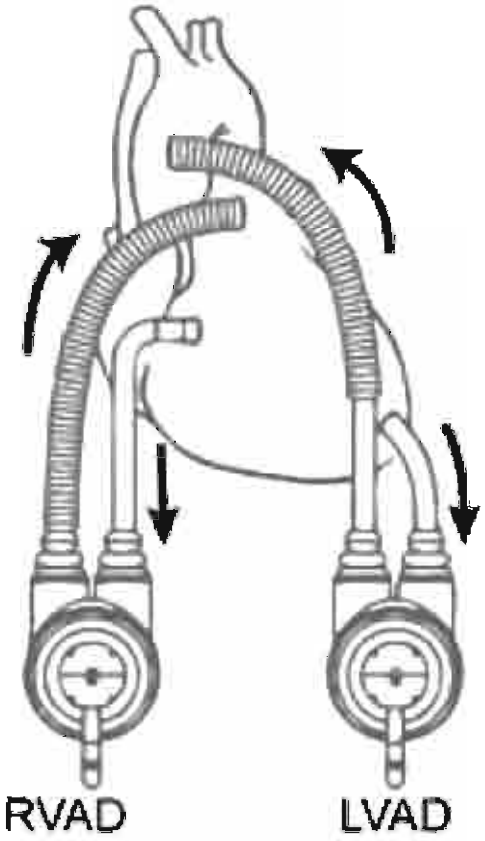

APOLLO 11

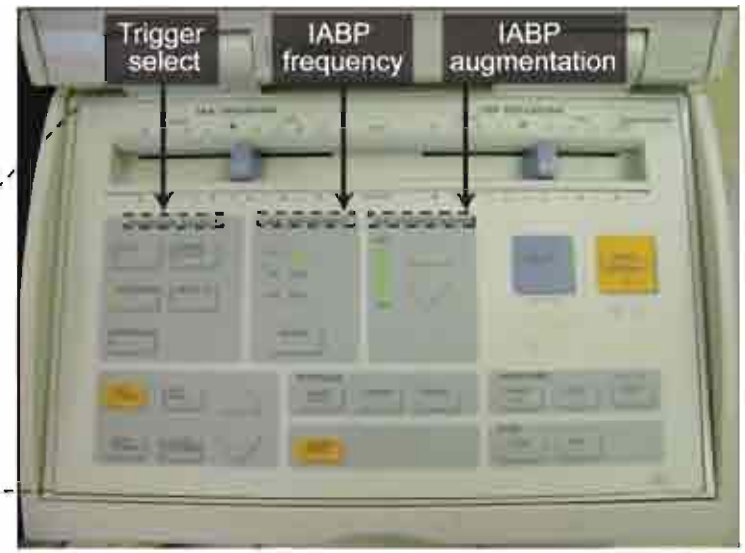
« Houston, we've had a problem. »

Apollo XIII Ron Howard 1995

What is difficult separation from CPB?


ALARMES DE
II
V
FC
107
ST-II
-0.2
ST-V
0.1
PA
PAP
PVC
104/37
PAP
44/29
PVC
57(16)
(31)
Temp
CO2
50
25
CO2fe
40
20
34
CO2mi 0
PA
AGT-fe


RVAD
LVAD


Trigger select
IABP frequency
IABP augmentation


3470
500
128


FC 48
FR
PA (91)
132/ 66
AP (13)
21/ 8
PVC(6)
P4A(94)
139/ 67
%SO2 100
PR 50
T1A
T1B33.5
DC 3.0
TS 33.1

Key points

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- Difficult separation from CPB leads to brain and systemic desaturation
- Right ventricular failure is the common denominator in difficult separation from CPB
- Proposed strategy to approach difficult weaning from CPB

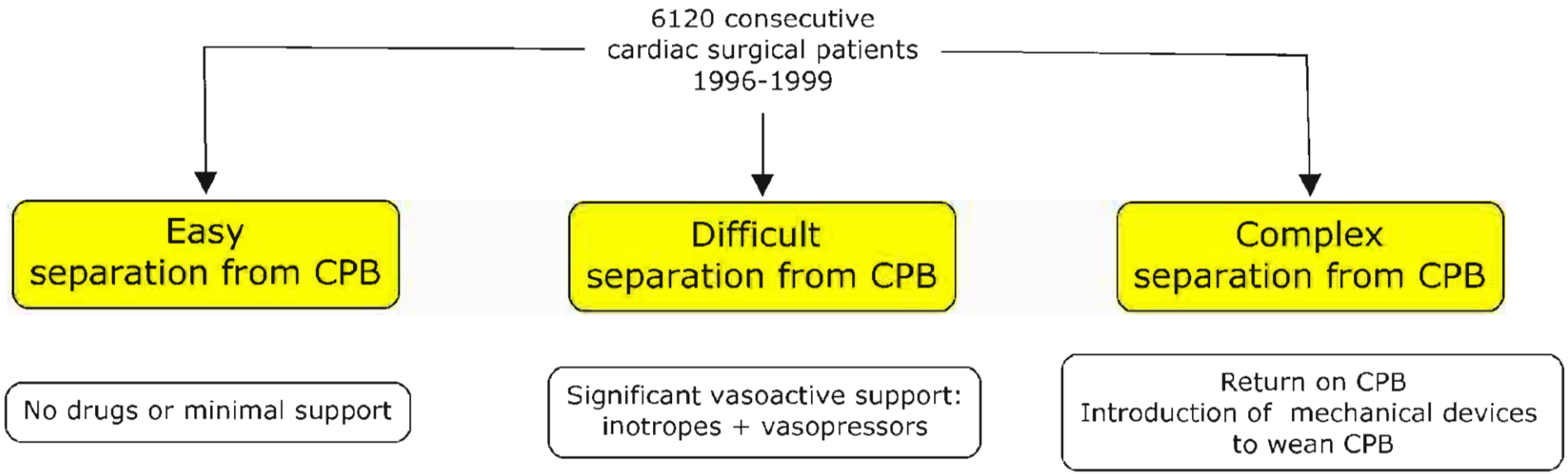
Difficult and Complex Separation from Cardiopulmonary Bypass in High-Risk Cardiac Surgical Patients: A Multicenter Study

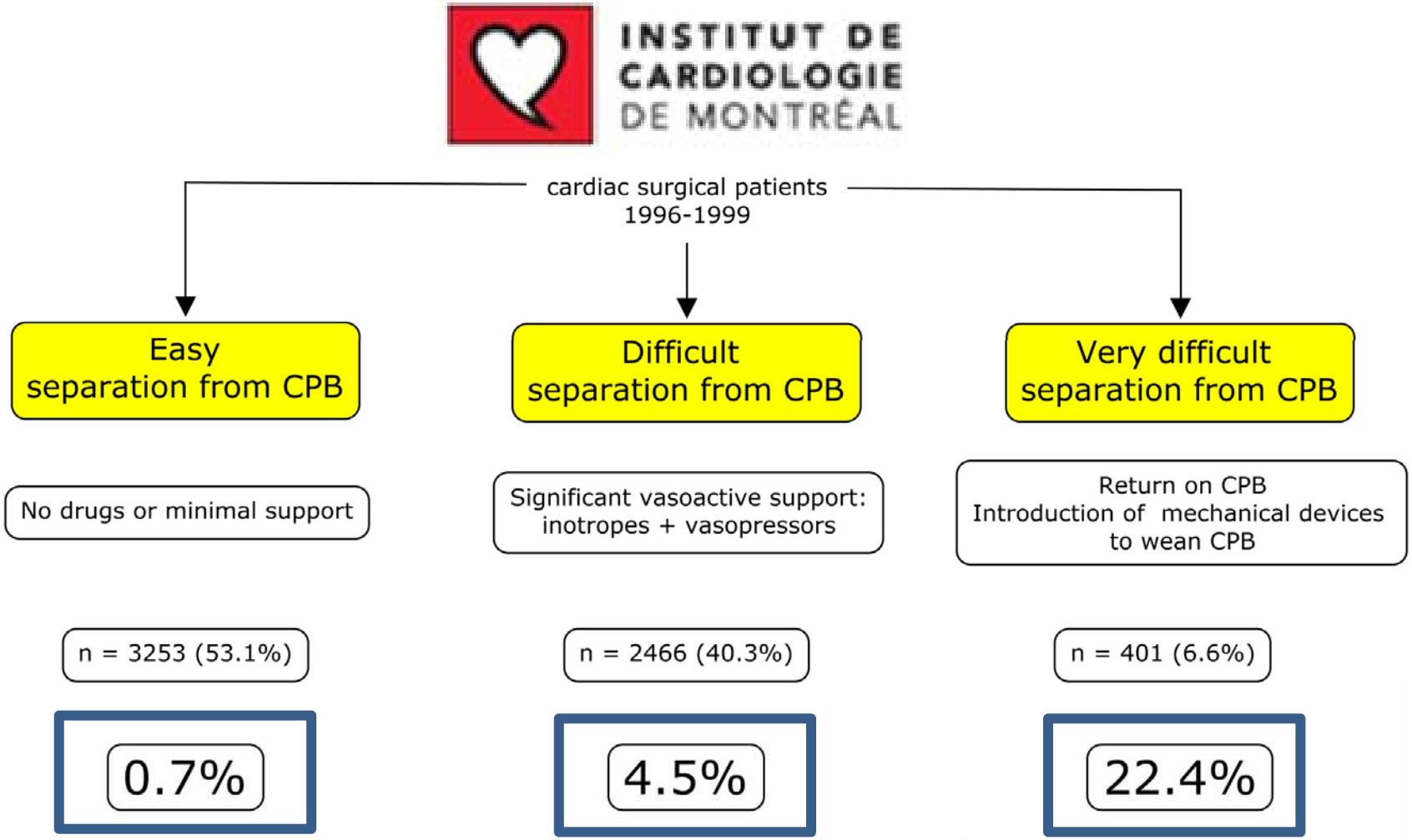
André Y. Denault, MD, PhD,* Jean-Claude Tardif, MD,† C. David Mazer, MD,‡ and Jean Lambert, PhD,§ for the BART Investigators

Dr Raymond Martineau
1945-2005

JTCVA 2012

INSTITUT DE CARDIOLOGIE DE MONTRÉAL

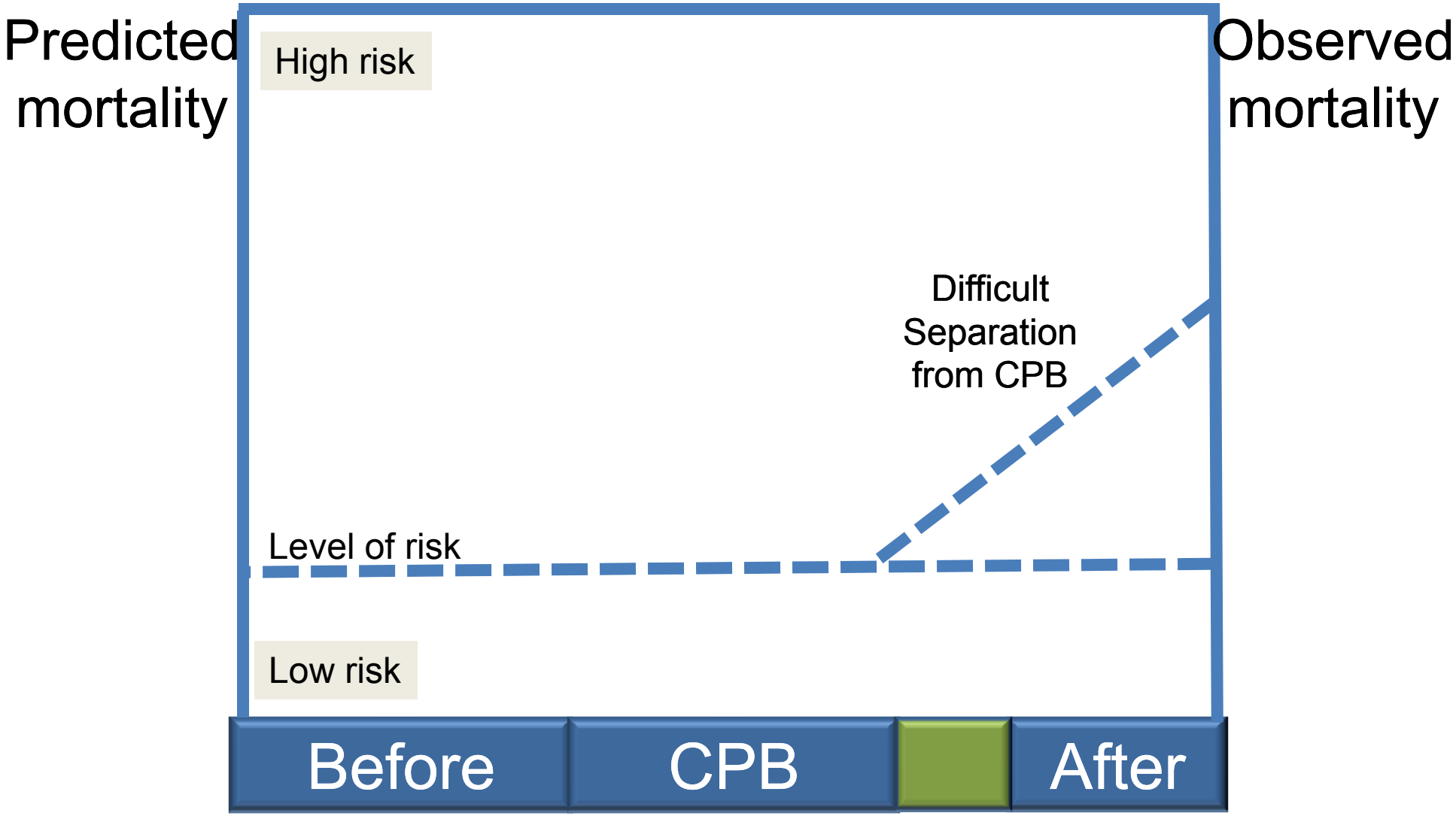



INSTITUT DE CARDIOLOGIE DE MONTRÉAL
cardiac surgical patients
1996-1999
Easy separation from CPB
Difficult separation from CPB
Very difficult separation from CPB
No drugs or minimal support
Significant vasoactive support: inotropes + vasopressors
Return on CPB
Introduction of mechanical devices to wean CPB
n = 3253 (53.1%)
n = 2466 (40.3%)
n = 401 (6.6%)
0.7%
4.5%
22.4%

Mortality

Hypothesis #1

Difficult separation from CPB is an **independant** risk factor of morbidity and mortality


Predicted mortality
Observed mortality
High risk
Difficult Separation from CPB
Level of risk
Low risk
Before
CPB
After

