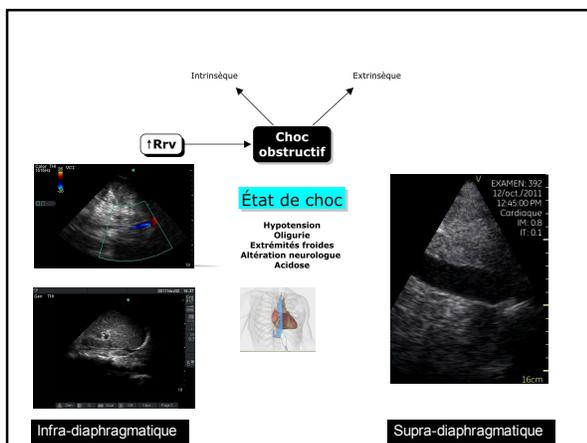
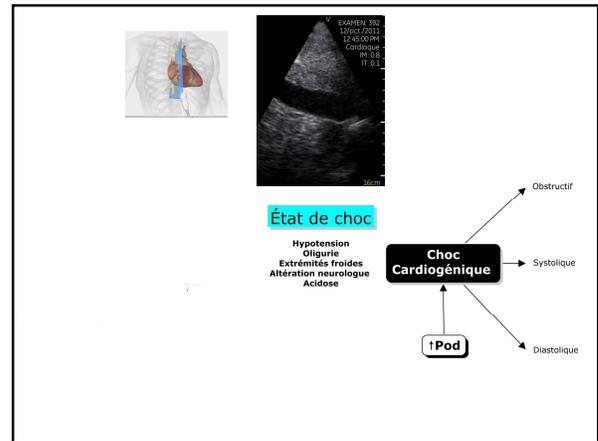
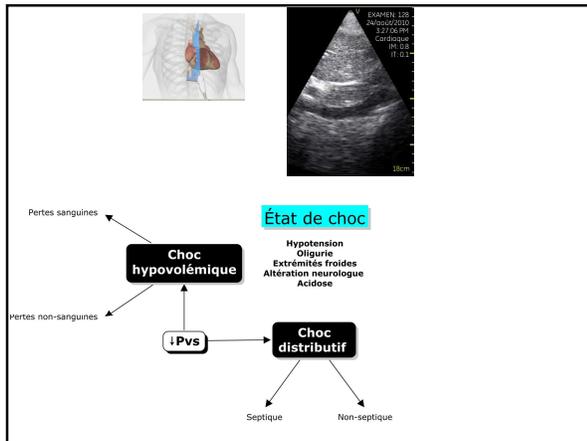




Concept du retour veineux

André Denault MD PhD

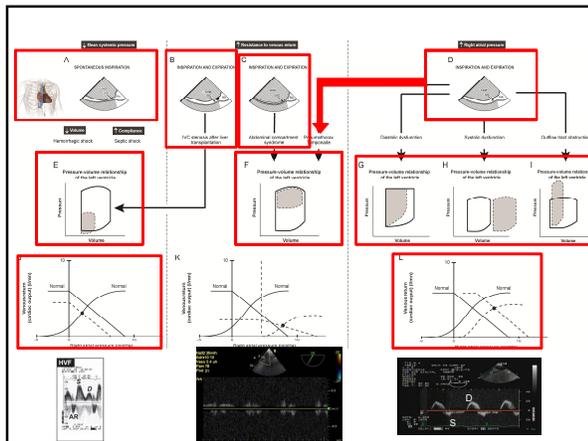
Université de Montréal
Montréal, le 25 septembre 2013



Courbe pression-volume

André Denault MD PhD

Université de Montréal
Montréal, le 9 octobre 2013

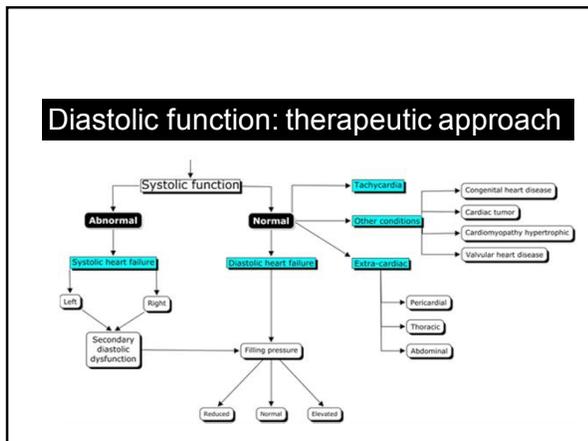


Fonction diastolique

André Denault MD PhD


 Université de Montréal
 Montréal, le 23 octobre 2013



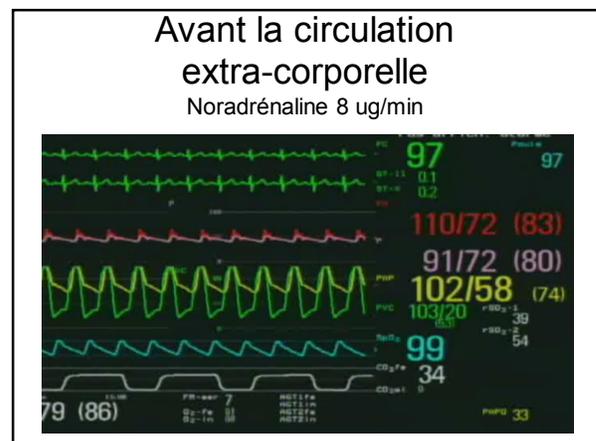
Fonction ventriculaire droite

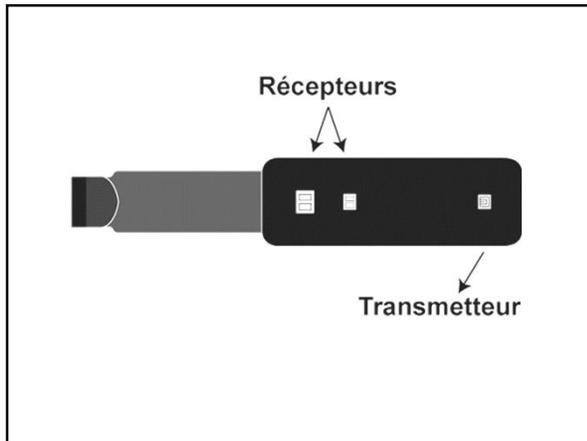
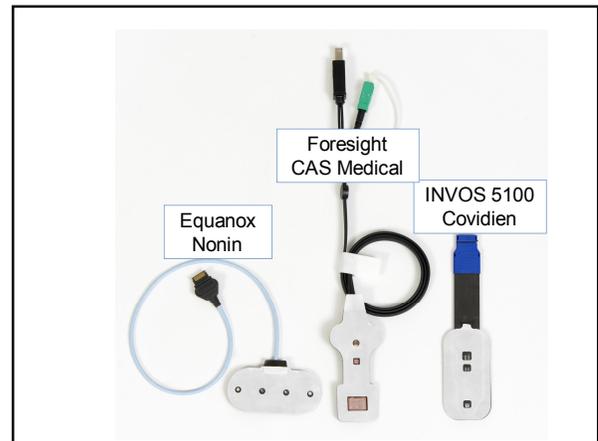
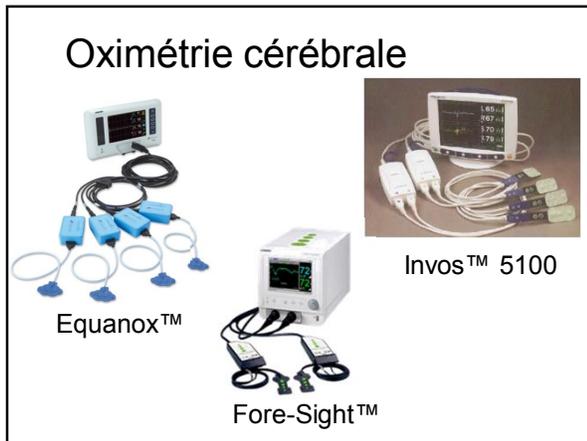
André Denault MD PhD


 Université de Montréal
 Montréal, le 26 novembre 2013



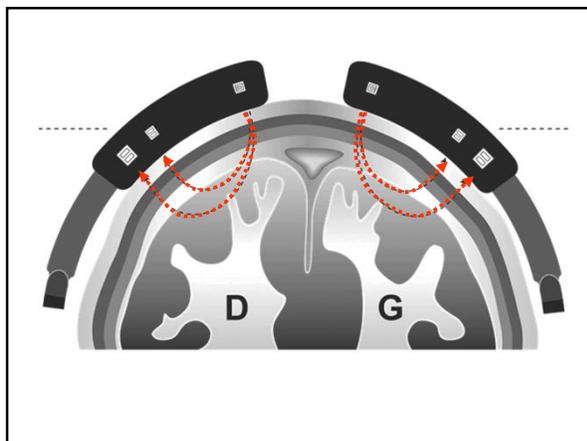

- ♀ de 23 ans fatigue et œdème des membres inférieurs
- Pas d'antécédents médicaux
- INR = 1.7
- Échographie transthoracique: myxome de l'oreillette gauche (5.5 X 8 cm)
- Transfer ICM pour chirurgie cardiaque





Mode de fonctionnement

- Une diode envoie des photons IR avec 2 longueurs d'onde captées par 2 récepteurs
- Le signal pénètre les tissus superficiels et profonds de la peau jusqu'au cortex frontal
- Le signal superficiel obtenu par le récepteur proximal est soustrait du processus final ("Spatially resolved NIRS")
- Par conséquent, le signal final: rSO₂ provient des régions plus profondes du tissu cérébral



THÉORIE D'OPÉRATION

Monitoring de la saturation en oxygène dans les régions entre l'ACA et l'ACM (watershed)

Trajet des photons

Shallow Detector

Deep Detector

Light Source

Pericranial Bone Matter

Light Source

Shallow Detector

Deep Detector

ANTERIOR CIRCULAR ARTERY

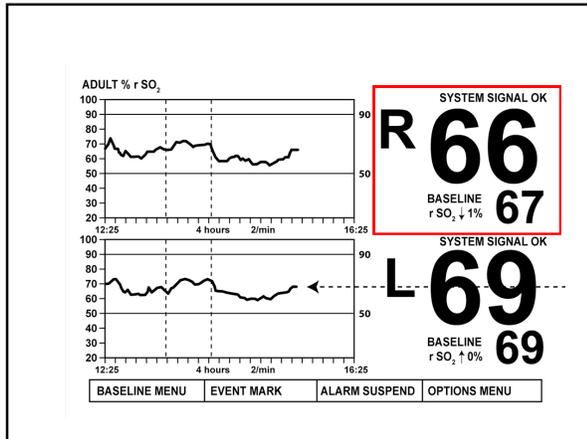
MIDDLE CIRCULAR ARTERY

POSTERIOR CIRCULAR ARTERY

ANTERIOR CIRCULAR ARTERY

MIDDLE CIRCULAR ARTERY

POSTERIOR CIRCULAR ARTERY



Regional Cerebral Oxygen Saturation correlates with Ventricular Systolic and Diastolic Function.

