

HEART FAILURE AND ARRHYTHMIAS

Echocardiography in the algorithm of the diagnostic workup of acute heart failure in 2021 ESC guidelines

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DECLARATION OF INTEREST

I have nothing to declare

ACUTE HEART FAILURE

Rapid or gradual onset of symptoms and/or signs of HF, severe enough for the patient to seek urgent medical attention, leading to an unplanned hospital admission or an emergency department visit.

- **New onset** (first manifestation of HF) or, more frequently, **Acute decompensation of CHF**
- Leading cause of hospitalizations in pts > 65 years
- Associated with high mortality (In-hospital mortality 4% - 10%)
- Require urgent evaluation and treatment

- Nieminen et al. Eur Heart J 2006;27:2725-2736.
- Chioncel O, et al. Eur J Heart Fail 2019;21:1338-1352.
- Miro O, et al. Eur J Heart Fail 2019;21:1231-1244.

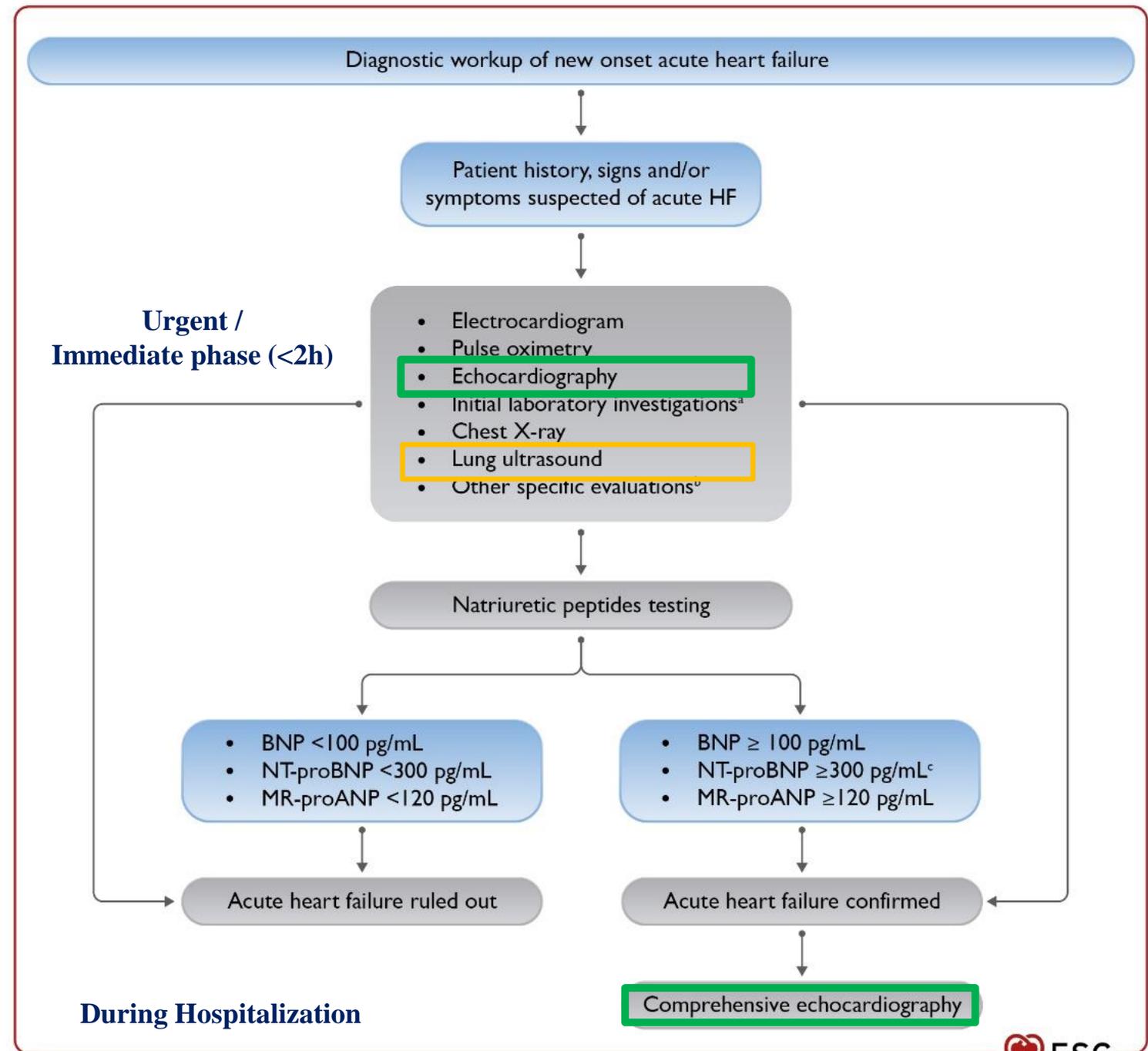
CLINICAL PRESENTATIONS OF AHF

	Acutely decompensated heart failure (ADHF)	Acute pulmonary oedema	Isolated right ventricular failure	Cardiogenic Shock
Main mechanisms	LV dysfunction Sodium and water renal retention	Increased afterload and/or predominant LV diastolic dysfunction Valvular heart disease	RV dysfunction and/or pulmonary hypertension	Severe cardiac dysfunction
Main cause of symptoms	Fluid accumulation, increased intraventricular pressure	Fluid redistribution to the lungs and acute respiratory failure	Increased central venous pressure and often systemic hypoperfusion	Systemic hypoperfusion
Onset	Gradual (days)	Rapid (hours)	Gradual or rapid	Gradual or rapid
