EAE TEACHING COURSE
Cardiac Emergencies: What could be expected from echocardiography in different clinical scenarios?
October 22-23, 2010, Belgrade, Serbia

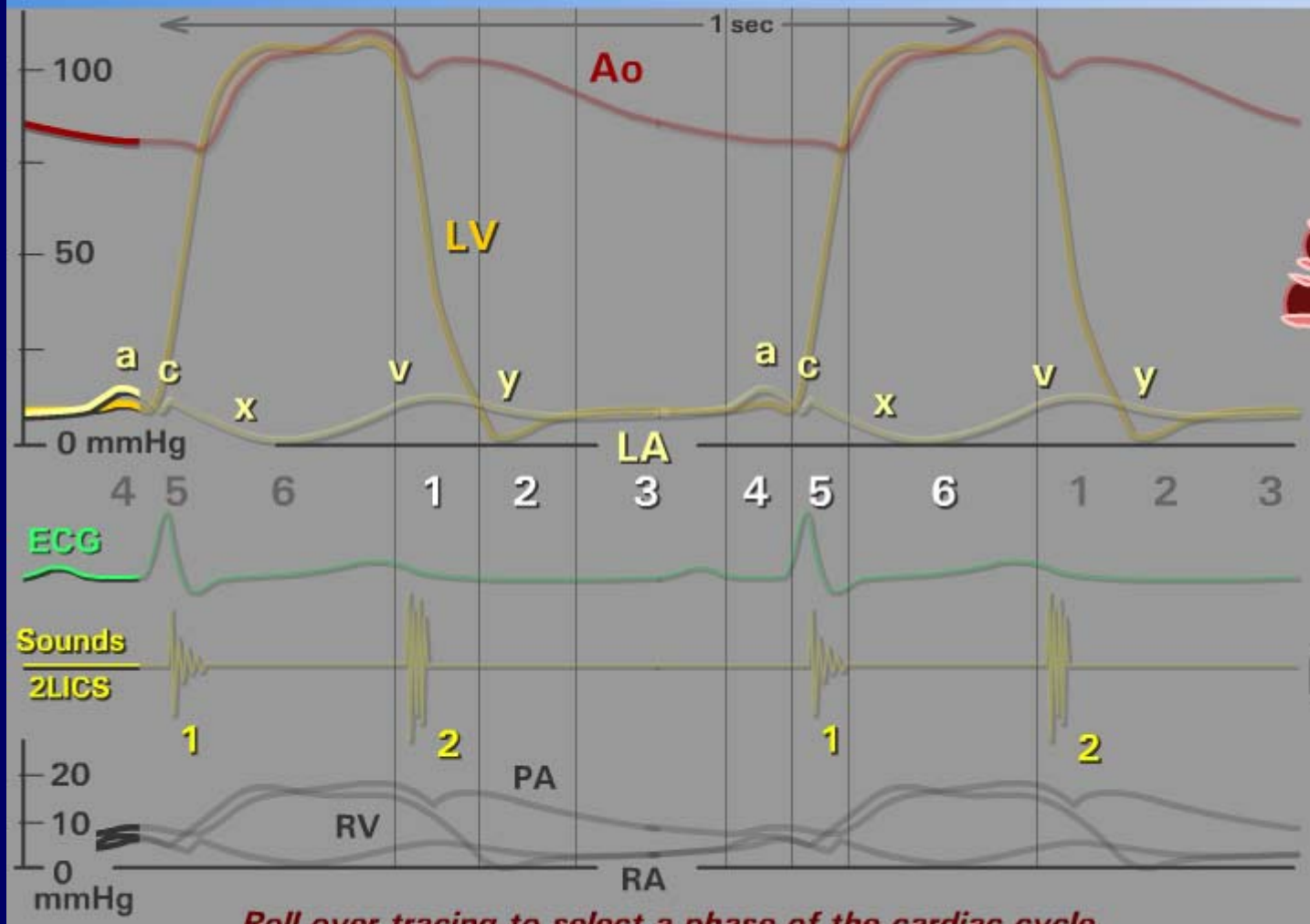
Cardiogenic shock, cardiac arrest, CPR

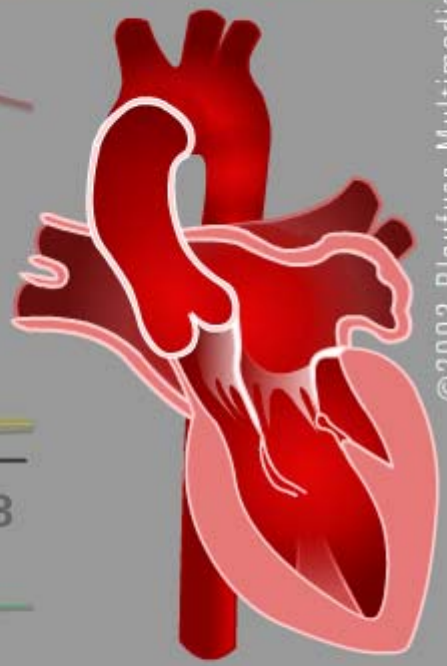
Fabio Guarracino

Cardiothoracic Anaesthesia & Intensive Care Medicine

University Hospital of Pisa, Italy

Phases of the Cardiac Cycle





Step ▮▶

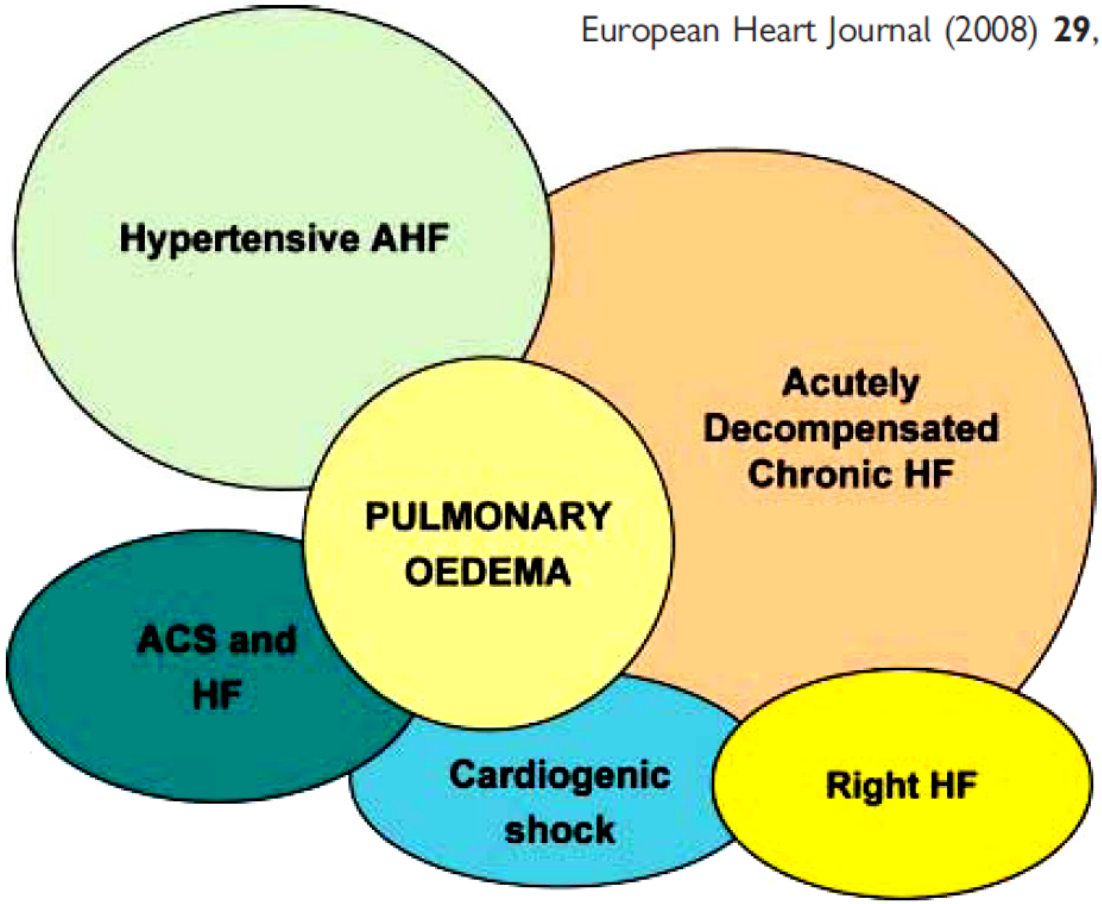
Roll over tracing to select a phase of the cardiac cycle.

European Heart Journal (2008) **29**, 2388–2442
doi:10.1093/eurheartj/ehn309

ESC GUIDELINES

ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008‡

European Heart Journal (2008) **29**, 2388–2442



Clinical classification of acute heart failure.

ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2008‡

Cardiogenic shock: is defined as evidence of tissue hypoperfusion induced by HF after adequate correction of preload and major arrhythmia. There are no diagnostic haemodynamic parameters. However, typically, cardiogenic shock is characterized by reduced systolic blood pressure (SBP; <90 mmHg or a drop of mean arterial pressure >30 mmHg) and absent or low urine output (<0.5 mL/kg/h). Rhythm disturbance are common. Evidence of organ hypoperfusion and pulmonary congestion develop rapidly.

Causes of Cardiogenic Shock

Acute Myocardial Infarction

Right Ventricular failure

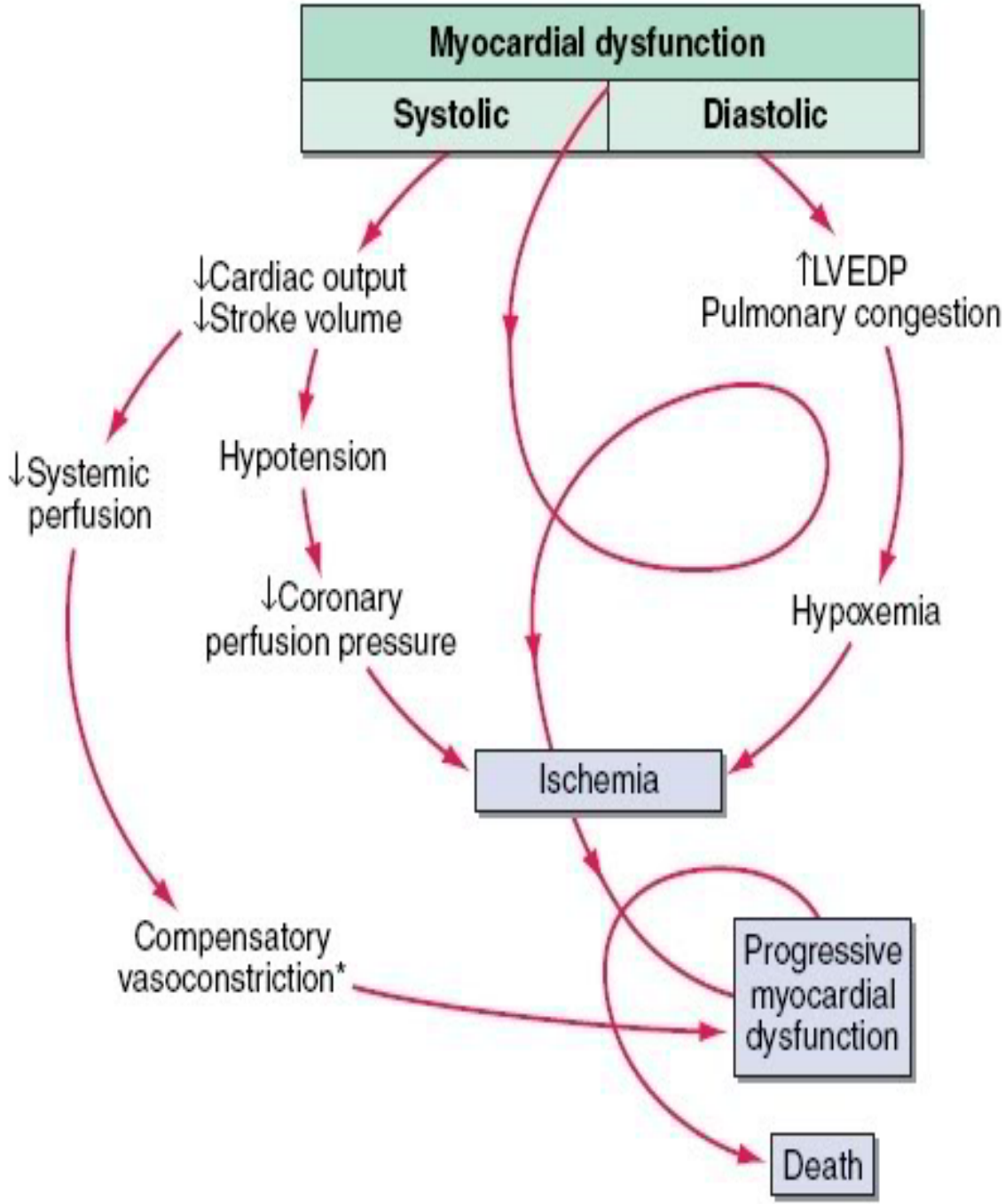
Mechanical complications

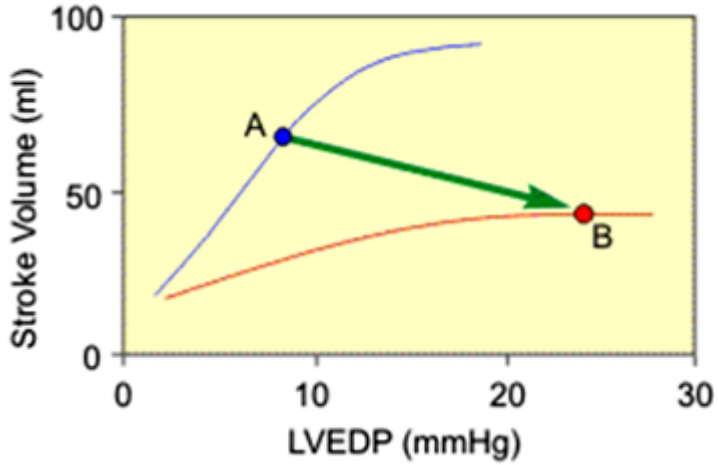
- **Papillary muscle rupture**
- **Ventricular septal defect**
- **Cardiac rupture**
- **Tamponade**

- **Septic shock**
- **End-stage cardiomyopathy**
- **Myocarditis**
- **Beta blocker overdose**
- **Ao dissection with acute AR**
- **Myocardial contusion**
- **LVOT obstruction**

EAE TEACHING COURSE
Cardiac Emergencies: What could be expected from echocardiography in different clinical scenarios?
October 22-23, 2010, Belgrade, Serbia

- **The commonest cause of CS is AMI**
- **CS complicates 5-10% of all AMI**
- **mortality rate approaching 80%**
- **75% of CS following AMI will occur within 24 hours**


Myocardial dysfunction
Systolic
Diastolic
↓Cardiac output
↓Stroke volume
↑LVEDP
Pulmonary congestion
↓Systemic perfusion
Hypotension
↓Coronary perfusion pressure
Hypoxemia
Ischemia
Compensatory vasoconstriction*
Progressive myocardial dysfunction
Death


100
50
0
Stroke Volume (ml)
A
B
0
10
20
30
LVEDP (mmHg)

ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 Appropriateness Criteria for Transthoracic and Transesophageal Echocardiography*

Cardiovascular Evaluation in an Acute Setting—Hypotension or Hemodynamic Instability	
Evaluation of hypotension or hemodynamic instability of uncertain or suspected cardiac etiology	A (9)
Cardiovascular Evaluation in an Acute Setting—Myocardial Ischemia/Infarction	
Evaluation of acute chest pain with suspected myocardial ischemia in patients with nondiagnostic laboratory markers and ECG and in whom a resting echocardiogram can be performed during pain	A (8)
Evaluation of suspected complication of myocardial ischemia/infarction, including but not limited to acute mitral regurgitation, hypoxemia, abnormal chest X-ray, VSD, free-wall rupture/tamponade, shock, right ventricular involvement, heart failure, or thrombus	A (9)
Cardiovascular Evaluation in an Acute Setting—Respiratory Failure	
Evaluation of respiratory failure with suspected cardiac etiology	A (8)
Cardiovascular Evaluation in an Acute Setting—Pulmonary Embolism	
Evaluation of patient with known or suspected acute pulmonary embolism to guide therapy (i.e., thrombectomy and thrombolytics)	A (8)

Assess symptoms and signs

Abnormal ECG?
Abnormal blood gasses?
X-ray congestion?
Natriuretic peptides ↑
Known heart disease or chronic HF?