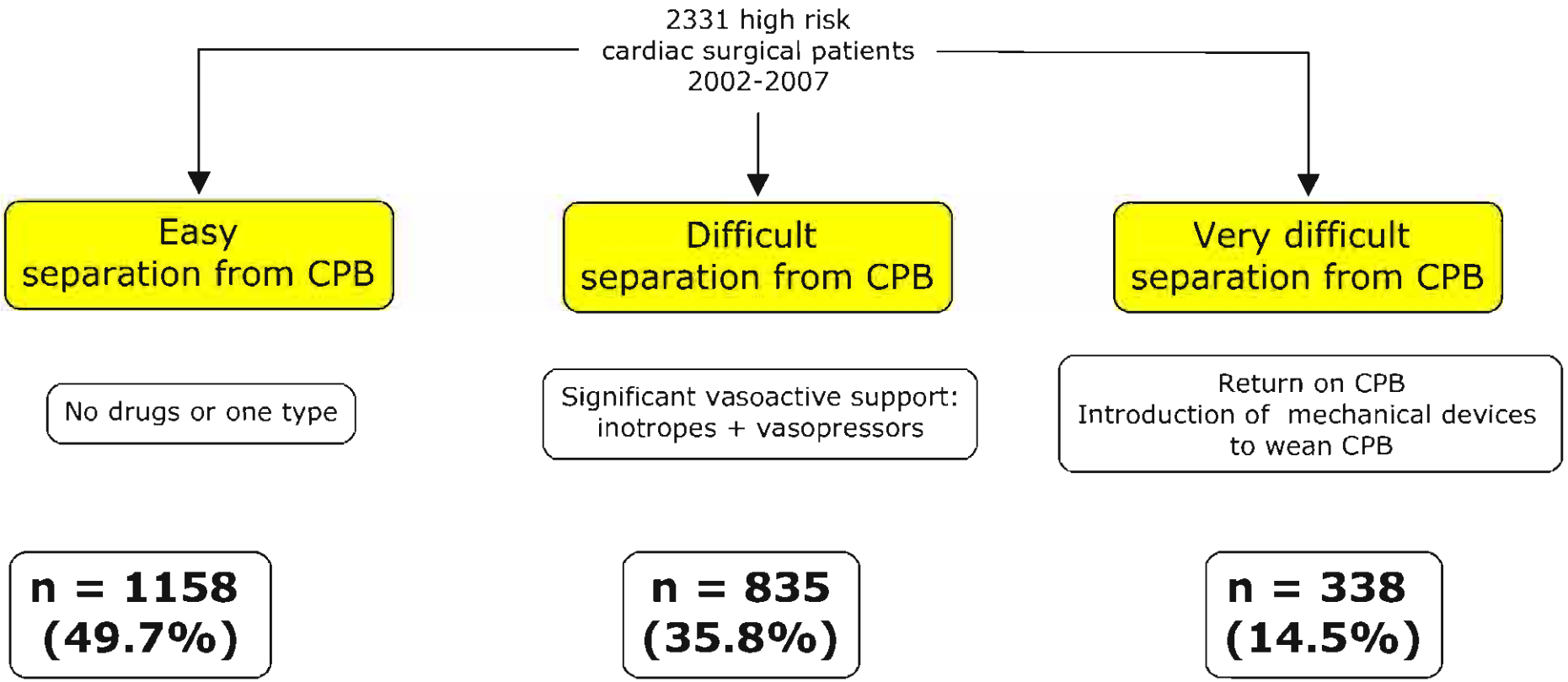
The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 MAY 29, 2008 VOL. 358 NO. 22

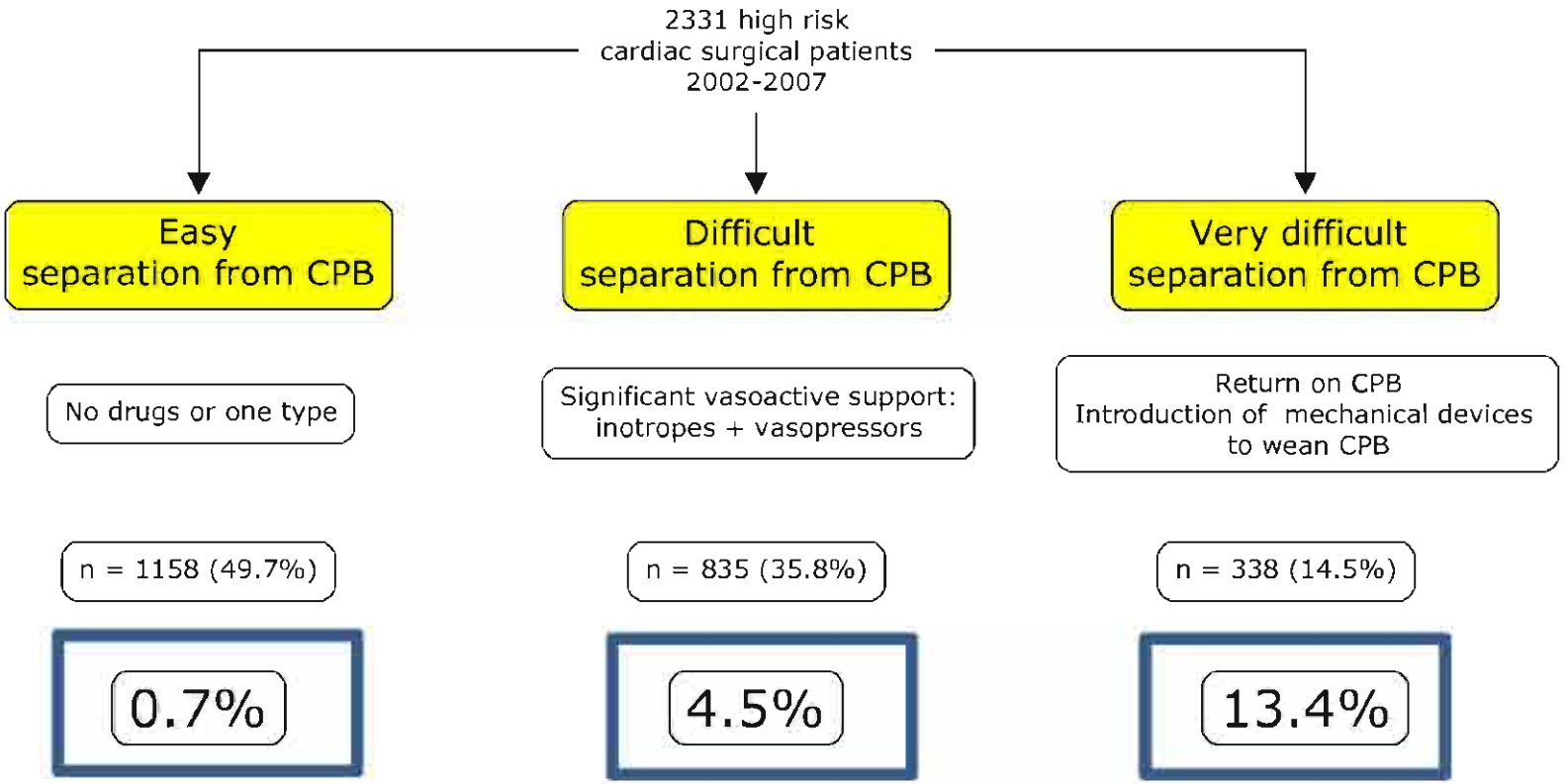
A Comparison of Aprotinin and Lysine Analogues in High-Risk Cardiac Surgery

Dean A. Fergusson, M.H.A., Ph.D., Paul C. Hébert, M.D., M.H.Sc., C. David Mazer, M.D., Stephen Fremes, M.D., Charles MacAdams, M.D., John M. Murkin, M.D., Kevin Teoh, M.D., M.Sc., Peter C. Duke, M.D., Ramiro Arellano, M.D., M.Sc., Morris A. Blajchman, M.D., Jean S. Bussières, M.D., Dany Côté, M.D., Jacek Karski, M.D., Raymond Martineau, M.D.,* James A. Robblee, M.D., M.B.A., Marc Rodger, M.D., M.Sc., George Wells, Ph.D., Jennifer Clinch, M.A., and Roanda Pretorius, M.Sc., for the BART Investigators†

A Comparison of Aprotinin and Lysine Analogues in High-Risk Cardiac Surgery



A Comparison of Aprotinin and Lysine Analogues in High-Risk Cardiac Surgery



A Comparison of Aprotinin and Lysine Analogues in High-Risk Cardiac Surgery

Predictors of mortality

Variables	B ± SE	Odds Ratio	95% CI	*P* value
Age (10 units)	0.0443 ± 0.0131	1.557	1.213-2.028	0.0007
Renal disease	0.6526 ± 0.3184	1.921	1.029-3.585	0.0404
Use of diuretics	0.5644 ± 0.2355	1.758	1.108-2.790	0.0165
Hemoglobin (1 unit)	-0.0147 ± 0.00692	0.985	0.972-0.999	0.0342
Prothrombin time (10 units)	0.0091 ± 0.00316	1.096	1.024-1.164	0.0039
Easy *vs.* difficult separation from CPB	0.5155 ± 0.2875	1.674	0.953-2.942	0.0730
Easy *vs.* very difficult separation from CPB	1.1285 ± 0.3033	3.091	1.706-5.601	0.0002
CPB duration (60 units)	0.0097 ± 0.0013	1.788	1.529-2.103	< 0.0001

B, estimate; BART, Blood Conservation Using Antifibrinolytics in a Randomized Trial; CI, confidence interval; CPB, cardiopulmonary bypass; SE, standard error

Key points

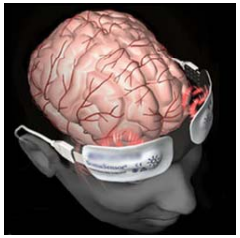
- Difficult separation from CPB is the most important factor associated with post-operative complications and mortality
- Difficult separation from CPB leads to brain and systemic desaturation
- Right ventricular failure is the common denominator in difficult separation from CPB
- Proposed strategy to approach difficult weaning from CPB

Hemodynamic instability following CPB

1. ↓ NIRS

Mode of operation

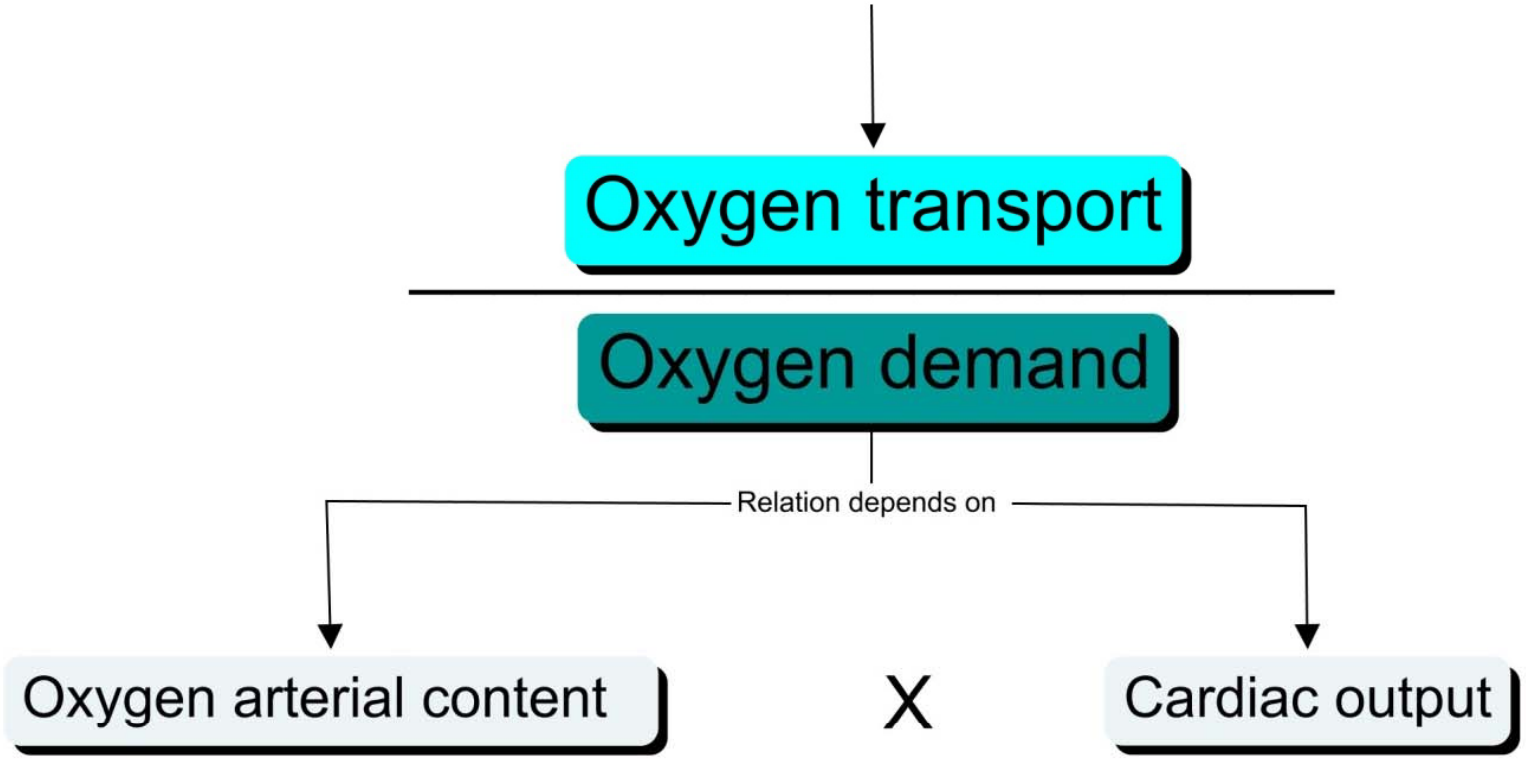
- Photons with two separate wavelenght are captures by a receptor
- The photons will penetrate superficial and deep tissues down to the frontal cortex
- The superficial signal is substracted from the final signal
  (“Spatially resolved NIRS”)
- The final signal originates from deeper cortical tissue



At the same time


107
-0.2
0.1
104/37
44/29
34
PEDIATRIC
25.09.05
05:07:29
L 36
SYSTEM SIGNAL OK
R 43
LEFT
RIGHT
MAIN MENU

Difficult separation from CPB



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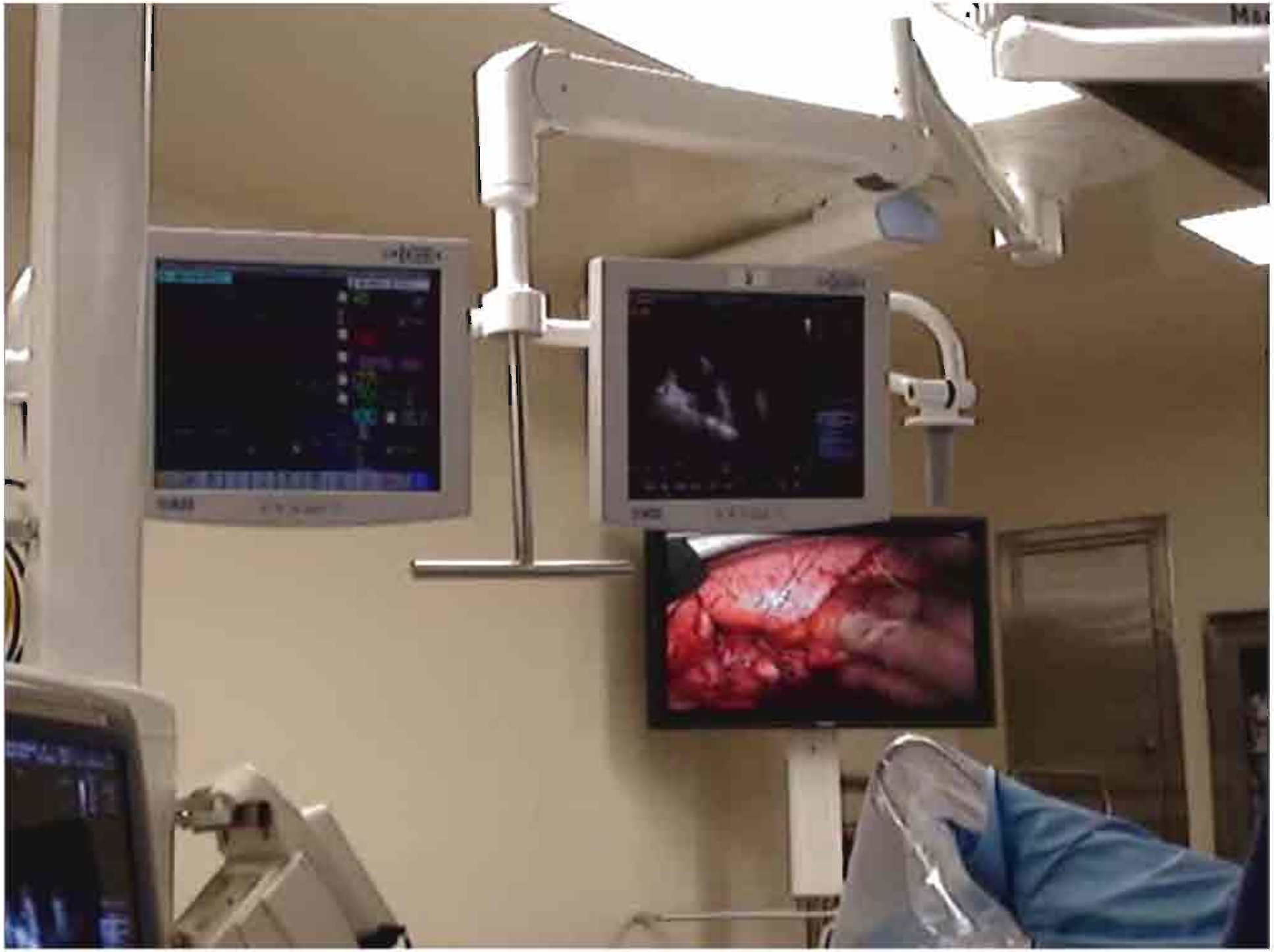
Hemodynamic instability following CPB

