

# THE ROLE OF ULTRASOUND IN THE DIAGNOSIS AND TREATMENT OF CARDIOGENIC SHOCK



# ECHOCARDIOGRAPHY

- recommended as the modality of first, even in an emergency situation
- Non-invasive
- rapid to initiate
- applied at the bedside
- Available day or night
- Useful particularly where the etiology is undifferentiated or multifactorial
- Unique tool for exact targeting of the underlying cardiac and hemodynamic problems whether it be the right heart, left heart, fluid perturbations, pericardial, or a cardiac response to vasoplegia
- Both TTE and TEE should be available
- basic assessment or rapid cardiac assessment by echo (RACE) is performed immediately in the deteriorating patient, followed at a later time by a more detailed advanced echocardiographic assessment



	Race	Advanced
Modality	2D, M-mode	2D, M-mode
		Colour Doppler
		Special Doppler
		TDI
Assessments	LV contraction	LV systolic function
	RV contraction	Diastolic function
	Intravascular fluid status	RV systolic function
	Pericardial tamponade	Intravascular fluid status
		Valve structure/function
		Pericardial tamponade
		Hemodynamics
		Pulmonary artery pressure
		Left atrial pressure
		Cardiac output
		Ventricular outflow obstruction

## ❑ OVERALL CARDIAC PERFORMANCE

- The estimation of **cardiac output** by echocardiography (echo) is well validated. Although it can be measured using the **2D Simpson's multidisc method**, the use of **pulsed-wave Doppler** across the left ventricular output tract (**LVOT**) is more accurate.
- This often **supplants invasively acquired CO measurements** unless continuous monitoring is considered important.
- overall cardiac function, such as myocardial performance index (**MPI**) and mitral annulus plane systolic excursion (**MAPSE**) are **not well validated** in critically ill subjects.
- The **LVOT velocity time integral (VTI)** as a single measure that can be used as a surrogate for the **stroke volume** with a normal value **>20 cm**.
- A value above 18 cm implies an adequate stroke volume.



## ❑ LEFT VENTRICULAR SYSTOLIC FUNCTION

- Echo is used to measure contraction as the degree of myocardial fiber shortening that occurs during systole.
- The most common cause of cardiogenic shock results from marked reduction in left ventricular contraction.
- The size of both the left atrium and ventricle may provide clues to the duration of the contractile impairment, with **dilatation** indicating a degree of **chronicity**.
- Left ventricular ejection fraction (LVEF) is a traditional parameter. The Simpson's multidisc method can be applied in RACE. Subjective evaluation or "eyeballing" the LVEF is reasonably accurate.
- objective measurement should always be considered in the advanced study.
- prognostic marker in chronic heart failure setting .
- contrast echo may enhance accuracy of endocardial border to be visualized

- **Fractional area change (FAC)** has been used to assess the left ventricle with reasonable accuracy in surgical patients undergoing TEE during cardiac surgery. It can be measured from either the parasternal short axis view (PSAX) using TTE or the transgastric view with TEE short axis views, using the difference between the end diastolic and end systolic areas divided by the end diastolic area, with a normal range being 38–60 %.
- The **reliability is less** certain in:
  - 1-hemodynamically unstable patients
  - 2-segmental wall motion defects
  - 3-left bundle-branch block
  - 4-right ventricular dysfunction



Grossly dilated left ventricle with biventricular pacing wire present in right heart in the apical four-chamber view. LV left ventricle, MV mitral valve, RA right atrium, RV right ventricle

## □ VALVULAR PATHOLOGY

- Echocardiographic investigation extends to possible valvular lesions, both acute and preexisting
- **Acute lesions** such as peri-infarction rupture of a papillary muscle resulting in severe mitral regurgitation may necessitate urgent surgical repair of the valve.
- The presence of **new onset aortic regurgitation**, particularly when it is associated with a pericardial effusion, should lead to investigation of dissection of the thoracic aorta. This requires a TEE.
- Initial examination of the valves in the acute setting, allowing for initiation of treatment, requires reasonable but not necessarily expert skills.
- Advanced valve examination can be performed later by clinicians highly skill.