Catherine Paquet* MD, André Denault* MD, Pierre Couture MD FRCP, FRCPC*, Michel Carrier MD†, FRCSC, Denis Babin MSc‡, Sylvie Lévesque MSc§, Dominique Piquette MD, Jean-Claude Tardif MD, FRCPC†

- 99 patients avant la chirurgie cardiaque
- Relation entre la valeur de rSO₂, le profil hémodynamique et la fonction cardiaque à l'ÉTO

Résultats:

- 1-Valeur de base de la rSO₂ est en corrélation avec la fonction systolique et diastolique
- 2- Valeur de rSO₂ est supérieure aux variables hémodynamiques pour prédire une fonction cardiaque normale

JCTVA 2008

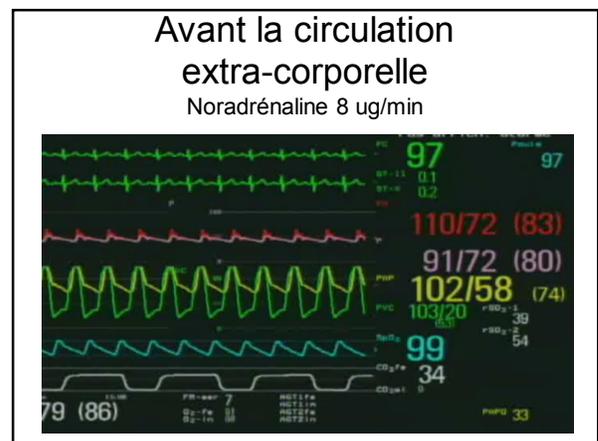
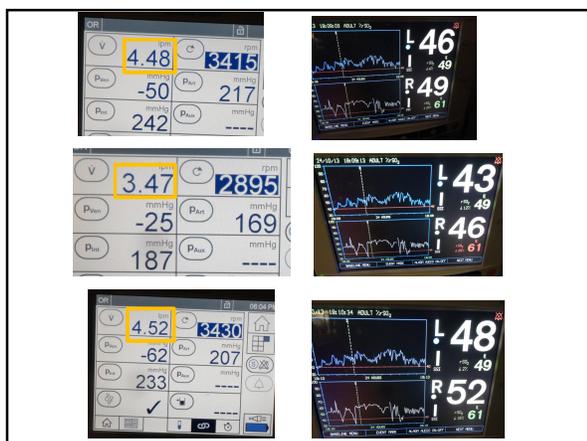
Lien rSO₂ et fonction cardiaque

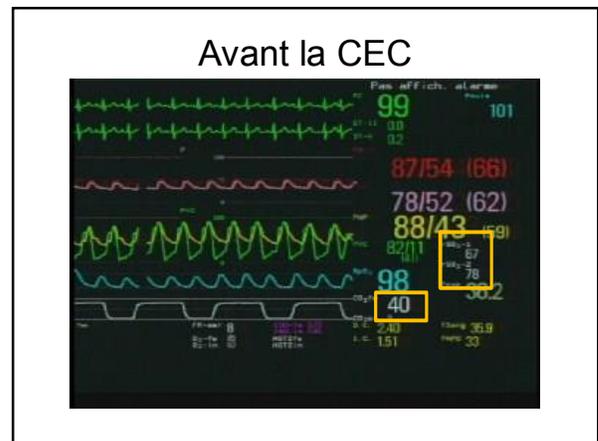
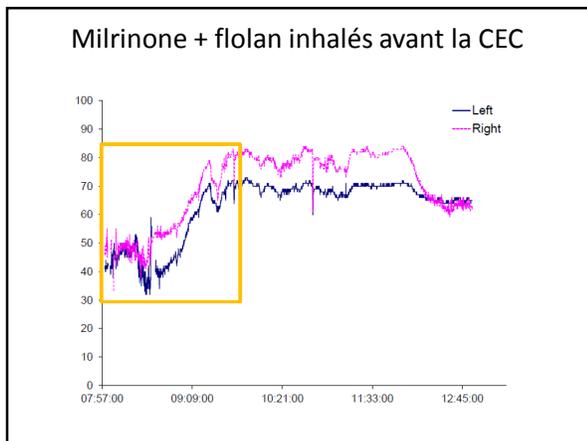
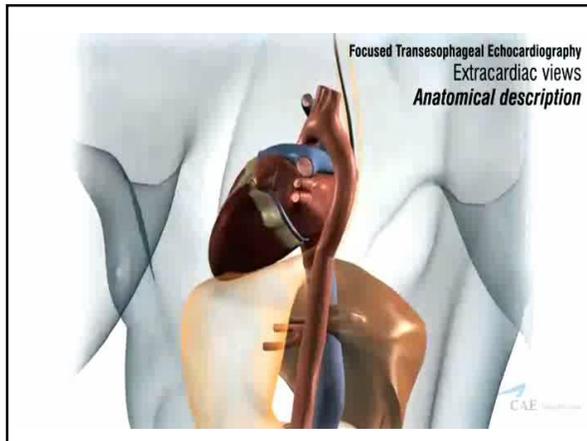
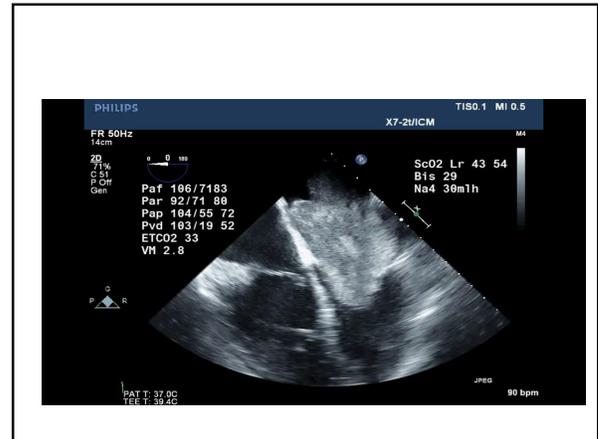
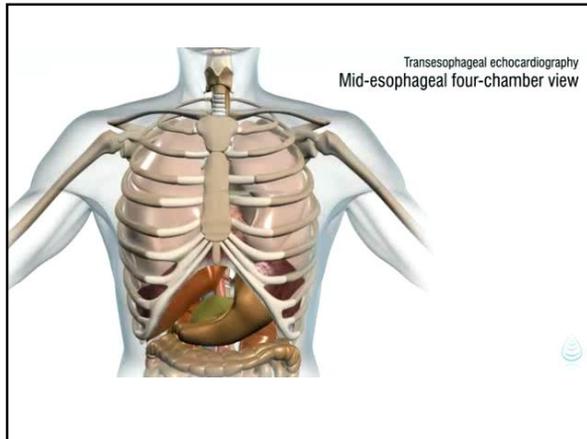
♂ de 74 ans avant PAC-RVA

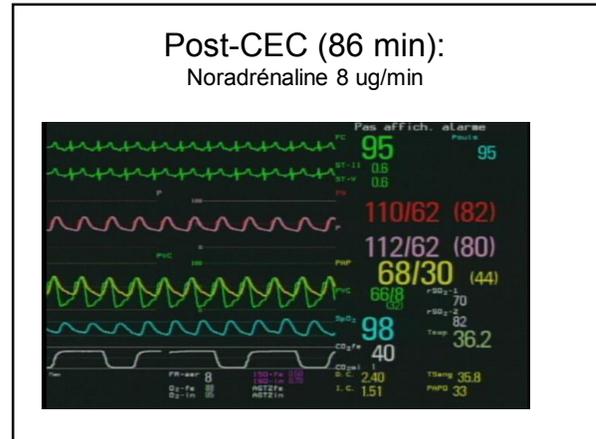
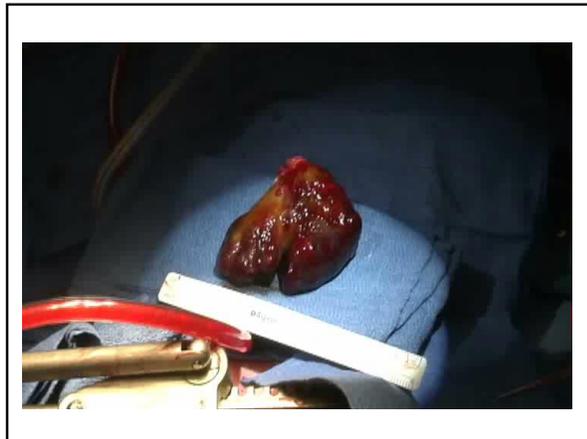
♀ de 77 ans saignement post-PAC

