Recent Updates in Management of Right Ventricular Failure with Pulmonary Hypertension in ICU

Essay

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By

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بسم الله الرحمن الرحيم

قالُوا سُبْحَانكَ لاَ عِلمَ لَنَا إِلاَّ ما

عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيم

صدق الله العظيم

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List of Contents

List of Tables

List of Figures

List of Abbreviations

Abb.	Full term
ACE	: Angiotensin converting enzyme
AF	: Atrial fibrillation
ALT	: Alanine aminotransferase
ARBS	: Angiotensin receptor blockers
ARDS	: Acute respiratory distress syndrome
ASD	: Atril septal defect
AST	: Aspartate aminotransferase
AV	: Atrio ventricular
BiPAP	: Bi level positive air way pressure
BNP	: Brain natriuretic peptide
CCB_S	: Calcium channel blocker
CHD	: Congenital heart disease
CO	: Cardiac output
CPAP	: Continuous positive pressure
CT	: Computed tomography
CTEPH	: Chronic thrombo-embolic pulmonary hypertension
ECG	: Electrocardiogram
ECLS	: Extracorporeal life support
ECOM	: Extracorporeal membrane oxygenation
EU	: European union
FDA	: Food and drug administration
FPAH	: Familial pulmonary hypertension
H/LTx	: Heart–lung transplantation
HF	: Heart failure
ICU	: Intensive care unit
INR	: International Normalization Ratio
IPAH	: Idiopathic pulmonary arterial hypertension
IV	: Intra venous
LM	: Left main coronary artery
LMCS	: Left main compression syndrome
LV	: Left ventricle

List of Abbreviations (Cont...)

Abb.	Full term
MCT	: Monocrotaline
MI	: Myocardial infarction
NO	: Nitric oxide
NSAIDs	: Non steroidal anti inflammatory druges
NT-proBNP	: N-terminal fragment of brain natriuretic peptide
PAD	: Pulmonary artery dissection
PAH	: Pulmonary arterial hypertension
PA–LA	: Pulmonary arteries and the left atrium
PAOP	: Pulmonary artery occlusion pressure
PAPm	: Mean pulmonary arterial pressure
PAR	: Pulmonary artery rupture
PCWP	: Pulmonary capillary wedge pressure
PE	: Pulmonary embolism
PPM	: Part per million
PVOD	: Pulmonary vascular occlusive disease
PVR	: Pulmonary vascular resistance
PVP	: Pulmonary vascular pressure
RV	: Right ventricle
RVEF	: Right ventricular ejection fraction
RVF	: Right ventricular failure
RVMI	: Right ventricular myocardial infarction
Scv_{O2}	: Central venous oxygen saturation;
$S\bar{V}_{O2}$	: Mixed venous oxygen saturation.
SVC	: Superior vena cava
TDD	: Total digitalizing dose
TGA	: Transposition of great arteries
TID	: Three times a day
TOF	: Tetralogy of fallot
TR	: Tricuspid regurge
v/a ECMO	: Veno arterial extracorporeal membrane oxygenation

INTRODUCTION

Right ventricular (RV) failure is the most common cause of death in patients with pulmonary hypertension, and RV function is the major determinant of morbidity and mortality in these patients population ***(Delcroix et al., 2010).***

Right ventricular failure is a common complication of pulmonary hypertension (PH). RV failure can also result from other diseases such as myocarditis, cardiomyopathy, or myocardial infarction, although any form of PH can result in RV dysfunction, the full picture of RV failure with low cardiac output and elevated RV filling pressures is typically seen in patients with pulmonary arterial hypertension (PAH) or chronic thromboembolic pulmonary hypertension (CTEPH) ***(Simonneau et al., 2009)***.

In the past it was not unusual to see patients being admitted to the intensive care unit (ICU) with RV failure due to undiagnosed and untreated PAH. Fortunately, with increased awareness of the condition, this scenario has become increasingly rare. Today, the majority of patients with PH and RV failure admitted to the ICU have exhausted their medical treatment options, which renders their management particularly challenging and, at times, frustrating. Patients with overt RV failure have never been included in randomized, controlled clinical trials and few articles have specifically addressed this patient population. Contemporary guidelines make no specific recommendations regarding the ICU management of patients with RV failure ***(Galie et al., 2009)***.

RV failure eventually results in multiorgan dysfunction. Reduced cardiac function can result in decreased bowel perfusion, loss of the intestinal barrier function, and bacterial translocation a complication that has been implicated as a common cause of death in these patients. Reduced hepatic perfusion can impair liver function or may even result in liver failure. Renal failure is another disastrous complication of RV failure ***(Tongers et al., 2007).***

The principles of care should focus on improving RV function and oxygen delivery to prevent the development of multi-organ failure, by optimizing preload, reducing after-load, and improving RV contractility. Preservation of coronary blood flow and avoiding treatment-induced increases in heart rate should also guide treatment decision ***(Erzurum et al., 2010).***

Aim of the Work

This work aims at highlighting the recent updates in guidelines of management of right ventricular failure with pulmonary hypertension in the critical care unit.