Ruptured mitral papillary muscle post infarction seen by 3D echocardiography from the apical four-chamber view. LA left atrium, LV left ventricle, MV mitral valve.



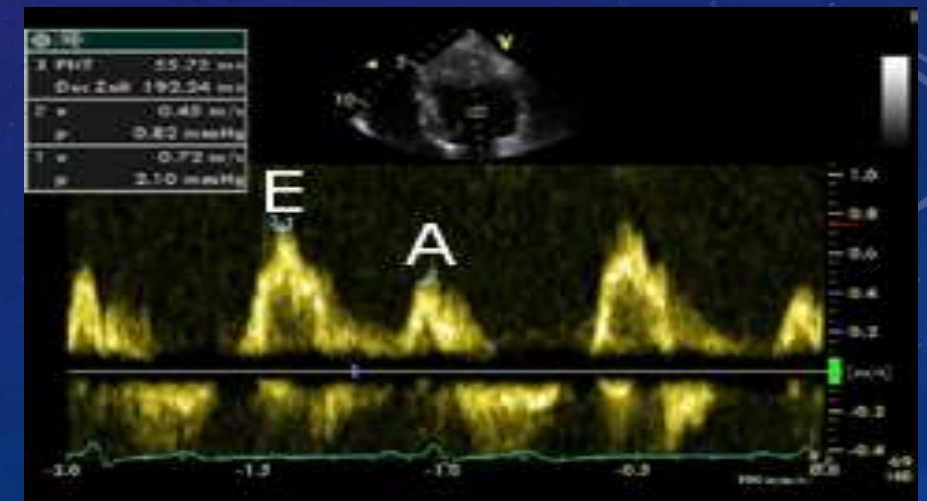


## □ LEFT VENTRICULAR DIASTOLIC FUNCTION

- half the patients presenting with acute heart failure have preserved ejection fraction via a number of mechanisms, including diastolic dysfunction-reduced coronary flow reserve.
- **High metabolic states** frequently found in critically ill patients can exacerbate cardiac failure by worsening diastolic function.
- In particular, TDI analysis of the mitral annulus allows for rapid estimation of left atrial pressure (LAP), an important parameter in evaluating left ventricular function and preload.
- The use of **spectral Doppler of mitral inflow** still remains paramount. Both an **E/A ratio >2** and an **E wave deceleration time <120 ms** predict a **LAP >20 mmHg**.
- With **TDI**, the mitral annulus  $e'$  offers a quick guide to the presence of left ventricular diastolic dysfunction with a **lateral  $e'$  <10 and medial <7 cm/s** highly suggestive of diastolic dysfunction and elevated left atrial pressures.



- The  $E/e'$  ratio, although still affected by loading conditions, is of considerable value by giving a guide to elevated left atrial pressures. The original description using patients with coronary disease or heart failure used an  $E/e' < 8$  to indicate normal LAP and a value  $> 15$  gave an LAP  $> 13$  mmHg. The average of the lateral and septal  $e'$  measurements is recommended.
- The  $E/e'$  value used to identify elevated left atrial pressures in patients on positive ventilation is less than that used in non-ventilated patients, around 12 using the average septal/lateral  $e'$  rather than the classic 14–15. However, a precise and accurate value is unclear. Positive pressure ventilation affects left ventricular diastolic filling in a number of often opposing ways and the overall effects are difficult to predict.



- Increased intrathoracic pressure, by reducing systemic venous return, results in decreased left ventricular preload and, by decreasing the atrial–ventricular pressure gradient, reduces  $E$  and  $e'$ .