No

Consider pulmonary disease

Yes

Evaluate by echocardiography

Normal

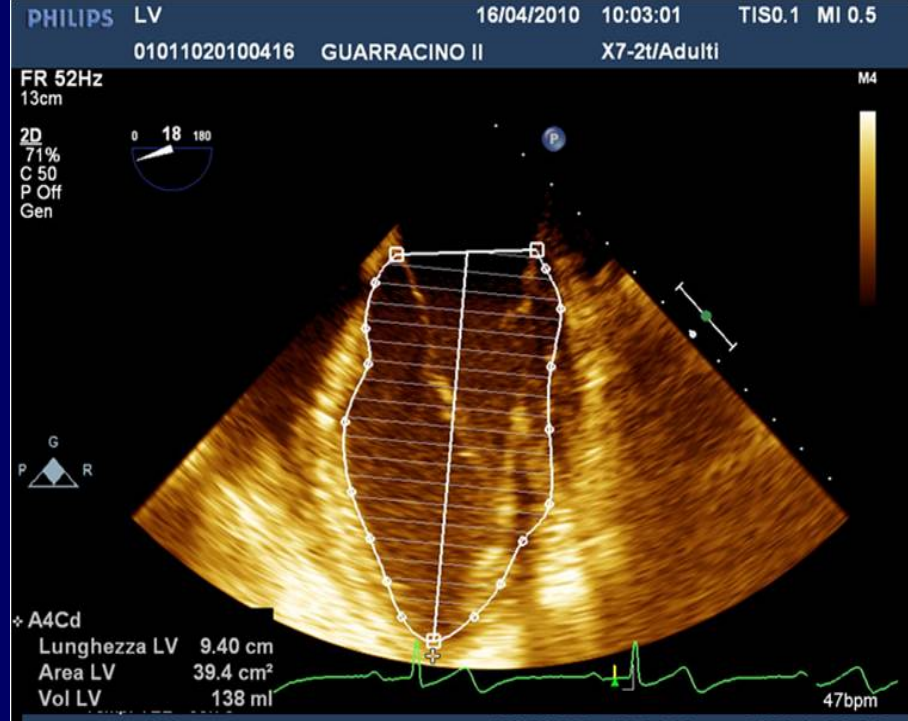
Abnormal

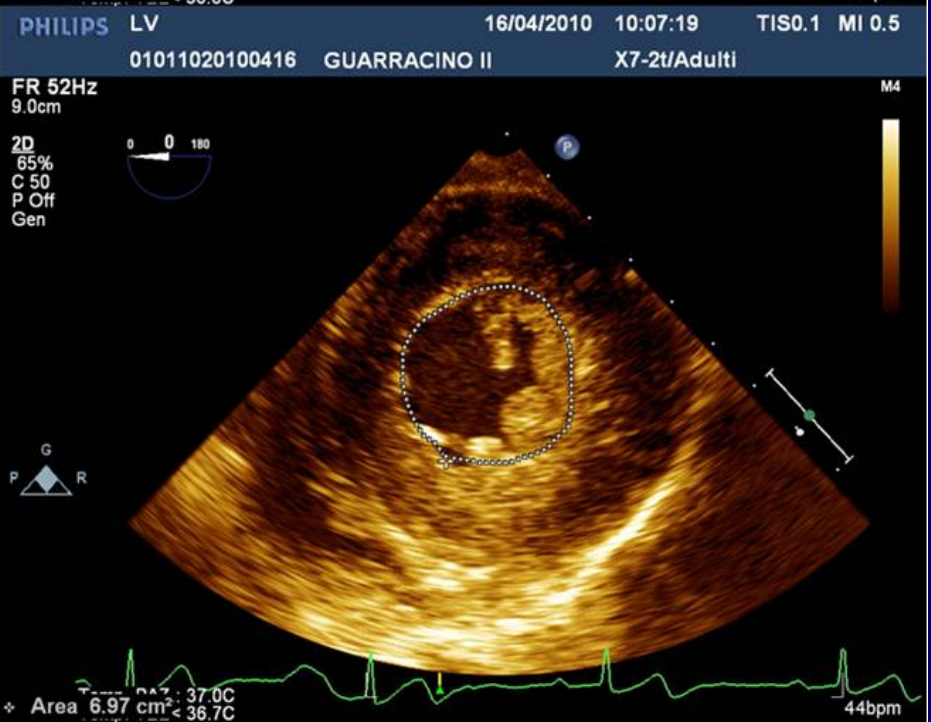
Heart failure confirmed

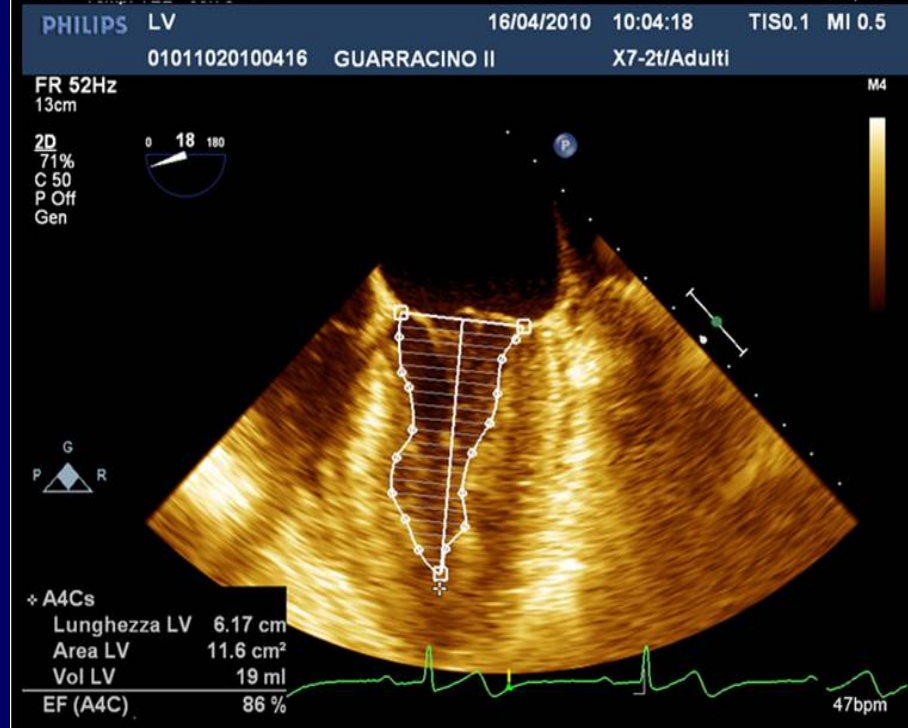
Plan treatment strategy

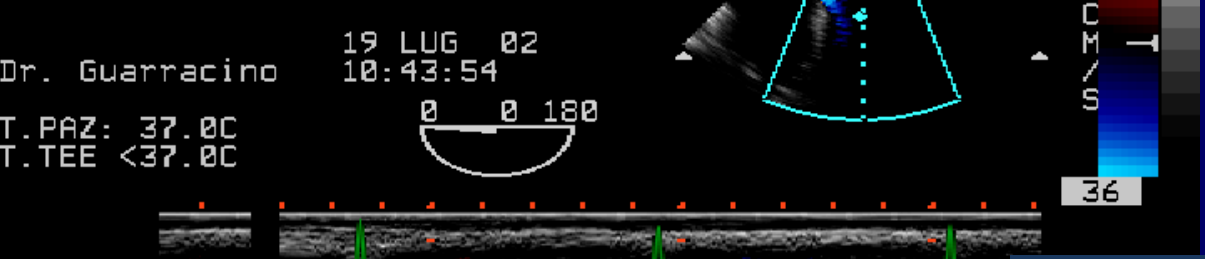
Assess type, severity and aetiology using selected investigations

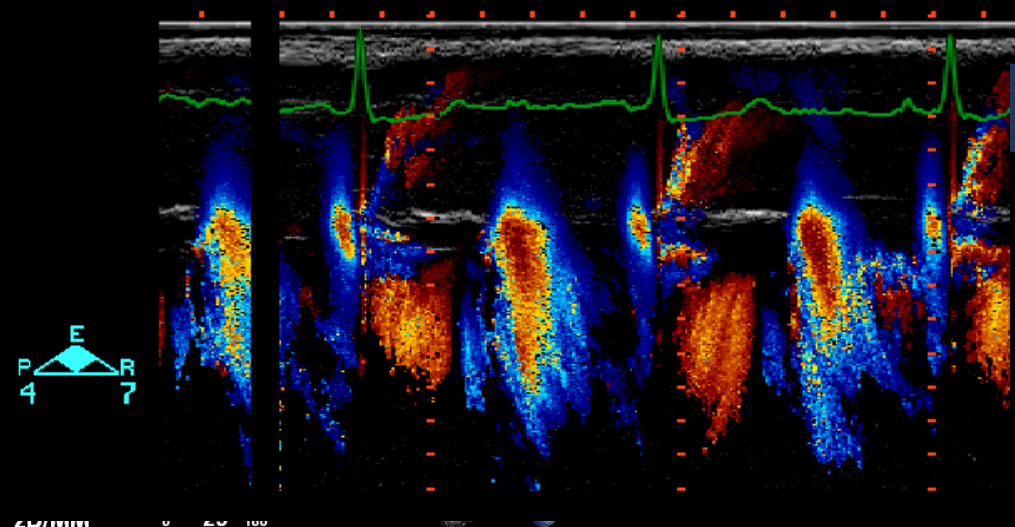

PHILIPS LV 16/04/2010 10:06:56 TIS0.1 MI 0.5
01011020100416 GUARRACINO II X7-2t/Adulti
FR 52Hz
9.0cm
M4
2D
65%
C 50
P Off
Gen
Area 21.2 cm²
44bpm

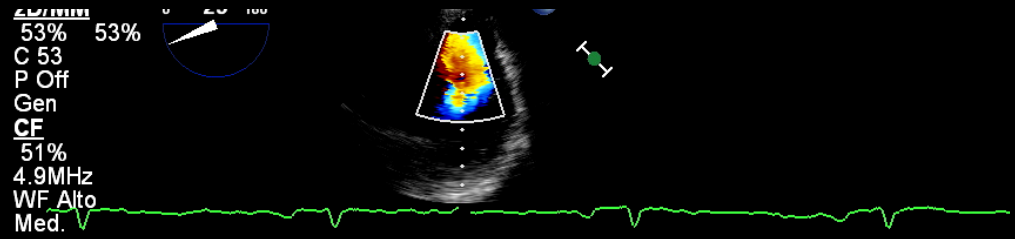

PHILIPS LV 16/04/2010 10:03:01 TIS0.1 MI 0.5
01011020100416 GUARRACINO II X7-2t/Adulti
FR 52Hz
13cm
M4
2D
71%
C 50
P Off
Gen
A4Cd
Lunghezza LV 9.40 cm
Area LV 39.4 cm²
Vol LV 138 ml
47bpm

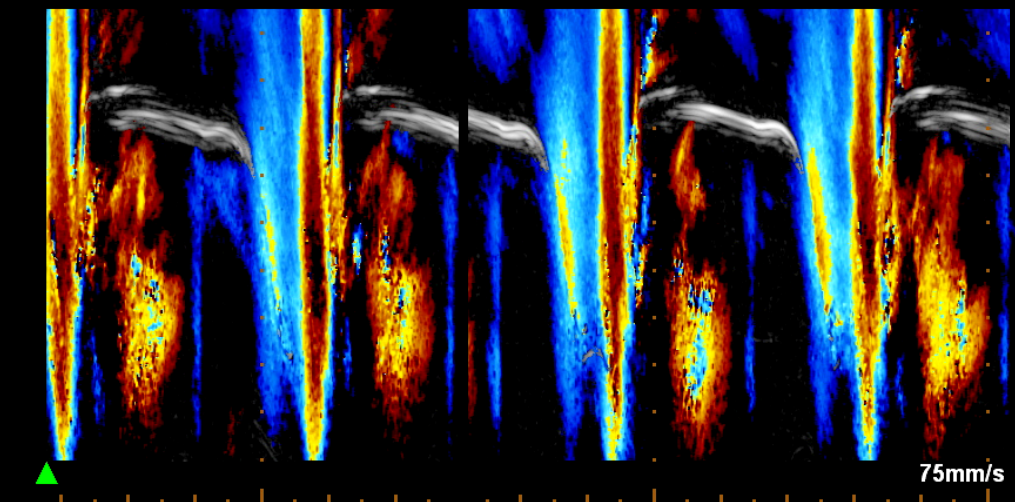

PHILIPS LV 16/04/2010 10:07:19 TIS0.1 MI 0.5
01011020100416 GUARRACINO II X7-2t/Adulti
FR 52Hz
9.0cm
M4
2D
65%
C 50
P Off
Gen
Area 6.97 cm²
44bpm

