Instabilité hémodynamique
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Cours de science de base
2007

Support and disclosure

Fondation de la Recherche en Santé du Québec
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Career in Anesthesia
Montreal Heart Institute Foundation
Consultant for Actelion

Étiologie of hemodynamic instability in cardiac surgery
Right Ventricular Dysfunction in Low Output Syndrome After Cardiac Operations: Assessment by TEE

- RV Dysfunction (n = 17)
- RV and LV Dysfunction (19)
- LV Dysfunction (n = 18)
- Normal (n = 21)

Davila-Roman VG, Ann Thorac Surg 1995;60:1081-4

The hemodynamically unstable patient in the intensive care unit: Hemodynamic vs. transesophageal echocardiographic monitoring

Critical Care Medicine 2002
The hemodynamically unstable patient in the intensive care unit: Hemodynamic vs TEE monitoring

<table>
<thead>
<tr>
<th></th>
<th>Admission</th>
<th>SICU 2hr</th>
<th>SICU 4hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kappa</td>
<td>0.33</td>
<td>0.47</td>
<td>0.28</td>
</tr>
</tbody>
</table>

Diagnostic concordance

Limitations of the Swan-Ganz catheter

Hypovolemia

- Low PaP

LV dysfunction

- Elevated PaP

Echographic diagnosis

- 48 evaluations had
- 2 causes of hemodynamic instability or more (82%)
- 72% diastolic dysfunction
- 45% RV systolic dysfunction
- 38% LV systolic dysfunction
- 29% hypovolemia

Our hypothesis
LV hypertrophy: wall thickness

Figure 4 Transmural echocardiographic measurement of wall thickness of left ventricular (LV) septal wall (SWP) and posterior wall (PWP) from transmural short-axis view of LV, papillary muscle level, usually best imaged in angle of approximately 90 to 100 degrees.

<table>
<thead>
<tr>
<th>Region</th>
<th>Women</th>
<th>Men</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Mild</td>
</tr>
<tr>
<td>Septal thickness, mm</td>
<td>0-1.4</td>
<td>1.5-1.9</td>
</tr>
<tr>
<td>Papillary wall thickness, mm</td>
<td>1.0-1.2</td>
<td>1.3-1.8</td>
</tr>
</tbody>
</table>
SV = LVEF x LVEDV

Cardiac performance

Systolic function

Diastolic function

Pressure

Volume

Stroke

volume

LVEDV

LVESP

LVEDP

Pressure-volume loop

Adapted from Bettex D. Échocardiographie transoesophagienne en anesthésie-réanimation 1997

Pressure-Volume loop estimation

Stroke volume = CO

HR

Stroke work

LVEDP

Wedge

ESA

EDA

SAP

LVESP

Pressure

Volume
LV performance

- Load dependent
  - Cardiac output
  - LVEF and FAC
  - LV stroke work
  - dP/dT
  - Myocardial Performance Index
- Load independent
  - Elastance

LV stroke work

Adapted from Shoemaker Textbook of critical care Saunders 1999

Poor correlation between hemodynamic and echocardiographic indexes of left ventricular performance in the operating room and intensive care unit.

Critical Care Medicine 2004
Myocardial dysfunction after successful resuscitation from cardiac arrest

Left ventricular dysfunction

Bouchard et al. CCM 2004

Gazmuri RJ et al. CCM 1996
Limitation of LVSW measurement

Stroke volume: 60 ml
LVSW (X 0.0136): 60 X (100-10)

LVEF: 60 ml/100ml = 60% 60 ml/160ml = 40%

Contractility

Pressure
Volume

Pressure
Volume
Assessment of the immediate effects of cardiopulmonary bypass on left ventricular performance by on-line pressure-area relations

1. Estimation of LV function in mitral regurgitation
2. Estimation of left atrial systolic pressure
3. Estimation of systolic arterial pressure: is your radial arterial pressure reliable?

69 yo woman after MVR and AVR
Radial pressure = 111 mmHg

Aortic pressure measured by surgeon = 125 mmHg

Pressure gradient = 111 mmHg = LVESP - LAP
LV systolic pressure = PG + LAP = Aortic pressure
≈ 111 mmHg + pulmonary artery wedge pressure (v wave)
= 111 mmHg + 18 mmHg
Aortic pressure = 129 mmHg

Prevalence of a central to radial pressure gradient in high-risk surgery

Dr Antonio Su

Percentage of central-to-radial gradients in complex surgeries

N = 60
Why is this patient hemodynamically unstable?
2D Longitudinal strain rate

- Inferior wall
- Anterior wall

Hemodynamic instability

1. Coronary perfusion pressure
2. Left ventricular dysfunction

Doppler Tissue Imaging: A Noninvasive Technique for Evaluation of Left Ventricular Relaxation and Estimation of Filling Pressures

Sherif F. Nagib, MD, Katherine J. Middleton, RCT, Helen A. Kopelen, RDMN, William A. Zoghbi, MD, FACC, Miguel A. Quinones, MD, FACC

Y = 1.0 + 124 X

N = 50

JACC 1997
Left ventricular end-diastolic pressure is a predictor of mortality in cardiac surgery independently of left ventricular ejection fraction

R. Salem, A. Y. Dunsmuir, P. Couture, S. Bélisle, A. Fortier, M.-C. Guérin, N. Carrier and R. Martin

1Department of Anesthesiology, 2Department of Biostatistics and 3Department of Surgery, Montreal Heart Institute, Montreal, Quebec, H3T 1C5, Canada

Table 3: Multivariate analysis: mortality. CI, confidence interval; LVEDP, left ventricular end-diastolic pressure; LVEF, left ventricular ejection fraction. CPE, cyclophosphamide peritoneal.

