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REVIEW

Diastolic dysfunction in the critically ill patient

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Abstract Left ventricular diastolic dysfunction is a common finding in critically ill patients. It is characterized by a progressive deterioration of the relaxation and the compliance of the left ventricle. Two-dimensional and Doppler echocardiography is a cornerstone in its diagnosis.

Acute pulmonary edema associated with hypertensive crisis is the most frequent presentation of diastolic dysfunction critically ill patients. Myocardial ischemia, sepsis and weaning failure from mechanical ventilation also may be associated with diastolic dysfunction.

The treatment is based on the reduction of pulmonary congestion and left ventricular filling pressures. Some studies have found a prognostic role of diastolic dysfunction in some diseases such as sepsis.

The present review aims to analyze thoroughly the echocardiographic diagnosis and the most frequent scenarios in critically ill patients in whom diastolic dysfunction plays a key role.

PALABRAS CLAVE
Insuficiencia cardíaca diastólica;
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Enfermo crítico;
Shock séptico;
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Disfunción diastólica en el paciente crítico

Resumen La disfunción diastólica del ventrículo izquierdo es un hallazgo frecuente en pacientes críticos. Se caracteriza por una alteración progresiva de la relajación y la complianza del ventrículo izquierdo. La ecocardiografía bidimensional y doppler juega un papel primordial en su diagnóstico.

El edema agudo de pulmón asociado a una crisis hipertensiva es la presentación más frecuente de la disfunción diastólica en pacientes críticos. La isquemia miocárdica, la sepsis y el fracaso del destete de la ventilación mecánica también pueden asociarse a la disfunción diastólica.

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El tratamiento se basa en la reducción de la congestión pulmonar y en disminuir las presiones de llenado del ventrículo izquierdo. Algunos estudios han hallado un papel pronóstico de la disfunción diastólica en algunas afecciones como la sepsis.

La presente revisión procura analizar en profundidad el diagnóstico ecocardiográfico y las enfermedades del paciente crítico en las que la disfunción diastólica juega un papel clave.

Introduction

Heart failure (HF) is a major public health problem due to the huge economics and social costs involved. Despite improvements in the treatment of cardiovascular diseases over the past years, prevalence, survival and mortality of HF have marginally changed.[1]

HF can be defined as an abnormality of cardiac structure or function leading to failure of the heart to deliver oxygen according to the requirements of the tissues, despite normal filling pressures, or only at the expense of increased filling pressures.[2]

Symptoms of HF are non-specific (breathlessness, orthopnoea, paroxysmal nocturnal dyspnea, reduced exercise tolerance, fatigue) and do not help to discriminate between HF and other problems. Signs of HF are also not specific (tachycardia, tachypnea) and many result from sodium and water retention (peripheral edema, pulmonary crepitations, elevated jugular venous pressure, hepatojugular reflux, ascites).

A change has occurred in the clinical–hemodynamic profile of patients with HF in the past decade. HF has classically been associated with impaired systolic function, however is now recognized that both, systolic and diastolic function, play a key role in its pathophysiology.[3]

The term diastolic heart failure refers to the conjunction of signs and symptoms of HF, preserved left ventricular ejection fraction and diastolic dysfunction, but it is currently replaced by the term HF with preserved ejection fraction.[4]

Nowadays HF with preserved ejection fraction accounts for as many as 35–50% of all cases of HF. Furthermore readmission and mortality rates are similar to those observed in patients with HF with reduced ejection fraction.[5] HF with preserved ejection fraction patients are older and more commonly female, with greater hypertension, obesity, anemia, and atrial fibrillation compared to those with HF with reduced ejection fraction.[6]

HF is a common feature in intensive care unit (ICU) patients, occurring in about 30% of cases.[7] In critically ill patients signs and symptoms of HF are non-specific, therefore the study of cardiac function, invasively or non-invasively, is crucial to the proper treatment of patients. ICU patients have frequently predisposing factors associated with diastolic dysfunction: related to patient's history (advanced age, female sex, hypertension, obesity), diseases (myocardial ischemia, arrhythmia, sepsis) or treatments applied (volume resuscitation, mechanical ventilation).[8,9] The purpose of this article is to provide an overview of the diagnosis and role of diastolic dysfunction in ICU patients, condition that is underestimated, mainly because it is underdiagnosed.

Pathophysiology

Left ventricular diastole extends from the closure of the aortic valve to the closure of the mitral valve, and its duration, at rest, is usually two-thirds of the cardiac cycle. The first diastolic phase, after closing the aortic valve to the opening of the mitral valve, is the isovolumetric relaxation time. During this period, the intraventricular pressure decreases rapidly before the ventricular filling begins.

Ventricular filling includes three phases in patients with sinus rhythm. The early filling phase begins with the opening of the mitral valve due to the reduction of intraventricular pressure below the atrial pressure. During the second phase, or equilibrium phase, the ventricular volume remains constant due to the equalization of the atrio-ventricular pressure. Finally, the late filling phase depends on the increase in atrial pressure due to the atrial contraction.

Several physiological parameters interact during ventricular diastole.[10] Among these, the most fundamental are ventricular relaxation characteristics, compliance, and atrial contraction.[11,12]

Relaxation of cardiac muscle fibers is an active property that uses energy as adenosine triphosphate (ATP). This energy is required to transfer the cytoplasmic calcium back to the sarcoplasmic reticulum, reactivating the inhibitory effect of troponin-tropomyosin complex and allowing the dissociation of actin and myosin filaments. Relaxation not only depends on the availability of energy, but also on the abundance of calcium in the cytoplasm. The effect of the relaxation of the cardiac muscle fibers is a sudden drop in left ventricular pressure. The rate at which pressure decreases during the isovolumetric relaxation period directly reflects the rate of muscle fibers relaxation. This velocity can be measured with invasive techniques and is often defined as the maximum descent velocity (−) dP/dt or the time constant of isovolumetric relaxation (tau).[13]

Compliance depends on the relationship between the stretching of the myocardial fiber and stress (force applied by surface). This association is affected by active relaxation of the sarcomeres and the relative content of elastic and collagen fibers in the connective tissue. These fibers determine the size and the anatomical shape of the left ventricle, and configure the matrix that convert the shortening and lengthening of muscle fibers in pressure changes.[14] The force required to stretch the fibers is initially low, but increases geometrically as the fibers are stretched. This phenomenon explains that, even in normal subjects, excessive volume overload can result in heart failure.[15]

Left atrial function depends on its preload, afterload and contractility.[16] In patients with abnormal ventricular