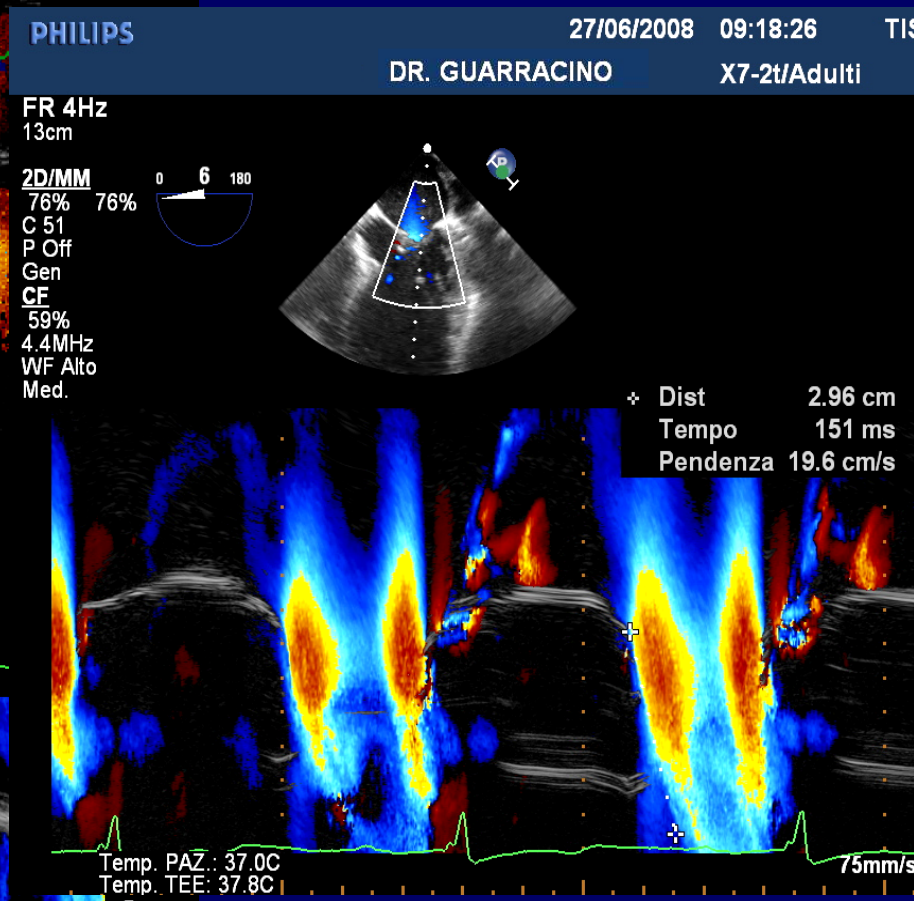

PHILIPS LV 16/04/2010 10:04:18 TIS0.1 MI 0.5
01011020100416 GUARRACINO II X7-2t/Adulti
FR 52Hz
13cm
M4
2D
71%
C 50
P Off
Gen
A4Cs
Lunghezza LV 6.17 cm
Area LV 11.6 cm²
Vol LV 19 ml
EF (A4C) 86 %
47bpm


19 LUG 02
Dr. Guarracino
10:43:54
0 0 180
T.PAZ: 37.0C
T.TEE <37.0C
36

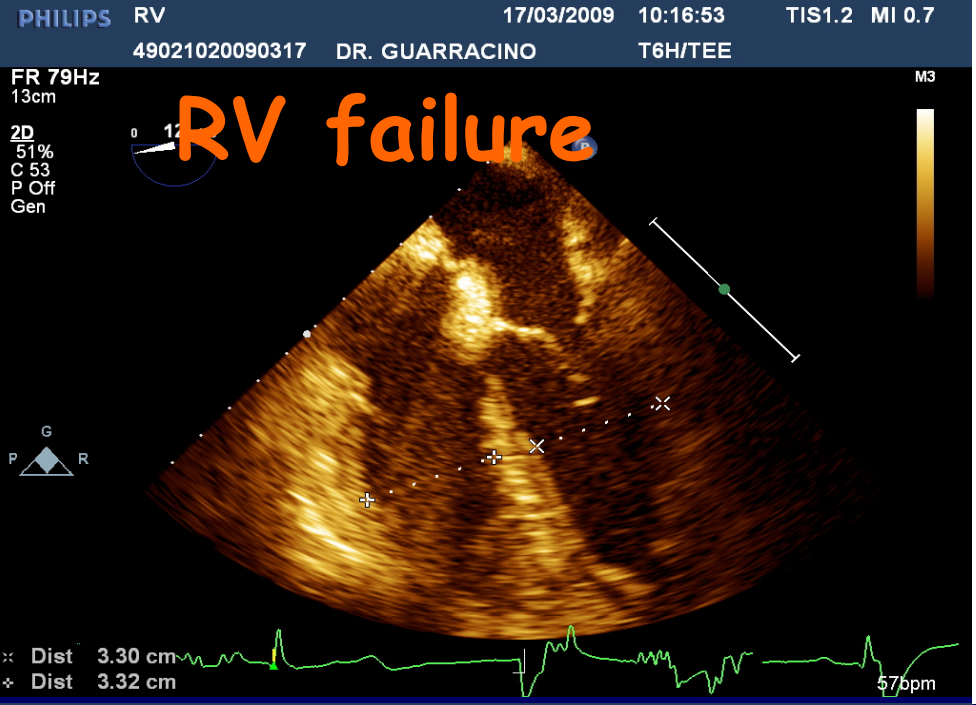

E
P
R
4
7

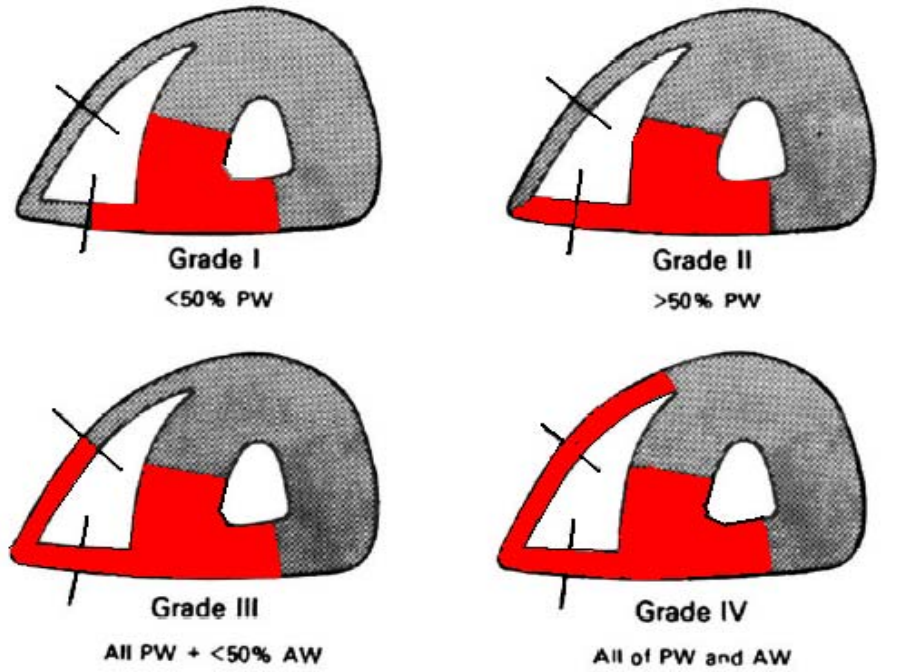

53% 53%
C 53
P Off
Gen
CF
51%
4.9MHz
WF Alto
Med.

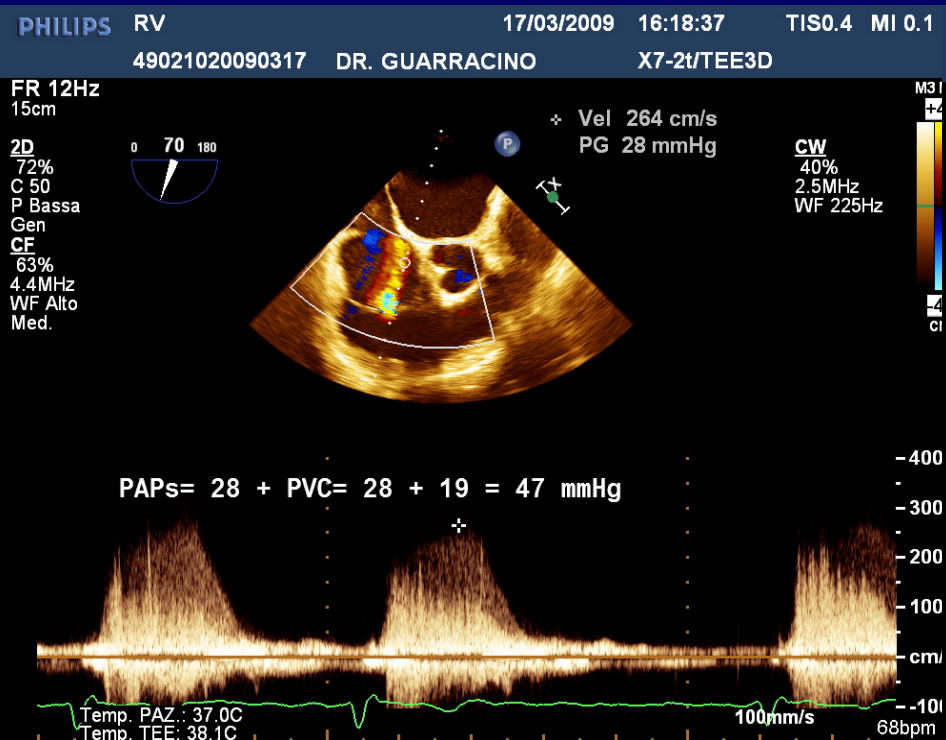

75mm/s
79bpm

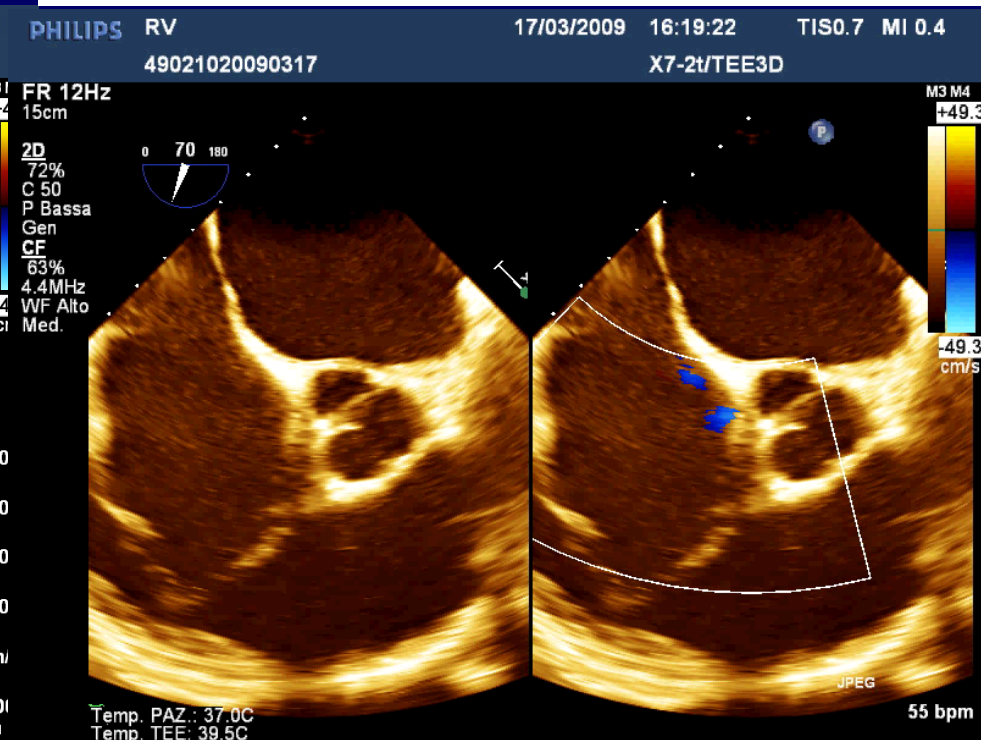

PHILIPS
27/06/2008 09:18:26
DR. GUARRACINO
X7-2t/Adulti
FR 4Hz
13cm
2D/MM
76% 76%
C 51
P Off
Gen
CF
59%
4.4MHz
WF Alto
Med.
0 6 180
Dist 2.96 cm
Tempo 151 ms
Pendenza 19.6 cm/s
Temp. PAZ.: 37.0C
Temp. TEE: 37.8C
75mm/s