L 54
R 50

L 67
R 63







- ### Objectifs éducationnels
- Apprécier l'importance de l'évaluation du ventricule droit
 - Connaître les méthodes d'évaluation de la fonction ventriculaire droite
 - Développer une approche thérapeutique en défaillance du cœur droit

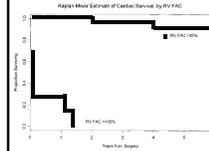
- ### Objectifs éducationnels
- Apprécier l'importance de l'évaluation du ventricule droit
 - Connaître les méthodes d'évaluation de la fonction ventriculaire droite
 - Développer une approche thérapeutique en défaillance du cœur droit right ventricular failure



Precardiopulmonary Bypass Right Ventricular Function Is Associated with Poor Outcome After Coronary Artery Bypass Grafting in Patients with Severe Left Ventricular Systolic Dysfunction

Andrew D. Maslow, MD¹, Meredith M. Regan, ScD¹, Peter Panzica, MD¹, Stephanie Heindel, MD¹, John Mashikian, MD¹, and Mark E. Comunale, MD²

¹Department of Anesthesiology, Rhode Island Hospital, Brown Medical School, Providence, Rhode Island; and ²Beth Israel Deaconess Medical Center, Boston, Massachusetts



Analyse rétrospective de 41 patients avec dysfonction VG sévère ($\leq 35\%$) subissant un PAC
RVFAC $\leq 35\%$ (n = 7) and $> 35\%$ (n = 34)

RVFAC $\leq 35\%$ = tous décédés <18 mois

RVFAC $\leq 35\%$ = hypertension pulmonaire

Figure 2. Kaplan-Meier survival curve for patients with normal RVFAC (>35%) and abnormal RVFAC ($\leq 35\%$) right ventricular systolic function and severe left ventricular systolic dysfunction (left ventricular ejection fraction <25%). RVFAC = right ventricular fractional area of contraction.

Anesth Analg 2002



Diastolic Dysfunction is Predictive of Difficult Weaning from Cardiopulmonary Bypass

Francis Bernard, MD¹, André Denault, MD, FRCP¹, Denis Babin, MS¹, Caroline Goyer, MD¹, Pierre Couture, MD, FRCP¹, André Couturier, MS¹, and Jean Buihieu, MD, FRCP¹

Departments of ¹Medicine and ²Cardiology, CHUM, Notre-Dame Hospital; and ³Department of Anesthesia, Montreal Heart Institute Montreal, Quebec, Canada



Anesth Analg 2001;92:291-8

European Heart Journal (2006) 27, 867-874
doi:10.1093/eurheartj/ehi752

Clinical research
Cardiovascular surgery

Comparison of 19 pre-operative risk stratification models in open-heart surgery

Table A2. Pre-operative cardiac risk factors in 6222 open-heart operations

Pre-operative risk factor	Mean (±SD) or n (%)	Amstelveen	Cambridge	Cleveland Clinic	EuroSCORE ^{II}	French score	Magnum	NYU	Northern New England	Ottawa	Parsonnet (modified)	Park	Toronto	Toronto (modified)	Trentham	Tunne	UP national score	Vancouver Affairs
Previous cardiac surgery	457 (7.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Active endocarditis	35 (0.5)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Heart failure	1156 (18.6)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Cardiomegaly	327 (5.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Unstable angina	744 (12.0)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
CCP	2.6 (1.0)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NYHA ^b	2.4 (1.0)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Recent MI (within 24 h)	144 (2.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Recent MI (within 48 h)	202 (3.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Recent MI (within 21 days)	793 (12.7)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Noncardiac arrhythmia (acute)	144 (2.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Atrial fibrillation	508 (8.3)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Preoperative	11 n (%)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pulmonary hypertension	179 (2.9)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Pulmonary hypertension	179 (2.9)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

CCS, Canadian Cardiovascular Society; QEC, left ventricular ejection fraction; NYHA, New York Heart Association; MI, myocardial infarction.
Additive and logistic.
Continuous variables are presented as mean (±SD). The analysis is based on operations where the risk factor data were available.

Journal of the American College of Cardiology Vol. 45, No. 10, 2005
© 2005 by the American College of Cardiology Foundation ISSN 0735-1097/05/\$30.00
Published by Elsevier Inc. doi:10.1016/j.jacc.2005.02.055

Pulmonary Hypertension

Impact of Pulmonary Hypertension on the Outcomes of Noncardiac Surgery
Predictors of Perioperative Morbidity and Mortality

Gautam Ramakrishna, MD,* Juraj Sprung, MD, PhD,† Barugur S. Ravi, MD,* Krishnaswamy Chandrasekaran, MD, FACC,* Michael D. McGoon, MD, FACC*
Rochester, Minnesota

« patients with pulmonary hypertension are very fragile with little or no compensatory reserve »

Definition of pulmonary hypertension

- Absolute values
 - Systolic Pap: >30 or ≥ 40 mmHg
 - Systolic Pvd: > 35 mmHg
 - Mean Pap: > 25 mmHg
 - Pulmonary vascular resistance: >125-200 dynes/s/cm⁵
- Relative values
 - Systemic to pulmonary vascular resistance ratio: > 10%
 - Pulmonary to systemic mean pressures: >33-50%
 - Systemic to pulmonary mean pressures: (ratio MAP/MPAP: normal ≥4 and abnormal < 4)

Denault et al Cardiologie Contemporaine 2006

Classification of Pulmonary Hypertension

1. Pulmonary arterial hypertension
2. Pulmonary hypertension with left heart disease
 - 2.1. Left-sided atrial or ventricular heart disease
 - 2.2. Left-sided valvular heart disease
3. Pulmonary hypertension associated with lung diseases and/or hypoxemia
 - 3.1. Chronic obstructive pulmonary disease
 - 3.2. Interstitial lung disease
 - 3.3. Sleep-disordered breathing
 - 3.4. Alveolar hypoventilation disorders
4. Pulmonary hypertension due to chronic thrombotic and/or embolic disease
5. Miscellaneous

Simoneau G JACC 2004;43:5S-12S

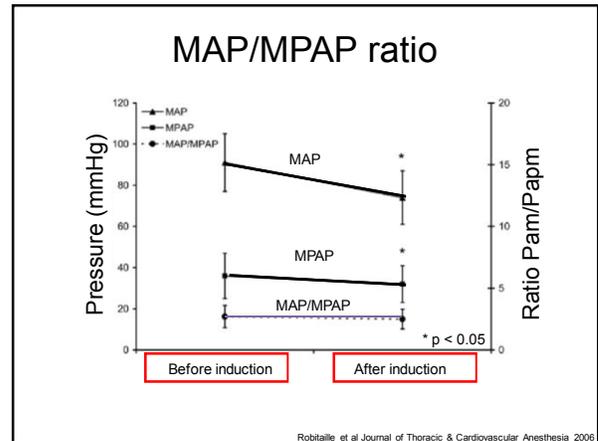
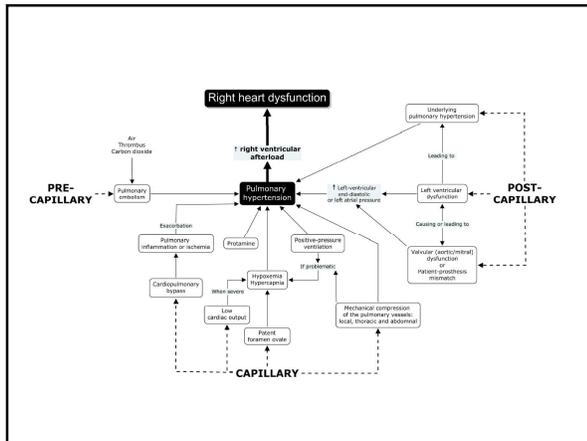


15

A Pathophysiological Approach to Understanding Pulmonary Hypertension in Cardiac Surgery

Anne Q. N. Nguyen, Alain Deschamps,
France Varin, Louis P. Perrault
and André Y. Denault
*Montreal Heart Institute and Université de Montréal
Canada*

Cardiac Surgery 2012, InTech Book
ISBN: 978-953-307-1000-8.



Importance of Relative Pulmonary Hypertension in Cardiac Surgery: The Mean Systemic to Pulmonary Artery Pressure Ratio

Arnaud Robitaille, MD,* André Y. Denault, MD, FRCPC,* Pierre Couture, MD, FRCPC,* Sylvain Béteille, MD, FRCPC,* Annik Fortier, MSc,† Marie-Claude Guertin, PhD,† Michel Carrier, MD, FRCSC,† and Raymond Martineau, MD, FRCPC*

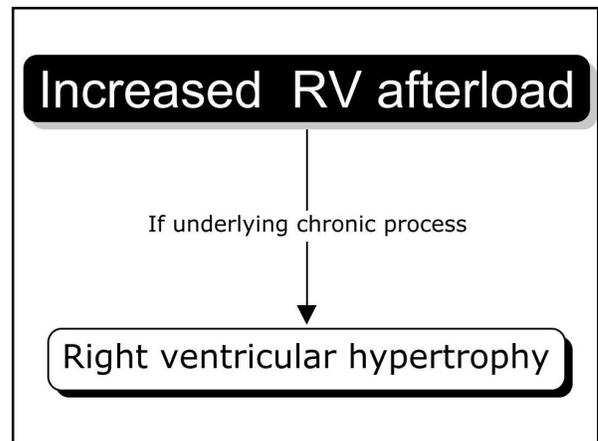
1439 patients undergoing cardiac surgery in 1999