Main haemodynamic abnormalities	Increased LVEDP and PCWP ^a Low or normal cardiac output Normal to low SBP	Increased LVEDP and PCWP ^a Normal cardiac output Normal to high SBP	Increased RVEDP Low cardiac output Low SBP	Increased LVEDP and PCWP ^a Low cardiac output Low SBP
Main clinical presentations	Wet and warm OR Wet and cold	Wet and warm	Wet and cold	Wet and cold
Main treatment	Diuretics Inotropic agents/vasopressors (if peripheral hypoperfusion/hypotension) Short-term MCS if needed	Diuretics Vasodilators	Diuretics for peripheral congestion Inotropic agents/vasopressors (if peripheral hypoperfusion/hypotension) Short-term MCS if needed	Inotropic agents/vasopressors Short-term MCS

DIAGNOSTIC TESTS IN PATIENTS WITH AHF

Exam	Time of measurement	Possible findings	Diagnostic value for AHF	Indication
ECG	Admission, during hospitalization, ^{a,b} pre-discharge	Arrhythmias, myocardial ischaemia	None	Recommended
Chest-X ray	Admission, during hospitalization ^a	Congestion, lung infection	Confirmatory	May be considered
LUS	Admission, during hospitalization ^a pre-discharge	Congestion	Confirmatory	May be considered
Echocardiography	Admission, during hospitalization, ^a pre-discharge	Congestion, cardiac function, mechanical causes	Major	Recommended
Natriuretic peptides (BNP, NT-proBNP, MR-proANP)	Admission, pre-discharge	Congestion	High negative predictive value	Should be considered
Serum troponin	Admission	Myocardial injury	Exclusion of ACS	Recommended
Serum creatinine	Admission, during hospitalization, ^a pre-discharge	Renal function	None	Recommended for prognostic assessment