1 ↓ NIRS

2

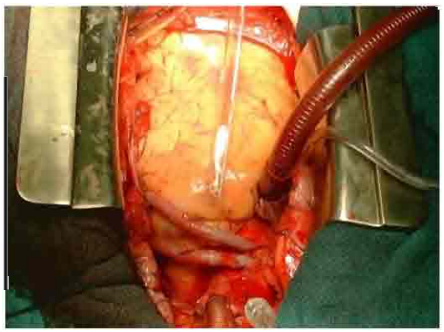
RV evaluation

- Visual assessment
- RV pressure waveform
- TEE



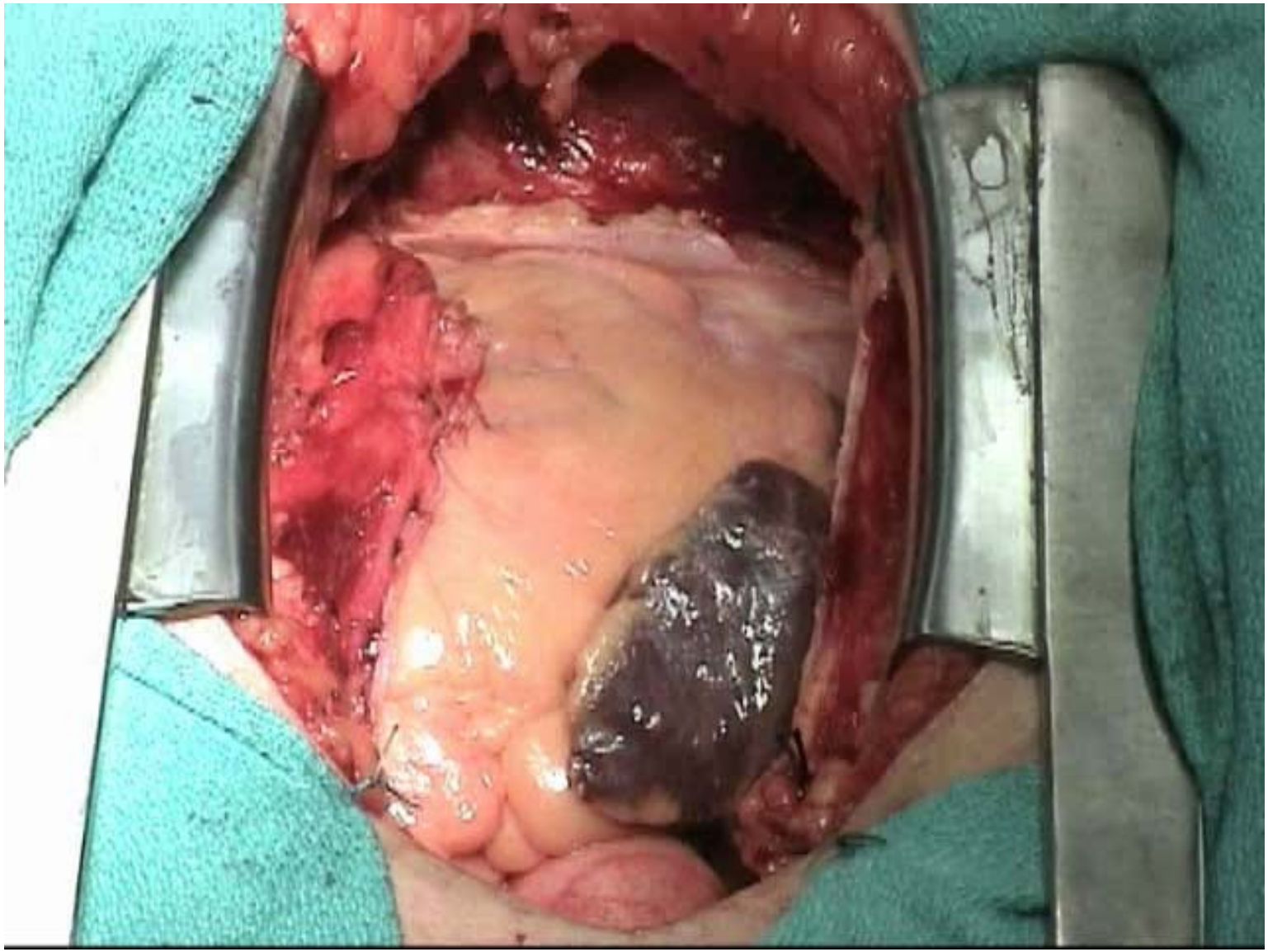
Hemodynamic instability following CPB

1. ↓ NIRS
2. RV evaluation
   - Visual assessment
   - RV pressure waveform
   - TEE



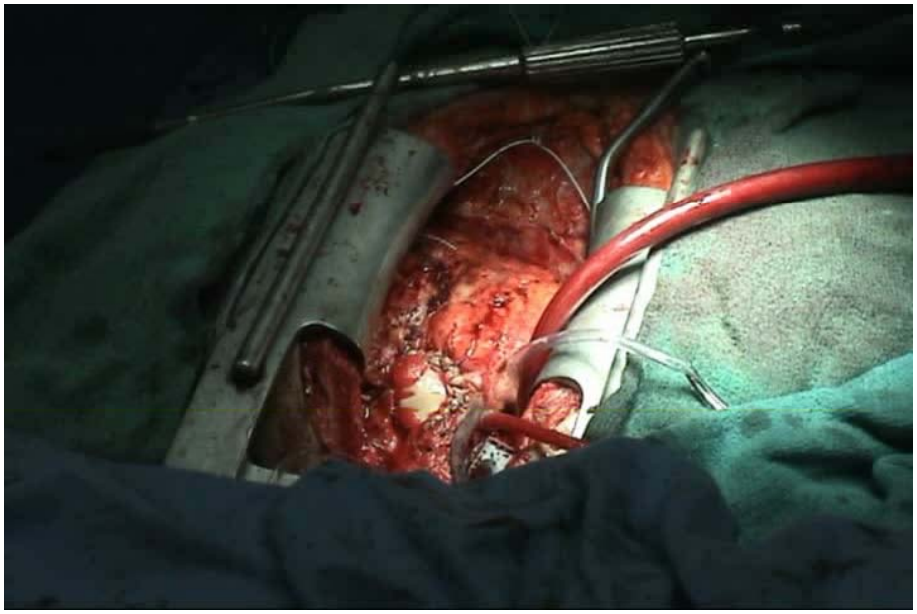
Case 1

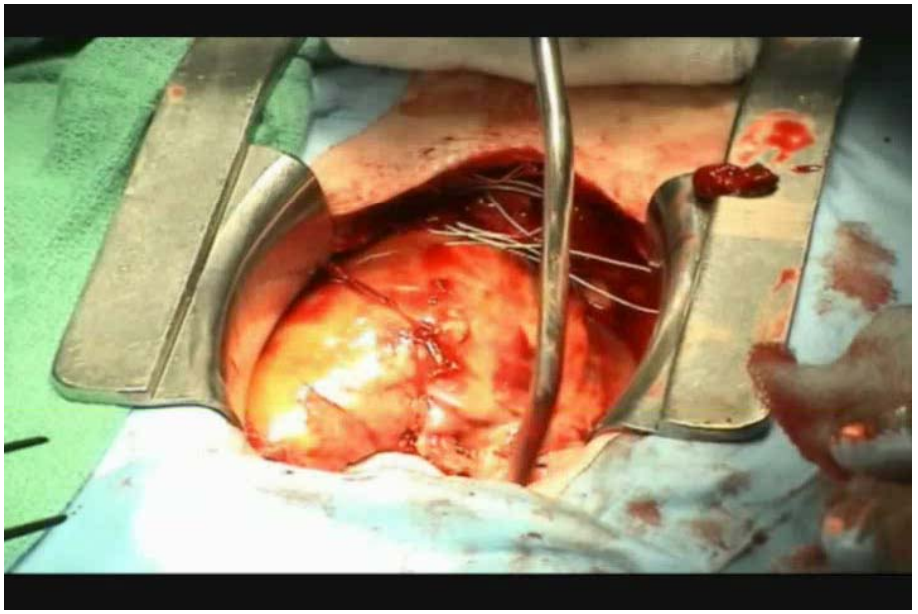
Normal RV function



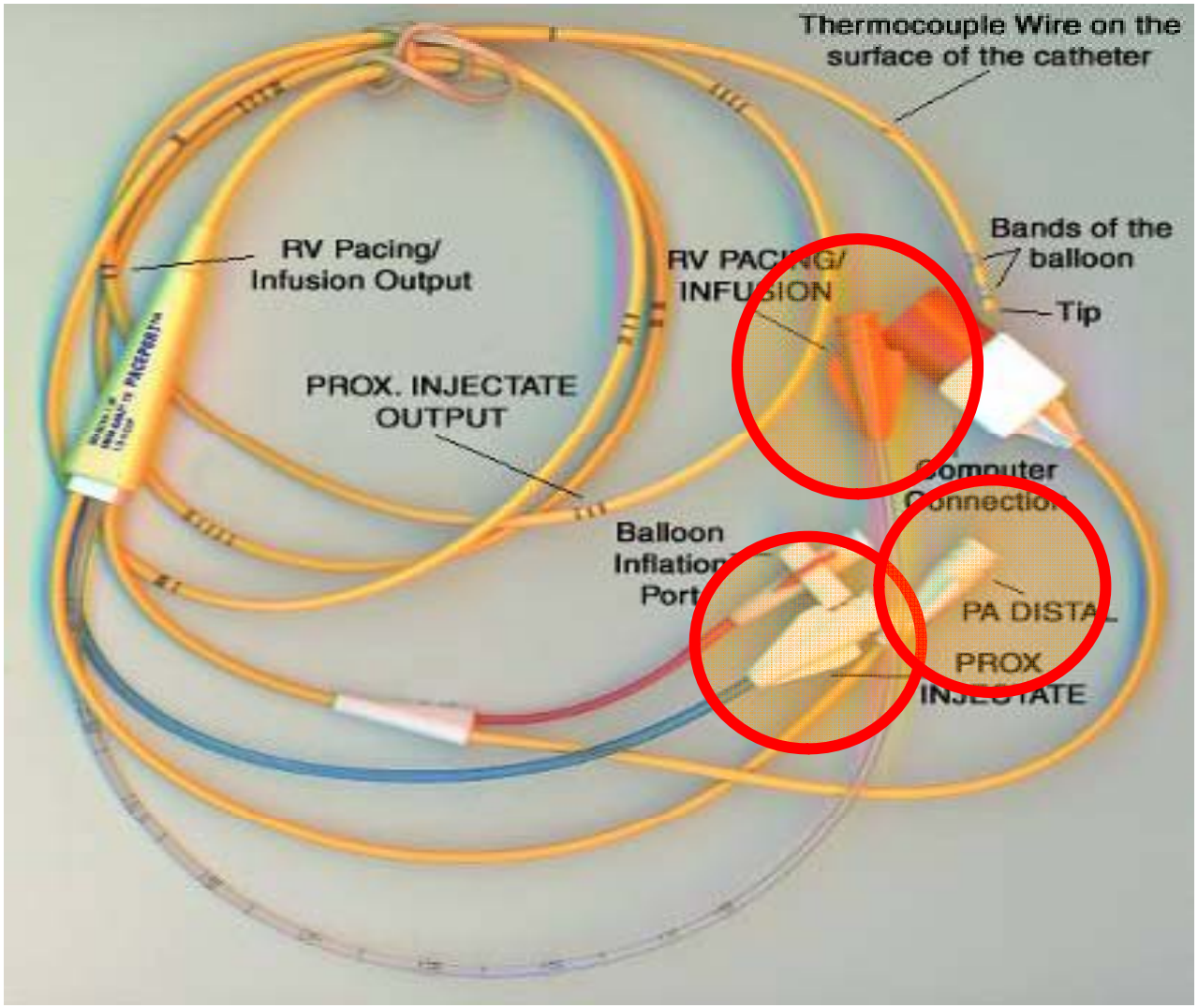
Case 1

Abnormal RV function





Is the Swan-Ganz useful in diagnosing RV dysfunction?