## INTERPRETATION:

### Grade 0 (Normal)

$E/A \geq 0.8$   
 $e' \geq 8$  cm/s  
 $E/e' < 8$

### Grade 1 (Impaired Relaxation)

$E/A < 0.8$   
 $e' < 8$  cm/s  
 $E/e' < 8$

### Grade 2 (Pseudonormal)

$E/A \geq 0.8$   
 $e' < 8$  cm/s  
 $E/e' 8 - 15$

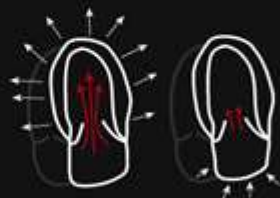
### Grade 3 (Restrictive)

$E/A \geq 2$   
 $e' < 8$  cm/s  
 $E/e' > 15$

## MITRAL INFLOW

Measures **BLOOD FLOW**  
 coming into the Left Ventricle

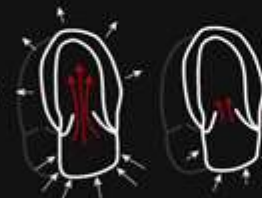
PULSE Wave gate at  
 Mitral Valve Tips



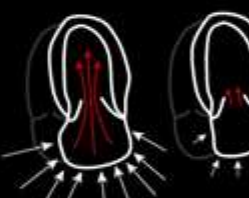
Impaired  
 Relaxation &  
 Decreased LV  
 Compliance



Increase in  
 LAP causing  
 more "Push" from  
 LA during Early  
 Filling



Severe increase  
 in LAP causing  
 more "Push" from  
 LA during Early  
 Filling. Also  
 LA enlargement

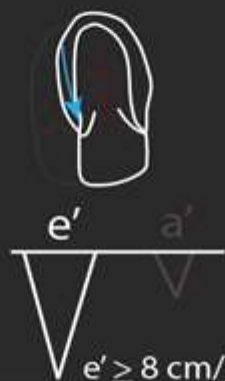


## TISSUE DOPPLER

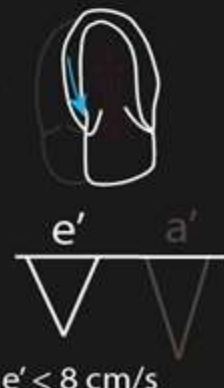
Measures **MUSCLE MOVEMENT**  
 of the Left Ventricle AWAY from  
 probe during Diastole



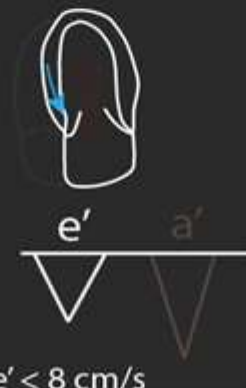
Tissue Doppler gate  
 at Septal Annulus