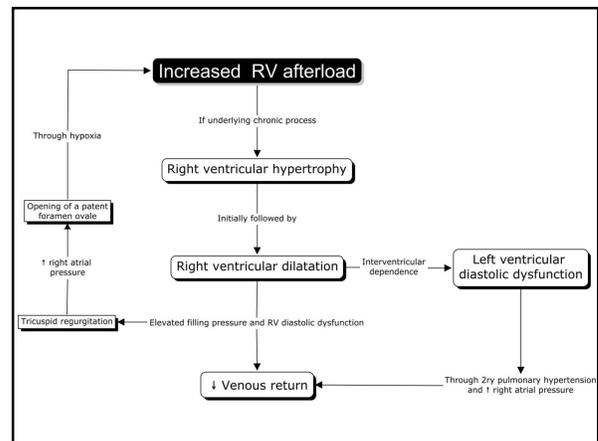
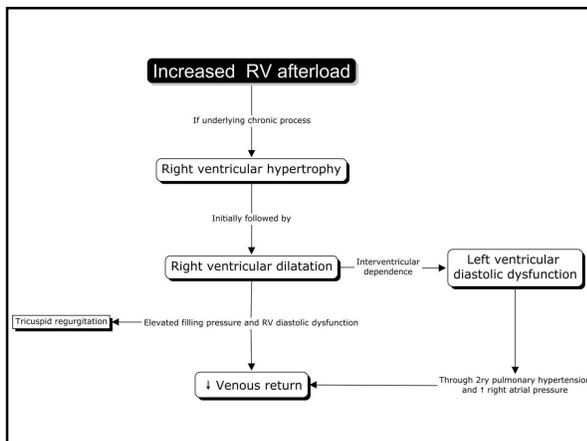
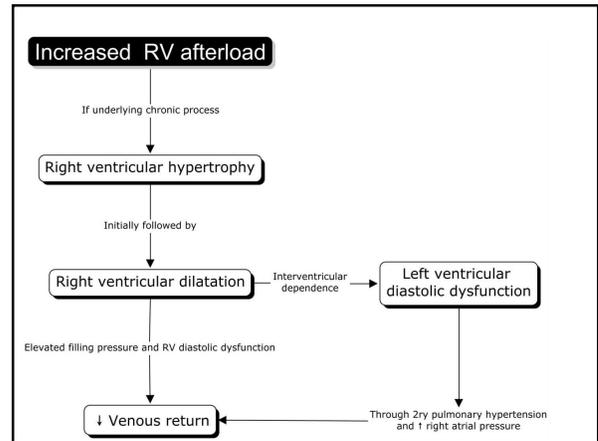
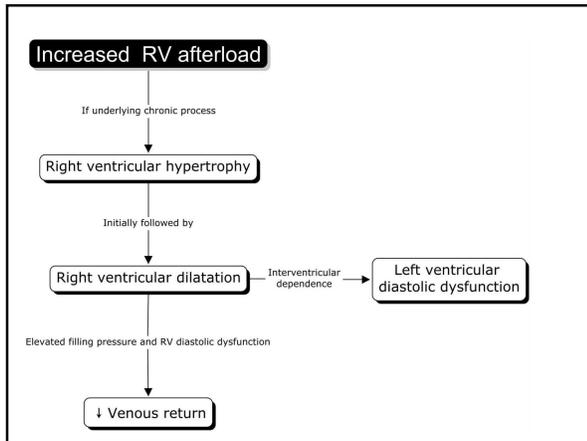
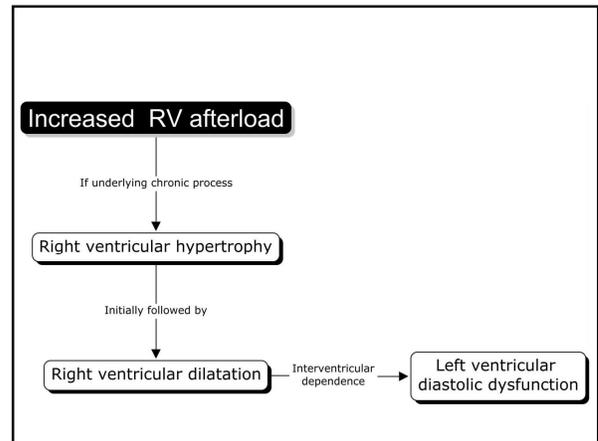
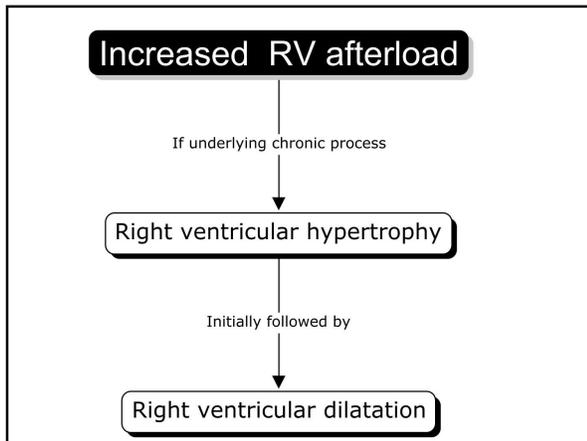
Primary end-point: composite index of death, cardiac arrest, vasoactive support >24 hours, post-operative IABP

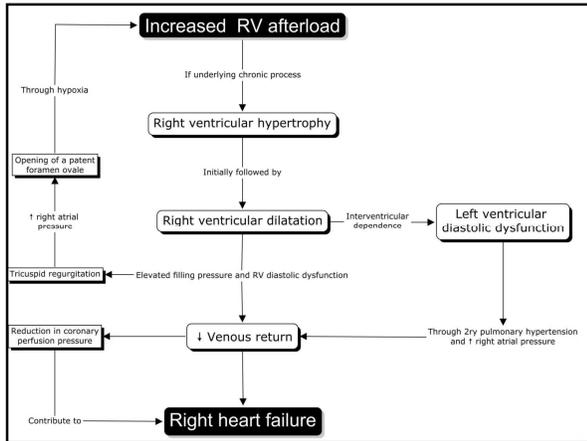
Results: 302 patients (21%)

- MAP/MPAP ratio only hemodynamic predictor odds ratio **1.3 (95% CI: 1.1-1.5)**
- DSB: odds ratio 3.5 (95% CI: 2.5-5.1)

JTCVA June 2006







The right ventricle in pulmonary hypertension
 Kelly M. Chin, Nick H.S. Kim and Lewis J. Rubin
 Coronary Artery Disease 2005, 16:13-18

“It is the ability of the right ventricle to function under this increased load that determines the degree of symptoms and survival %o”

Right Ventricular Myocardial Performance Index Predicts Perioperative Mortality or Circulatory Failure in High-Risk Valvular Surgery

François Haddad, MD, André Y. Denault, MD, Pierre Couture, MD, Raymond Cartier, MD, Michel Pellerin, MD, Sylvie Levesque, MSc, Jean Lambert, PhD, and Jean-Claude Tardif, MD, *Montréal, Québec, Canada*

Journal of the American Society of Echocardiography 2007

Right Ventricular Myocardial Performance Index Predicts Perioperative Mortality or Circulatory Failure in High-Risk Valvular Surgery

François Haddad, MD, André Y. Denault, MD, Pierre Couture, MD, Raymond Cartier, MD, Michel Pellerin, MD, Sylvie Levesque, MSc, Jean Lambert, PhD, and Jean-Claude Tardif, MD, *Montréal, Québec, Canada*

$a = IVRT + IVCT + ET$
 $b = MRT + IVCT$
 $MPI = (a-b)/b = (MRT + IVCT)/ET$

N = 50 patients undergoing valvular surgery
 Journal of the American Society of Echocardiography September 2007

Hypertension pulmonaire: NS

Table 4 Multivariate logistic regression for perioperative mortality and heart failure

Variable	Odds ratio	95% Confidence interval	P
Model I*			
RVMPI \geq 0.50	25.20	5.24-121.15	<.0001
Model II† (with the exclusion of RVMPI)			
Parsonnet score per additional unit	1.088	1.019-1.161	.012
RVFAC per 1% increase	0.001	<0.001-0.727	.048

N = 50

Right Ventricular Function and Failure: Report of a National Heart, Lung, and Blood Institute Working Group on Cellular and Molecular Mechanisms of Right Heart Failure

Norbert F. Voelkel, Robert A. Quinlan, Leslie A. Leinwand, Robyn J. Barst, Michael D. McGoon, Daniel R. Meldrum, Jocelyn Dupuis, Carlin S. Long, Lewis J. Rubin, Frank W. Smart, Yuichiro J. Suzuki, Mark Gladwin, Elizabeth M. Denholm and Dorothy B. Gail
 Circulation 2006;114:1883-1891

Circulation American Heart Association
 SOURCE OF THE AMERICAN HEART ASSOCIATION
 Learn and Live.