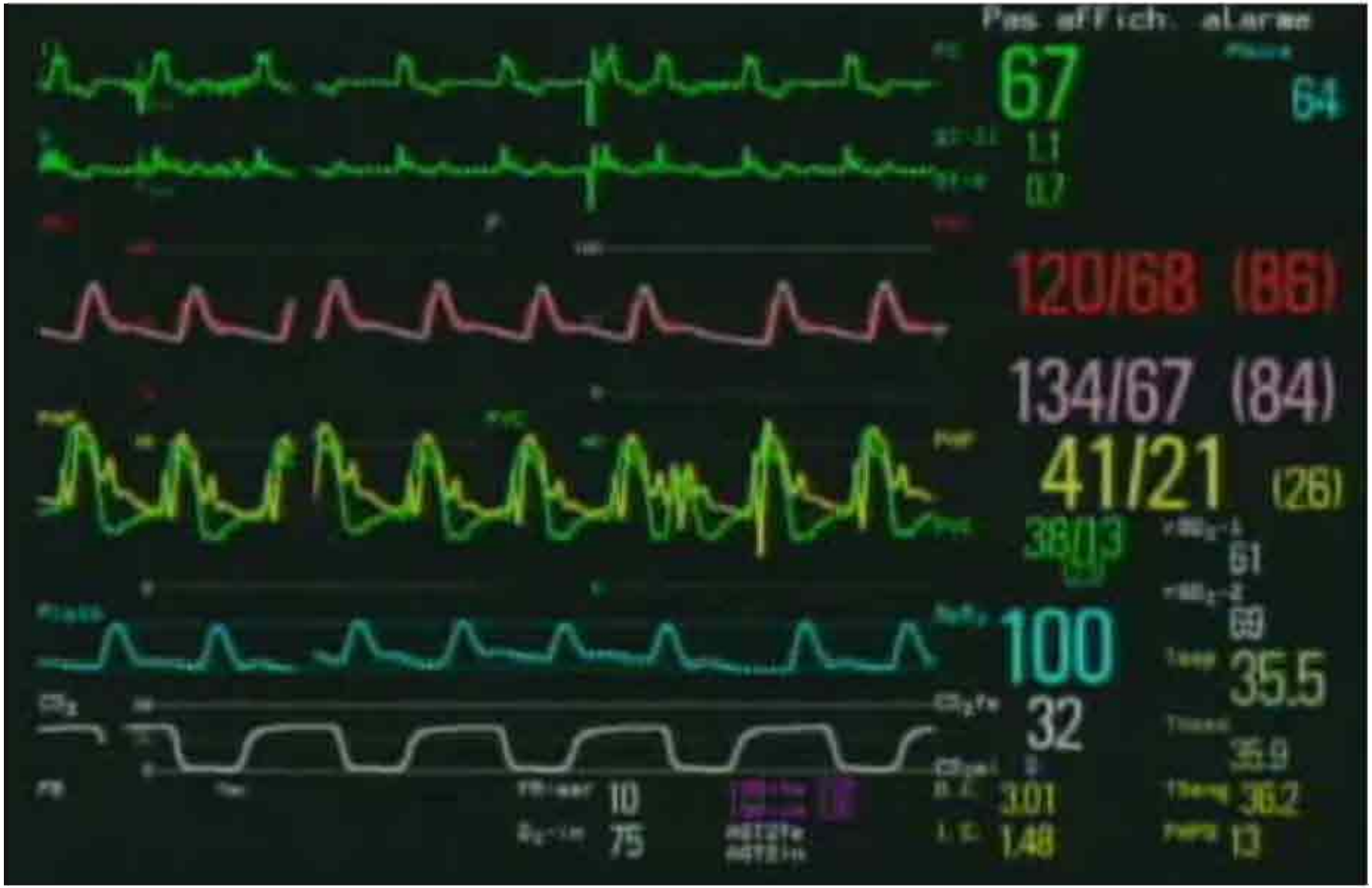
Hemodynamic instability following CPB

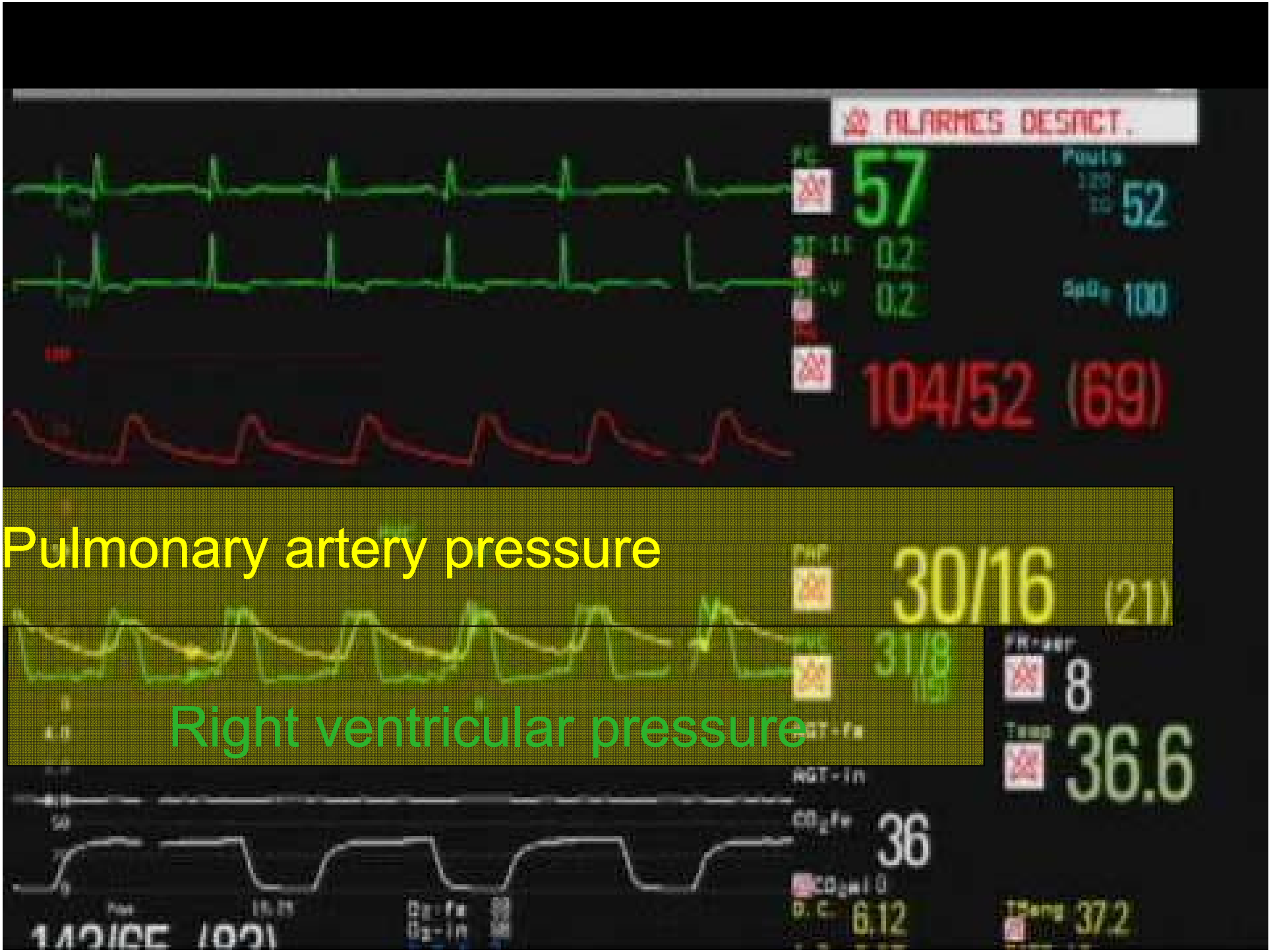
1 ↓ NIRS

2

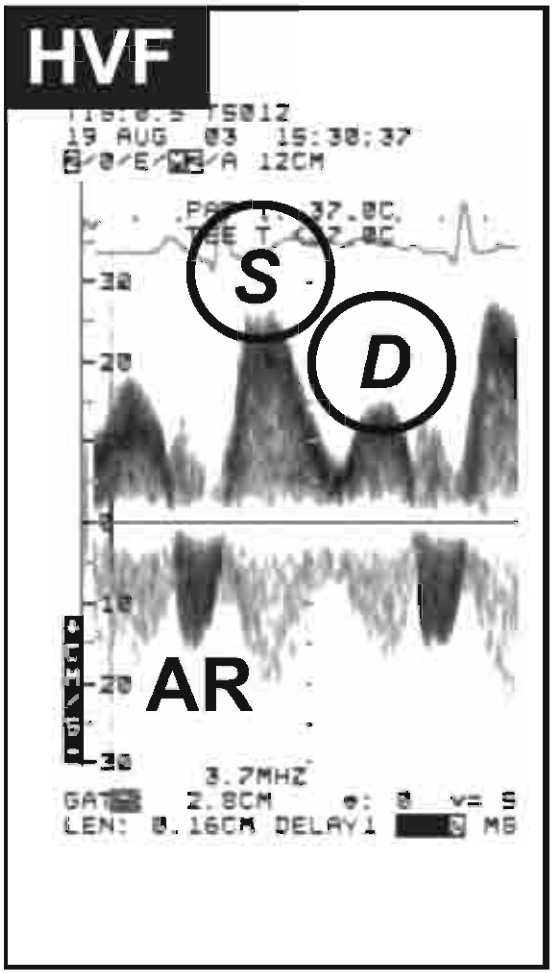
RV evaluation

- Visual assessment
- RV pressure waveform
- TEE

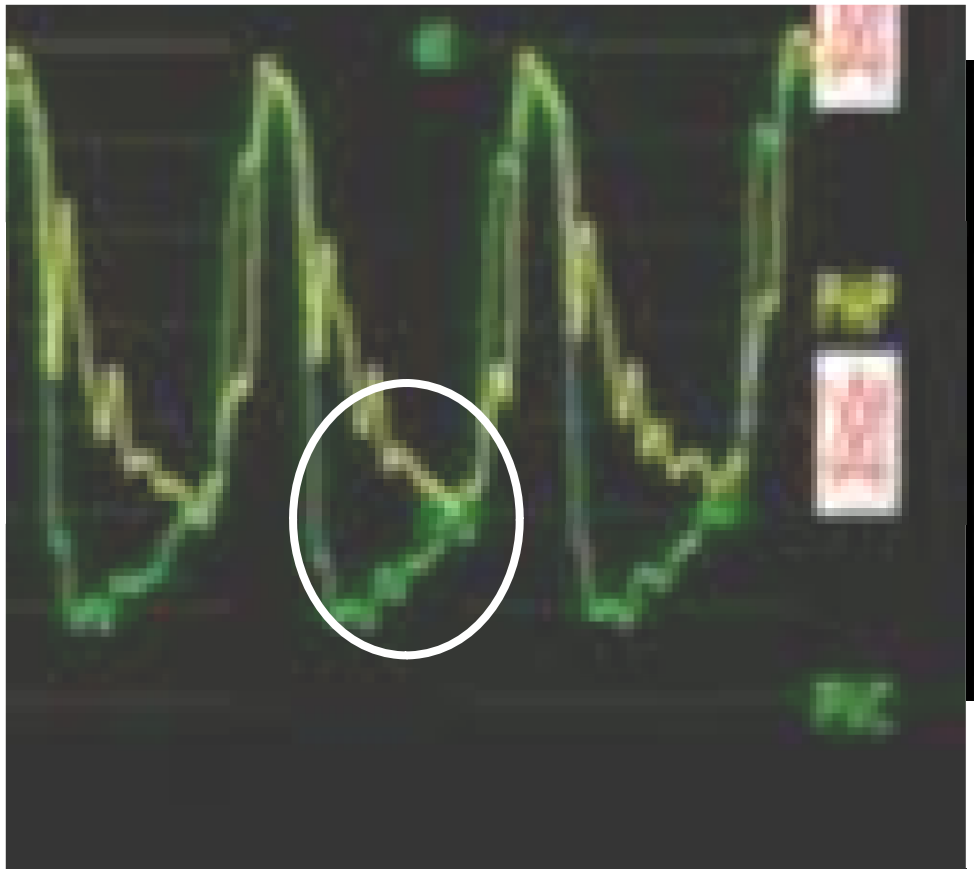

Pas affich. alarme
67
64
1.1
0.7
120/68 (86)
134/67 (84)
41/21 (26)
36.3
61
69
100
35.5
32
35.9
36.2
10
75
3.01
1.48
13


ALARMES DESACT.
57
52
0.2
0.2
100
104/52 (69)
Pulmonary artery pressure
30/16 (21)
Right ventricular pressure
8
36.6
36
6.12
37.2