DIAGNOSTIC WORK UP OF A NEW ONSET AHF



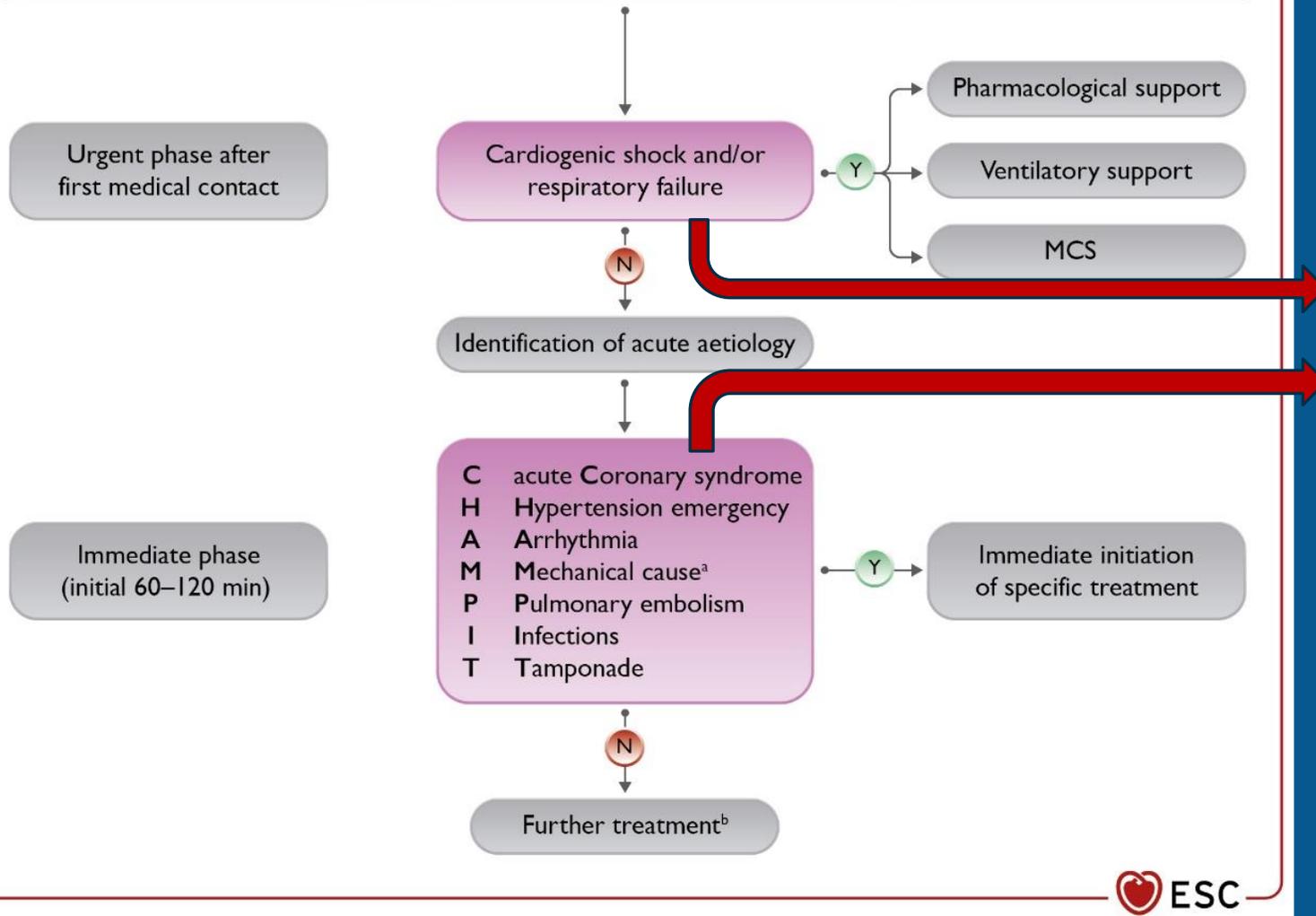
McDonagh T, et al. 2021 ESC Guidelines for the diagnosis and treatment of A/CHF. EHJ 2021;00:1-28

A. ECHOCARDIOGRAPHY IN THE URGENT and IMMEDIATE PHASE – Focused study

- ▶ Misdiagnosis rates $\leq 33\%$ if the diagnosis of AHF is based on medical history and physical examination only.
- ▶ Echo reveal the aetiology of hypotension in 48% and change therapy in 60–80% of patients in the pre-hospital setting
- ▶ First-choice test in the differential diagnosis of AHF

- Mebazaa et al. Eur Heart J 2010;31:832–841
- Kitcher, et al. Curr Cardiovasc Imaging Rep. 2017;10(2):6