Chapter one

Pathophysiology

Definitions:

Right ventricular (RV) failure is a complex clinical syndrome that can result from any structural or functional cardiovascular disorder that impairs the ability of the RV to fill or to eject blood. The cardinal clinical manifestations of RV failure are:

(1) Fluid retention, which may lead to peripheral edema, ascites, and anasarca.

(2) Decreased systolic reserve or low cardiac output which may lead to exercise intolerance and fatigue.

(3) Atrial or ventricular arrhythmias.

RV dysfunction, on the other hand, refers to abnormalities of filling or contraction without reference to signs or symptoms of heart failure (HF). Many indices can be used to describe RV dysfunction. Among them, RV ejection fraction (RVEF) is the most commonly used index of RV function even though it is a highly load-dependent index of contractility ***(François Haddad et al., 2008).***

Table (1): Selected Markers of RV Dysfunction Associated With Clinical Status and Prognosis ***(Daniel et al., 2008).***

Systolic performance indices: • RVEF • RV fractional area change • Tricuspid annular plane systolic excursion • RV myocardial performance index • Hemodynamics • Right atrial pressure • Cardiac index • Maximal pressure-time derivative
Indices derived form pressure–volume measurements: • Ventricular elastance • Preload recruitable stroke work • Diastolic filling profiles
Tissue Doppler indeces: • Isovolumic acceleration • Systolic and diastolic myocardial velocities • Right-sided dilation • RV dilation absolute or relative to LV • Right atrial size • Tricuspid regurgitation
Electrophysiological characteristics: • Arrhythmias • Inducibility of ventricular tachycardia • QRS duration
Neurohormones and cytokines: • B-type natriuretic peptide • Norepinephrine • Endothelin • Tumor necrosis factor

Pathophysiology:

RV dysfunction begins with an initial injury or a stress on the myocardium and may progress in the absence of a new identifiable insult to the heart. The time course (acute or chronic) and time of onset of the disease process (newborn, pediatrics, or adults) also influence RV adaptation to disease. Neurohormonal activation and altered gene expression modulate the development of RV dysfunction Protein-losing enteropathy is multifactorial in the setting of RV failure ***(Voelkel et al., 2006).***

The most common cause of RV dysfunction is chronic left-sided HF. Pulmonary hypertension is an important cause of RV dysfunction. The classification separates causes of pulmonary hypertension into those that affect primarily the pulmonary arterial tree (pulmonary arterial hypertension [PAH]), the pulmonary venous system, and the pulmonary vasculature as a result of lung disease, hypoventilation, or pulmonary emboli. RV dysfunction also is a prominent feature of various forms of congenital heart diseases such as tetralogy of Fallot (TOF), transposition of the great arteries, Ebstein's anomaly, and Eisenmenger's syndrome. RV adaptation to disease is complex and depends on many factors. The most important factors appear to be the type and severity of myocardial injury or stress, the time course of the disease (acute or chronic), and the time of onset of the disease process (newborn, pediatric, or adult years). Other important factors may include the importance of neurohormonal activation factors, altered gene expression, and the pattern of

ventricular remodeling. Multiple interactions exist between myocardial injury, neurohormonal activation, altered gene expression, and ventricular remodeling ***(Davlouros et al., 2006).***

In general, the RV adapts better to volume overload than to pressure overload. In atrial septal defect (ASD) and tricuspid regurgitation, the RV may tolerate volume overload for a long time without a significant decrease in RV systolic function ***(Gatzoulis et al., 2006).***

Another studies, however, have demonstrated that longstanding volume overload may lead to an increase in morbidity and mortality. In contrast to volume-overload states, moderate to severe acquired pulmonary hypertension in the adult often leads to RV dilatation and failure ***(Davlouros et al., 2006).***

Pressure overload of the RV also may lead to RV ischemia, which may further aggravate ventricular dysfunction. Compared with volume-overload states, histological changes are more pronounced in RV pressure-overload states as demonstrated by the increased density of myocardial connective tissue seen in both animal and human studies ***(Kasimir et al., 2004).***

In acute pressure-overload states such as pulmonary embolism (PE), an adult with a previously normal RV is incapable of acutely generating a mean pulmonary artery pressure 40 mm Hg, and RV failure occurs early in the presence of a significant embolic burden ***(Goldhaber et al., 1999).***