Mild Decrease  
 in LV Muscle  
 Relaxation  
 Speed



Moderate  
 Decrease  
 in LV Muscle  
 Relaxation  
 Speed



Severe  
 Decrease  
 in LV Muscle  
 Relaxation  
 Speed





## ❑ OTHER PATHOLOGIES IN CARDIOGENIC SHOCK



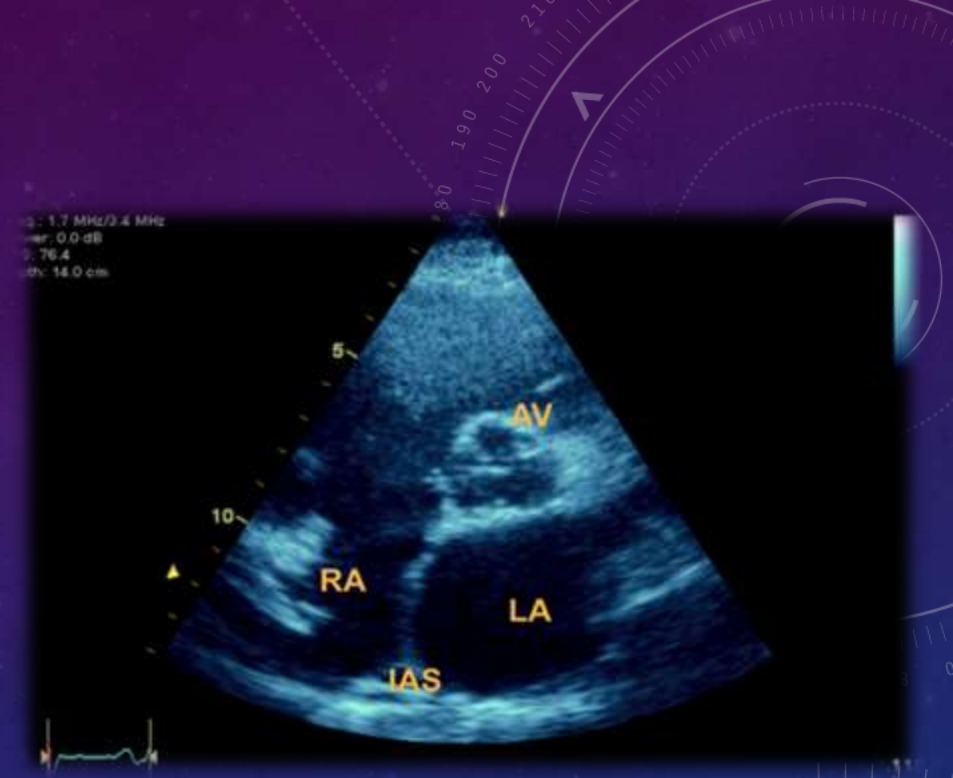
- right heart dysfunction
- Post-infarction ventricular septal defects, although uncommon, often occur some days after the actual infarction and are usually catastrophic



## Echocardiography finding in Hypovolemic shock

when hypovolemia is severe, 2D views can be impelling when they show collapse of the left ventricular walls at end-systole, the so-called “kissing walls”.

Conversely, **fixed bowing** of the **atrial septum** into the right atrium throughout the cardiac cycle implies elevated left atrial pressures and **further fluid is not necessary**.