« Right ventricular function is the most important determinant of longevity in patients with pulmonary arterial hypertension. »



Tezosentan therapy in patients with significant pulmonary hypertension undergoing cardiac surgery: a multicenter, placebo-controlled trial

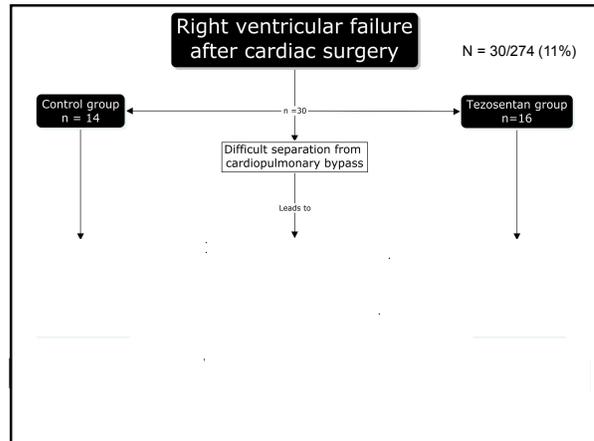
NCT00458276




JTCVS 2013

31 centers in 14 countries

 Austria	 Czech Republic	 Canada	 France
 Germany	 India	 Israel	 Italy
 Poland	 Serbia	 Slovakia	 Sweden
 United Kingdom	 United States of America		



Objectifs éducationnels

- Apprécier l'importance de l'évaluation du ventricule droit
- Connaître les méthodes d'évaluation de la fonction ventriculaire droite
- Développer une approche thérapeutique en défaillance du cœur droit right ventricular failure

Dysfonction ventriculaire droite

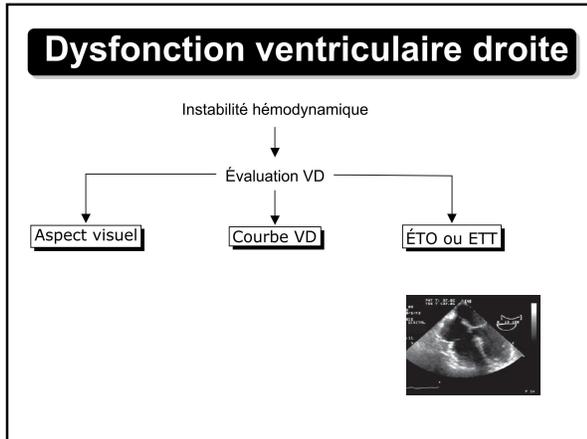
Instabilité hémodynamique

Évaluation VD

Aspect visuel

Courbe VD

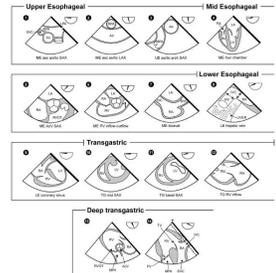
ÉTO ou ETT



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*

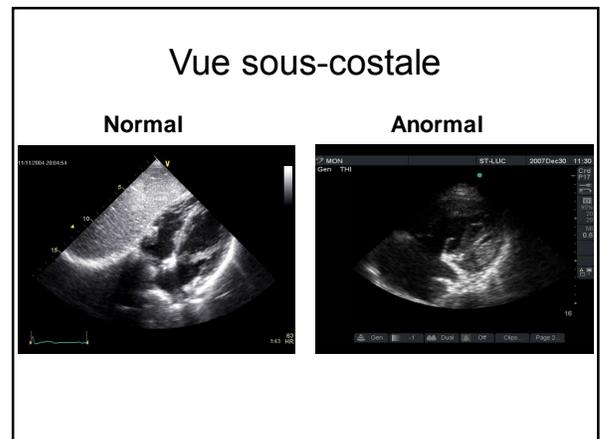
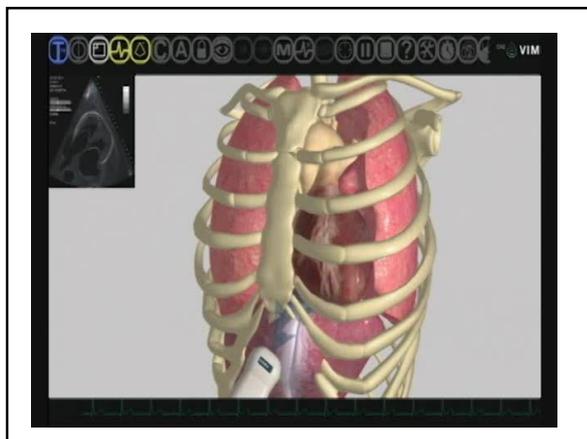


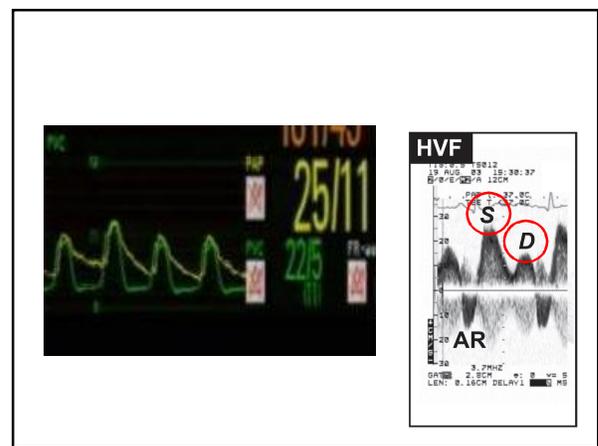
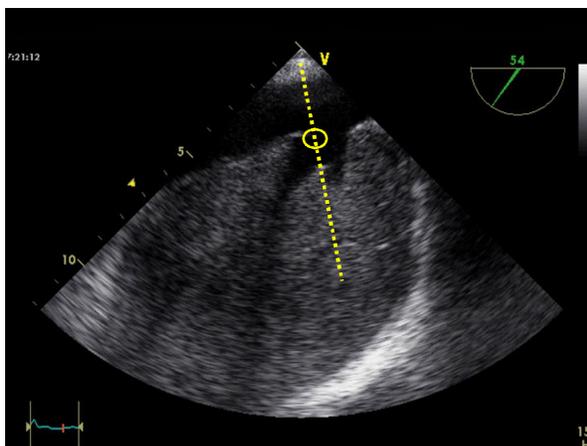
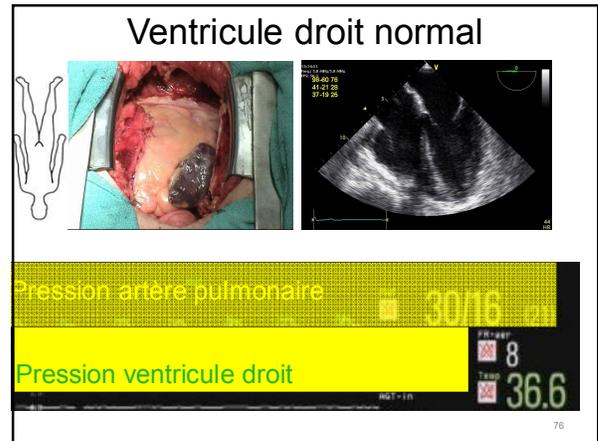
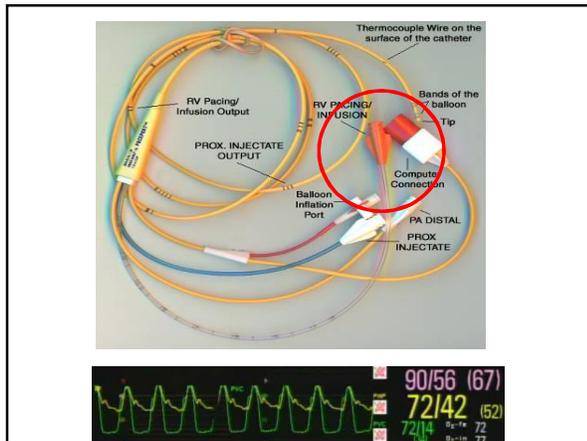
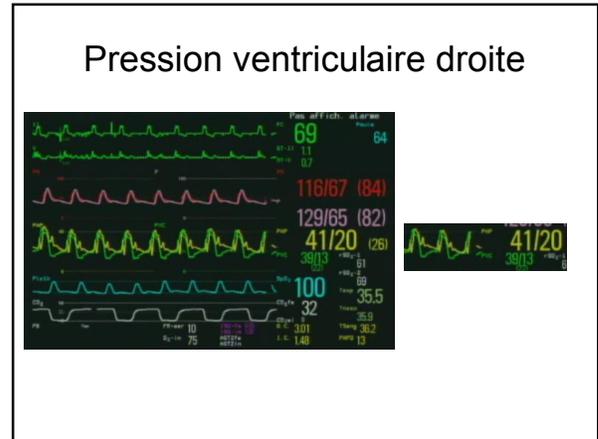
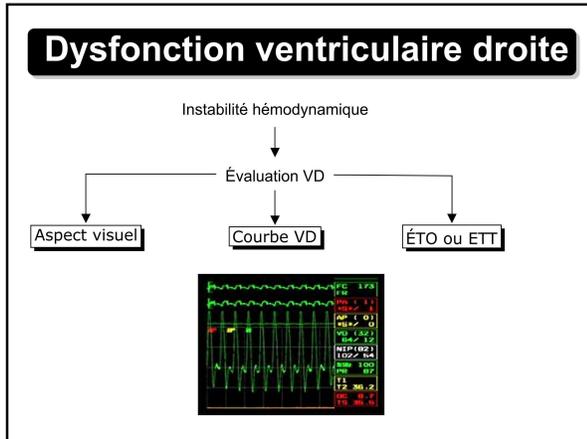
Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography

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 Allala, MD, Msc, Lanqi Hua, RDCS, FASE, Mark D. Handschumacher, BSc, Krishnaswamy Chandrasekaran, MD, FASE, Scott D. Solomon, MD, Eric K. Louis, 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.)