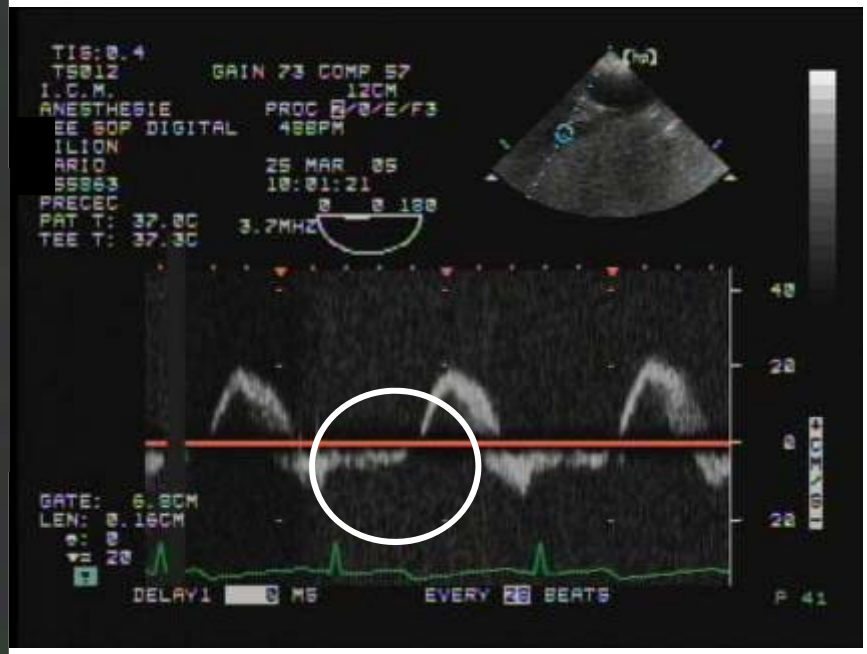

25/11


HVF
19 AUG 03 15:30:37
S
D
AR
3.7MHZ
2.8CM
LEN: 0.16CM DELAY

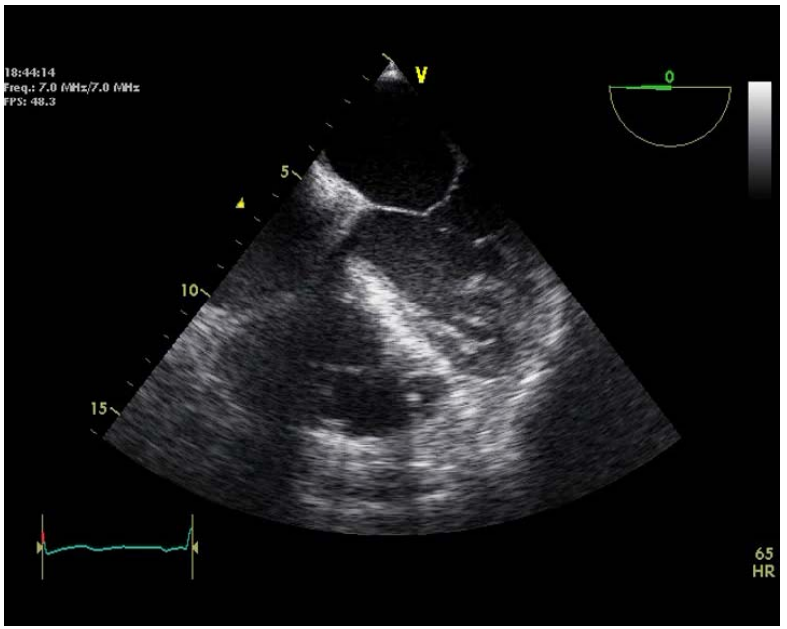
RV dysfunction



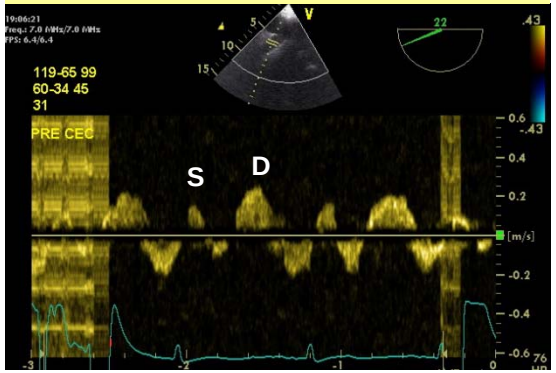
Hepatic venous flow



xPre-op RV dysfunction: ventricular septal defect

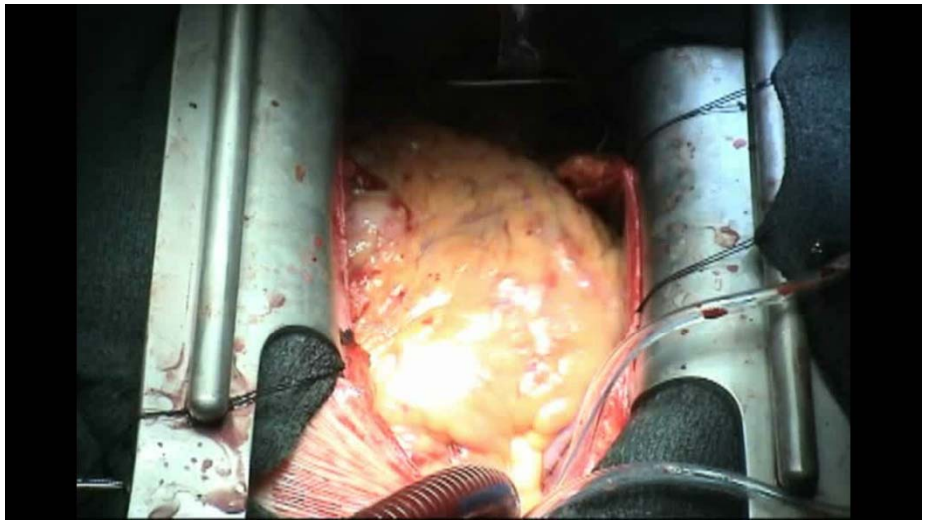


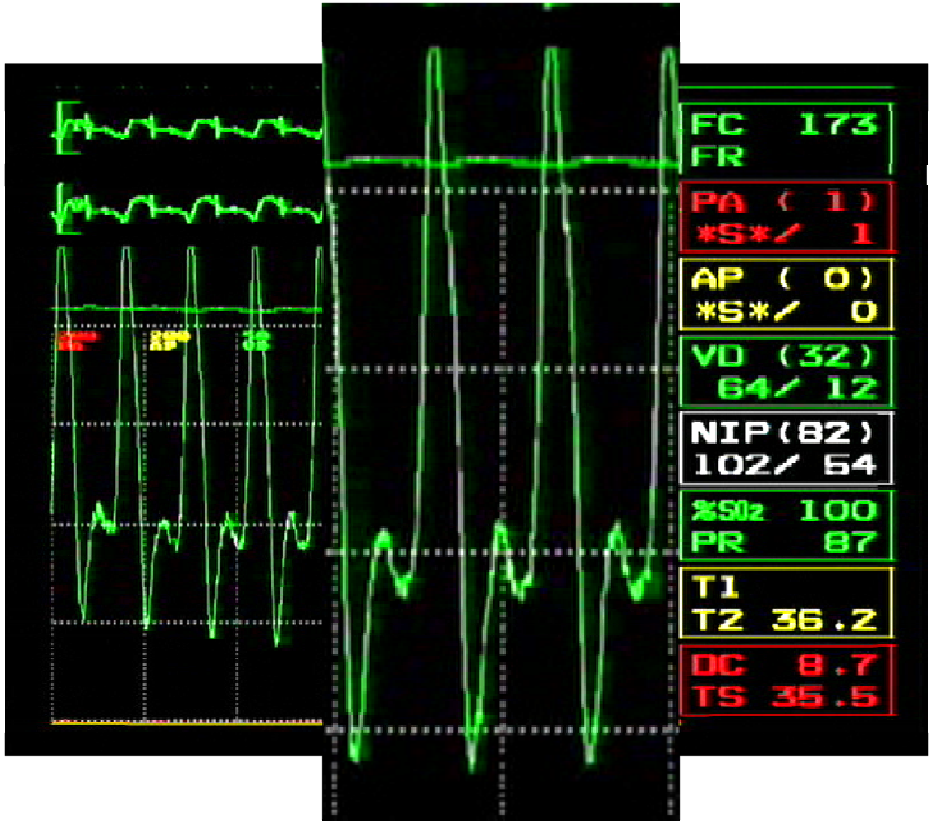
Hepatic venous flow



Robitaille JTCVA 2006

Severe RV dysfunction





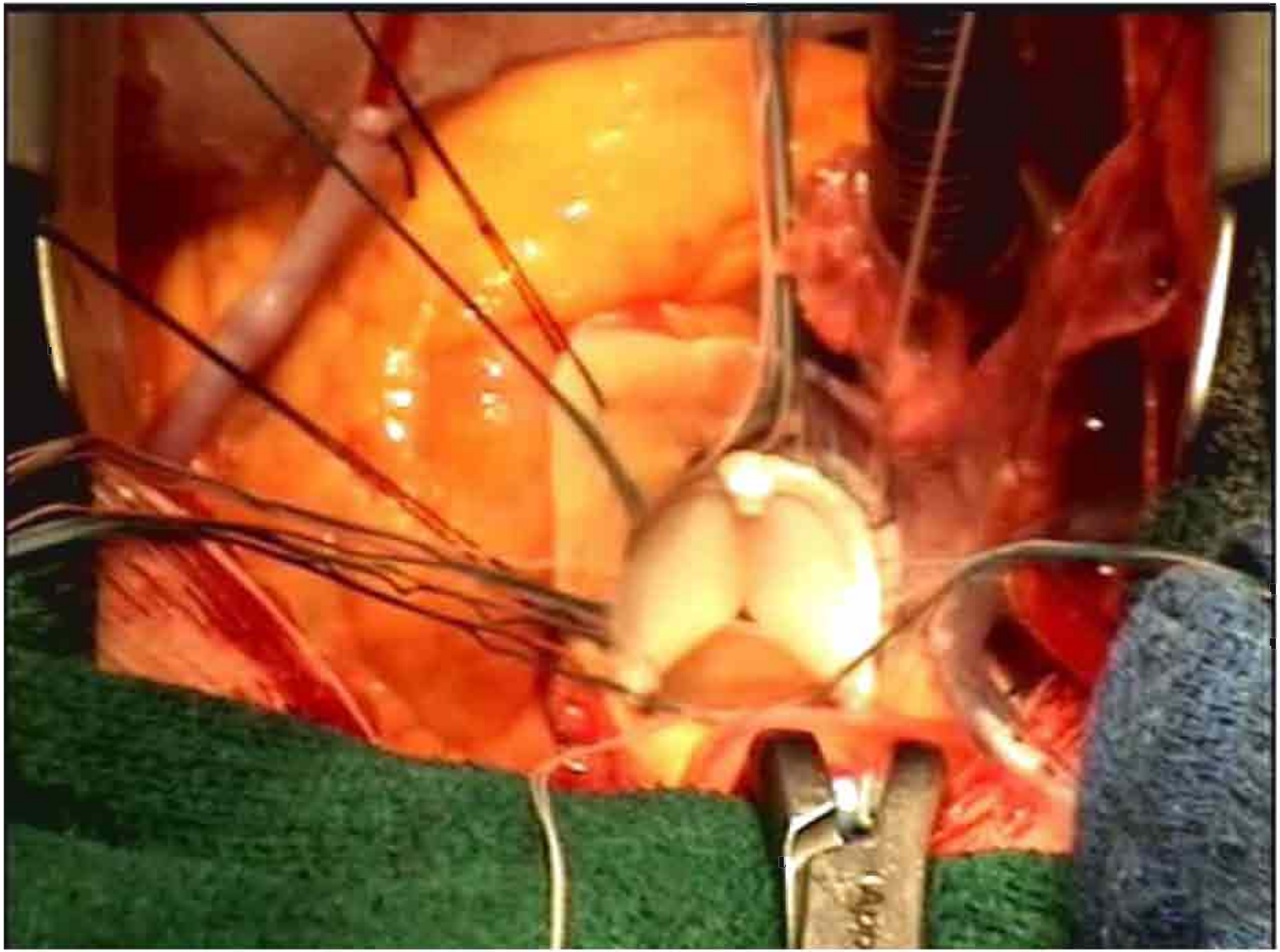
Hemodynamic instability

Severe RV dysfunction

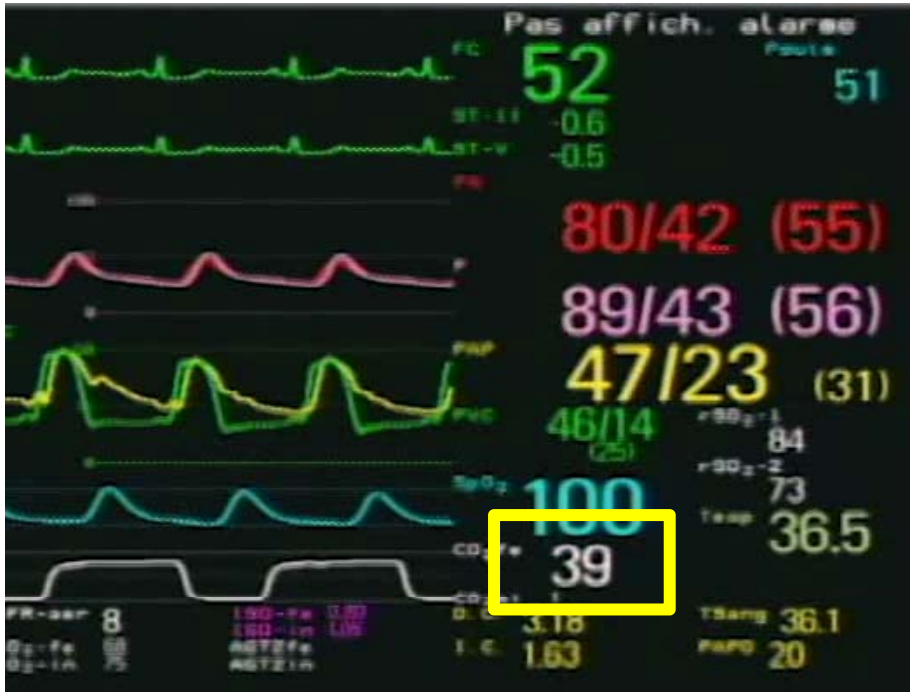
Diastolic equalisation

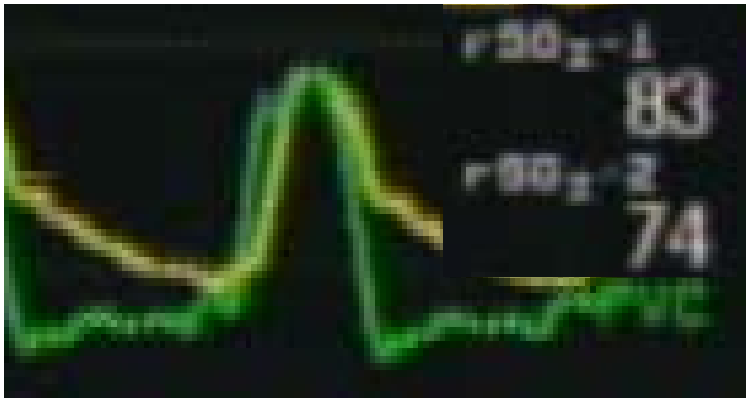
RV Pulsus tardus and ↓ pulse pressure

68 yo ♂ CABG and AVR

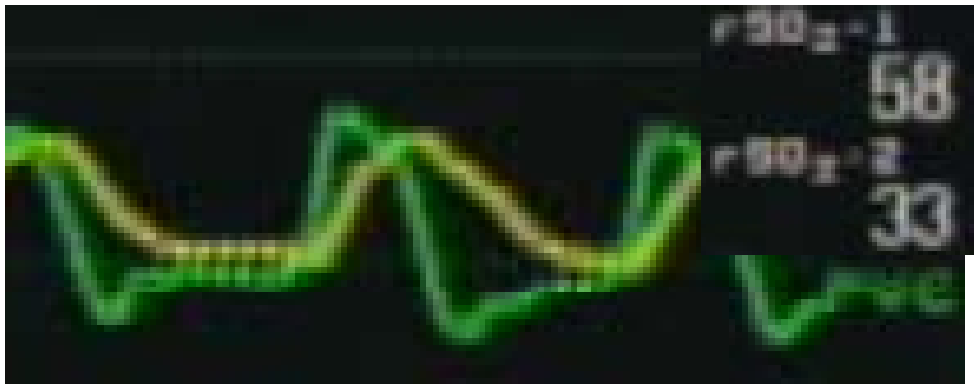


Before CPB





After CPB



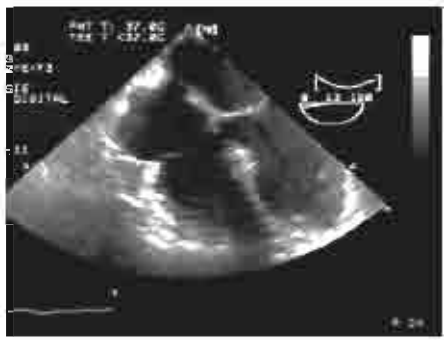
Hemodynamic instability following CPB

1 ↓ NIRS

2

RV evaluation

- Visual assessment
- RV pressure waveform
- TEE



Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography

Lawrence G. Rudski, MD, FASE, Chair, Wyman W. Lai, MD, MPH, FASE, Jonathan Afilalo, MD, Msc, Lanqi Hua, RDCS, FASE, Mark D. Handschumacher, BSc, Krishnaswamy Chandrasekaran, MD, FASE, Scott D. Solomon, MD, Eric K. Louie, MD, and Nelson B. Schiller, MD, *Montreal, Quebec, Canada; New York, New York; Boston, Massachusetts; Phoenix, Arizona; London, United Kingdom; San Francisco, California*

(J Am Soc Echocardiogr 2010;23:685-713.)

The Right Ventricle in Cardiac Surgery, a Perioperative Perspective: I. Anatomy, Physiology, and Assessment

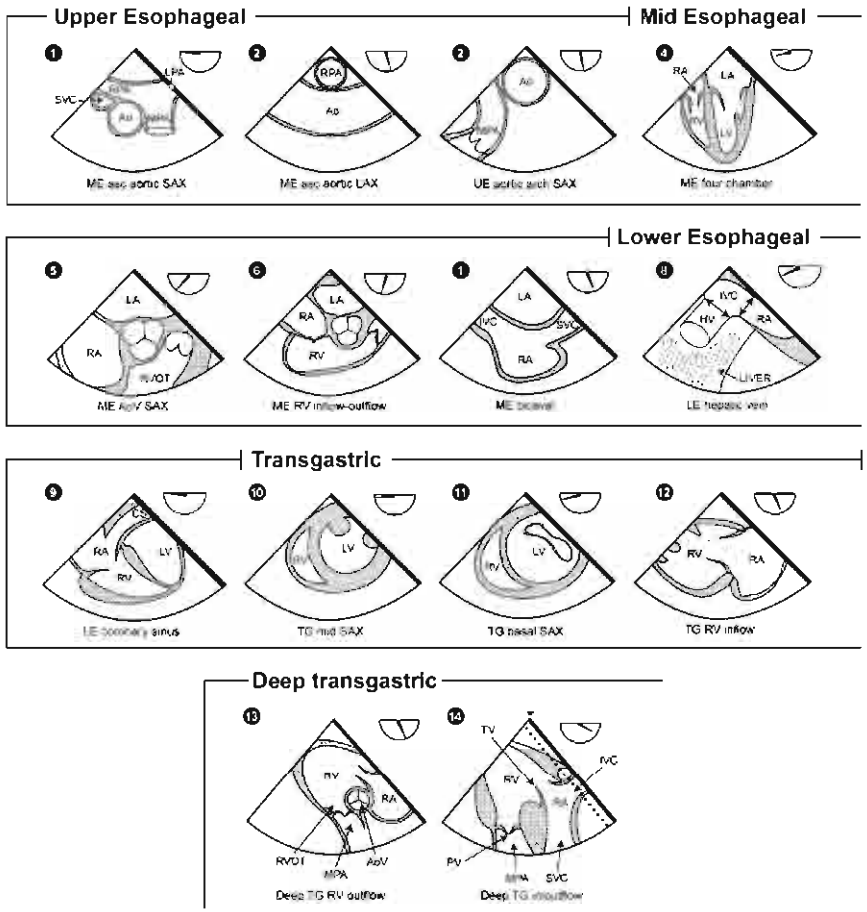
(Anesth Analg 2009;108:407–21)