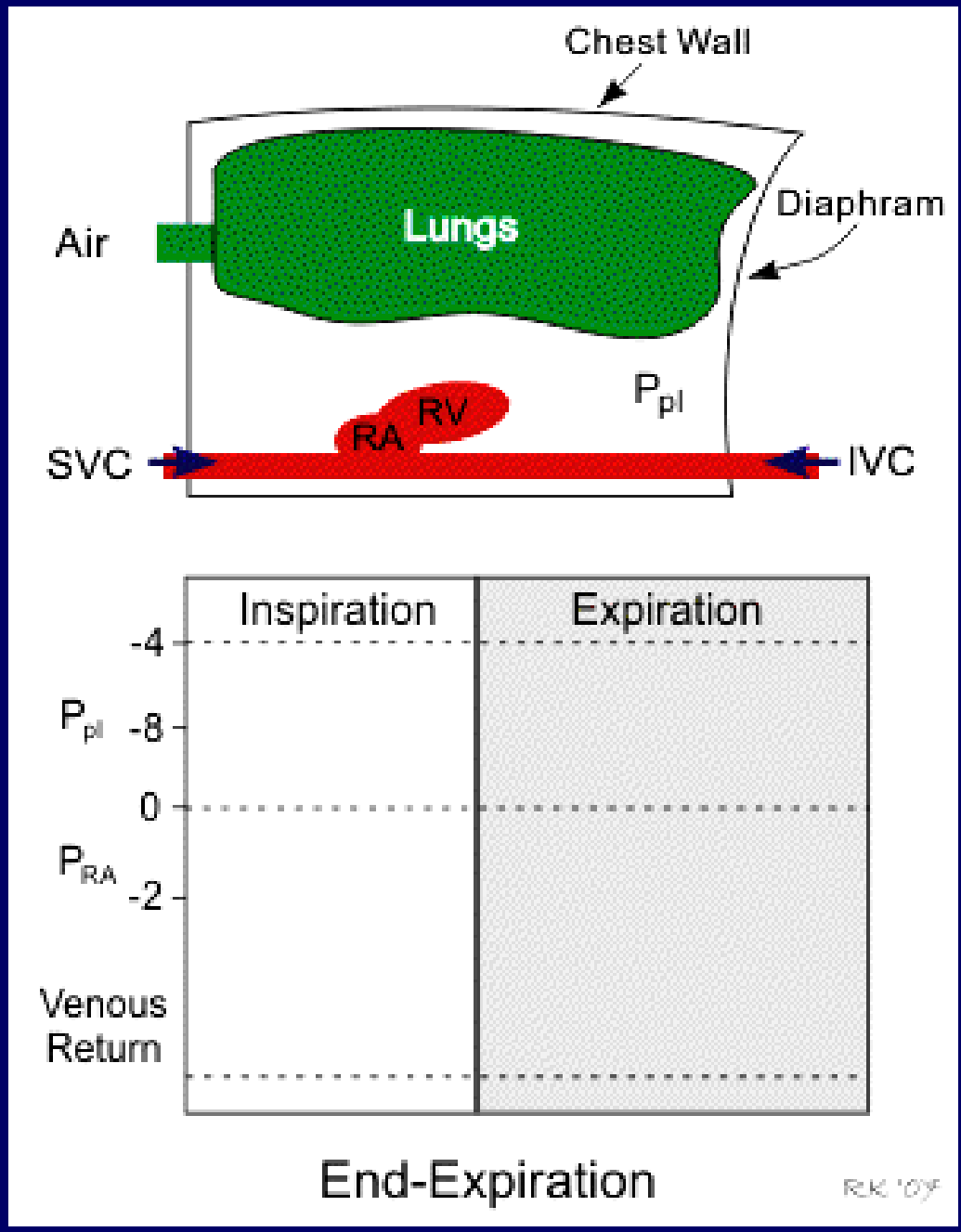
RV failure

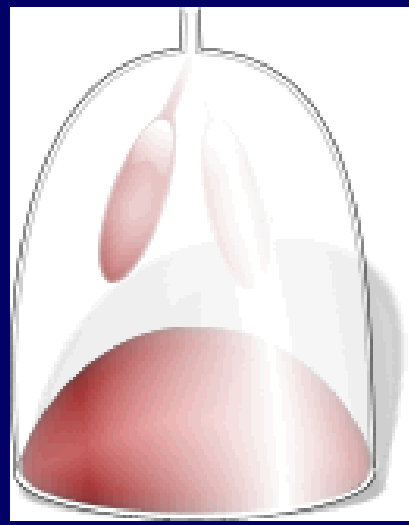

PHILIPS RV 17/03/2009 10:16:53 TIS1.2 MI 0.7
49021020090317 DR. GUARRACINO T6H/TEE
FR 79Hz
13cm
2D
51%
C 53
P Off
Gen
M3
Dist 3.30 cm
Dist 3.32 cm
57bpm

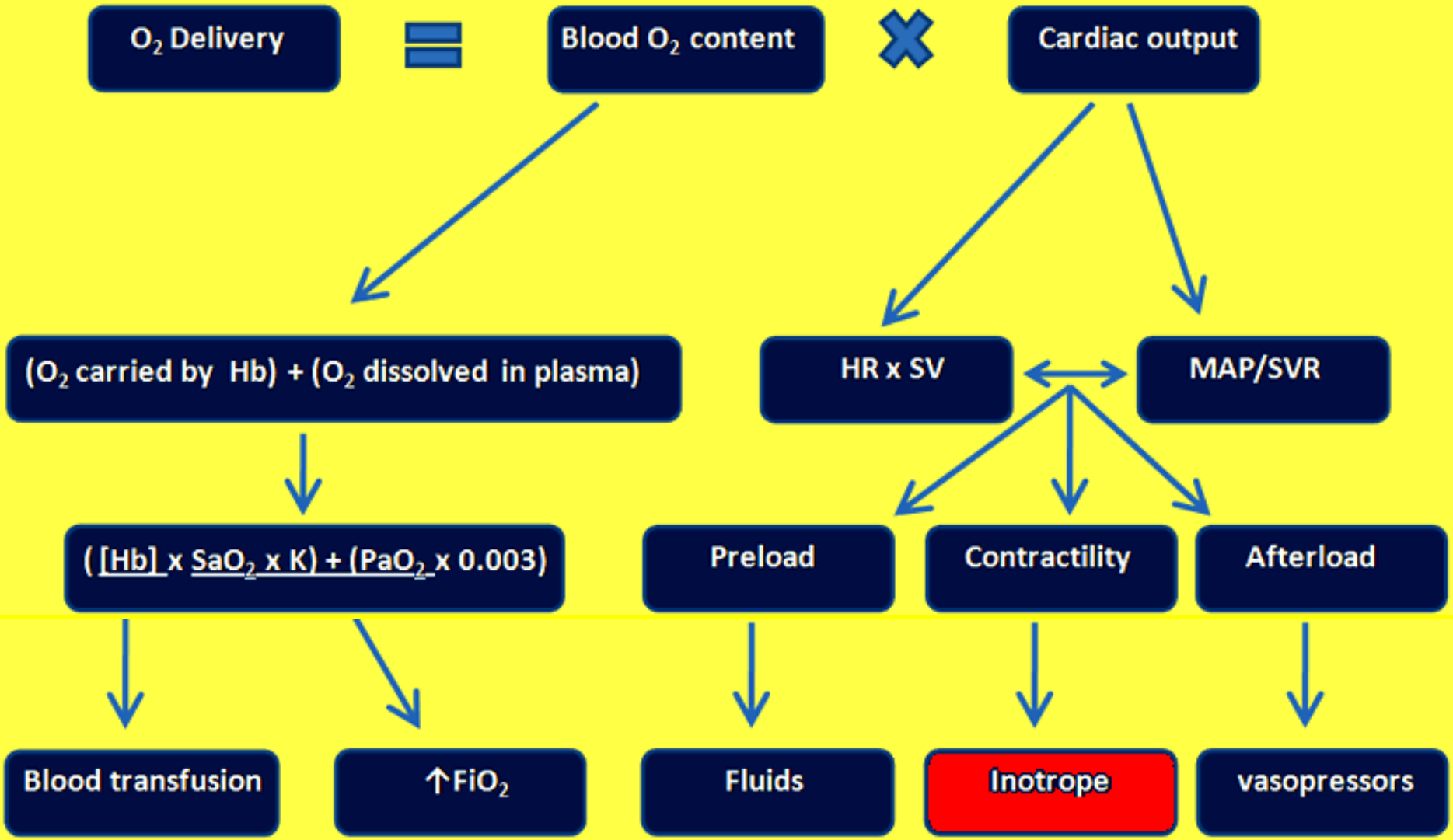

Grade I
<50% PW
Grade II
>50% PW
Grade III
All PW + <50% AW
Grade IV
All of PW and AW


PHILIPS RV 17/03/2009 16:18:37 TIS0.4 MI 0.1
49021020090317 DR. GUARRACINO X7-2t/TEE3D
FR 12Hz
15cm
2D
72%
C 50
P Bassa
Gen
CF
63%
4.4MHz
WF Alto
Med.
Vel 264 cm/s
PG 28 mmHg
CW
40%
2.5MHz
WF 225Hz
PAPs= 28 + PVC= 28 + 19 = 47 mmHg
400
300
200
100
Temp. PAZ.: 37.0C
Temp. TEE: 38.1C
100mm/s
68bpm

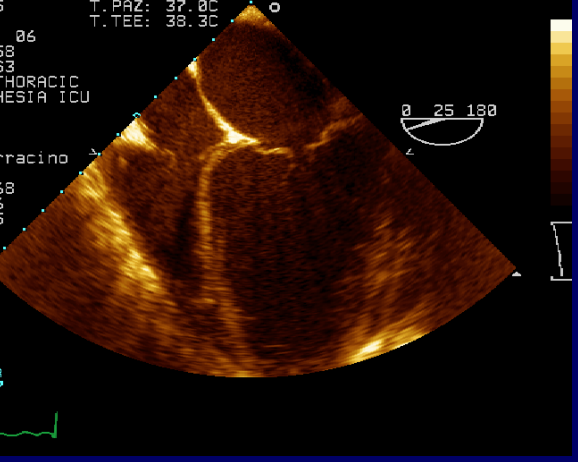

PHILIPS RV 17/03/2009 16:19:22 TIS0.7 MI 0.4
49021020090317 X7-2t/TEE3D
FR 12Hz
15cm
2D
72%
C 50
P Bassa
Gen
CF
63%
4.4MHz
WF Alto
Med.
M3 M4
-49.3
cm/s
JPEG
Temp. PAZ.: 37.0C
Temp. TEE: 39.5C
55 bpm


Chest Wall
Air
Lungs
Diaphram
P_{pl}
RA
RV
SVC
IVC
Inspiration
Expiration
-4
P_{pl}
-8
0
P_{RA}
-2
Venous
Return
End-Expiration
RK '07




O_2 Delivery
=
Blood O_2 content
×
Cardiac output
(O_2 carried by Hb) + (O_2 dissolved in plasma)
HR x SV
↔
MAP/SVR
([Hb] x SaO_2 x K) + (PaO_2 x 0.003)
Preload
Contractility
Afterload
Blood transfusion
↑FiO_2
Fluids
Inotrope
vasopressors