Management of patients with suspected acute heart failure



ECHOCARDIOGRAPHY

A. For distinguish cardiac vs non-cardiac aetiology of:

- ▶ Hypotension or shock
- ▶ Acute Dyspnea

B. For the evaluation of **Cardiac Causes** of AHF that need specific, urgent treatment

A. For distinguish cardiac vs non-cardiac aetiology of:

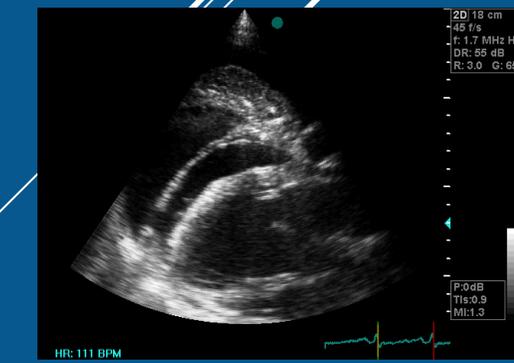
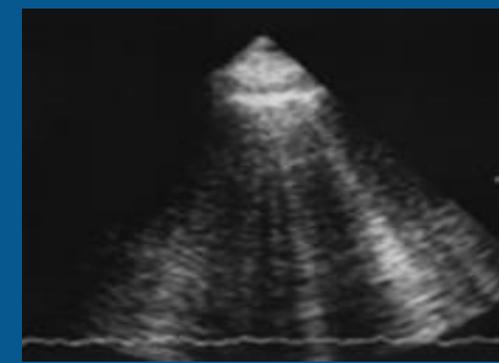
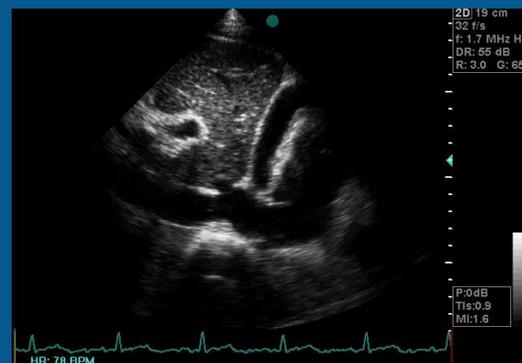
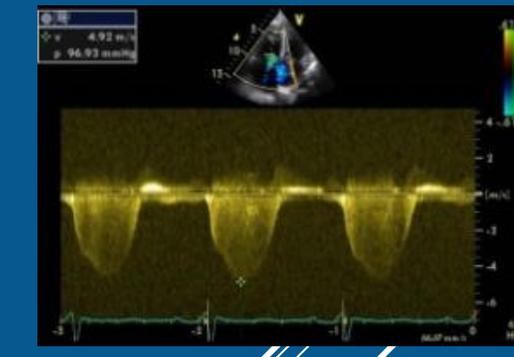
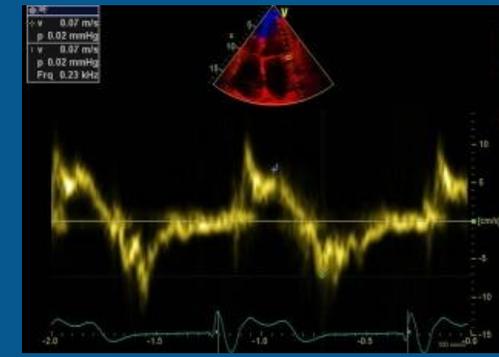
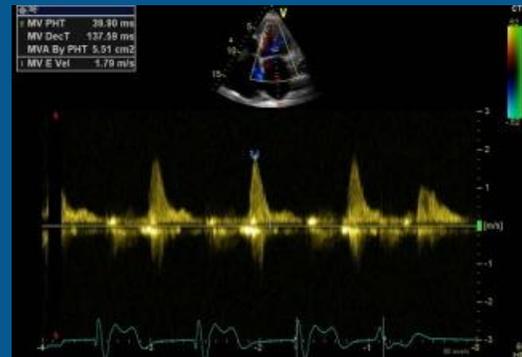
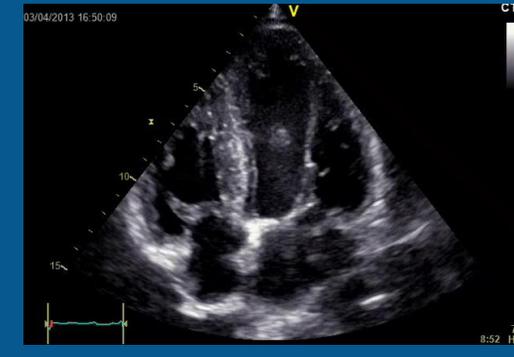
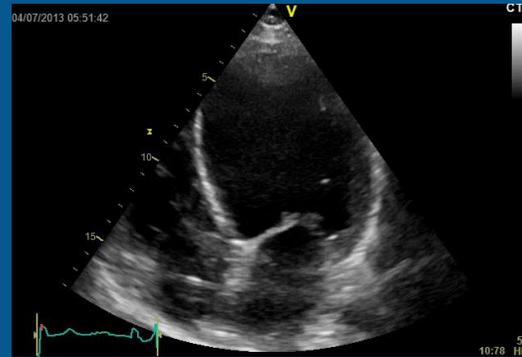
- Hypotension or shock
- Acute Dyspnea

When:

Clinical and laboratory findings are ambiguous

How:

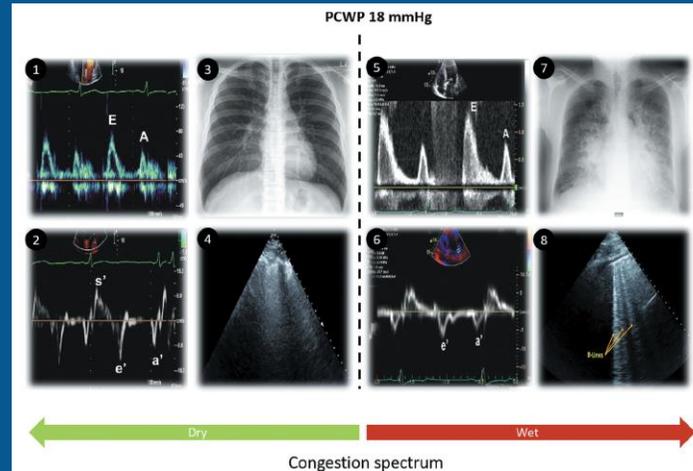
- LV, RV dimensions / Systolic function
- PCWP (LA pressures)
- SPRV
- Cardiac Valves
- Pericardium
- Pleural effusion/ B-Lines



ECHO INDICES OF DIASTOLIC FUNCTION - PRESSURES

KEY VARIABLES

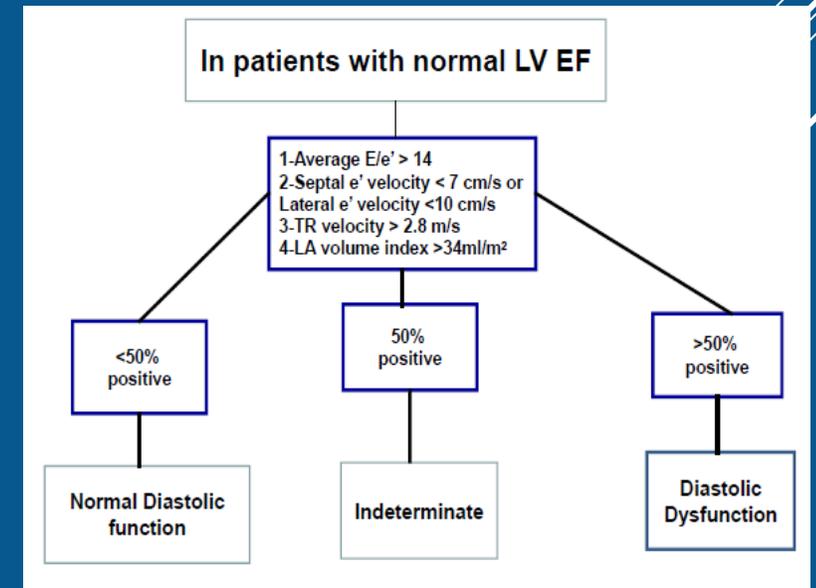
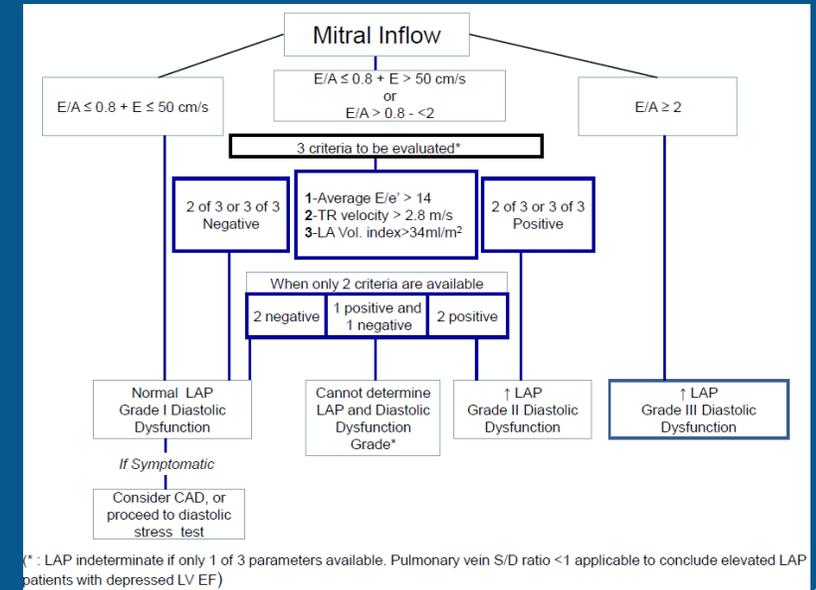
- ▶ Mitral flow velocities,
- ▶ Mitral annular e' velocity,
- ▶ E/e' ratio,
- ▶ Peak velocity of TR jet,
- ▶ LA maximum volume index