François Haddad, MD*†

Pierre Couture, MD*

Claude Tousignant, MD*

André Y. Denault, MD*



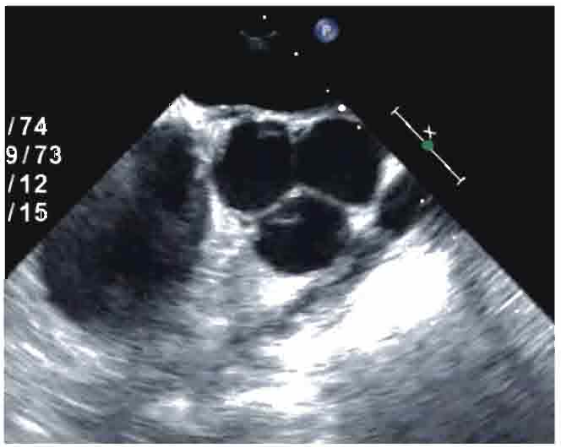
Hemodynamic instability following CPB

1 ↓ NIRS

2

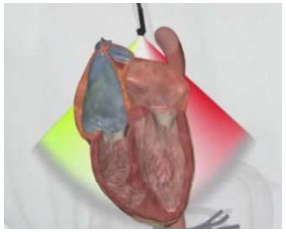
RV evaluation

- Visual assessment
- RV pressure waveform
  - Gradient
    - ≻25 mmHg
      - 3 TEE confirmation
        - 
        - Stop inotropes
        - Fluid and heart rate control
- TEE

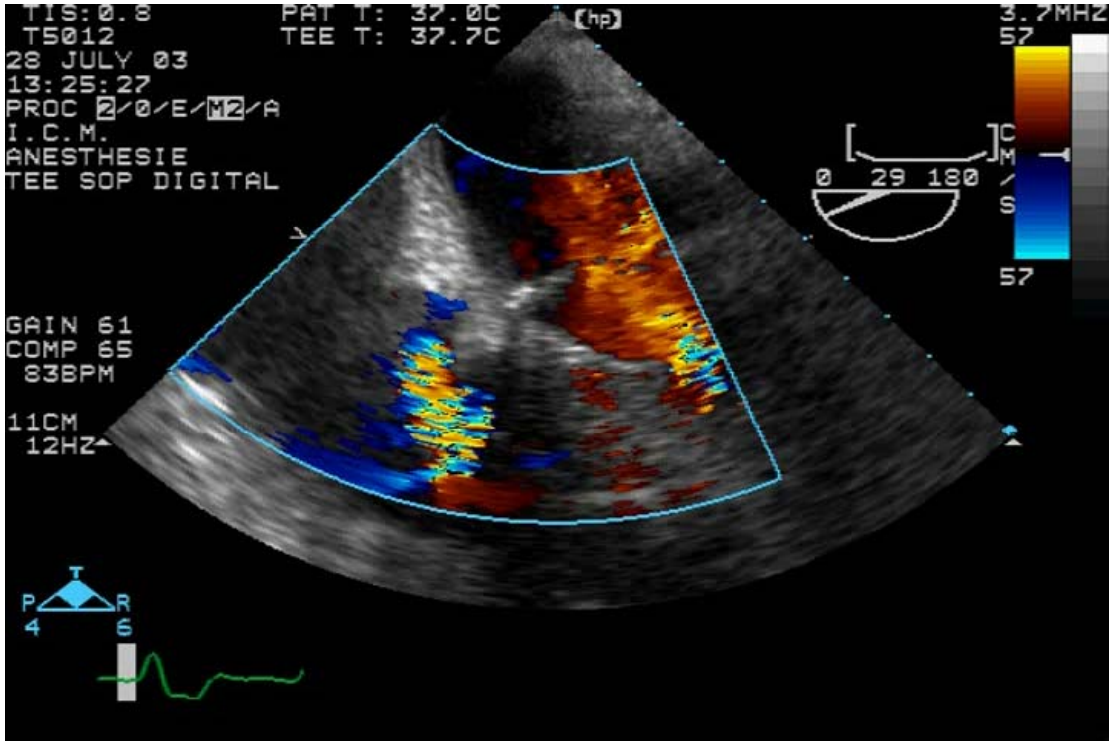


Case 2

- 75 year old woman
- Underwent CABG and AVR
- Went back on CPB X 2
- MAP 91/30, PAP 34/26 ,Pra 20 mmHg
- On adrenaline, milrinone and dopamine



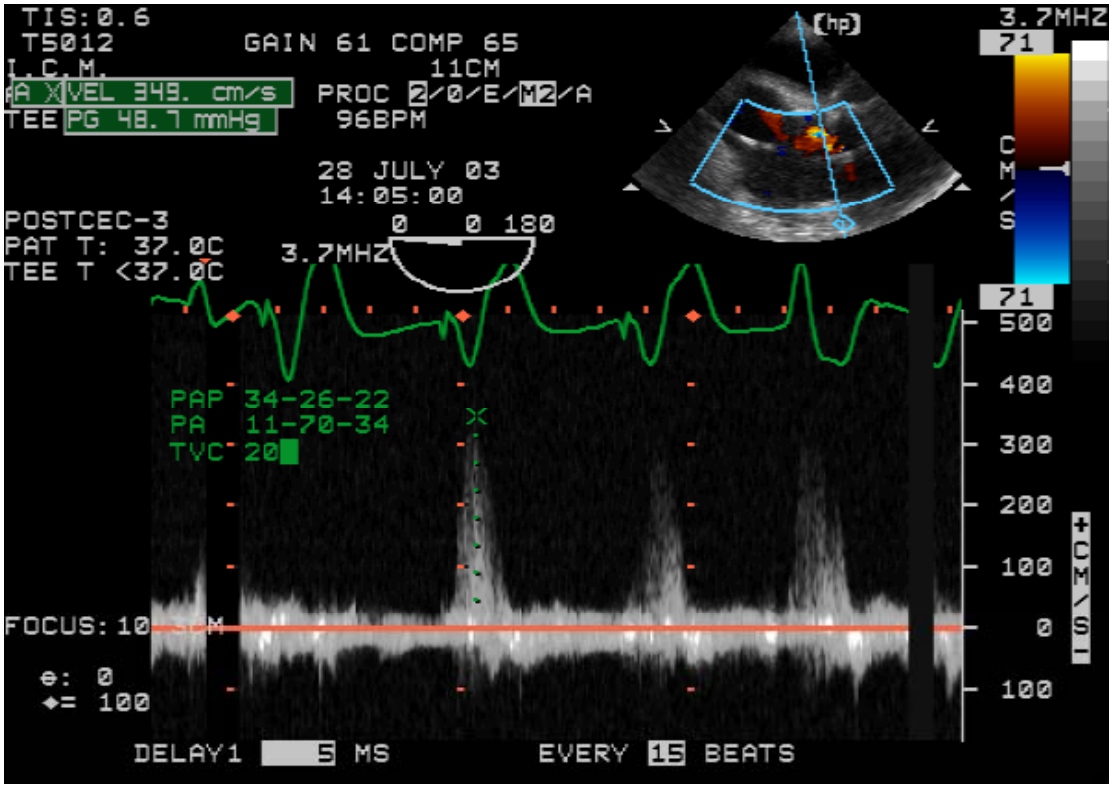
Normal

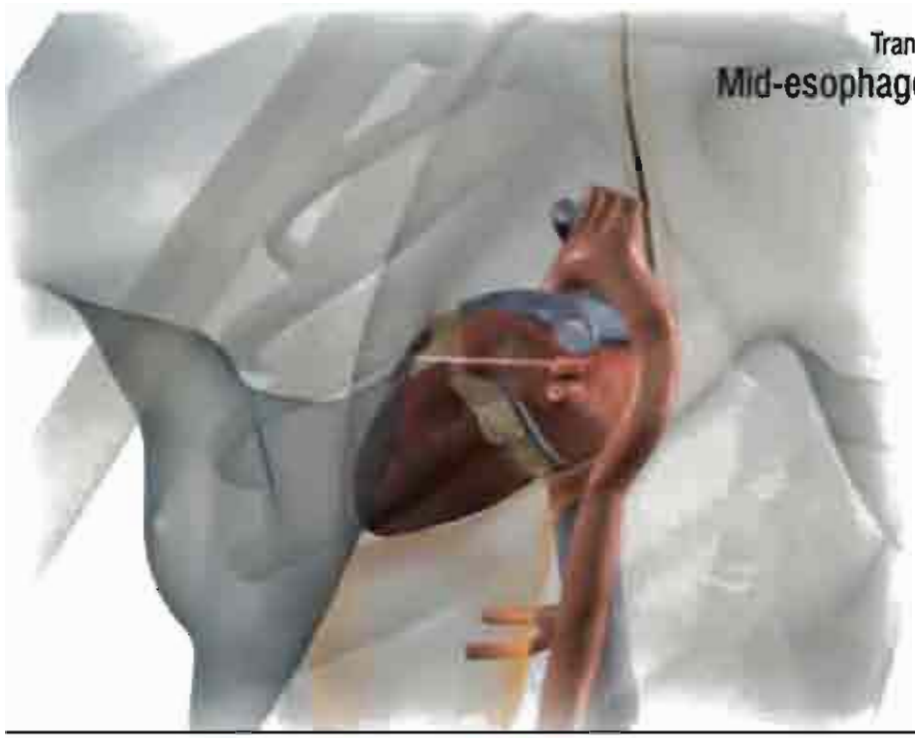


Case 2

48 mmg gradient with a Pra of 20 mmHg
Systolic Pap of 68 mmHg
Measured systolic Pap = 34 mmHg ???