Dysfonction VD pré-op: communication interventriculaire

Flux veineux hépatique

Robitaille JTCVA 2006

Dysfonction VD

Flux veineux hépatique

Défaillance ventriculaire droite

Dysfonction VD sévère

Égalisation diastolique

Pulsus tardus VD and ↓ pression pouls

♂ de 68 ans RVA et PAC

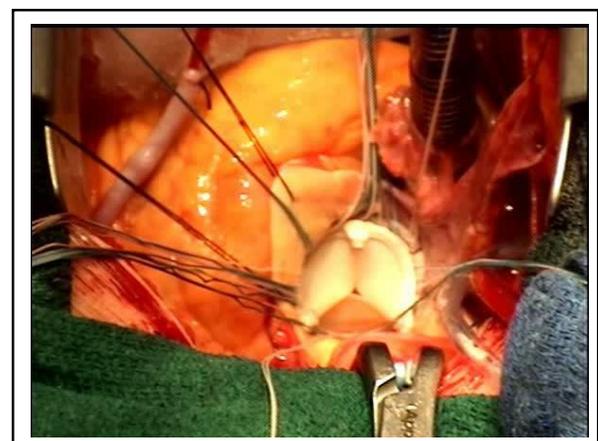
SpO ₂	71	49
FiO ₂	0.6	
PEEP	80/43 (57)	
MAP	87/48 (60)	
MAP ₂	46/23 (31)	
MAP ₃	47/16	83
MAP ₄	100	74
CO ₂ pa	39	30.2
HR	59 (71)	

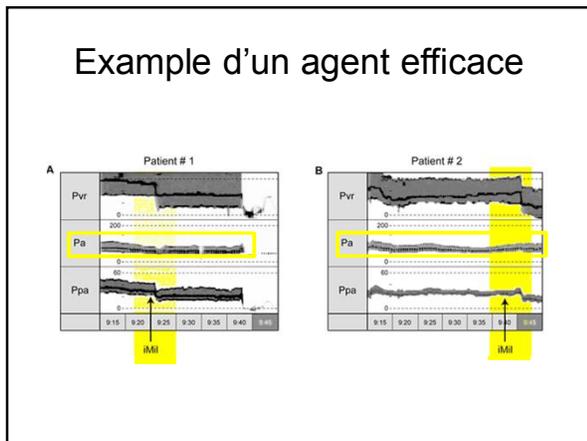
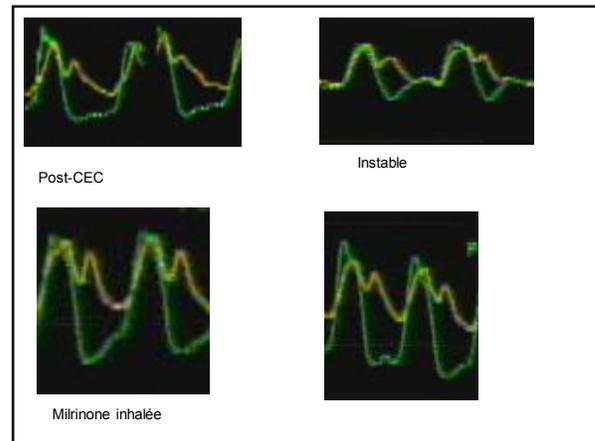
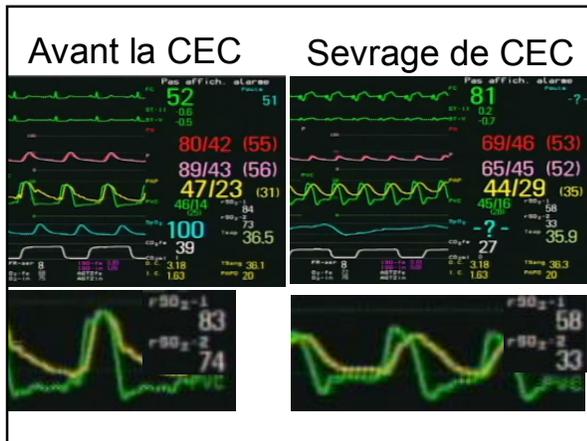
StO₂

83

74

ScO₂





ClinicalTrials.gov
Protocol Registration System

Protocol Registration Receipt
01/08/2009

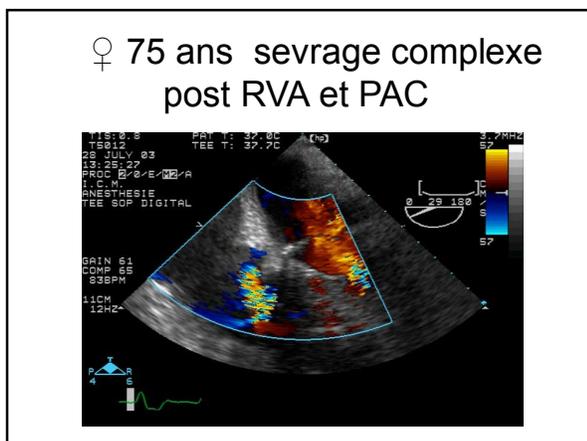
Mirirone Inhaled in Cardiac Surgery

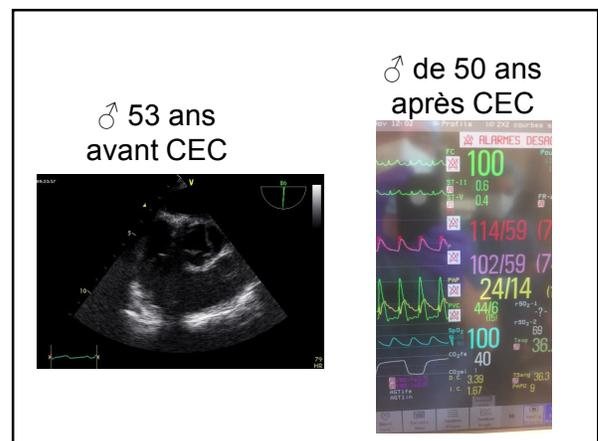
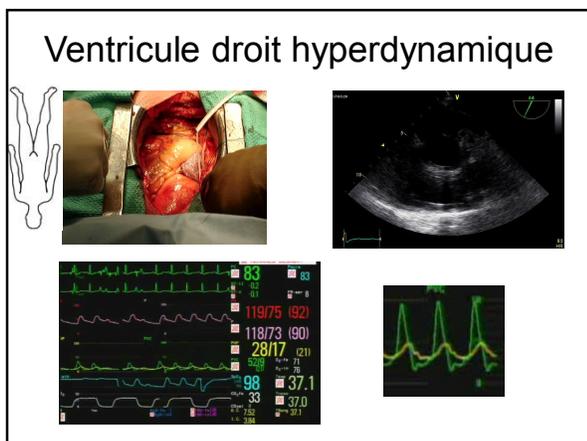
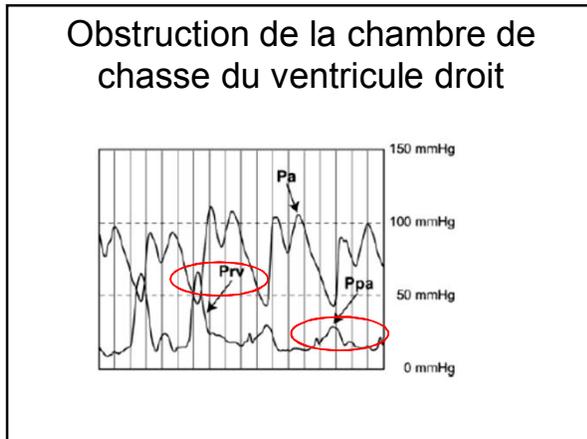
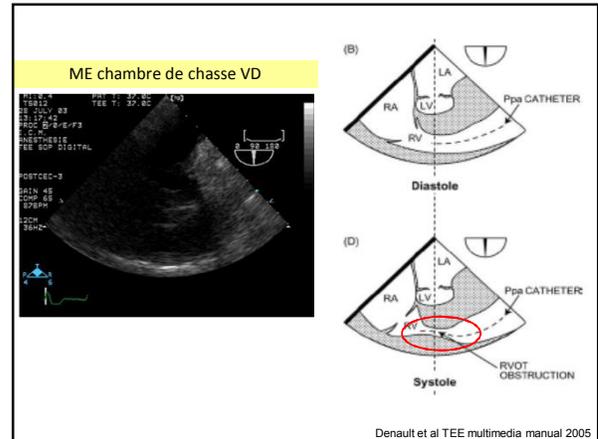
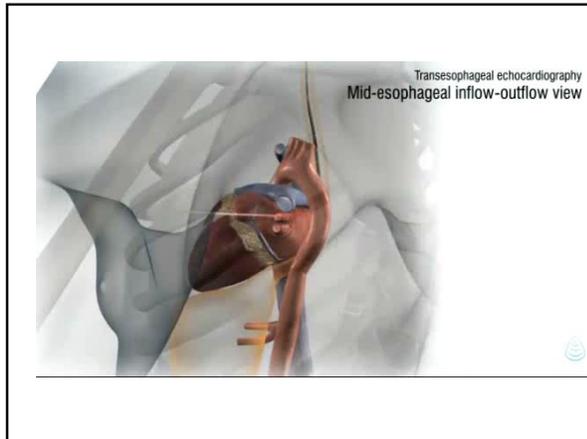
This study is not yet open for participant recruitment.
Verified by Montreal Heart Institute, January 2009

Sponsored by:	Montreal Heart Institute Heart and stroke fondation of Quebec Ordre des Anesthésiologistes du Québec Canadian Anesthesiologists' Society
Information provided by:	Montreal Heart Institute
ClinicalTrials.gov Identifier:	NCT00819377

Purpose

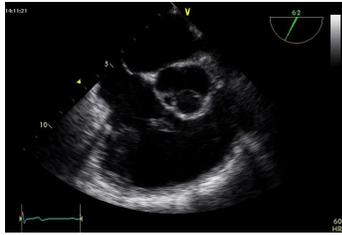
Pulmonary hypertension is an important morbidity factor in patients having to undergo cardiac surgery with cardiopulmonary bypass (ECC). Mirirone used in inhalation, shows evidence of being a pulmonary vasodilator able to possibly contribute to the reduction of pressure on the pulmonary artery.