LV failure



- EF < 40%
- No MR
- Vp > 45 cm sec
- TDI E’ > 10

- EF < 30%
- No MR
- Vp < 25 cm sec
- TDI E’ < 8

- EF < 30%
- MR
- Vp < 25 cm sec
- TDI E’ < 5

- Beta adren.
- Nitrates

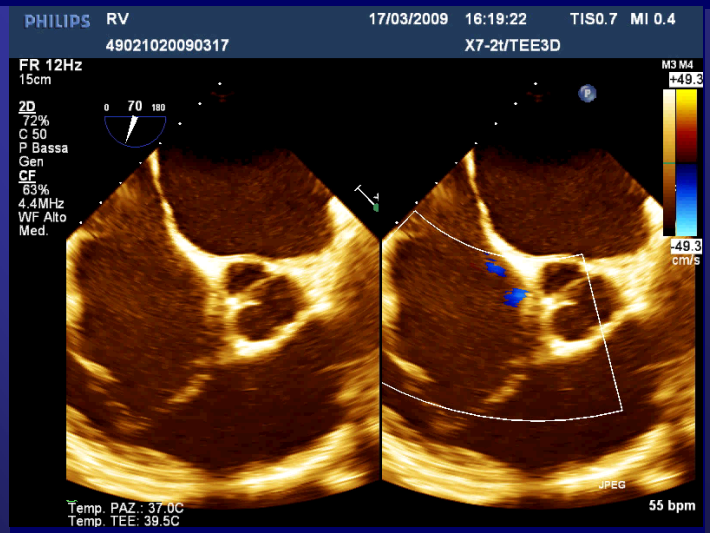
- Levosimendan

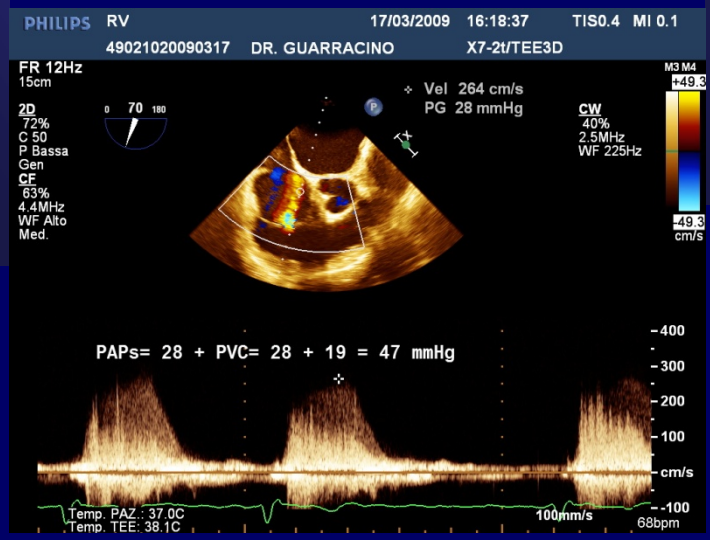
- Levosimendan

RV failure & cardiogenic shock

REF < 30%
CI < 2.2
↑ PAPs

- **↑ Noradrenaline**
- **Levosimendan**
- **iNO**





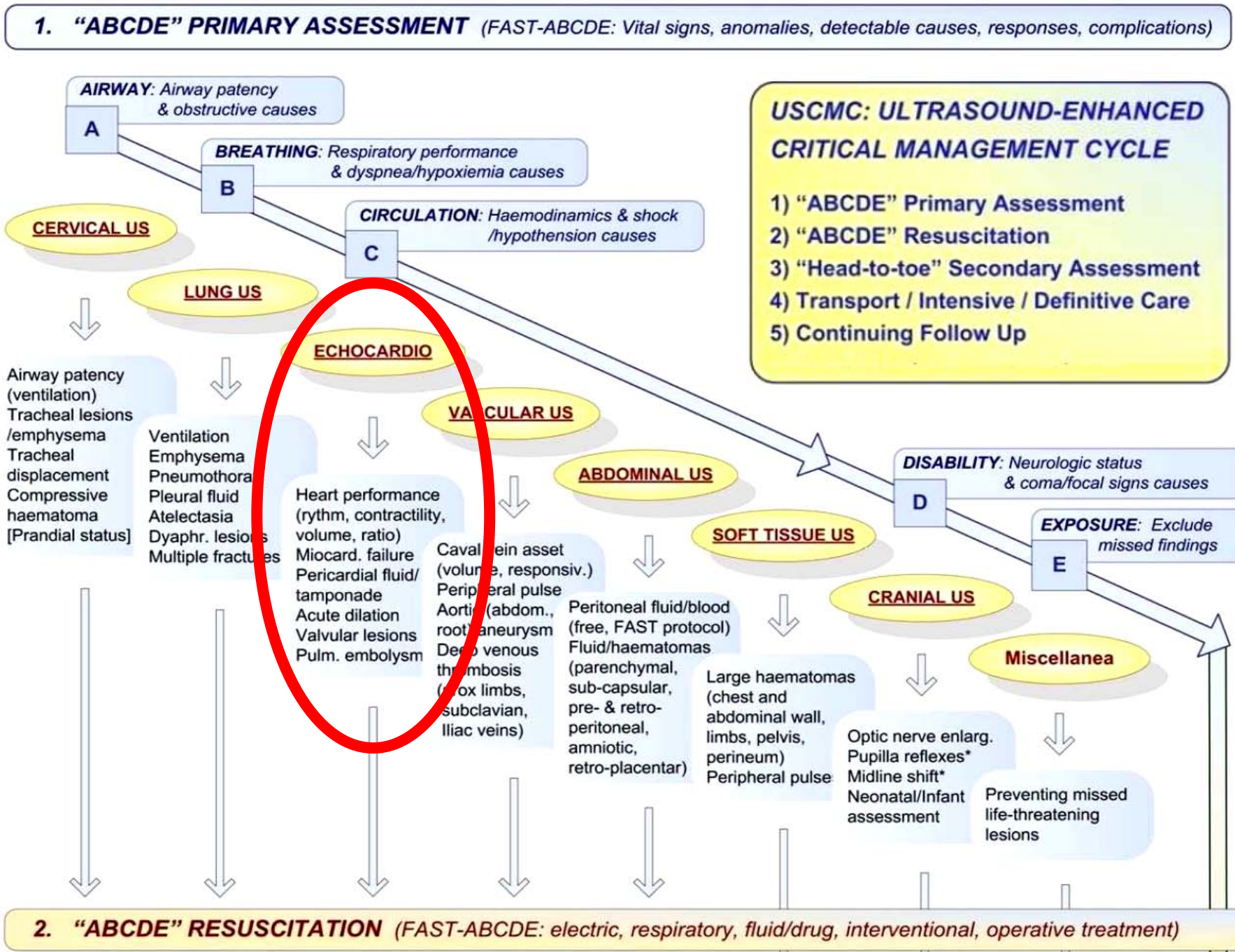
REF < 30%
CI < 2.2
↑ WP

- **Levosimendan**
- **Noradrenaline**

5.10 Echocardiography in shock

- Tamponade
- Cardiogenic shock
- Hypovolemia
- Massive pulmonary embolism

CARDIOVASCULAR ULTRASOUND
Cardiovascular Ultrasound 2008, **6**:49


1. "ABCDE" PRIMARY ASSESSMENT (FAST-ABCDE: Vital signs, anomalies, detectable causes, responses, complications)
AIRWAY: Airway patency & obstructive causes
A
BREATHING: Respiratory performance & dyspnea/hypoxiemia causes
B
CIRCULATION: Haemodinamics & shock /hypothension causes
C
DISABILITY: Neurologic status & coma/focal signs causes
D
EXPOSURE: Exclude missed findings
E
USCMC: ULTRASOUND-ENHANCED CRITICAL MANAGEMENT CYCLE
1) "ABCDE" Primary Assessment
2) "ABCDE" Resuscitation
3) "Head-to-toe" Secondary Assessment
4) Transport / Intensive / Definitive Care
5) Continuing Follow Up
CERVICAL US
LUNG US
ECHOCARDIO
VASCULAR US
ABDOMINAL US
SOFT TISSUE US
CRANIAL US
Miscellanea
Airway patency (ventilation)
Tracheal lesions /emphysema
Tracheal displacement
Compressive haematoma
[Prandial status]
Ventilation
Emphysema
Pneumothora
Pleural fluid
Atelectasia
Dyaphr. lesio
Multiple fractu
Heart performance (rythm, contractility, volume, ratio)
Miocard. failure
Pericardial fluid/ tamponade
Acute dilation
Valvular lesions
Pulm. embolysm
Caval ein asset (volu e, responsiv.)
Perip eral pulse
Aorti (abdom., root aneurysm
Dee venous th mbosis (ox limbs, subclavian, Iliac veins)
Peritoneal fluid/blood (free, FAST protocol)
Fluid/haematomas (parenchymal, sub-capsular, pre- & retro-peritoneal, amniotic, retro-placentar)
Large haematomas (chest and abdominal wall, limbs, pelvis, perineum)
Peripheral pulse
Optic nerve enlarg.
Pupilla reflexes*
Midline shift*
Neonatal/Infant assessment
Preventing missed life-threatening lesions
2. "ABCDE" RESUSCITATION (FAST-ABCDE: electric, respiratory, fluid/drug, interventional, operative treatment)

A position statement: echocardiography in the critically ill

Focused echocardiography in the critically ill

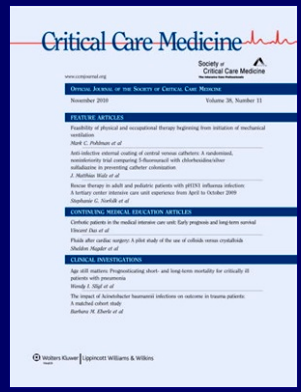
	FEEL Focused Echo Evaluation in Life Support	FATE Focused Assessed Transthoracic Echocardiography	FAST Focused Assessed Sonography in Trauma
Views	PLAX PSAX A4Ch Subcostal	PLAX PSAX A4Ch Subcostal *Pleural*	Subcostal *RUQ* *LUQ* *Pelvic*
Pathology	Pericardial collection Cardiac activity Gross ventricular function	Pericardial collection Measurement of ventricular dimensions Pleural collection	Free intra-peritoneal or pericardial fluid
Training	One-day course Supervised practice (eg 50 cases)	Two-day course Practical/theory exam	25-50 documented and outcome reviewed scans

Table 1 Focused ultrasound protocols devised for the critically ill. FEEL (previously FEER) incorporates only echocardiography, whereas FATE and FAST include additional views to image other organs (shown in italics). PLAX; parasternal long axis view, PSAX; parasternal short axis view, A4CH; apical four chamber view, RUQ right upper quadrant view; LUQ; left upper quadrant view.

JICS Volume 9, Number 2, July 2008

Focused echocardiographic evaluation in resuscitation management: Concept of an advanced life support–conformed algorithm

Raoul Breitkreutz, MD; Felix Walcher, MD, PhD; Florian H. Seeger, MD



Crit Care Med 2007 Vol. 35, No. 5

Hypotension, Acute Severe Dyspnea, Cyanosis, Pulseless, Unresponsive, Suspected PEA, PM-ECG, CPR, Postresuscitation Care

↓

FEER

↓

1) subcostal 4-chamber, long axis
2) parasternal, short or long axis
3) apical 4-chamber view

↙ ↘

no wall motion?

wall motion?

Consider:
Pericardial effusion?
RV>LV?
underfilled RV associated with hypercontractile LV?
Consequences or Treatment implications?

↙ ↘

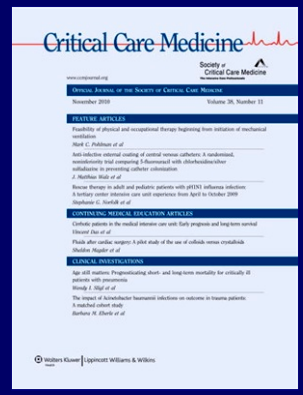
limited?

normal

↙ ↘

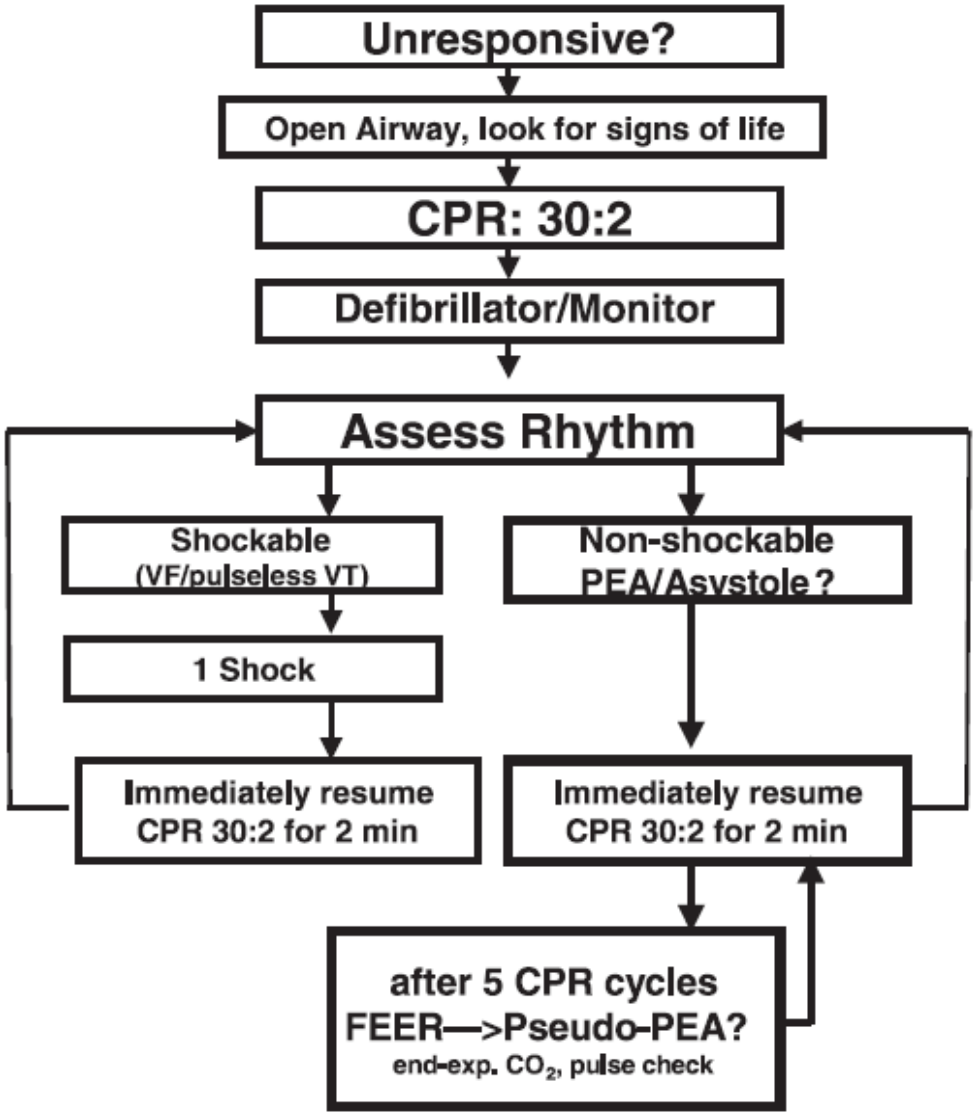
severely limited

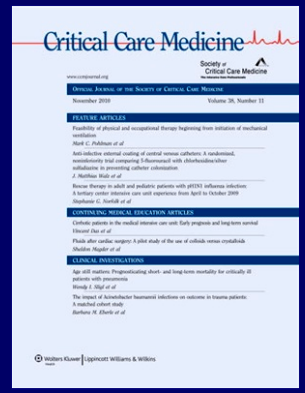
moderately limited



Crit Care Med 2007 Vol. 35, No. 5

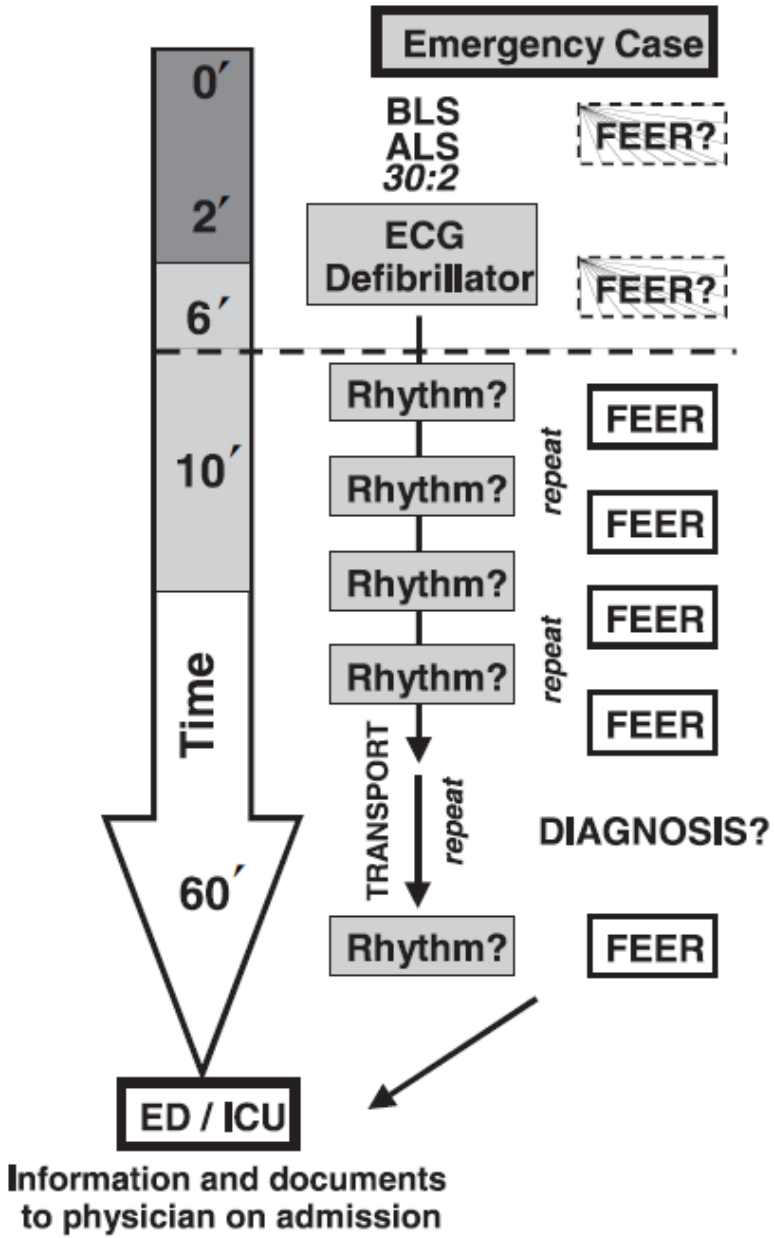
Proposed Integration of a brief Echocardiography (FEER) into the ALS to identify Reversible Causes