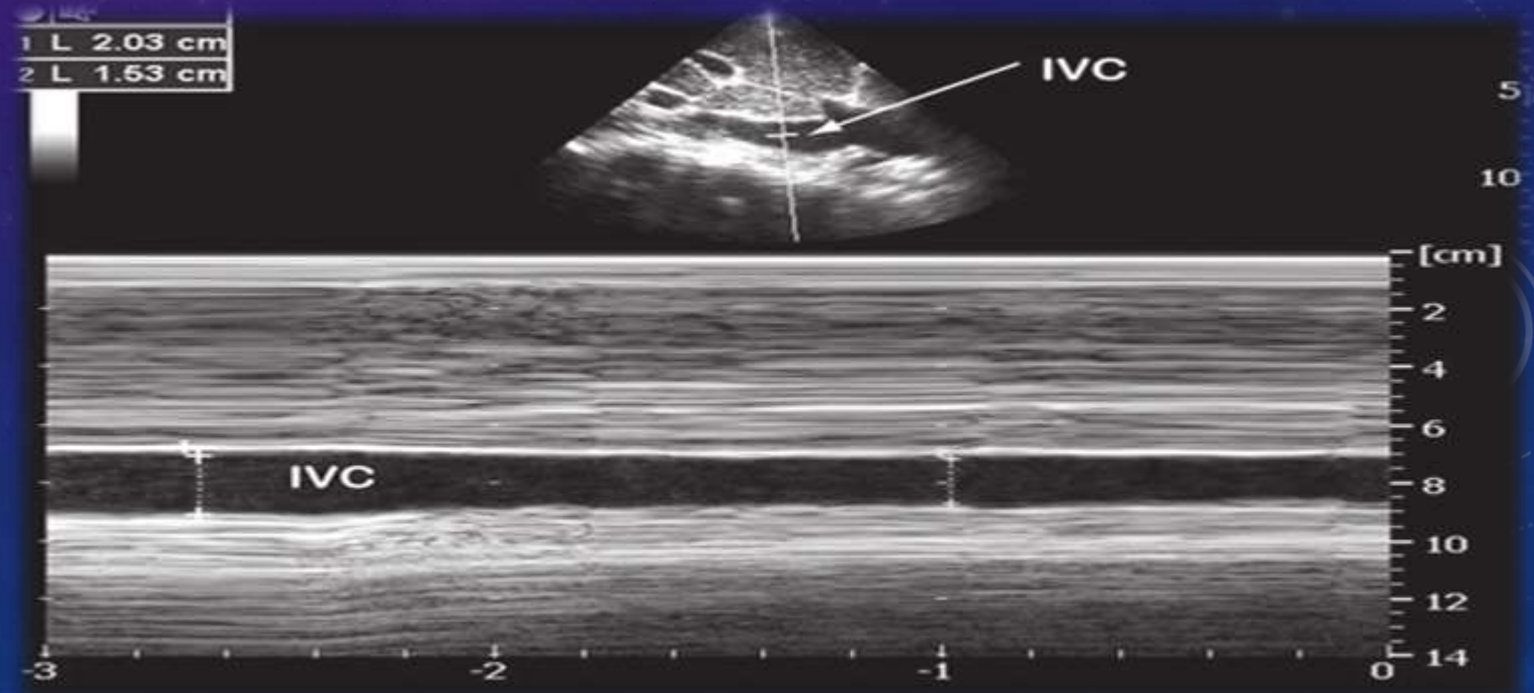


- Left ventricular end diastolic area (LVEDA) appears to be helpful in assessing response to a volume load in anaesthetized patients undergoing surgery but unfortunately **not validated in the critically ill patients.**



In the spontaneously breathing patient an **IVC diameter (D) <21 mm** that **more than 50 % collapses** with a sniff indicates a **normal RAP of 3 mmHg**, whereas an IVC diameter >21 mm that collapses <50 % with a sniff indicates a RAP of >15 mmHg.

In a study on IVC diameter variation following fluid administration to hypovolemic trauma patients, **inadequate dilatation** indicated **insufficient circulating blood volume** despite normalization of blood pressure.



# Echocardiography finding in obstructive shock

The common mechanism in patients with obstructive shock is resistance to blood flow through the cardiopulmonary circulation. Specific pathological diagnoses are acute pulmonary embolus, cardiac tamponade, and dynamic outflow obstruction; on occasion, it also occurs as a result of a type A dissection of the thoracic aorta or a tension pneumothorax. Constrictive pericarditis is a rare cause of obstructive shock.



## Diagnostic criteria

include :

Dilated right heart chambers, changes in right ventricular contraction, elevated pulmonary artery pressures, decreased cardiac output, and intra-cavity emboli.

