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Role of echocardiography in the management of shock

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ABSTRACT

Hemodynamic instability and inadequate cardiac performance is frequently found in critically ill patients. Transthoracic and transesophageal (in the case of inadequate visibility) echocardiography is increasingly used for non-invasive hemodynamic assessment and monitoring in the ICU setting. Using echocardiography, it is possible to assess preload, fluid responsiveness, systolic and diastolic cardiac function, and calculate cardiac output, intravascular and intra-cardiac pressures. It is the golden standard in the initial hemodynamic assessment and should be used as complementary tool in invasively monitored patients in the case of new circulatory or respiratory failure. Echocardiography is indispensable in the management of shock patients and is extremely powerful diagnostic role for the cardiac abnormalities (pericardial effusion and tamponade, acute cor pulmonale and acute or chronic valvular disorders) as a cause for hemodynamic instability. It is the most important and suitable method for assessment of right ventricular function, for diagnosis of septic cardiomyopathy and cardiac causes of weaning failure. Because of these advantages it should be routinely used by intensivists for hemodynamic assessment and monitoring and should be continuously available in the intensive care unit. The most important limitations of echocardiography are its inability to estimate adequacy of cardiac output and its intermittent nature. Therefore it should be used in rational combination with other complementary and continuous monitoring methods.

Key words: echocardiography, circulatory shock, critically ill patients

INTRODUCTION

Shock is defined as a condition of inadequate tissue perfusion, which if untreated, leads to multi-organ failure and death. It is a common reason for ICU admission and requires immediate hemodynamic assessment in order to start proper hemodynamic supportive treatment and to evaluate the response to the initial treatment Hemodynamic assessment is based on estimation of preload, flow and flow adequacy. Beside these, the early etiological diagnosis is mandatory.
Echocardiography can be used for assessment of all mentioned elements except for flow adequacy and if performed early in the treatment of shock it improves hemodynamic management of shock. (1, 2)
However, even more important is early recognition of etiologic diagnosis, which enables immediate correction and etiologic treatment (e. g. pericardiocenthesis in cardiac tamponade, thrombolysis in massive pulmonary embolism). Transthoracic echocardiography can identify the great majority of cardiac causes of shock and is therefore considered initial and principal echocardiographic test in the critical care conditions. (1) Nevertheless, transesophageal echocardiography is occasionally necessary for hemodynamic assessment in patients with poor visibility and for specific diagnostic questions (e. g. localized tamponade, endocarditis).

Echocardiographic assessment in shock
Hemodynamic assessment of the patients in shock requires early transthoracic echocardiographic investigation which should give conclusive findings concerning the variables and conditions listing in the table. (Table 1)

Table 1. Elements of hemodynamic assessment of the patient in shock

Cardiac tamponade
Preload status
Fluid responsiveness
Global and regional contractility of both ventricles
Relation between left and right ventricular size
Gross valvular abnormalities
Other less common abnormalities

The echocardiographic approach to the patient in shock should be systematic:

1. Pre-existing cardiac diseases such as dilative cardiomyopathy can be suspected in patients with dilated left ventricle and atrium. Hypertensive heart disease, hypertrophic cardiomyopathy or aortic stenosis is usually present in patients with concentric left ventricular hypertrophy. RV dilation and hypertrophy indicates chronic cor pulmonale.
2. With examination of inferior vena cava clear hypovolemia can be confirmed, if there is a complete inspiratory collapse of the vein, but dilated and fixed vena cava gives no reliable information concerning hypovolemia. Small left ventricle with left ventricular end diastolic area smaller than 5,5 cm2/m2 is strongly suggestive for hypovolemia. Nevertheless, in patients with pre-existing dilation of the left ventricle, hypovolemia can occur also with much larger end-diastolic area. The bulging of the intraatrial septum indicates the lower atrial pressure in the atrium where the septum is bulging.
3. Estimation of fluid responsiveness is even more important than preload as-

sessment. It is usually based on the respiratory collapsibility of inferior vena cava in spontaneously breathing patients or its distensibility in mechanically ventilated patients. Despite wide use of these variables for assessment of fluid responsiveness, one should realized that they are not very reliable because of the following reasons:

A. Inferior vena cava is placed in the abdominal cavity and therefore the change of the diameter does not reflect always the change of the intrathoracic pressure. In that sense the change of superior vena cava diameter is more reliable.
B. Estimation of fluid responsiveness by distensibility is more reliable than by collapsibility. (3)
C. For reliable estimation of fluid responsiveness the assessment of right and left ventricular systolic function is mandatory. Patients with markedly reduced right or/and left ventricular contractility will not be able to increase the stroke volume after fluid loading.

4. Dilated right ventricle with severely impaired contractility is suggestive for the right ventricular dysfunction due to biventricular failure, right ventricular infarction or acute cor pulmonale. The assessment of tricuspid regurgitation and estimation of pulmonary artery pressure is mandatory for differentiation of right ventricular failure. D shape of the right ventricle is typical for right ventricular pressure overload. The right ventricular function should be expressed according to eye balling or/and according to measurements of TAPSE (tricuspid annulus systolic excursion) or systolic velocity of tricuspid annulus movement measured by tissue Doppler.
5. Patients with severely depressed left ventricular contractility can have coronary artery disease, septic myocardial dysfunction, fulminant myocarditis and cardiomyopathy. Severe functional and morphological valvular disorders should be detected and categorised as acute (e.g. mitral and aortic regurgitation) or chronic (e.g. aortic stenosis). Severe and clear new or reversible regional wall motion abnormalities are suggestive for acute myocardial ischemia. Global left ventricular systolic function is usually estimated by eye balling, extensive and sophisticated measurements and calculations are not necessary. However, quantitative measurements of left ventricular systolic function include calculation of fractional shortening, fractional area change and ejection fraction. (4)
6. In selected patients (i.e. patients with preserved systolic function and congestive symptoms) left ventricular diastolic function should be determined, usually by analysis of transmitral flow and velocity of movement of mitral annulus by tissue Doppler.
7. Assessment of contractility, volume status and basic morphological characteristics allows differentiation of four major categories of circulatory shock. (5, 6)

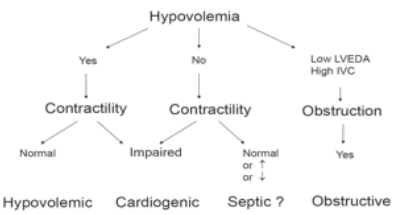

Figure 1. Hemodynamic differentiation of shock by echocardiographic assessment
LVEDA, left ventricular enddiastolic area; IVC, inferior vena cava

8. Finally, some specific situation should be recognized immediately in order to perform specific procedure or start proper treatment:

A. Cardiac tamponade, which requires pericardiocenthesis
B. Left ventricular outflow obstruction, which requires volume loading
C. Complication of myocardial infarction (rupture of the intraventricular septum or papillary muscle)
D. Complications of endocarditis (perforation of valvular cusps with acute regurgitation)
E. Severe acute valvular disorders (mitral and aortic regurgitation)
F. Severe chronic valvular diseases (aortic stenosis)

7. Since the echocardiographic examination is nonivasive and bedside procedure it could be repeated in order to evaluate the impact of the initial treatment. In the case of inadequate visibility transthoracic echocardiography can be immediately upgraded with transesophageal investigation, which enables superior visibility in almost all patients.

CONCLUSION

Basic hemodynamic assessment by transthoracic echocardiography allows differentiation of four major categories of circulatory shock and enables proper and immediate hemodynamic support. Recognition of most important etiologic diagnosis, which requires immediate specific treatment is also possible and therefore the method (equipment and skilled operator) should be available on the 24 hours basis in every ICU. Even limited echocardiography (long and short axis parasternal, four chamber and subcostal view) guided management following initial resuscitation is associated with improved survival, less fluid and increased inotropic treatment. (7)

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