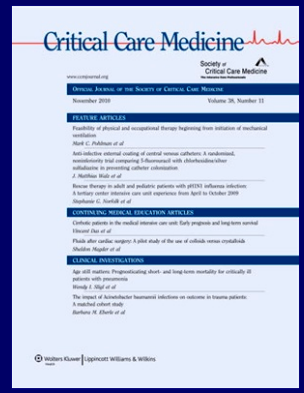




Crit Care Med 2007 Vol. 35, No. 5

Time dependent Use of FEER during CPR





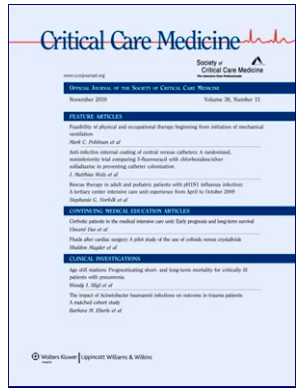
Crit Care Med 2007 Vol. 35, No. 5

Table 2. Potential echocardiographic findings during cardiopulmonary resuscitation[a]

Possible Echocardiographic Findings	(Qualitative) Diagnoses
Wall movement	Circulation present
No wall movement in asystole, pulselessness, PEA, other rhythms	Proven cardiac standstill
Limited pump function	Myocardial insufficiency
Severely limited	
Moderately limited	
Wall motion, pulselessness, regular rhythm	Pseudo-PEA
No wall motion, pulselessness, regular rhythm	True PEA
Hypercontractile ventricular walls, underfilled right ventricle and atrium, hypotension, tachycardia, "kissing" trabecular muscles	Hypovolemia
Enlarged right ventricular cavum, "D-sign"	Suspected pulmonary artery embolism
Pericardial effusion (small or massive) and pericardial tamponade	Pericardial effusion (small or massive), with or without functional relevance, tamponade
No conclusive finding	No diagnosis

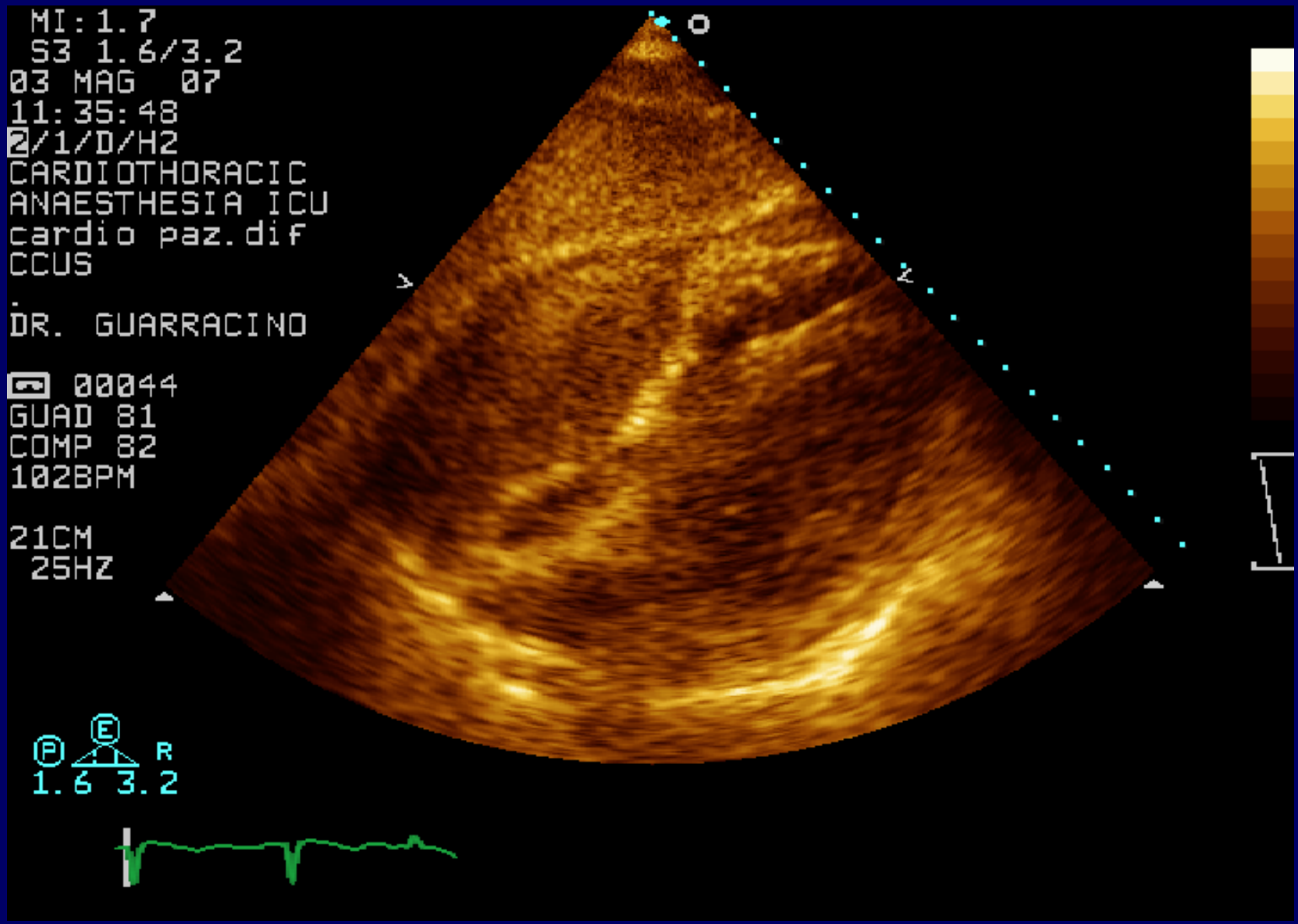
Table 3. Indications for an immediate echocardiography in periresuscitation care

Preresuscitation care	Penetrating trauma, blunt trauma
	Postcardiotomy due to cardiac surgery
	Hypotension, shock of unknown origin
	Unconsciousness, unresponsiveness
	Acute severe dyspnea
	Syncope in young adults
	Vein thrombosis
	Acute myocardial infarction (AMI), mechanical complications of AMI
	"Atypical" chest pain: suspected aortic dissection, suspected aortic abdominal or thoracic aneurysm, nontraumatic cardiac rupture
	Iatrogenic complications because of invasive procedures (e.g. insertion of an artificial pacemaker, pulmonary artery catheter, electrophysiologic investigative procedures)
	Great-vessel disease
Resuscitation (CPR)	Pulseless electrical activity
	Suspected cardiac tamponade
	Early detection of ROSC
	Bradycardia-asystole, pacemaker-ECG
	Performance of CPR
	Effectiveness of chest compressions
Postresuscitation care	Hypotension, adaptation of vasopressors



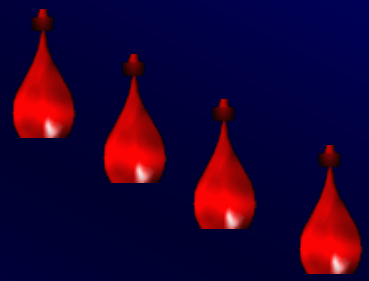
CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation; ECG, electrocardiogram.

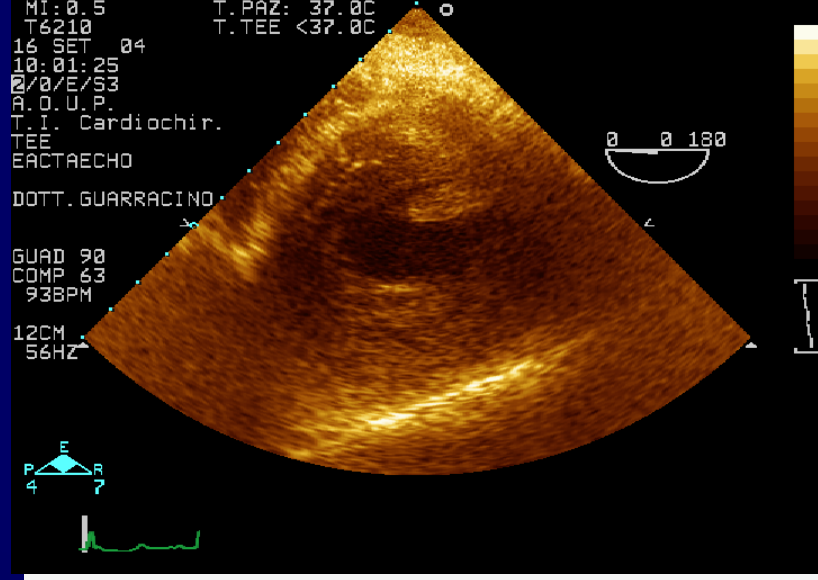
Pericardial effusion

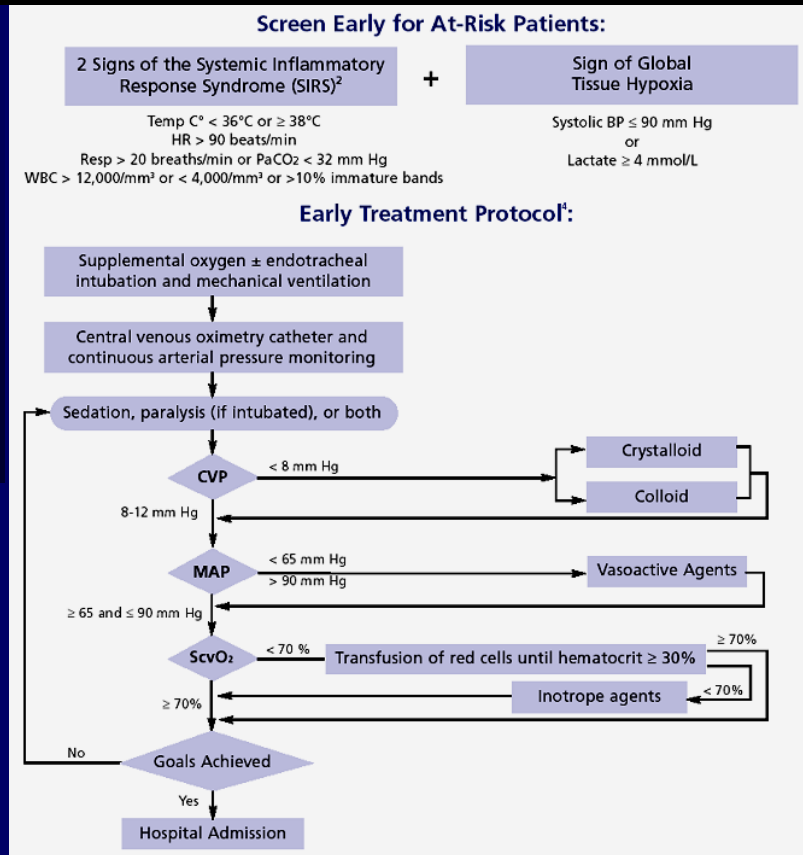


Volume problem

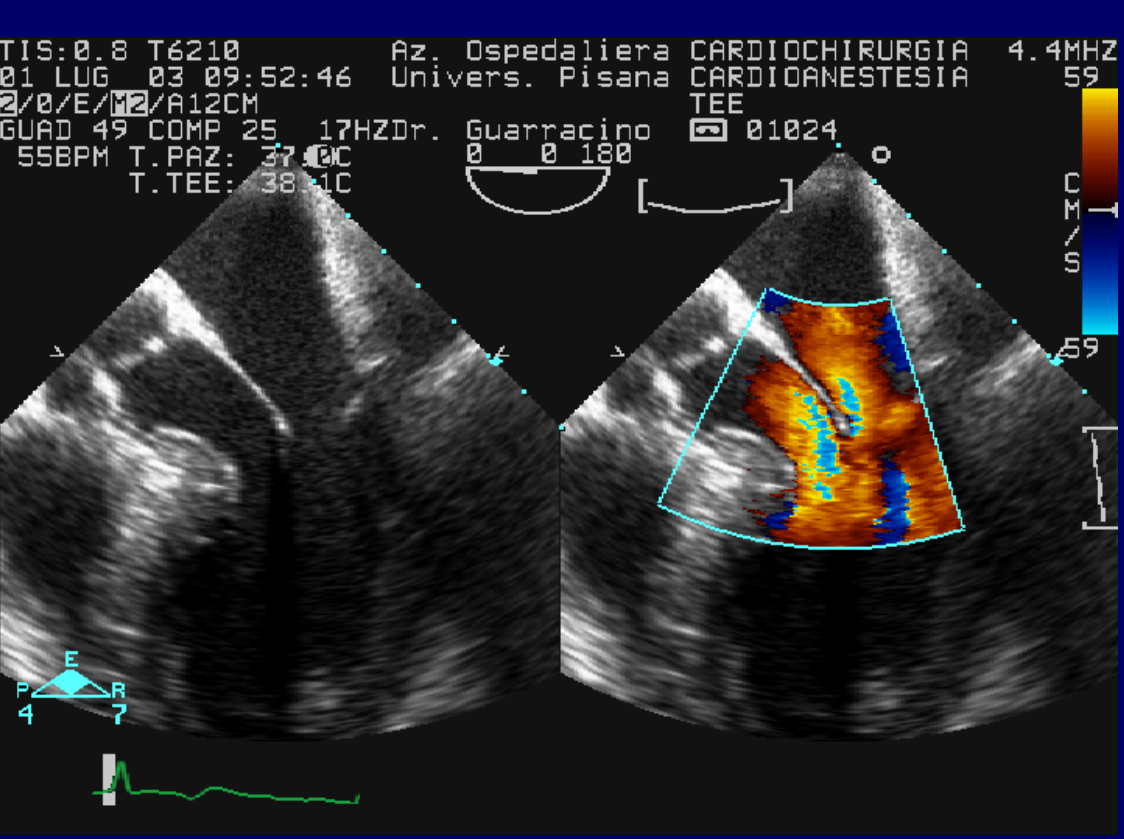
- Increase preload
- Transfusions
- Early goal therapy in sepsis