Continuous wave Doppler





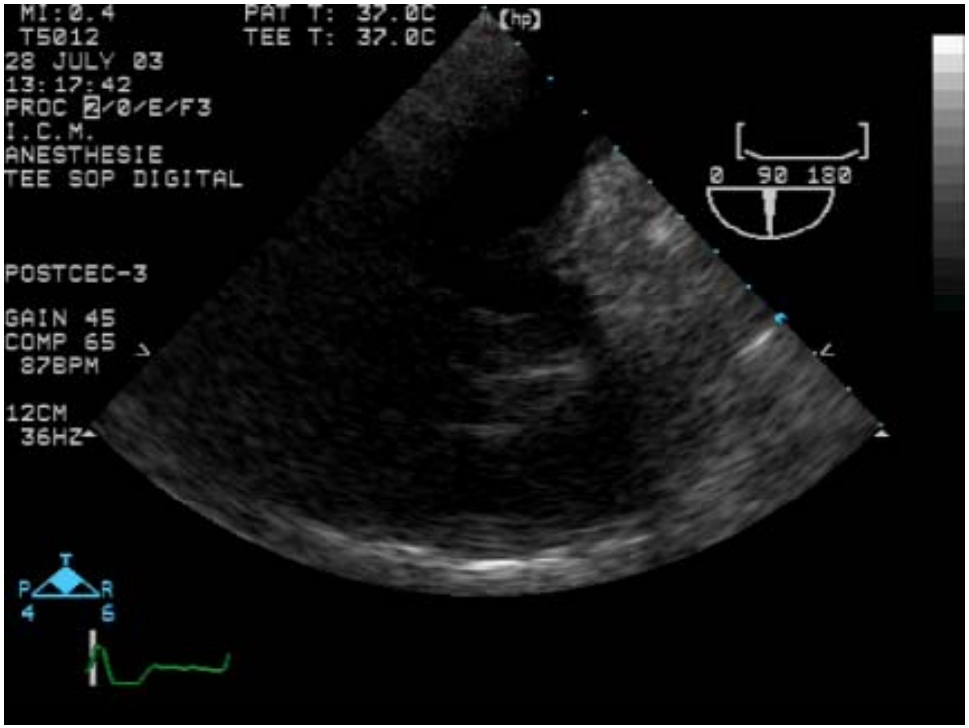
Transesophageal echocardiography

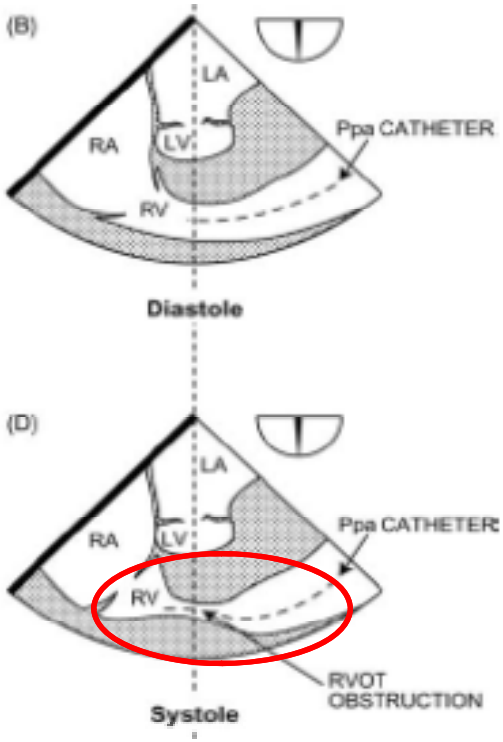
Mid-esophageal inflow-outflow view

Case 2

Normal

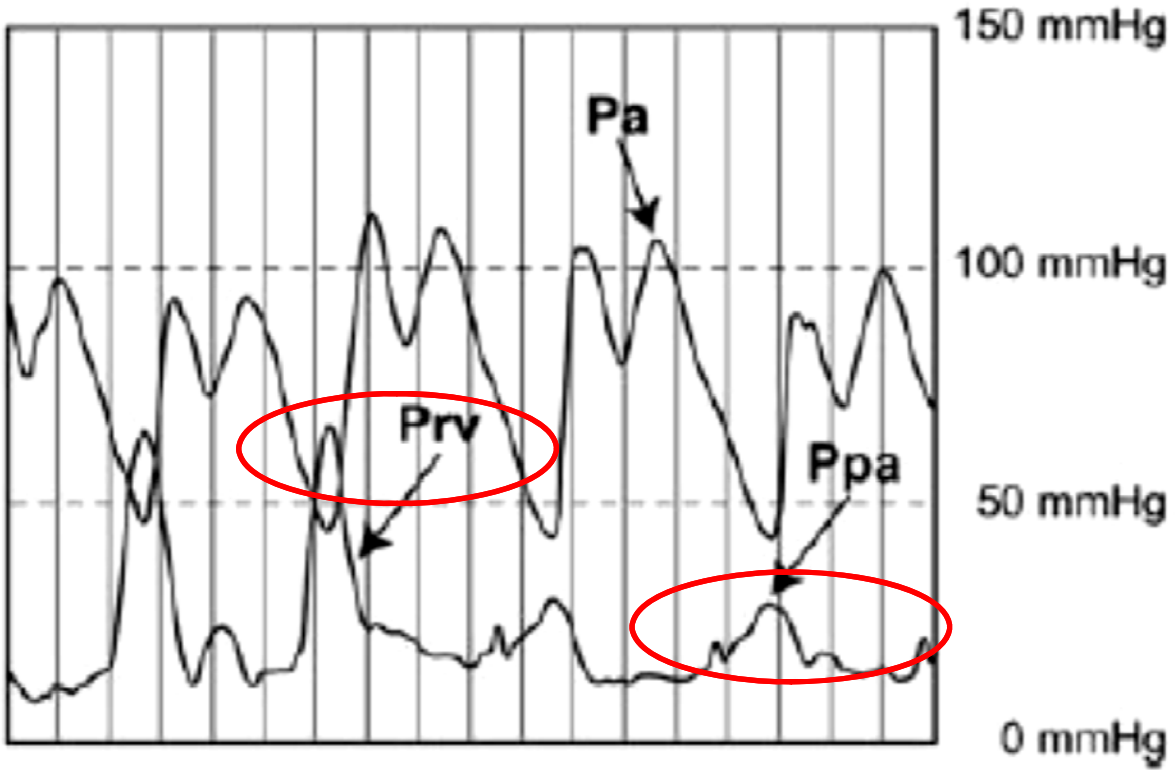
ME inflow-outflow view

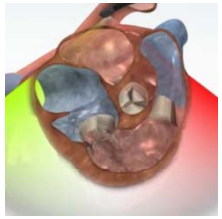


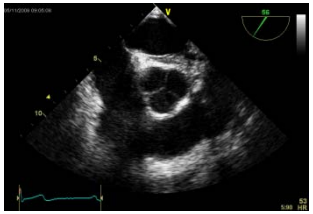


Denault et al TEE multimedia manual 2005

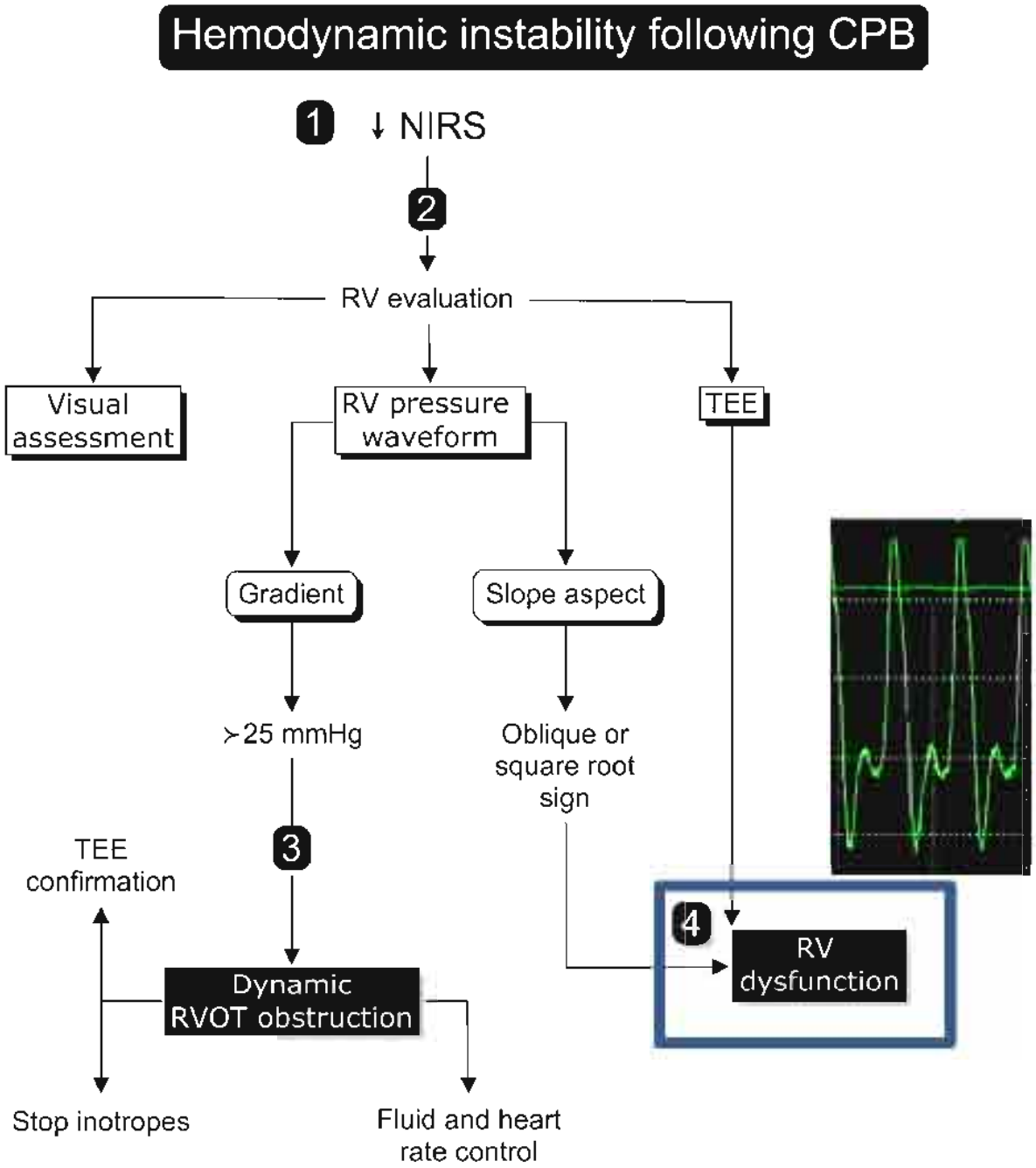
RVOT obstruction

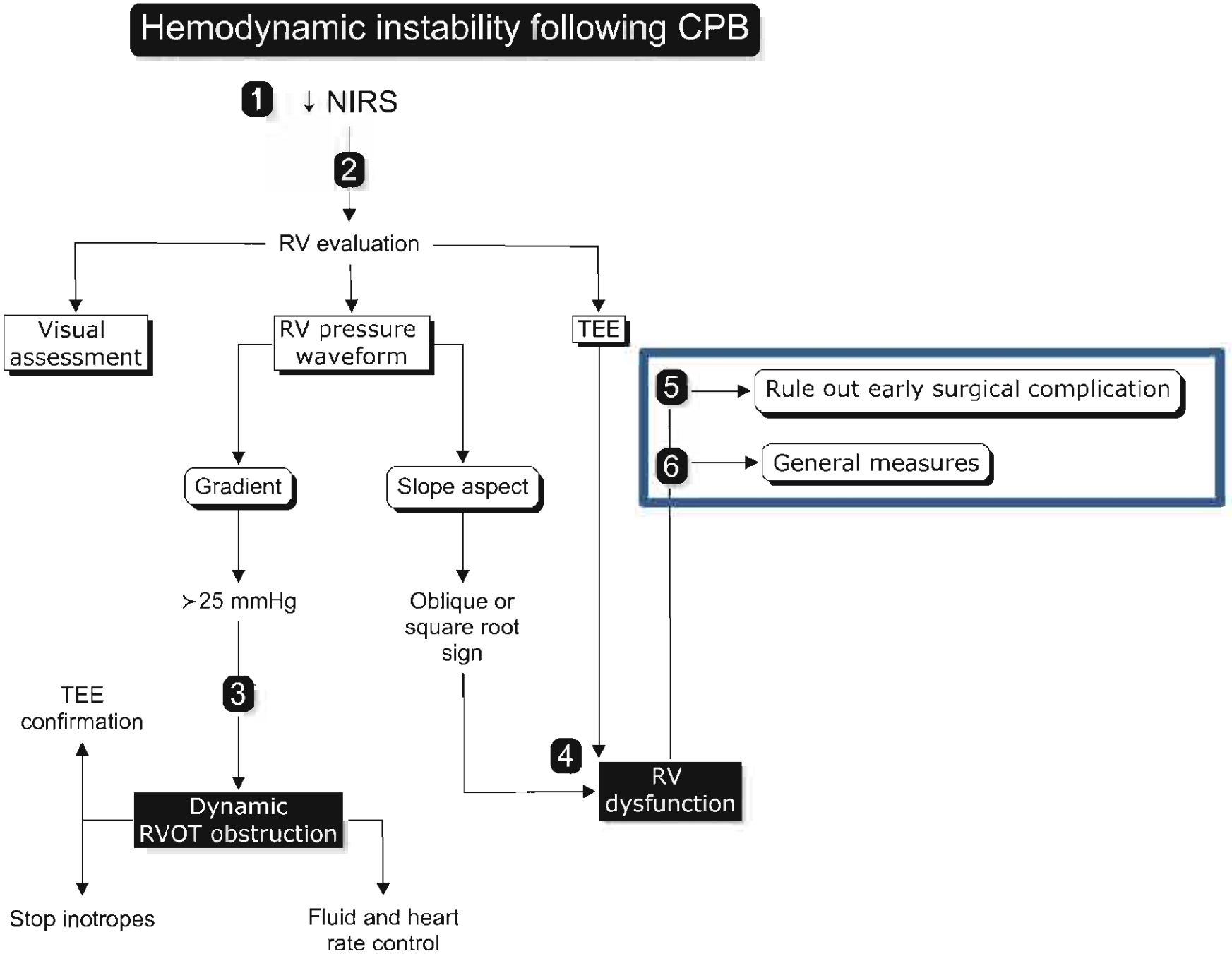




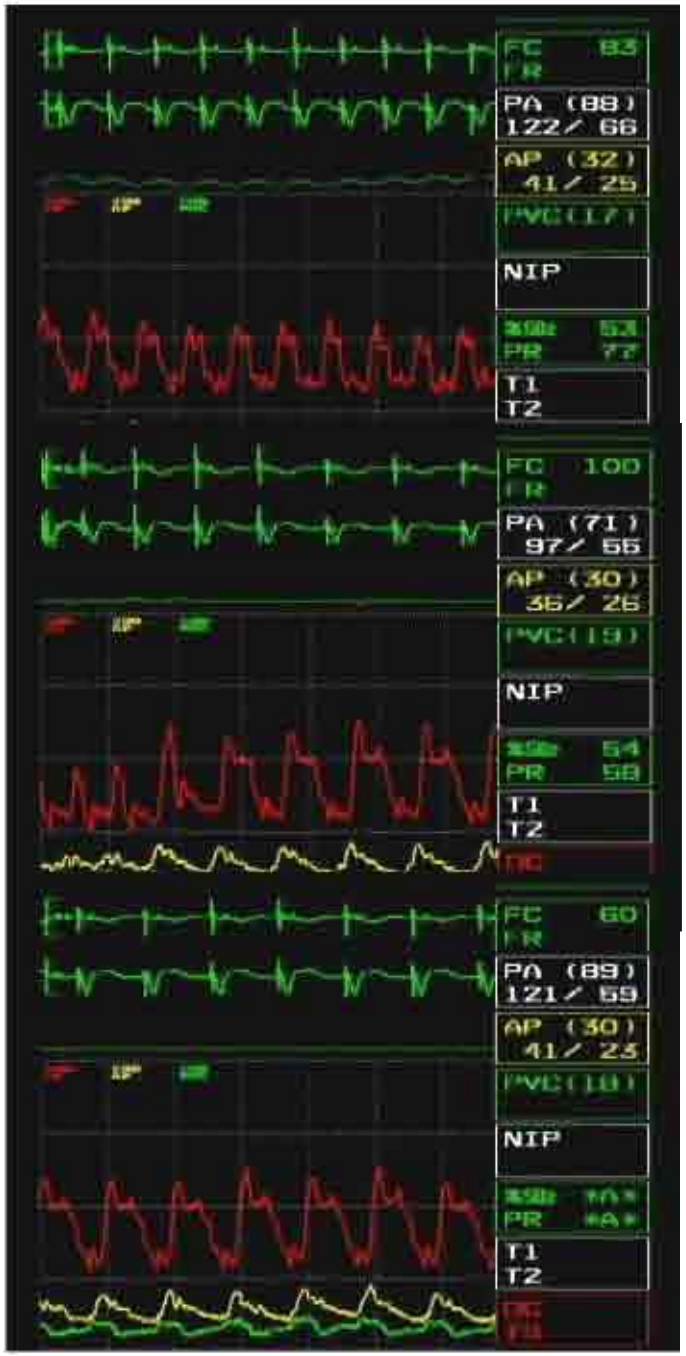


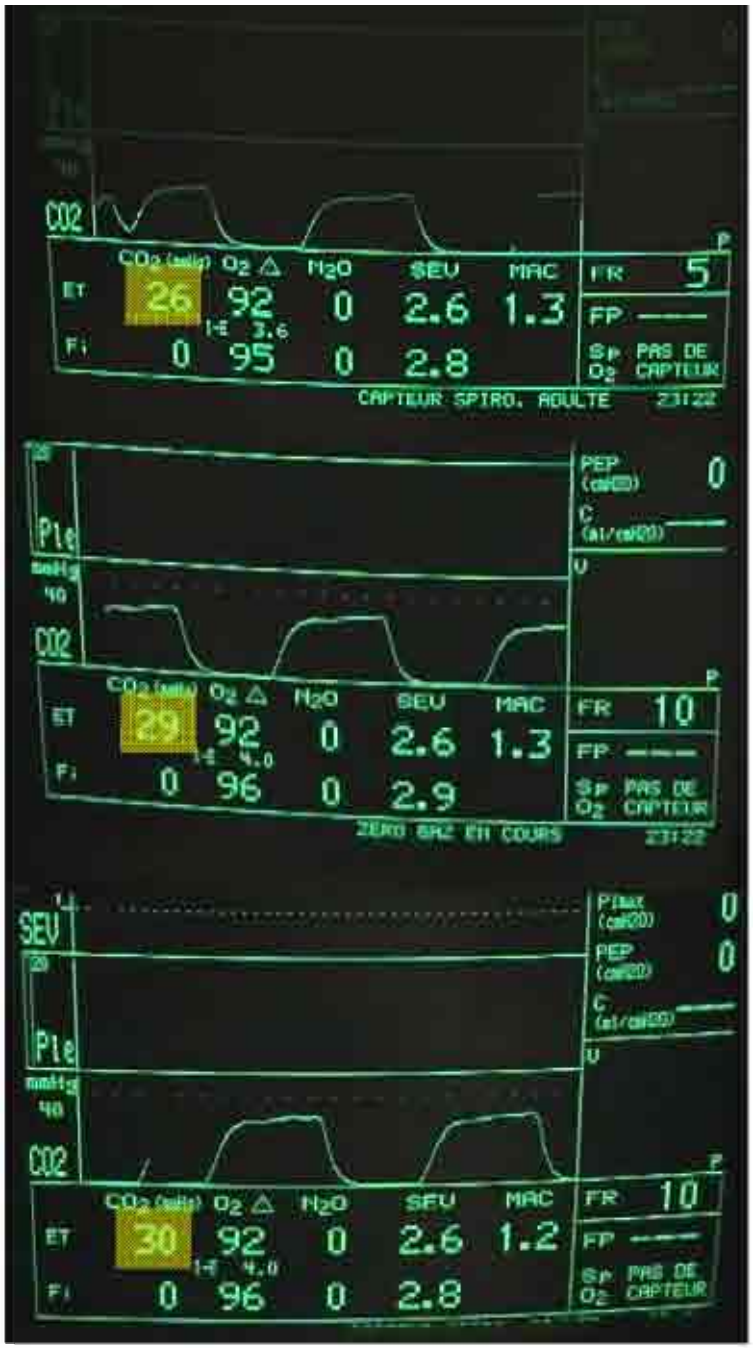
Haddad et al Anesth Analg 2009


Hemodynamic instability following CPB
1
↓ NIRS
2
RV evaluation
Visual assessment
RV pressure waveform
TEE
Gradient
Slope aspect
>25 mmHg
Oblique or square root sign
3
TEE confirmation
Dynamic RVOT obstruction
Stop inotropes
Fluid and heart rate control
4
RV dysfunction


Hemodynamic instability following CPB
1
↓ NIRS
2
RV evaluation
Visual assessment
RV pressure waveform
TEE
5
Rule out early surgical complication
6
General measures
Gradient
Slope aspect
>25 mmHg
Oblique or square root sign
3
TEE confirmation
4
RV dysfunction
Dynamic RVOT obstruction
Stop inotropes
Fluid and heart rate control

Heart rate optimisation


FC 83
FR
PA (88)
122/ 66
AP (32)
41/ 25
PVC(17)
NIP
SpO2 93
PR 72
T1
T2
FC 100
FR
PA (71)
97/ 55
AP (30)
36/ 25
PVC(19)
NIP
SpO2 94
PR 98
T1
T2
FC 60
FR
PA (89)
121/ 59
AP (30)
41/ 25
PVC(10)
NIP
SpO2 ***
PR ***
T1
T2


