Right heart dysfunction in the non-cardiac operating room

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Disclosures

none
Objectives

- Review right heart disease incidence, anatomy, pathophysiology, morbidity and mortality
- Review current literature regarding management of right heart disease
- Examine the anesthetic implications of right heart disease
Outline

- Anatomy
- Physiology/Pathophysiology
- Current Therapies
- Anesthetic Implications
- Addressing acute right heart failure in the operating room
Case

2\textsuperscript{nd} case in the ortho room

76yoF

Right hip hemiarthroplasty

-dx of pulmonary hypertension
Case

Medications include:

- Lasix
- Digoxin
- Macitentan
- Sildenafil
- Spironolactone
- Continuous infusion of treprostinil
case

More…

8-10L home O2 + nasal CPAP
Can’t walk across a room (at baseline)
Can’t lay flat
RVSP 87mmHg with RVH and RV dilation

Plan?
Incidence of right heart failure

Overall prevalence varies with different populations. Universally associated with worse outcomes

Right heart dysfunction found in 48% of pts with HFrEF and 33% in pts with HFpEF

Two year mortality in pts with HFpEF and RHD was 45% vs 7% without
Anatomy

Hemi-ellipsoid shape with a thin (highly compliant) free wall 2-3mm in thickness

Divided into two areas
- sinus inflow
- conus (infundibulum)

Physiology

Normal function is related to:

- Venous return
- RV afterload
- Pericardial compliance
- Contractility of the free wall and interventricular septum

**afterload is the primary determinant of normal RV function**

Haddad et al. 2009, Konstam et al, 2018
Physiology

The association with the low resistance, highly compliant pulmonary vascular system leads to the ability to tolerate changes in volume much better than changes in pressure.

Konstam et al. 2018
Physiology

- Compared to left ventricle, there is an absence of isovolumetric periods (higher momentum of blood → continued ejection after the end of LV systolic ejection)

Konstam et al, 2018
Causes of Right Heart Failure

- Myocarditis
- Myocardial infarction
- Post-surgical acute right heart failure (related to acute PH or myocardial ischemia)
- Post-cardiac transplant
- Post LVAD
- Acute PE
- Arrhythmogenic RV cardiomyopathy
- Valvular disease
- Pulmonary Hypertension
- Congenital Heart Disease

Konstam et al, 2018, up-to-date
Presentation

Acute
- acute RV dilation
- ventricular independent effect, limiting LV filling
- decreased RVEF/CO
- increased venous congestion
- pt may have signs of hypoperfusion, hypotension and cyanosis

Chronic
- exercise intolerance
- atrial tachyarrhythmias
- cardiorenal syndrome**
- cardiohepatic syndrome
- decreased GI absorption/malnutrition

**can be present in the absence of decreased CO

Konstam et al, 2018
WHO Pulmonary Hypertension Classification

Group 1
- pulmonary arterial hypertension

Group 2
- left heart disease

Group 3
- chronic lung disease and hypoxia

Group 4
- chronic thromboembolic disease

Group 5
- miscellaneous
Multiple studies showing an increased risk of morbidity and mortality with pulmonary hypertension and cardiac surgery

Little research into PH and non-cardiac surgery

Ramakrishna et al, 2005 (retrospective study, 145 pts, mean RVSP 68 mmHg)

- 42% of PH patients had a morbid event (most frequently respiratory failure 28%, cardiac dysrhythmia 12%, CHF 11%)
- 7% had early death
- Higher compared to other high risk patient populations
  - >80yo 4.6% mortality
  - >65yo 3.4% mortality
Pulmonary hypertension as an independent risk factor for morbidity and mortality in non-cardiac surgery

More likely to develop:
- CHF
- Hemodynamic instability
- Sepsis
- Respiratory failure

Needed longer ventilator times
Stayed longer in the ICU
More frequently readmitted to the hospital within 30 days

Kaw et al. 2011, Ramakrishna et al. 2005
Current Therapies for Chronic Right Heart failure

Diuretics

- mainstay therapy for tx congestion in chronic RHF
- goal to maintain preload adequate for cardiac filling, avoid RV volume overload and ventricular interdependence
- patients may require large doses due to upregulation of renin-angiotensin-aldosterone system axis

Konstam et al 2018, Testani et al. 2010
Current Therapies for Chronic Right Heart failure

Renin-angiotensin-aldosterone system inhibitors, beta-blockers and hydralazine

- small scale, single center studies support the use of these, although results are inconsistent depending on the underlying pathology of RHF

- currently not recommended in PH patients regardless of RHF, except associated with HTN, CAD or left heart failure

299-307, 308-311, 312, 321
Current Therapies for Chronic Right Heart failure

Pulmonary Vasodilators

- have shown benefits for patients with WHO class 1 PH
- probably not helpful for class 2

Prostacyclin analogs (epoprostenol, treprostinil, iloprost)

Phosphodiesterase inhibitors (sildenafil, tadalafil)

Endothelin Receptor Antagonists (sitaxentan, ambrisentan and bosentan)
Anesthetic concerns

Pathophysiology of RV failure in the perioperative period

- Pain (incisional, airway)
- Pulmonary emboli
- ↑ Sympathetic tone
- ↓ PO₂, ↑ PCO₂ acidosis
- Mechanical ventilation
- Hyperinflation
- ↑ PVR
- ↑ RV pressure
- Fluid overload
- ↑ RV myocardial oxygen uptake
- ↓ Subendocardial blood flow
- RV ischemia
- RV failure (↓ RV stroke volume)
- ↑ LV filling
- ↓ LV stroke volume and cardiac output
- Hypotension
- ↓ RV perfusion

Factors that may precipitate RV failure in the perioperative period.