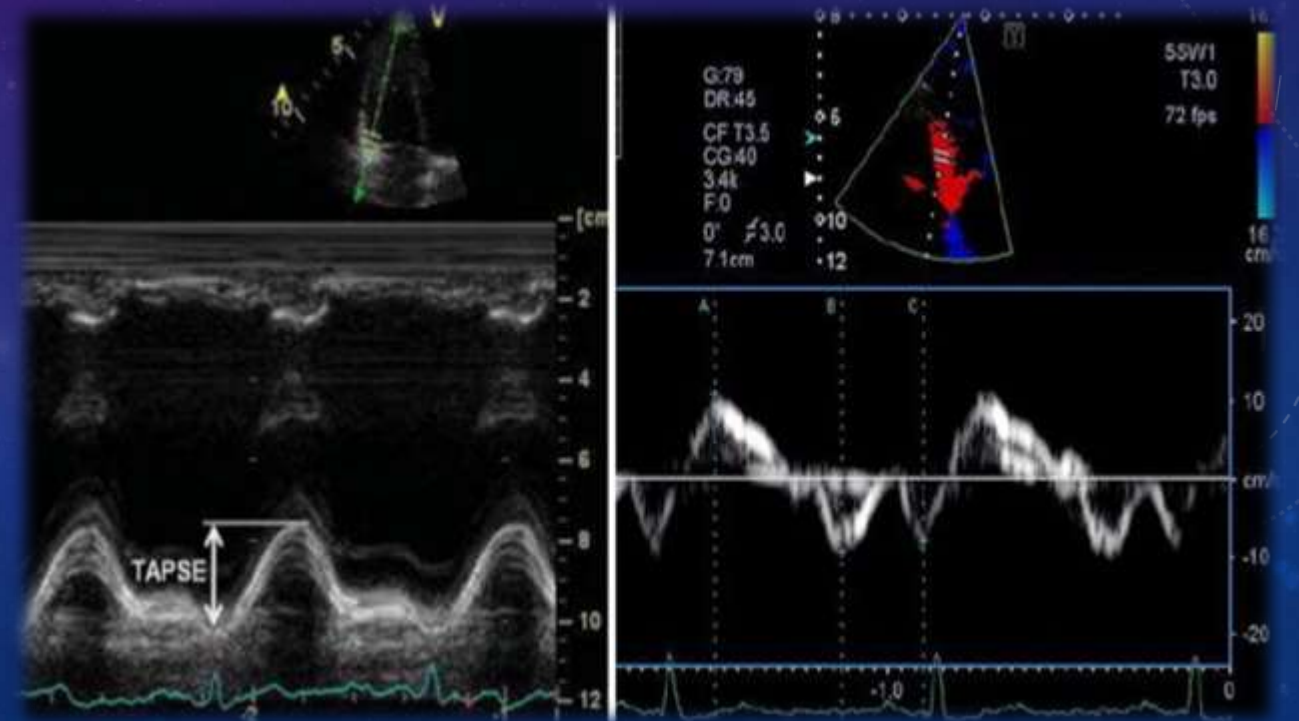
Dilatation of the right ventricle is readily assessed in the apical four-chamber view with a **right ventricle/left ventricle area ratio  $>0.6$** ; gross dilatation is seen with a ratio  $>1.0$ .

## useful tools to diagnosis

**TAPSE** Tricuspid annulus plane systolic excursion is a reasonably reliable and easily obtainable parameter for overall right ventricular contraction with a **abnormal value being less than 16 mm**.

**TDI**, using the lateral tricuspid annulus  $S'$  velocity, is a useful tool to identify early right ventricular dysfunction.

A right ventricular  **$S'$  velocity  $<11.5$  cm/s** predicts right ventricular dysfunction.