Après β -bloqueurs

♂ 53 ans avant CEC



♂ de 50 ans après CEC



Dynamic right ventricular outflow tract obstruction in cardiac surgery

André Y. Denault, MD, FRCPC,¹ Miguel Chaput, MD,² Pierre Couture, MD, FRCPC,³ Yves Hébert, MD, FRCSC,⁴ François Haddad, MD, FRCPC,⁵ Jean-Claude Tardif, MD, FRCPC⁶

(n = 800)

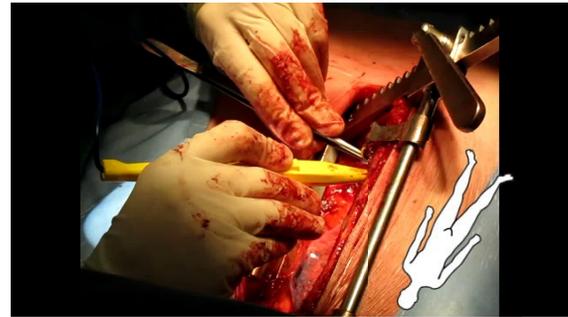
- Gradient systolic VD vs Pap > 6 mmHg (18%)
- Gradient systolic VD vs > 25 mmHg (4%)
 - N = 11 patients
 - 50% de RVA
 - 73% sous milrinone
 - 91% avec instabilité hémodynamique

JTCVS 2006

48 yo ♂ unstable during dissection of right mammary artery? Why?



48 yo ♂ unstable during dissection of right mammary artery



48 yo ♂ unstable during dissection of right mammary artery

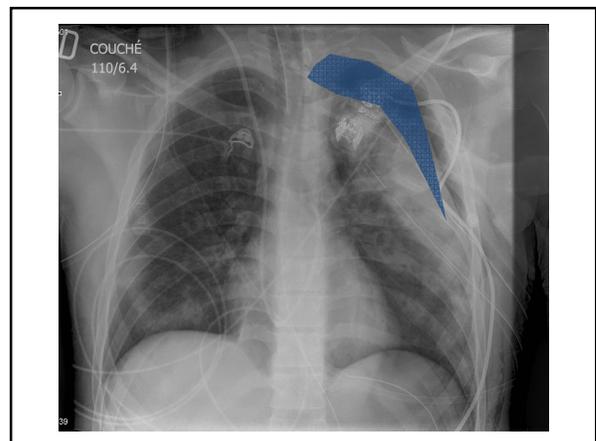
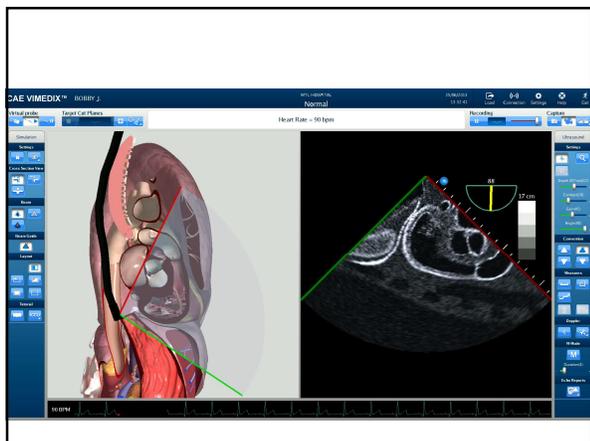
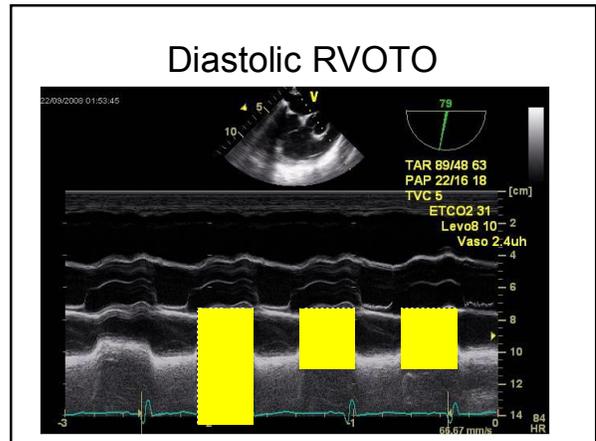
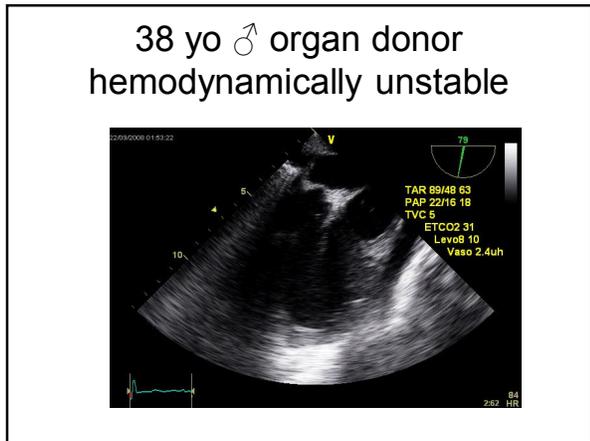
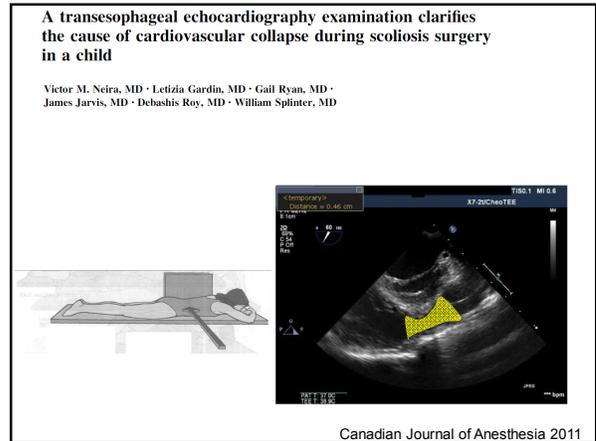
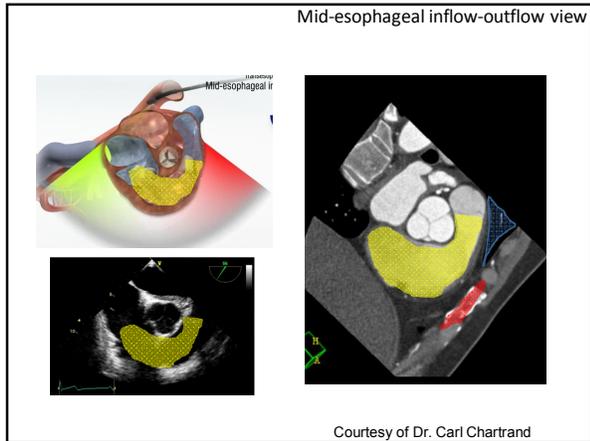
Before

After



Prone position





Objectifs éducationnels

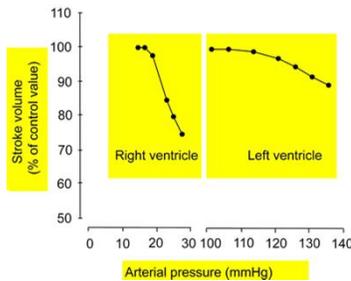
- Apprécier l'importance de l'évaluation du ventricule droit
- Connaître les méthodes d'évaluation de la fonction ventriculaire droite
- Développer une approche thérapeutique en défaillance du cœur droit right ventricular failure

Ideal agent in pulmonary hypertension and RV dysfunction

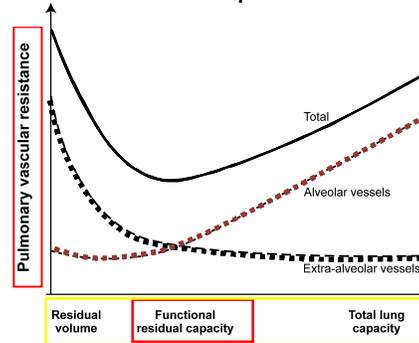
$$\text{Venous return} = \frac{\text{Pms} - \text{Pra}}{\text{Rvr}}$$

- ↑ Venous return
- ↑ Mean systemic pressure
- ↓ Right atrial pressure
- ↓ Resistance to venous return