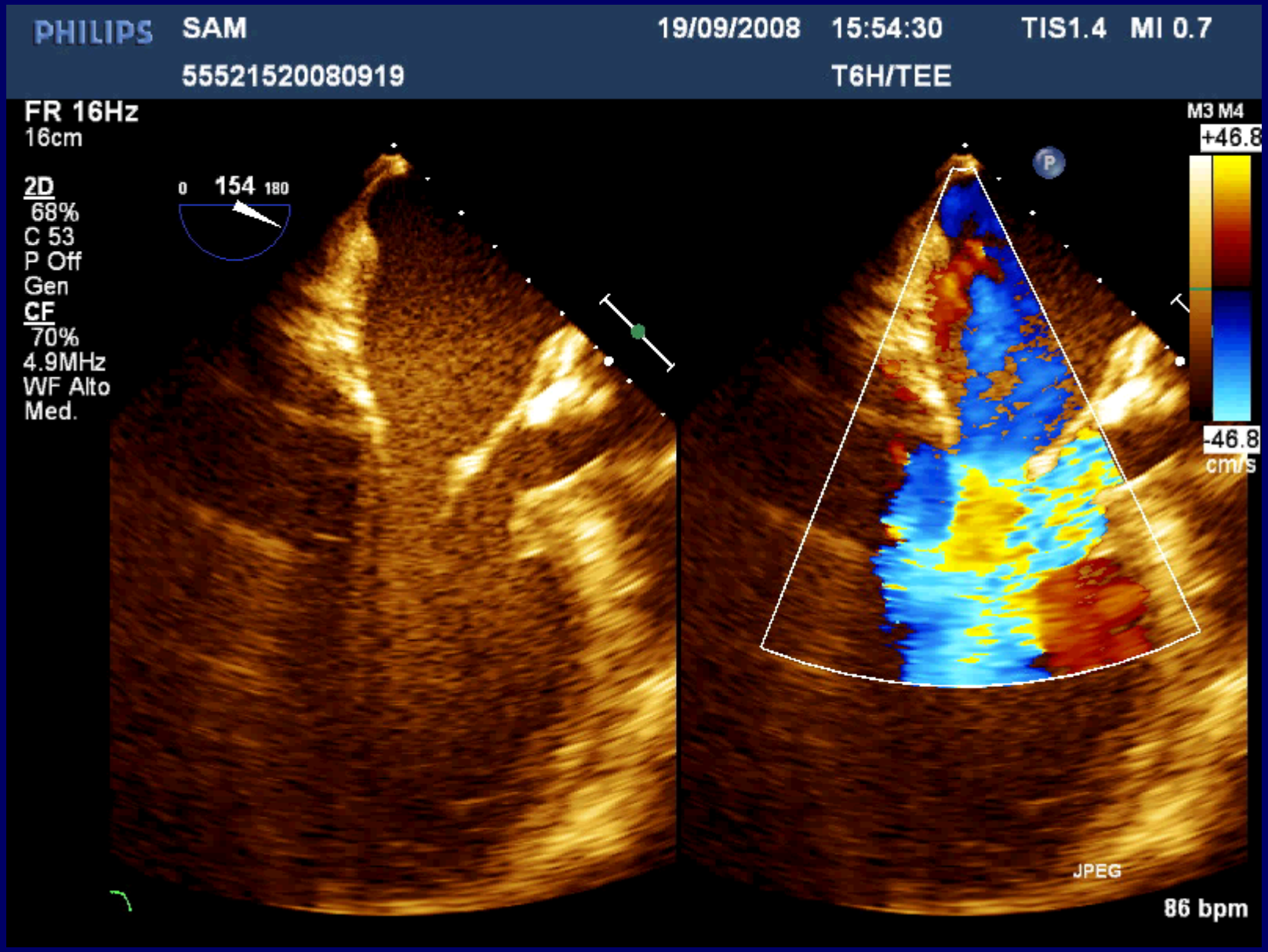


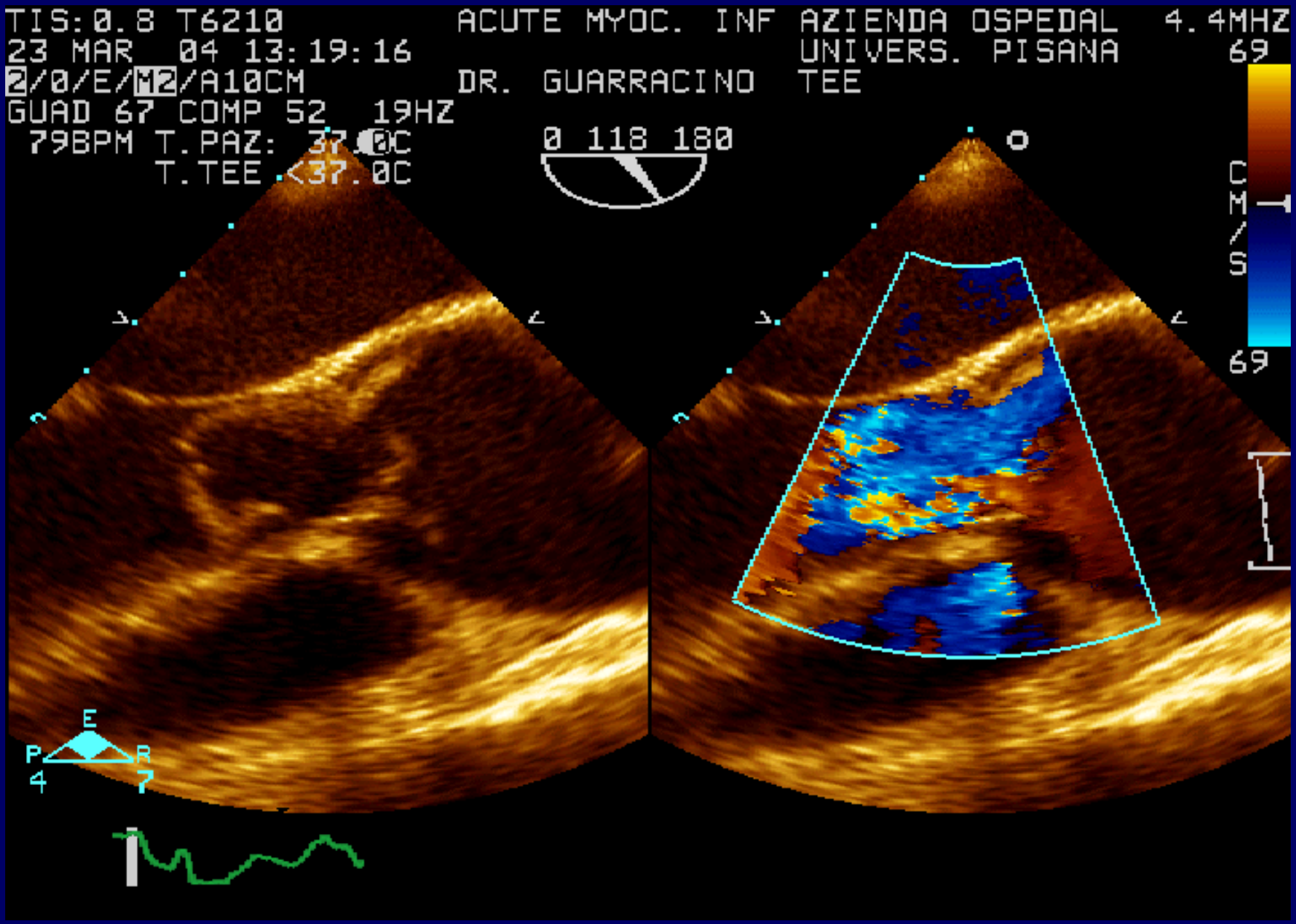


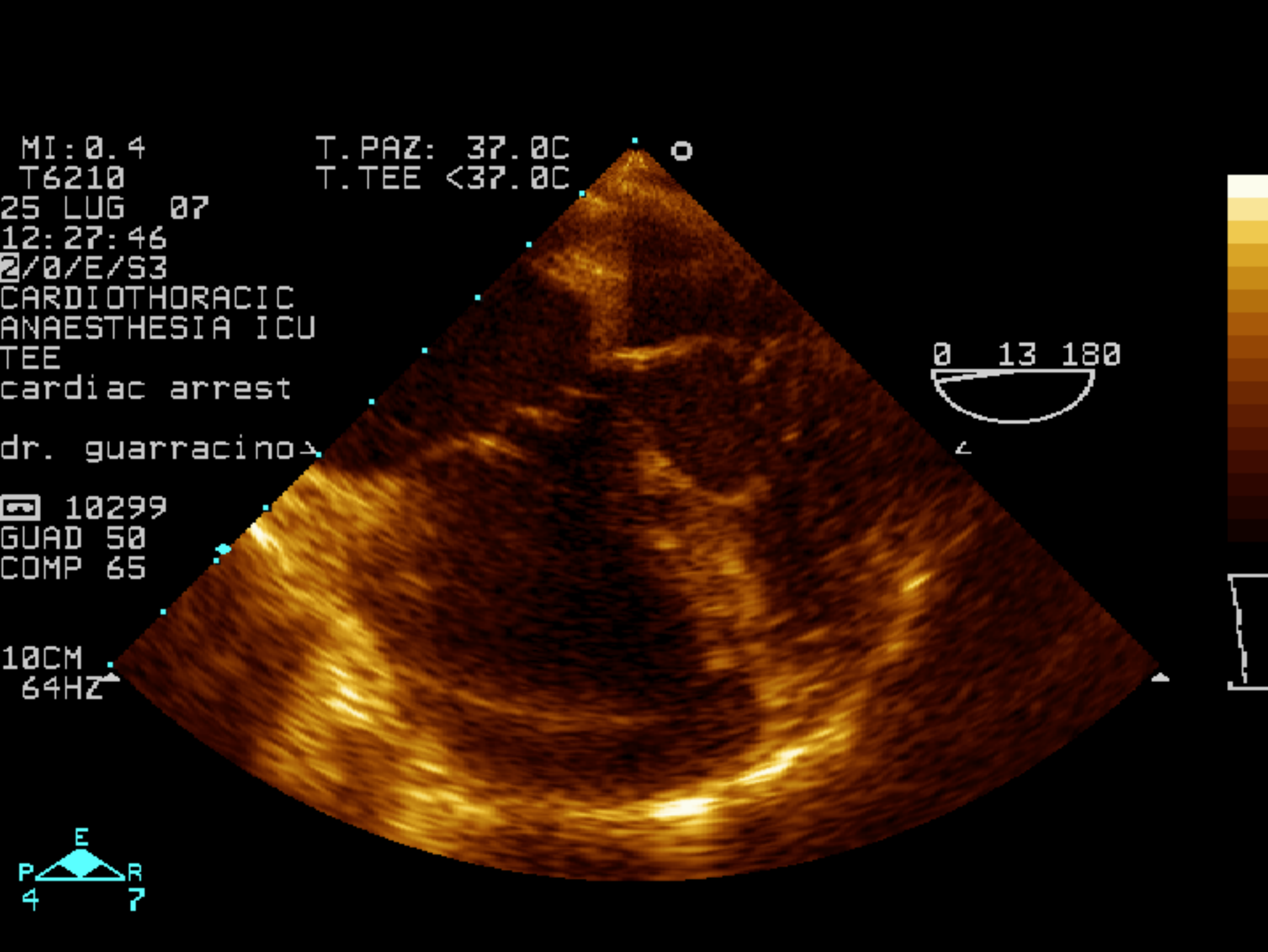


LVOT dynamic obstruction

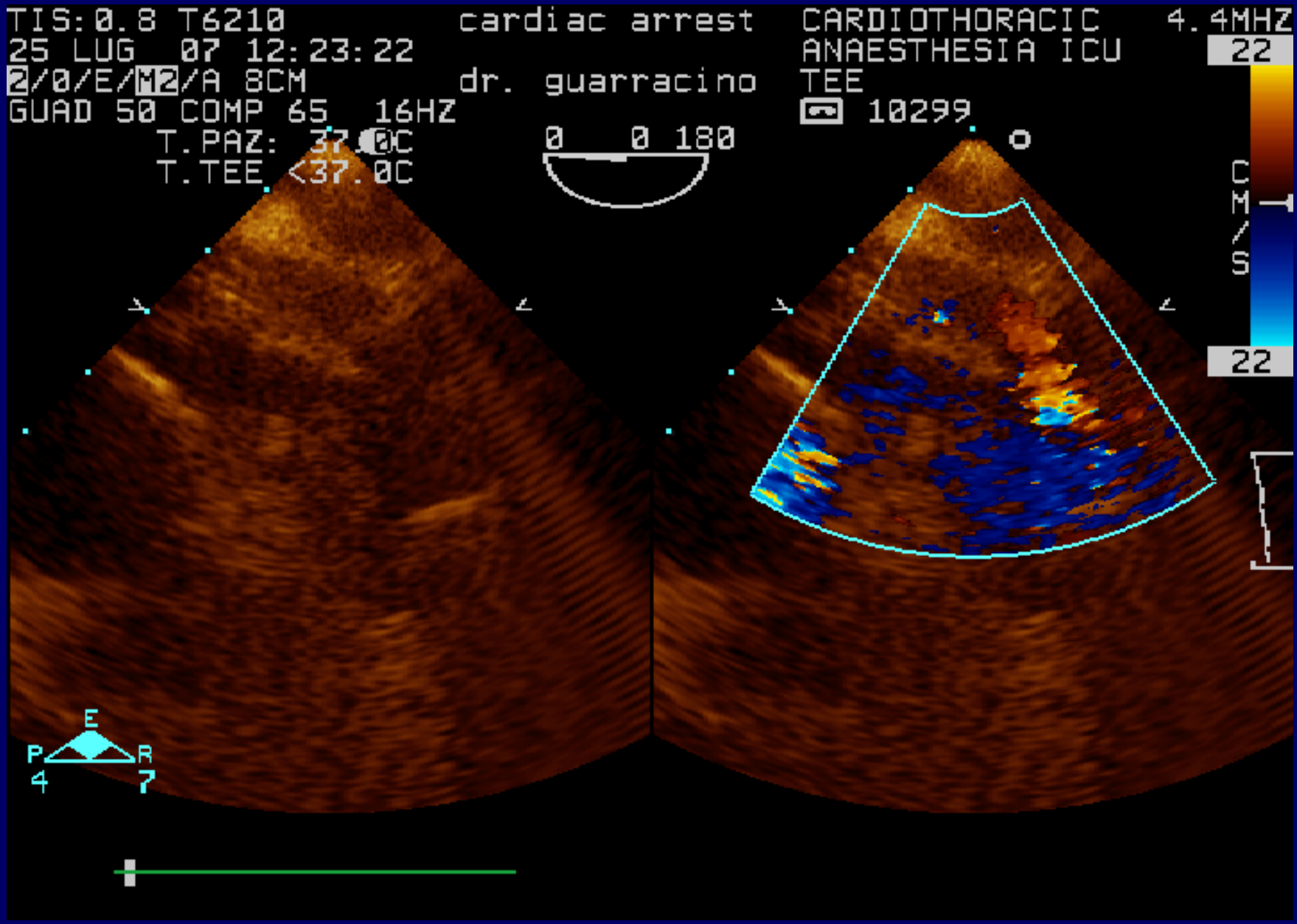



PHILIPS
SAM
19/09/2008
15:54:30
TIS1.4
MI 0.7
55521520080919
T6H/TEE
FR 16Hz
16cm
2D
68%
C 53
P Off
Gen
CF
70%
4.9MHz
WF Alto
Med.
0
154
180
M3 M4
+46.8
-46.8
cm/s
JPEG
86 bpm