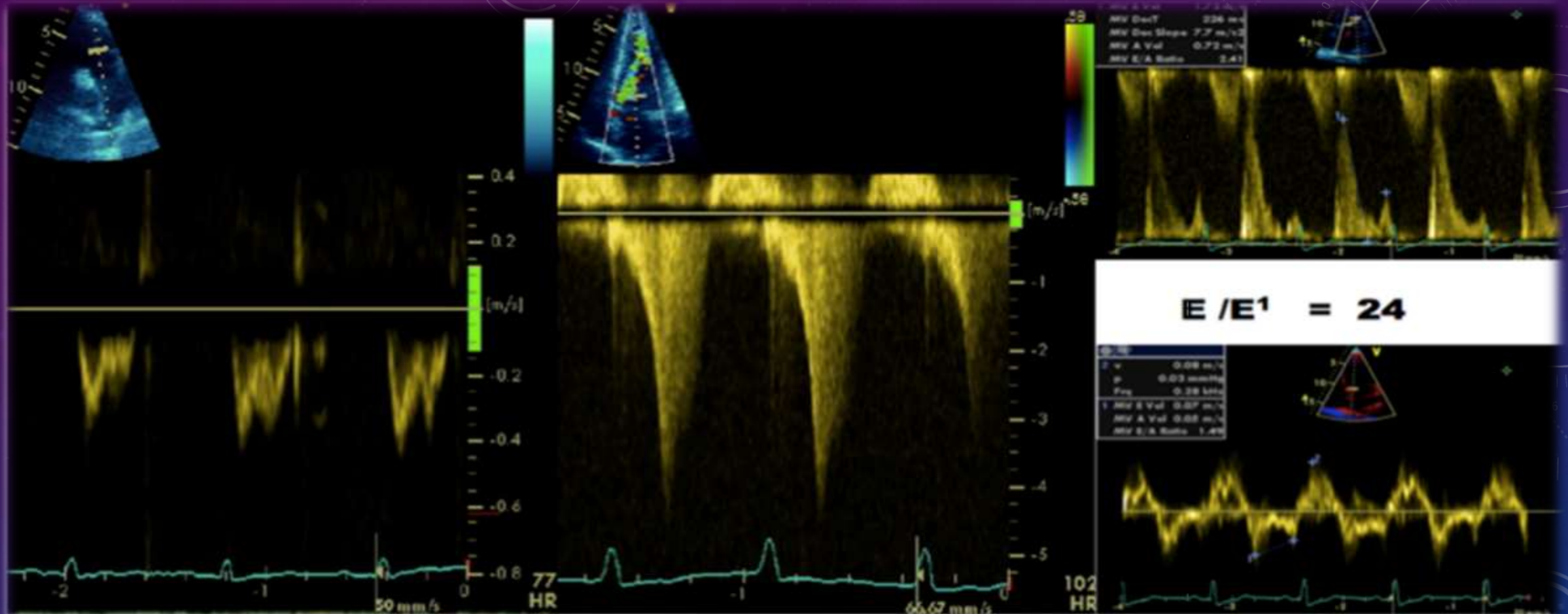


**pulmonary artery systolic pressure** is most commonly obtained by converting the peak velocity of the tricuspid regurgitation to pressure using the modified Bernoulli equation and adding to the right atrial pressure.

In the absence of a reliable tricuspid regurgitant signal, the **acceleration time** of the pulmonary ejection signal (PAcT) is used.

As a guide, a PAcT of 70–90 ms indicates a pulmonary artery systolic pressure of >70 mmHg. The presence of mid-systolic notch also indicates severe pulmonary hypertension





