Failing right ventricle: how to prevent and support?

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Perioperative right ventricular (RV) dysfunction can be a key determinant in survival following cardiac surgery, especially in patients with pulmonary artery hypertension (PAH). In cardiac surgery, RV dysfunction can lead to difficulty in weaning from cardiopulmonary bypass (CPB) and increased postoperative mortality. PAH by itself is considered to be a major risk factor for mortality in patients undergoing cardiac as well as noncardiac surgery. This increased mortality is in all likelihood related to the ensuing RV failure in these patients. PAH can also be present in patients having LV dysfunction or those suffering from mitral valve disease, congenital heart disease or pulmonary disease.

Pathophysiology: With the RV failure setting in, initially right atrial (RA) pressure increases that leads to decreased venous return and cardiac output. The resultant low perfusion pressure affects the tissue oxygenation. In addition, the increased venous pressure transmitted through both superior and inferior vena-cava leads to increase in outflow pressure of vital organs such as the brain, kidney, gastrointestinal tract and the liver. The tissue perfusion and oxygenation is thus severely affected. The increased mortality observed after RV failure is also related to delayed diagnosis and suboptimal management.

Diagnosis: Due to the foregoing, it is essential to identify a high risk group of patients and also aim for early diagnosis so that prevention and management strategies can be planned and implemented. There is no clear definition of RV failure based on hemodynamic criteria, but hypotension, elevated RA pressure (usually >15 mm Hg) and clear lungs have been proposed as key elements in the diagnosis of RV failure. The major drawback of this definition is that RA pressure can be elevated from raised intrathoracic and intra-abdominal pressure without RV dysfunction.¹

The Montreal heart institute has proposed and promoted the use of continuous RV pressure waveform monitoring.¹ The RV and the distal PA port of the pulmonary artery catheter (PAC) can be transduced continuously for this purpose. The RV diastolic slope is typically horizontal (right ventricular end-diastolic pressure (RVEDP) of 0-5 mm Hg) in a normally compliant RV. In RV failure, this slope changes to an oblique diastolic slope (increase in RVEDP) and in severe RV failure, it equalises with the PA diastolic pressure. The
simultaneous measurement of RV and PA pressure can also help to diagnose RVOT obstruction. A gradient of >6 mm Hg suggests RVOT obstruction. A gradient of > 25 mm Hg can be observed in some patients, which indicates dynamic or mechanical obstruction. The presence of dynamic obstruction is analogous with systolic anterior motion of mitral valve on left side, and in this scenario, inotropic agents should not be used. Further, volume and beta blockers can be beneficial.

The use of TEE along with the RV and PA pressure monitoring is recommended to further confirm the diagnosis of RV dysfunction. A dilated, hypokinetic or akinetic RV, flattening or deviation of the interventricular septum, tricuspid annular plane systolic excursion (TAPSE) <15 mm Hg, and systolic obtundation of the hepatic venous Doppler waveform are some of the important TEE features that would help to confirm the diagnosis of RV failure. The TEE can also be used to diagnose the left sided pathologies responsible for PAH and RV failure, such as LV dysfunction, mitral valve disease, left atrial myxoma, etc.

In some patients, despite the presence of RV dysfunction, adequate cardiac output and tissue oxygenation may still be maintained. This subset of patients can be identified by several markers such as mixed venous oxygen saturation (SvO\textsubscript{2}), arterio-venous CO\textsubscript{2} difference\textsuperscript{3} and lactate measurement.\textsuperscript{4} Since these measurements are intermittent, regional cerebral oxygen saturation (rSO\textsubscript{2}) using near infra red spectroscopy (NIRS) can be an attractive alternative. Thus a combination of RV pressure waveform, TEE, and NIRS monitoring can be useful in making the diagnosis of compensated or uncompensated RV failure. An elevated RVEDP, TEE evidence of RV failure, and reduced rSO\textsubscript{2} would indicate uncompensated RV failure, while normal RVEDP and reduced NIRS would indicate noncardiogenic reasons such as acute hemorrhage.

**Perioperative management:** Since the early diagnosis and treatment is crucial in the management, it is important to identify a high risk group of patient. These essentially include those with PAH, LV dysfunction, mitral valve disease, and congenital heart disease with left to right shunt or systemic RV pathologies. Adequate hemodynamic and TEE monitoring should be used in these patients. Once the diagnosis of RV dysfunction is made, the focus is on maintaining the hemodynamic stability. The general measures include optimisation of heart rate and rhythm, optimal fluid and blood management, avoiding reduced or excessive lung volumes (maintain normal functional residual capacity), or drugs that could increase PA pressure and maintain normal acid base status.\textsuperscript{5}

The reduction of RV afterload is another important objective in these patients. In this respect inhaled milrinone is preferred nowadays due to reduced cost, rapid onset of action and simplicity of administration.\textsuperscript{6,7} Other vasodilators that can be used in inhaled form include, prostaglandins, nitroglycerin, sodium nitroprusside, etc. Sublingual sildenafil has been suggested as an alternative.\textsuperscript{8,9} In high risk patients, the inhaled agents can also be administered before CPB is instituted.
Conclusion: RV function is an important cause for increased morbidity and mortality following cardiac surgery. Patients with PAH are at increased risk for developing RV failure. RV pressure monitoring along with PA pressure and TEE monitoring is useful in the early diagnosis. The management is based on the use of inhaled pulmonary vasodilators along with inotropes such as phosphodiesterase inhibitors.

References:

1 Denault AY, Haddad F, Jacobsohn E, Deschamps A. Perioperative right ventricular dysfunction. Curr Opin Anesthesiol 2013;26:000-000