SUPPLEMENTARY METHODS

- ▶ Pulmonary vein velocities
- ▶ LV GLS by speckle-tracking

Not well validated in AHF setting



B. For the evaluation of Cardiac Causes of AHF

Most common causes:

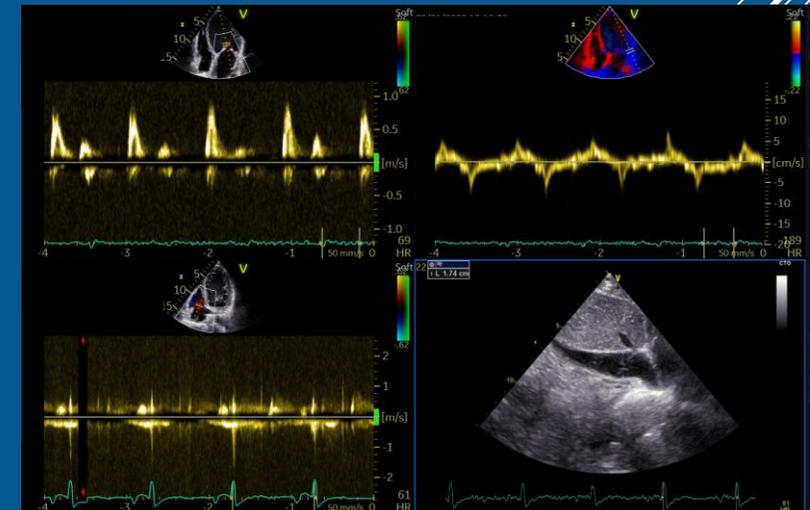
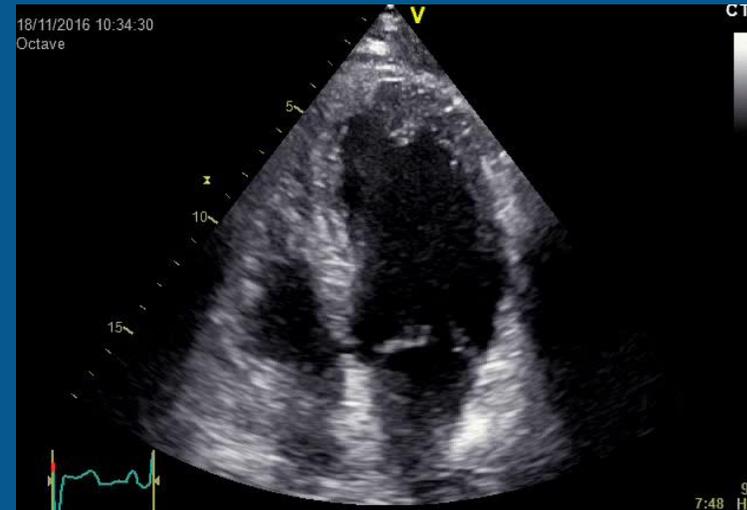
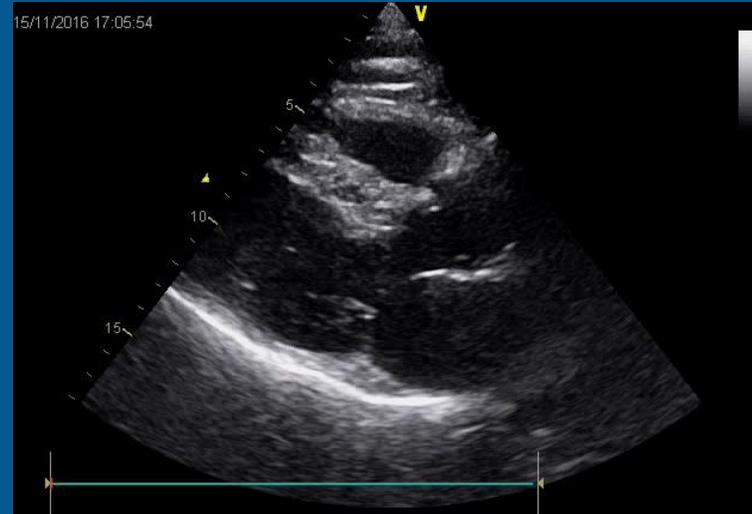
- ▶ Acute decompensated HF
- ▶ Acute coronary syndrome
- ▶ Acute Pulmonary Embolism
- ▶ Valvular heart disease
- ▶ Tamponade
- ▶ Acute myocarditis