CO2
ET
26
92
0
2.6
1.3
FR 5
FP
Sp PAS DE
O2 CAPTEUR
F
0
95
0
2.8
CAPTEUR SPIRO. ADULTE
23122
Ple
PEP 0
CO2
ET
29
92
0
2.6
1.3
FR 10
FP
Sp PAS DE
O2 CAPTEUR
F
0
96
0
2.9
ZERO SAT EN COURS
23122
SEV
Ple
CO2
ET
30
92
0
2.6
1.2
FR 10
FP
Sp PAS DE
O2 CAPTEUR
F
0
96
0
2.8

Hemodynamic instability following CPB

1 ↓ NIRS

2

RV evaluation

- Visual assessment
- RV pressure waveform
  - Gradient
    - ➢25 mmHg
      - 3
        - TEE confirmation
        - Dynamic RVOT obstruction
          - Stop inotropes
          - Fluid and heart rate control
  - Slope aspect
    - Oblique or square root sign
- TEE

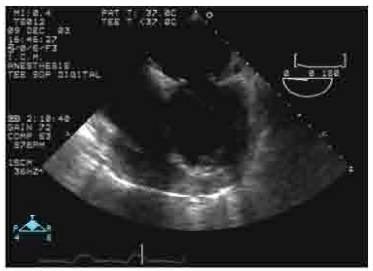
4 RV dysfunction

5 Rule out early surgical complication

6 General measures

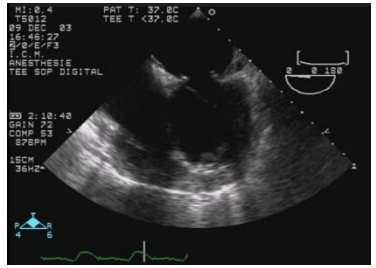
7 Possible ischemia & LV dysfunction

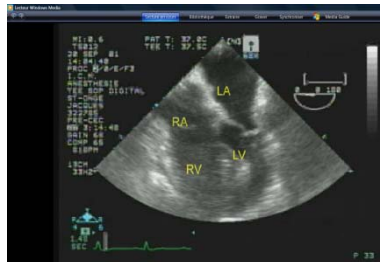
8 No ischemia & no LV dysfunction

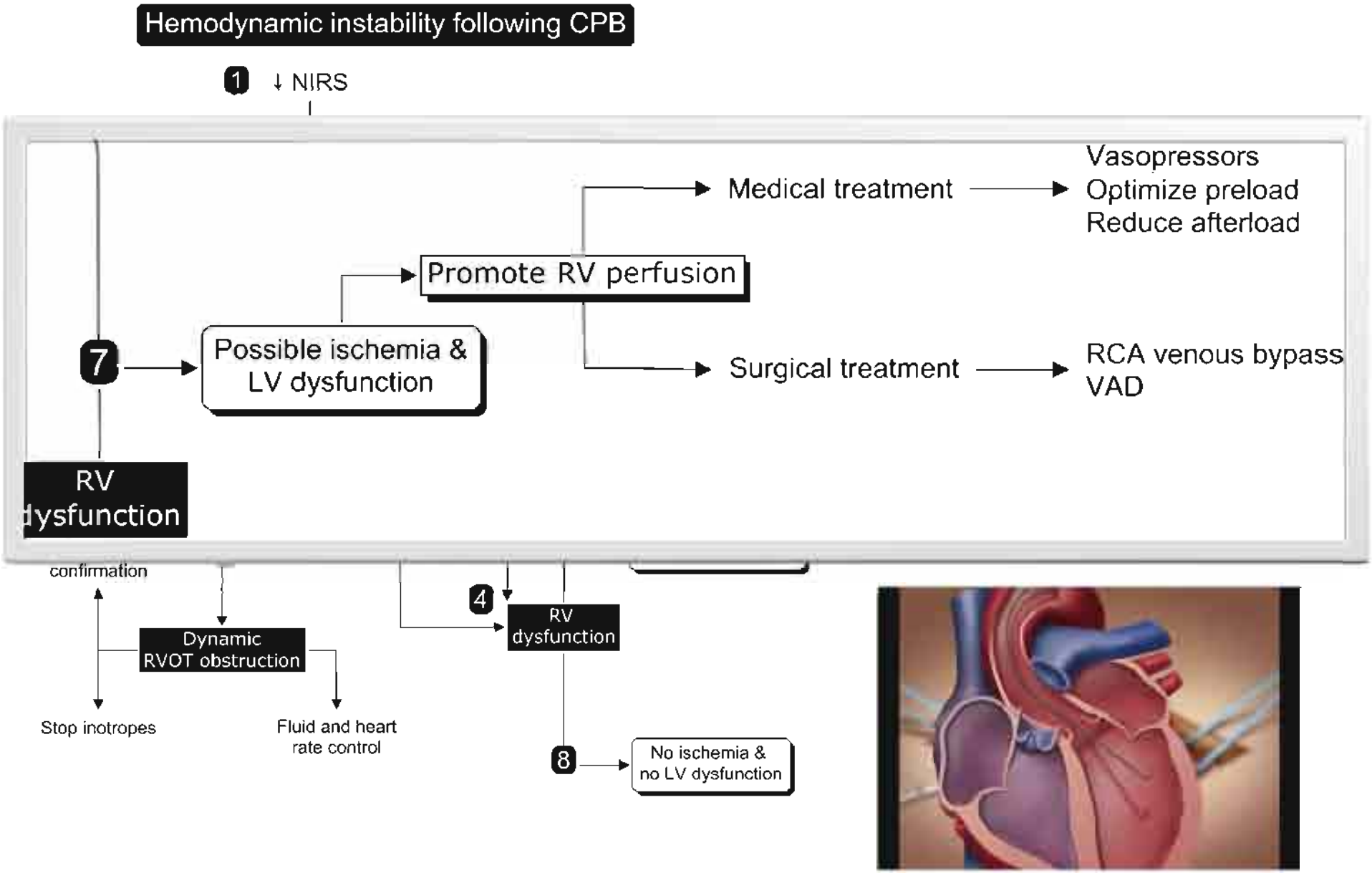


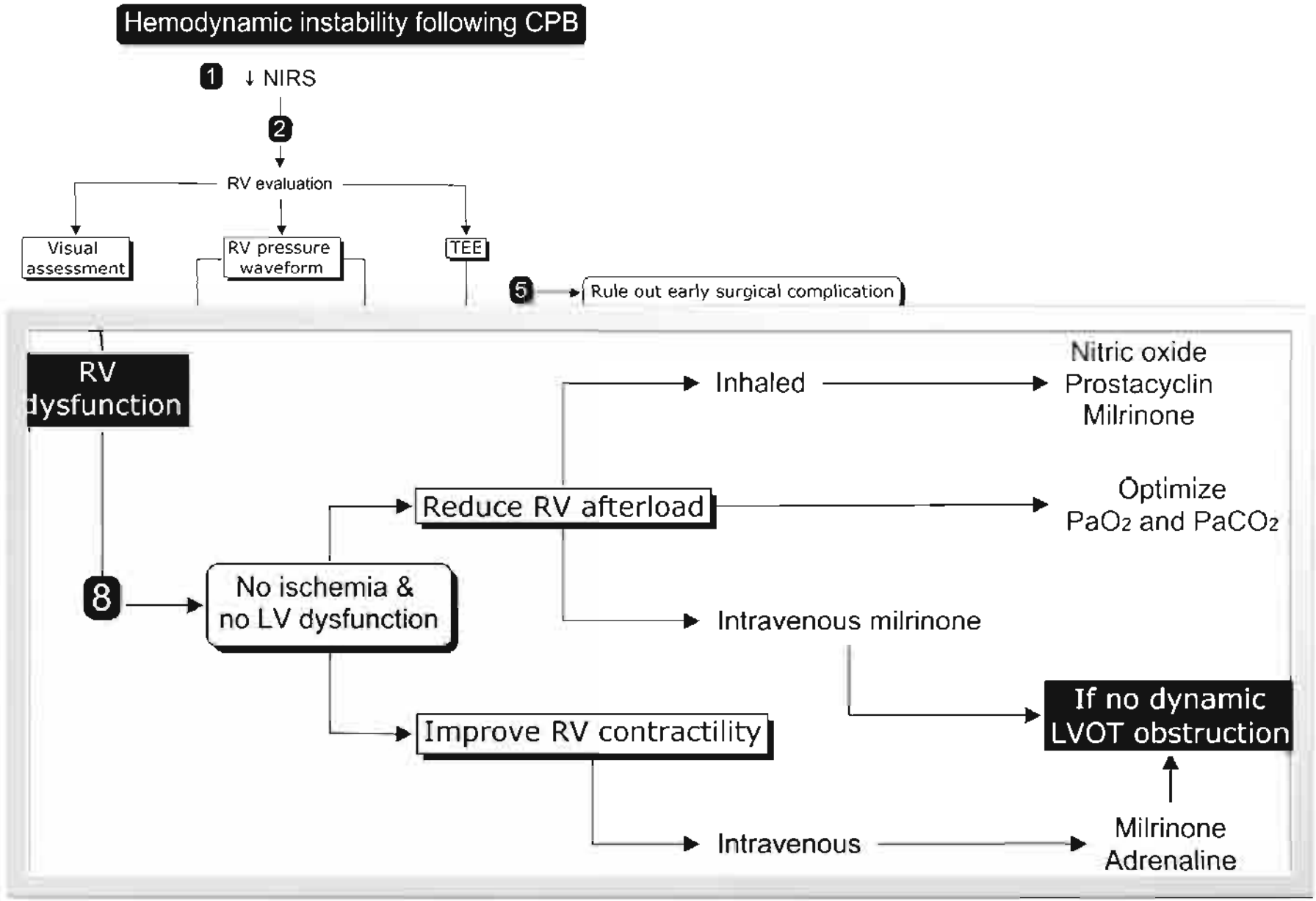
Management of RV failure

- Two types of acute RV failure
  - Systolic failure: ischemic or not
    - Associated with LV failure
  - Acute increase in afterload (non-ischemic)
    - Associated with normal LV function

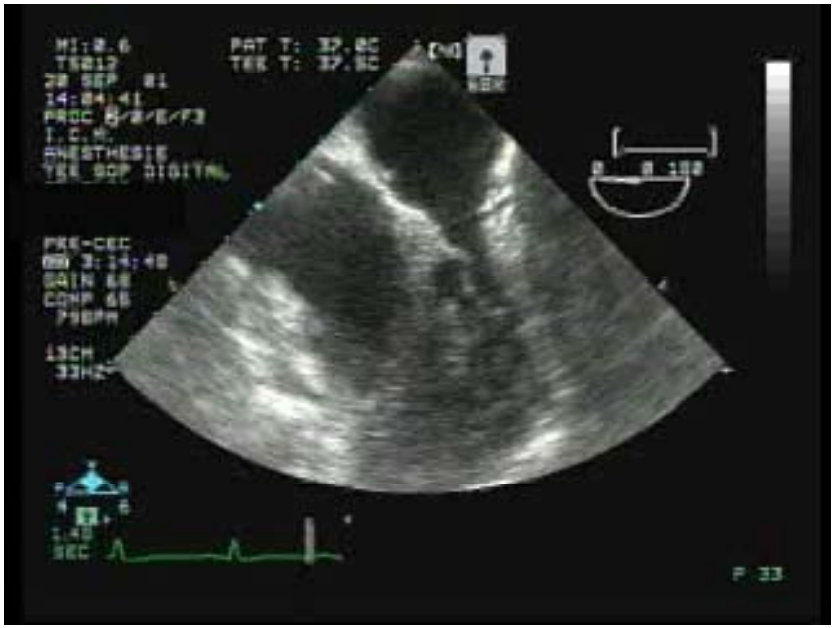


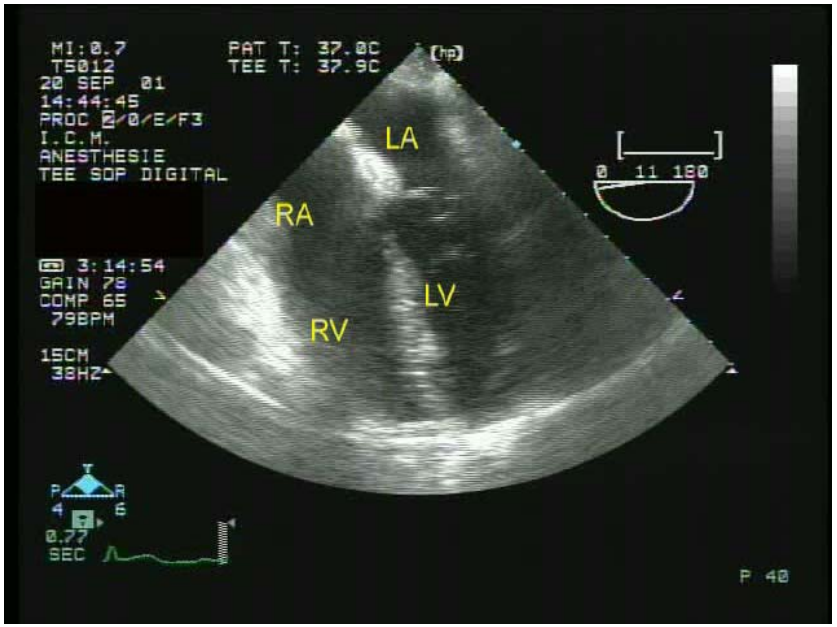



Hemodynamic instability following CPB
1
↓ NIRS
Medical treatment
Vasopressors
Optimize preload
Reduce afterload
Promote RV perfusion
7
Possible ischemia &
LV dysfunction
Surgical treatment
RCA venous bypass
VAD
RV
dysfunction
confirmation
Dynamic
RVOT obstruction
Stop inotropes
Fluid and heart
rate control
4
RV
dysfunction
8
No ischemia &
no LV dysfunction


Hemodynamic instability following CPB
1 ↓ NIRS
2
RV evaluation
Visual assessment
RV pressure waveform
TEE
5
Rule out early surgical complication
RV dysfunction
8
No ischemia & no LV dysfunction
Reduce RV afterload
Inhaled
Nitric oxide
Prostacyclin
Milrinone
Optimize PaO2 and PaCO2
Intravenous milrinone
If no dynamic LVOT obstruction
Improve RV contractility
Intravenous
Milrinone
Adrenaline

Severe RV Failure from CO2 embolism





After inhaled prostacyclin

Martineau Anesth Analg 2003


8
8

In summary


II
V
PC
107
ST-II
-0.2
AT-V
0.1
PA
PAP
PVC
104/37
44/29
57/16
(31)
Temp
CO_2
CO_2fe
34
TSang
PD
AGT-fe
AGT-in
O_2-fe 94
O_2-in 98
FR-aar
8
PAPD
32
I.C.

=


PEDIATRIC %SO2
25.09.05
05:07:20
ALARM LOW
L
36
SYSTEM SIGNAL OK
R
43
100
90
80
70
60
50
40
30
01:13
4 HOURS
2/MIN
05:13
LEFT
RIGHT
MAIN MENU

Conclusion

- 78% of patients dying after cardiac surgery have experienced difficult separation from CPB
- Tissue hypoperfusion associated with DSB explains why it can be lethal
- Right ventricular dysfunction is associated with DSB and is the most dangerous complication
- The diagnosis of RV failure is essential: visual, RV pressure waveform or echocardiography
- Treatment strategy has to be tailored in relation to the underlying mechanism and the associated conditions

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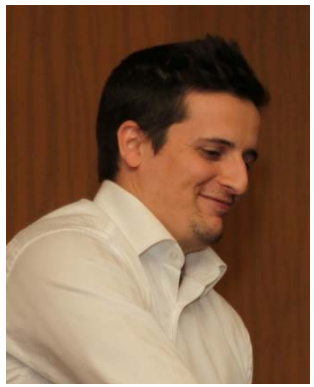

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