↓: decreased; PO₂: partial pressure of oxygen; ↑: increased; PCO₂: partial pressure of carbon dioxide; PVR: pulmonary vascular resistance; RV: right ventricular; LV: left ventricular.

* Ventricular interdependence refers to the relationship between LV and RV filling and function resulting from pericardial and myocardial effects, including septal displacement.
Anesthetic Concerns

• Generally, medications for PH/HF should be continued throughout the perioperative period

• Thorough pre-operative work-up with recent imaging, labs and RHC

• Careful consideration for need for surgery vs alternatives

• Coordination of post-operative care and monitoring
Anesthetic Concerns

Neuraxial vs. general anesthesia
-anti-platelet affect of prostacyclin analogs?

Laparoscopic vs. open

Patient positioning

Ventilation strategies

Post-operative pain control
Management of Acute Right Heart Failure

Causes:
- acute increases in PVR
  - decreased PaO2
  - increased PaCO2
  - acidosis
- Acute PE
- Myocardial infarction
- Acute left heart failure
- Acute lung injury
- Sepsis
- Abrupt discontinuation of PAH medications
Management of Acute Right Heart Failure

How do I get out of the right heart failure “death spiral”?!
Management of Acute Right Heart Failure

Unfortunately there is no secret weapon
Management of Acute Right Heart Failure

1. Assess severity
   - hemodynamics (SBP, CVP, PAP)
   - signs of end organ damage (lactate, bnp, etc..)
   - appropriate imaging (TEE/TTE)

Harjola et al. 2016
Management of Acute Right Heart Failure

2. Identify and manage modifiable causes
   - assess for reversible causes of increased PVR (low paO2, high paCO2, acidosis)
   - PE management
   - PCI for AMI
   - correction of arrhythmias

Harjola et al. 2016
Management of Acute Right Heart Failure

3. Volume management
   - diuresis if signs of volume overload
   - cautious volume replacement
   - renal replacement therapies

Harjola et al. 2016
Management of Acute Right Heart Failure

4. Optimize coronary perfusion
   - vasopressors
   - norepinephrine vs. vasopressin vs. phenylephrine

Harjola et al. 2016, Up-to-Date 2020
Vasopressor Choice

Norepinephrine and vasopressin can reduce PVR/SVR ratio compared to phenylephrine (unopposed pulm vasoconstriction and bradycardia)

Low dose vasopressin can decrease PVR through release of NO in the vascular endothelium and activation of V2 receptors in vascular smooth muscle

Caution with dose-dependent coronary vasoconstriction which can worsen myocardial perfusion

Up-to-date, 2020
Management of Acute Right Heart Failure

5. Inotropic support to maintain cardiac output
   - inodilators like milrinone and dobutamine
   - milrinone, a PDE-3 inhibitor is also a pulmonary vasodilator
   - use of inodilators limited by SBP

Harjola et al. 2016, Up-to-Date 2020
Management of Acute Right Heart Failure

6. Inhaled afterload reduction
   - iNO
   - prostacyclins

Harjola et al. 2016,
Up-to-Date 2020
Comparison of iNO to inhaled prostacyclins

Kahn et al. 2009 randomized, cross-over study of cardiac and lung transplant pts.
-both similarly reduced pulmonary artery pressure and cvp, increased cardiac output and mixed venous O2

Cost difference!
UofM hourly comparison:
inhaled epoprostenol (Veletri)=$17.71
Inhaled NO=$167
Veletri in the OR
Management of Acute Right Heart Failure

7. Consider temporary mechanical support
   - RVAD
   - ECMO
Case outcome

- Arterial and central lines placed awake
- Her treprostinil infusion was continued
- Vasopressin infusion started prophylactically
- Two failed attempts at an epidural
- Bupivicane spinal performed, required some supplementation by the surgeons
- No sedation given
- Pt had some desaturations to the low 80%, tx with increasing HOB, maintain 15L o2 by nasal cpap
- Hemodynamically stable throughout
- Transported to ICU post-operatively
Regardless of the cause, patients with right-heart dysfunction and/or pulmonary hypertension have worse outcomes.

Intraoperative management is challenging, with care being largely supportive while addressing reversible causes.
Thank you!

Questions?
references


6. Up-to-date, Anesthesia for patients with pulmonary hypertension and

7. https://radiopaedia.org