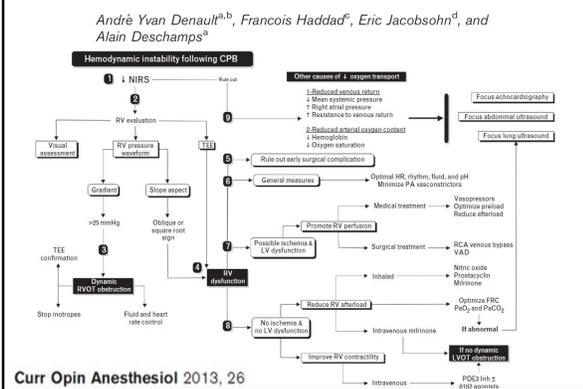
Hypertension pulmonaire et postcharge



Ventilation et résistance vasculaire pulmonaire

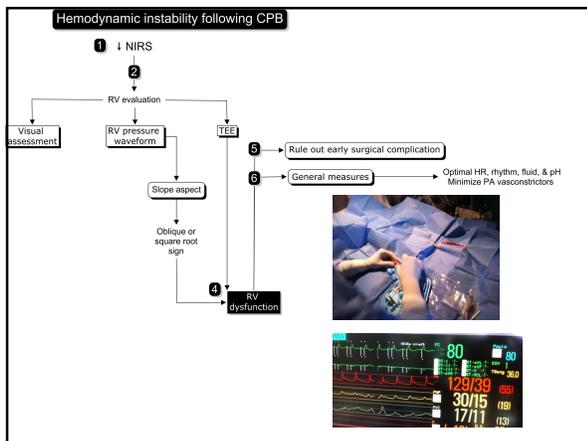
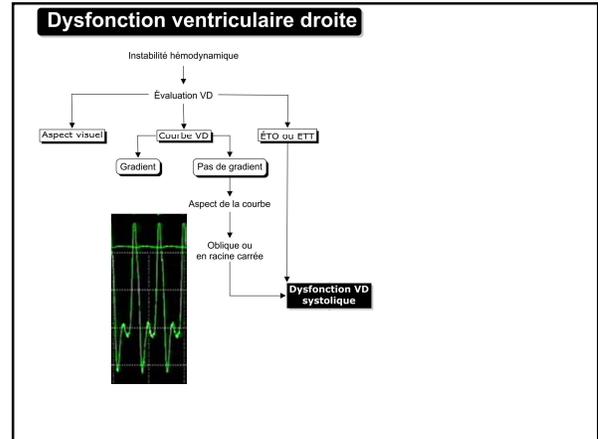
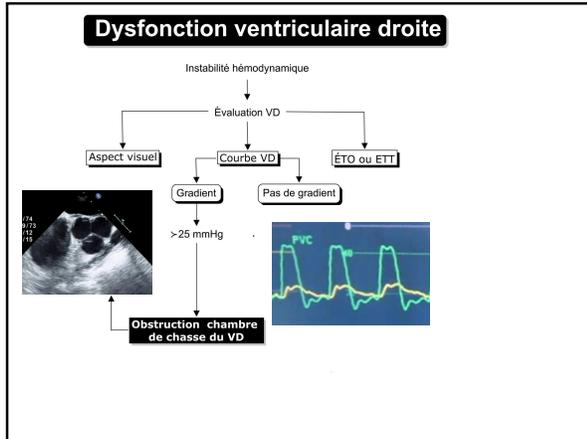
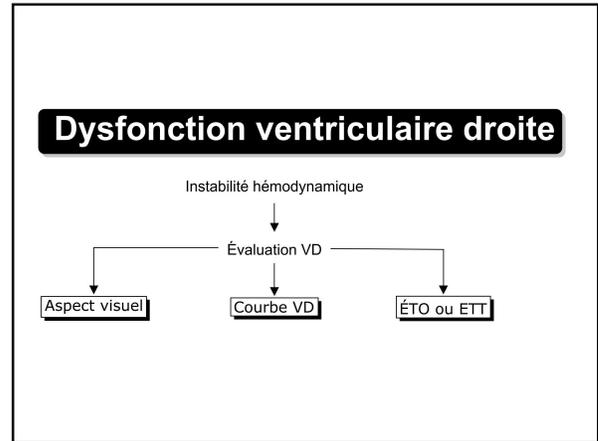


Perioperative right ventricular dysfunction



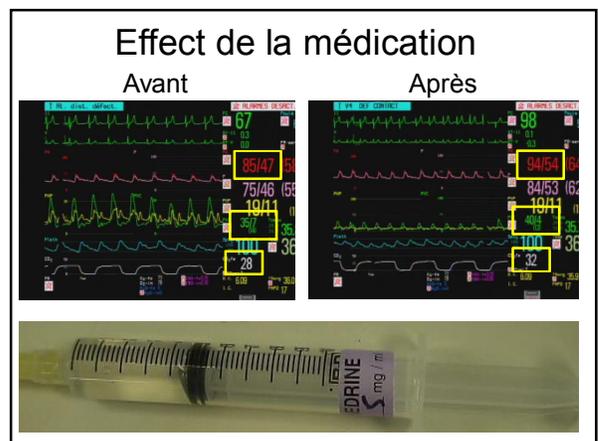
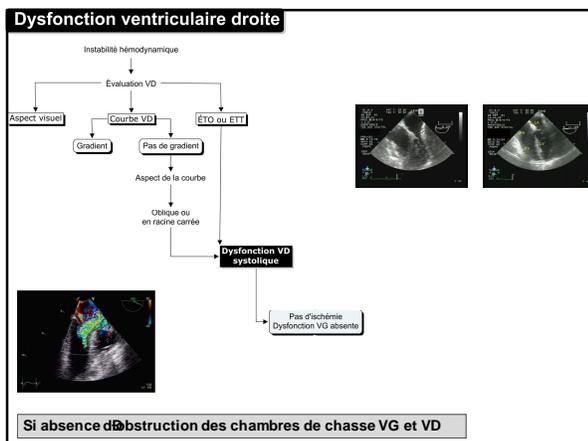
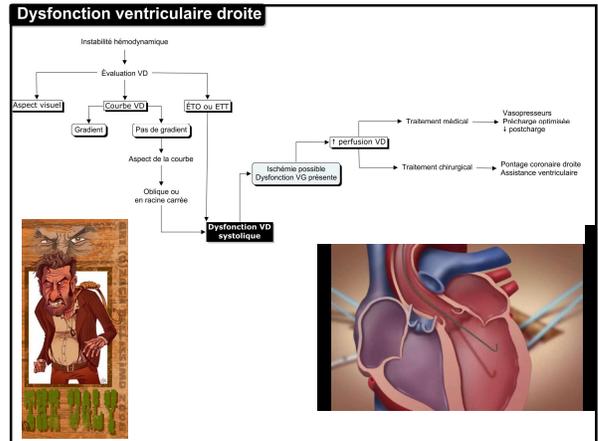
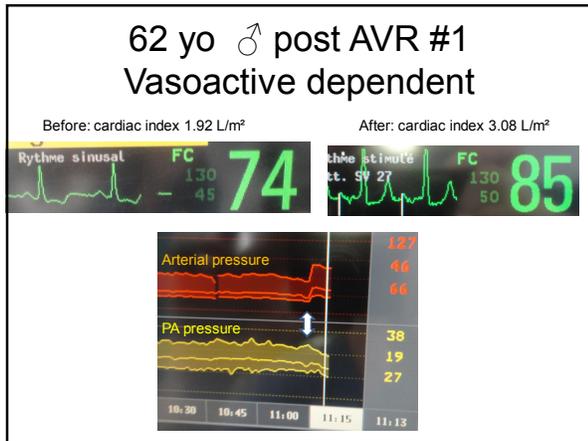
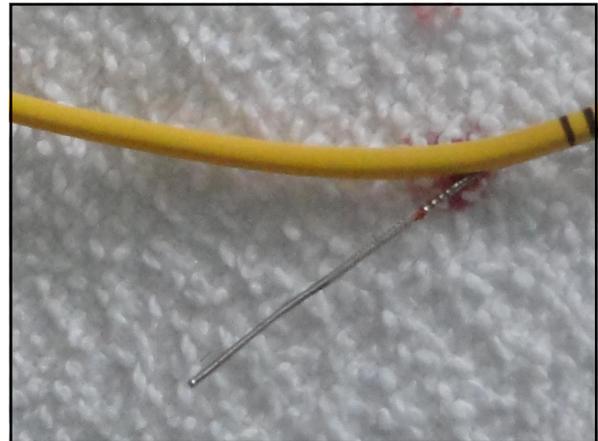
Défaillance ventriculaire droite **Obstruction chambre de chasse du ventricule gauche**

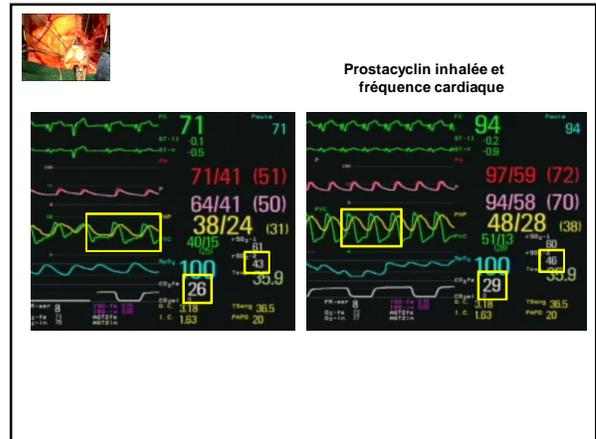
The top part shows a monitor with L: 36 and R: 43, flanked by two medicine bottles, one of which is crossed out with a red circle. Below are two echocardiogram images. The left image shows a cross-section of the heart with text: 'Pulst. Qc: 1.8', 'Dilatation en cours', 'Pul moy: 95', 'Pul max: 22', 'Pul min: 40', 'ETC: 28', 'Vmax: 4.4', 'Vmax: 2.6', 'Area: 18 cm²', 'Vmax: 25 high', 'M: 1.5', 'NTD: 100%', 'Flow: 1800', 'Stroke: 60 ml'. The right image shows a similar view with text: 'Pulst. Qc: 1.8', 'Dilatation en cours', 'Pul moy: 95', 'Pul max: 22', 'Pul min: 40', 'ETC: 28', 'Vmax: 4.4', 'Vmax: 2.6', 'Area: 18 cm²', 'Vmax: 25 high', 'M: 1.5', 'NTD: 100%', 'Flow: 1800', 'Stroke: 60 ml'.



VVI Pacemaker on Pacemaker off

The block contains two sets of vital signs and waveforms. The left set (Pacemaker on) shows: HR 87, BP 101/67 (79), SpO2 112/69 (83), RR 30/17 (22), and a waveform with a circled area. The right set (Pacemaker off) shows: HR 63, BP 88/49 (63), SpO2 107/51 (71), RR 36/13 (22), and a waveform with a circled area.





Dysfonction ventriculaire droite

Instabilité hémodynamique — Exclure —> Autres causes de ↓ du retour veineux:
 ↓ Pression veineuse systémique
 † Pression oreillette droite (SAM)
 † Résistance au retour veineux

Évaluation VD

- Aspect visuel
- Courbe VD
- ÉTO ou ETT

Conditions observées chez un même patient

- ### Conclusion
- La dysfonction ventriculaire droite est importante à reconnaître avant, pendant et après une chirurgie cardiaque ou non-cardiaque
 - Une défaillance droite non corrigée conduira à une hypoperfusion systémique
 - La défaillance droite est la cause la plus importante de mortalité en chirurgie cardiaque

Remerciements

Denis Babin
MSc Inh