<table>
<thead>
<tr>
<th>Prognostic factor</th>
<th>P-value</th>
<th>Units</th>
<th>Odds ratio</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.0001</td>
<td>20</td>
<td>2.135</td>
<td>1.465-3.105</td>
</tr>
<tr>
<td>BMI</td>
<td>0.0001</td>
<td>20</td>
<td>1.485</td>
<td>1.004-2.168</td>
</tr>
<tr>
<td>LVEDP</td>
<td>0.0001</td>
<td>20</td>
<td>1.250</td>
<td>0.825-1.904</td>
</tr>
<tr>
<td>LVEF</td>
<td>0.0001</td>
<td>20</td>
<td>1.250</td>
<td>0.825-1.904</td>
</tr>
<tr>
<td>ECMF (cm H2O)</td>
<td>0.0001</td>
<td>20</td>
<td>1.135</td>
<td>1.004-1.296</td>
</tr>
<tr>
<td>Pre-operative</td>
<td>0.0001</td>
<td>20</td>
<td>1.485</td>
<td>1.004-2.168</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.0011</td>
<td>10</td>
<td>1.485</td>
<td>1.004-2.168</td>
</tr>
<tr>
<td>Tobacco addiction</td>
<td>0.0277</td>
<td>10</td>
<td>1.729</td>
<td>1.004-2.906</td>
</tr>
</tbody>
</table>

N = 3024

British Journal Anesthesia 2006

Diastolic dysfunction

End-diastolic area

End-systolic area

Wedge = 5 mmHg
Summary

Evaluation of diastolic filling of left ventricle in health and disease: Doppler echocardiography is the clinician's Rosetta Stone

Nishimura RA JACC 1997
Diastolic Dysfunction is Predictive of Difficult Weaning from Cardiopulmonary Bypass

Francis Bernard, MD; André Donadie, MD, FRSC; Denis Babin, MD, MS; Caroline Guyot, MS; Pierre Couture, MD, FRSC; André Couturier, MS; and Jean Bouchard, MD, FRSC

Departments of Medicine and Cardiology, CIUSSS, Sainte-Catherine, and Department of Anesthesia, Montreal Heart Institute, Montreal, Quebec, Canada

Canadian J Anesthesia 2006

Cardiothoracic Anesthesia, Respiration and Airway

Left and right ventricular diastolic dysfunction as predictors of difficult separation from cardiopulmonary bypass

[La dysfonction ventriculaire diastolique gauche et droite comme prédicteur des difficultés de sevrage de la circulation extracorporelle]

Andre T. Donadie, MD, FRSC; Denis Babin, MD, MS; Caroline Guyot, MS; Pierre Couture, MD, FRSC; André Couturier, MS; Jean Bouchard, MD, FRSC; Michel Caissie, MD, MS; Denis Babin, MD, MS; Sylvie Leduc, MD, MS; Jean-Claude Bouchard, MD, FRSC

Canadian J Anesthesia 2006

Grade I: relaxation abnormality

[Diagram showing LVV and LVP with an abnormality shaded in yellow]
76 yo woman with aortic stenosis

Grade III: Increased Chamber Stifness

62 yo patient unstable after AVR
Beginning post-bypass

End post-bypass

Chamber Dilatation

Systolic Failure
Impaired Left Ventricular Filling Due to Right Ventricular Pressure Overload in Primary Pulmonary Hypertension: Noninvasive Monitoring Using MRI

Pericardial Restraint

Effet de la fréquence cardiaque sur la fonction diastolique
Hemodynamically unstable after cardiac surgery: paced

Slow down the pacemaker

Hemodynamically unstable after cardiac surgery
Unexpected hemodynamic instability. What happened?
LVOT obstruction

Normally
Fearful consequence

Hemodynamic instability

- 1. Cardiac output
- 2. Coronary perfusion pressure
- 3. Left ventricular dysfunction
- 4. Left ventricular outflow tract obstruction
- 5. Pulmonary hypertension
- 6. Exacerbation

With permission from Lang et al. JASE 2005;18:1440-1463
Right Ventricular Myocardial Performance Index Predicts Perioperative Mortality or Circulatory Failure in High-Risk Valvular Surgery

François Hazinski, MD, André V. Descamps, MD, Pierre Courtois, MD, Raymond Cattin, MD, Michel Pullicino, MD, Sylvie Lessouque, MSc, Jean Lambert, PhD, and Jean Claude Taralli, MD, Montreal, Quebec, Canada

JASE 2007 (In press)

Right ventricular pressure monitoring

ME: Normal RV waveform
RA and RV pressure waveform correlation

56 yo woman: CABG, MVR and LV remodeling

Effect of adrenalin and thoracic closure
Effect of adrenalin upon weaning from CPB

RV dysfunction impact

Another confounding factor
Right ventricular outflow tract obstruction

![Graph and images related to right ventricular outflow tract obstruction.]

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Right ventricular outflow tract obstruction

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Right ventricular outflow tract obstruction

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Right ventricular outflow tract obstruction

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Septal interaction
38 yo woman with grade IV SHA

In summary

- Hemodynamic instability often result from several mechanisms
- The concept of the pressure-volume allow the understanding of these various causes
- Every diagnosis can be diagnosed with TEE and has associated hemodynamic and ECG clues
- The hemodynamic clues are more often based on the appearance of the waveform rather than absolute pressure values
- Diastolic dysfunction or filling abnormalities is invariably present with or without systolic dysfunction
- The treatment of hemodynamic instability should be based on the underlying mechanism
L’équipe de recherche:

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Jean-Claude Tardif MD FRCP

Alain Deschamps MD FRCP PhD

Biostatistics

Thesis director

Pierre Couture MD FRCP

Jean Lambert PhD

Louis P. Perrault MD PhD FRCSIC

Jean-Claude Tardif MD FRCP