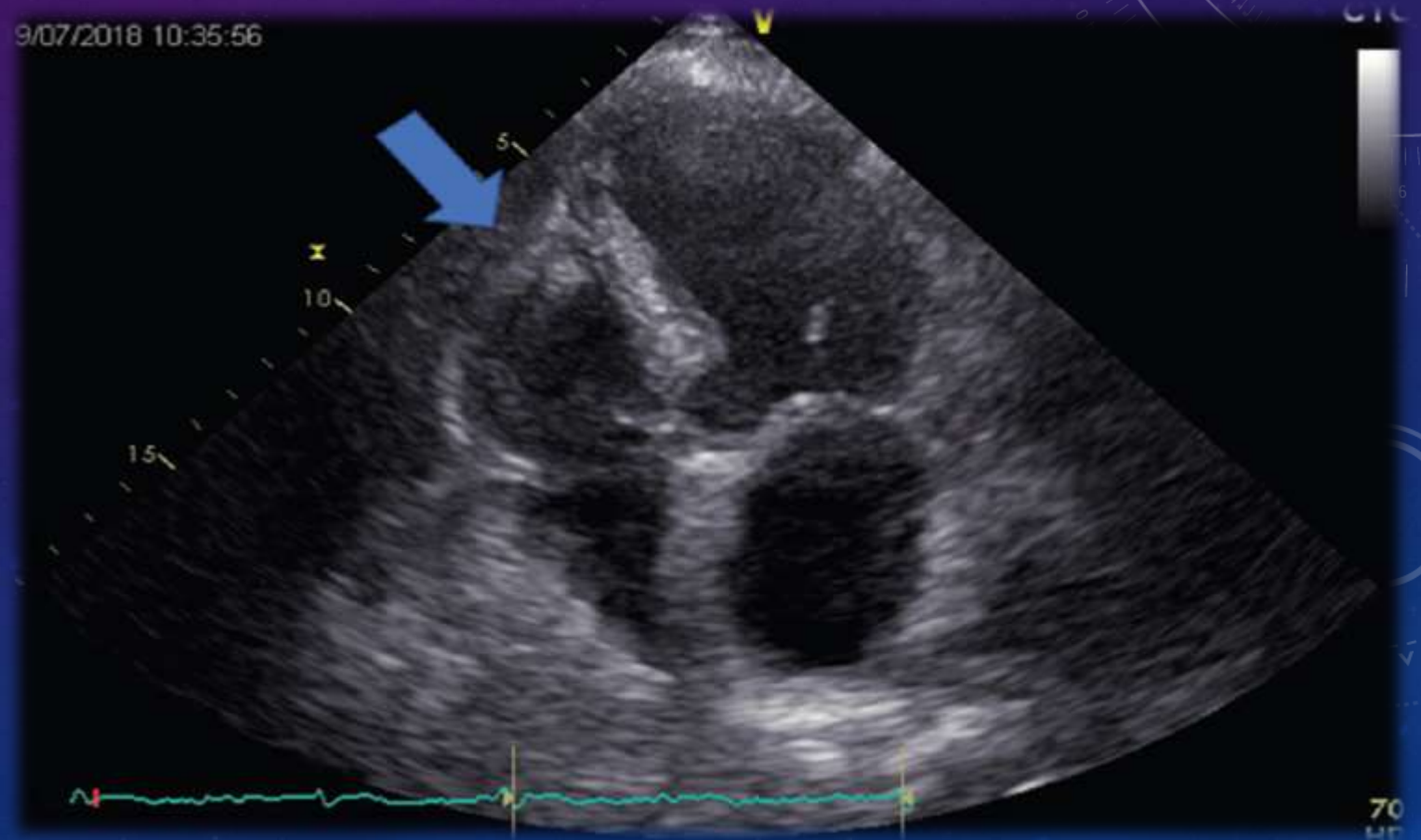
pulmonary outflow  
biphasic wave seen in acute  
cor pulmonale resulting  
from pulmonary embolus

'dagger' shape wave form on  
continuous wave Doppler  
across LVOT outflow

use of mitral inflow pulse  
wave Doppler and mitral  
annulus TDI to obtain  
 $E/E'$  ratio in the evaluation  
of left atrial pressure



**The McConnell sign**, where good apical but poor free wall contraction is seen, is considered an important sign by some. However, it is also found in right ventricular infarction and its specificity for pulmonary embolism has been called into question.



## cardiac tamponade

when the intrapericardial pressure exceeds right heart filling pressure (diastole), impaired filling of the chambers results in tamponade.

A pericardial effusion is usually readily identified by echo, although size is no guide to the presence of tamponade.

Echo is the investigation of choice in suspected cardiac tamponade, with the diagnosis generally easy to make when aligned with clinical findings. It also assists with urgent pericardiocentesis.



## Septic shock

A variety of cardiac changes can be associated with septic shock .Abnormalities in left ventricular systolic function, left ventricular diastolic function, and right ventricular function have all been described

**Table 2** Cardiac abnormalities in severe sepsis

Left ventricular dilatation

Left ventricular contraction impairment

Global

Segmental

Left ventricular diastolic dysfunction

Right ventricle systolic/diastolic dysfunction

Ventricular outflow obstruction

Valvular lesions

Functional

Endocarditis

## CONCLUSIONS

Echocardiography is perhaps the most single useful tool in the diagnosis and management of shock, particularly where the etiology is undifferentiated or multifactorial. Non-invasive and rapid to initiate, it can be applied at the bedside anytime during the day or night. An initial basic or RACE study can lead to commencement of treatment, with a more advanced study subsequently providing incremental and vital additional information.



*THE END*



*THANKS FOR YOUR ATTENTION*