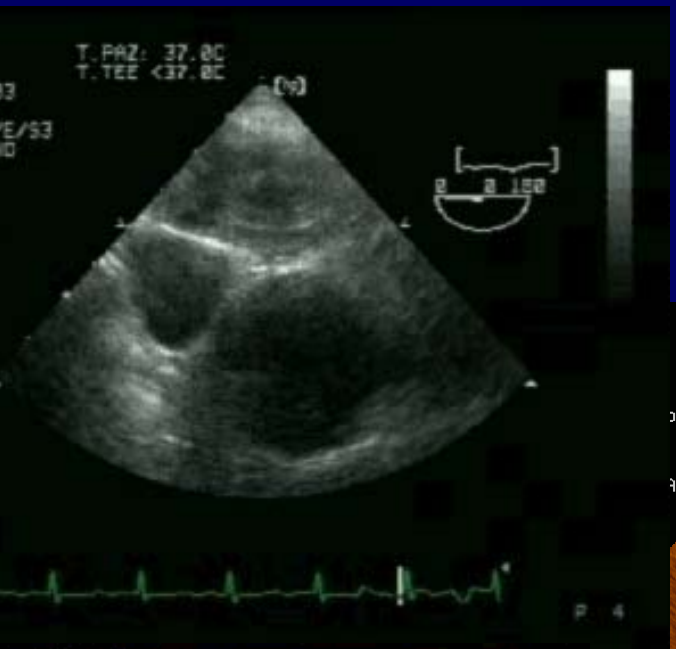

TIS: 0.8 T6210
ACUTE MYOC. INF
AZIENDA OSPEDAL
4.4MHZ
23 MAR 04 13:19:16
UNIVERS. PISANA
69
2/0/E/M2/A10CM
DR. GUARRACINO
TEE
GUAD 67 COMP 52 19HZ
79BPM T.PAZ: 37.0C
T.TEE <37.0C
0 118 180
CM/S
69
E
P
R
4
7

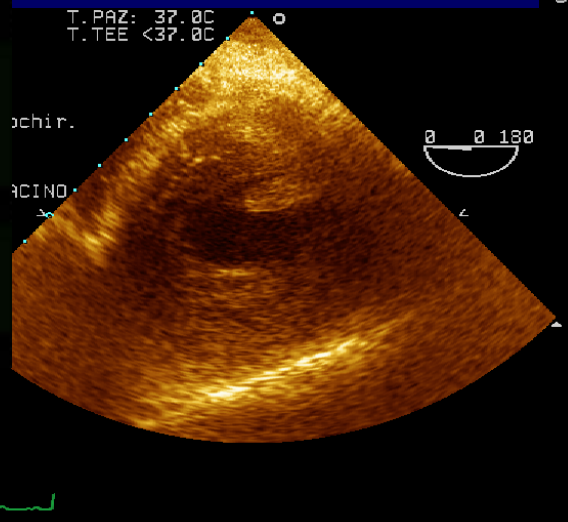

MI:0.4
T6210
T.PAZ: 37.0C
T.TEE <37.0C
25 LUG 07
12:27:46
2/0/E/S3
CARDIOTHORACIC
ANAESTHESIA ICU
TEE
cardiac arrest
dr. guarracino
10299
GUAD 50
COMP 65
10CM
64HZ
0 13 180
E
P
R
4
7

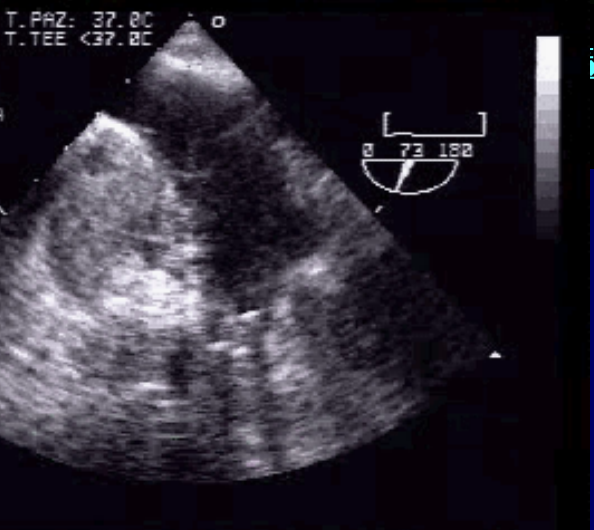

MI:0.4
T6210
T.PAZ: 37.0C
T.TEE <37.0C
25 LUG 07
12:30:58
2/0/E/S3
CARDIOTHORACIC
ANAESTHESIA ICU
TEE
cardiac arrest
dr. guarracino
10299
GUAD 50
COMP 65
10CM
64HZ
0 35 180
E
P
A
4
7

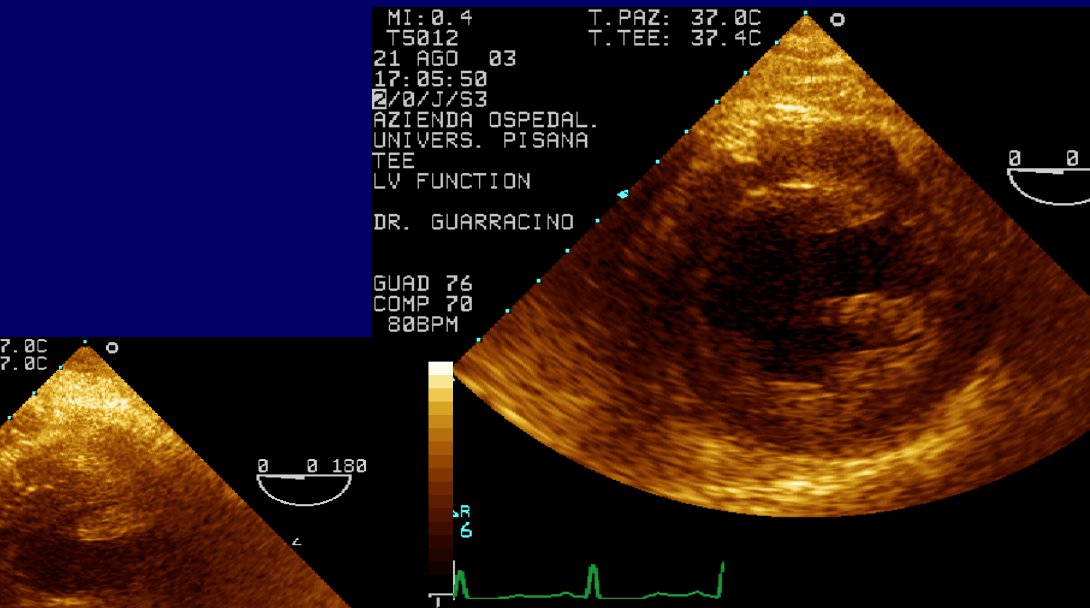

TIS:0.8 T6210
cardiac arrest
CARDIOTHORACIC
4.4MHZ
25 LUG 07 12:23:22
ANAESTHESIA ICU
22
2/0/E/M2/A 8CM
dr. guarracino
TEE
GUAD 50 COMP 65 16HZ
10299
0 0 180
T.PAZ: 37.0C
T.TEE <37.0C
CM/S
22
E
P
R
4
7

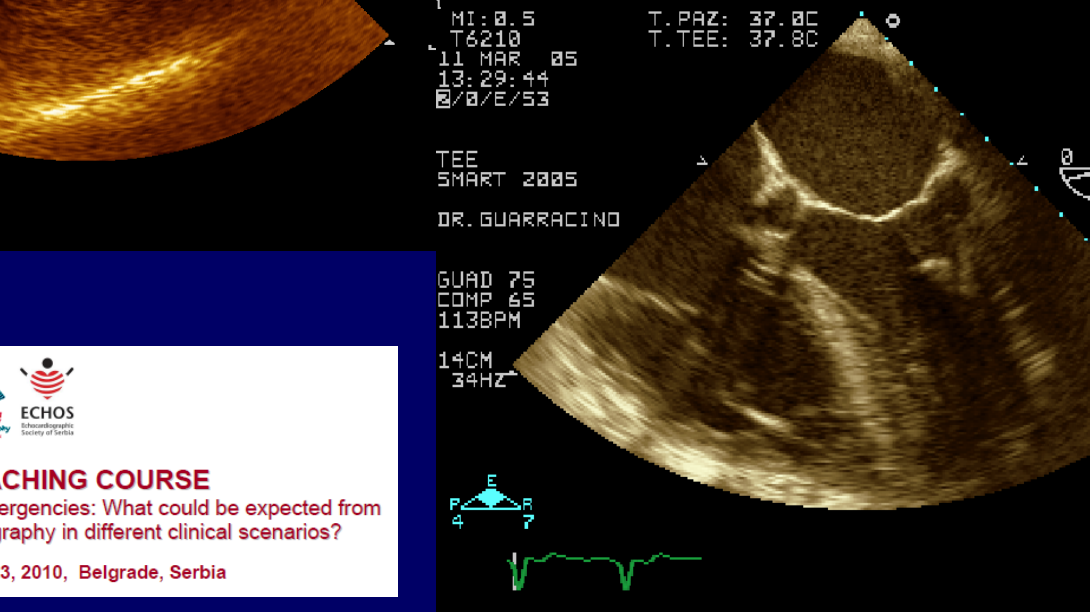
Echo diagnosis in shock states











EUROPEAN SOCIETY OF CARDIOLOGY | EUROPEAN ASSOCIATION OF ECHOCARDIOGRAPHY | ECHOS Echocardiographic Society of Serbia

EAE TEACHING COURSE

Cardiac Emergencies: What could be expected from echocardiography in different clinical scenarios?

October 22-23, 2010, Belgrade, Serbia

Echocardiogram

LV - RV Function & Hemodynamics

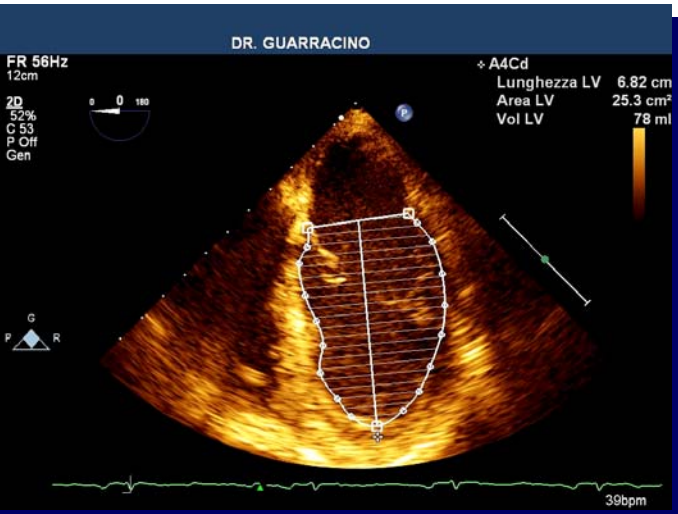
1. EF and diastolic parameters
2. Estimate chamber pressures
3. Estimate cardiac output

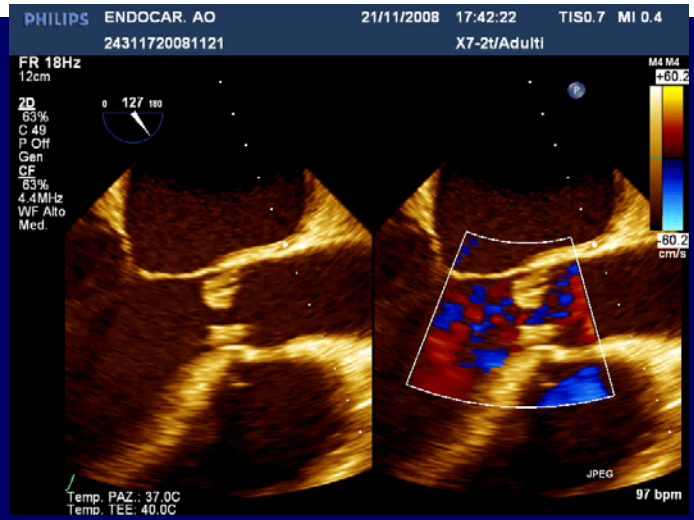
Structural Disease

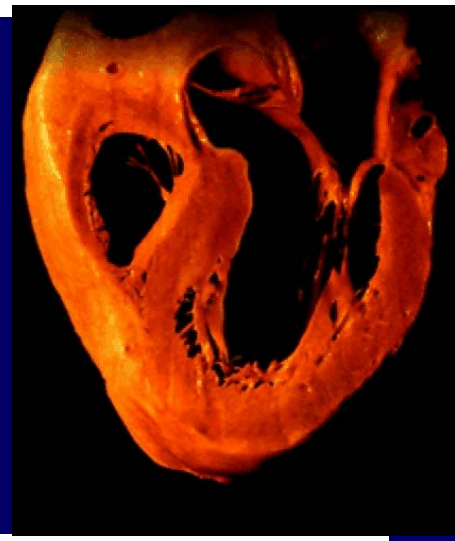
1. Valve disease
2. Septal defects
3. Endocarditis
4. Pulmonary embolism
5. Tamponade

LVOTO

1. Detection of SAM
2. Severity of LVOTO
3. Associated MR







Adapted from Crit Care Med 2009 Vol. 37, No. 2

Review

Echocardiography practice, training and accreditation in the intensive care: document for the World Interactive Network Focused on Critical Ultrasound (WINFOCUS)

Susanna Price*[1], Gabriele Via[2], Erik Sloth[3], Fabio Guarracino[4], Raoul Breitkreutz[5], Emanuele Catena[6], Daniel Talmor[7] and World Interactive Network Focused On Critical UltraSound ECHO-ICU Group[8]

Cardiovascular Ultrasound 2008, **6**:49