Less common causes:

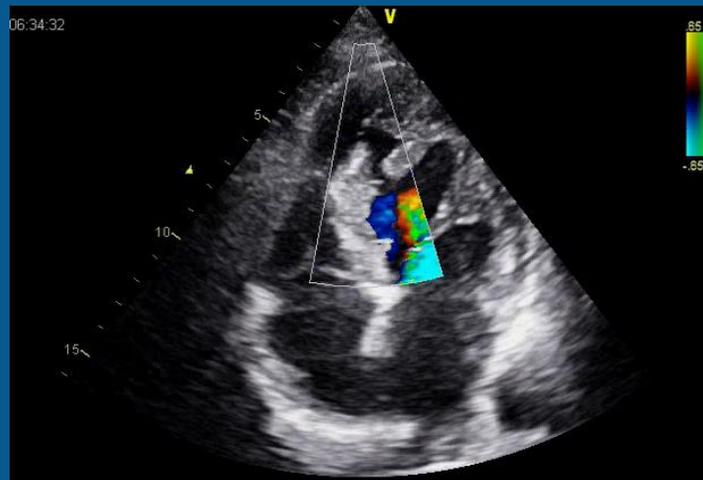
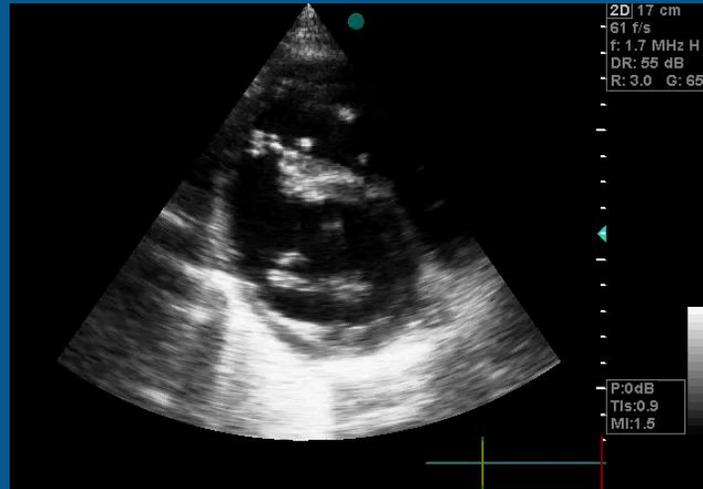
- Aortic dissection

1. Distinguishing cardiac vs. non-cardiac aetiology of dyspnoea in patients in whom clinical and laboratory findings are ambiguous.
2. Assessment of left-ventricular size, shape, and global and regional function in patients with suspected clinical diagnosis of heart failure.
3. Detection of echocardiographic signs of tamponade.
4. Detection of acute valvular regurgitation and/or prosthetic valve dysfunction.
5. Detection of suspected complication of myocardial ischaemia/infarction, including but not limited to acute mitral regurgitation, ventricular septal defect, free-wall rupture/tamponade, right-ventricular involvement, heart failure.

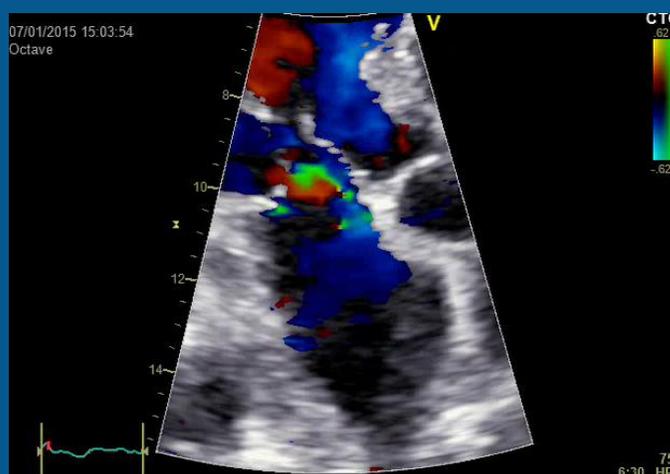
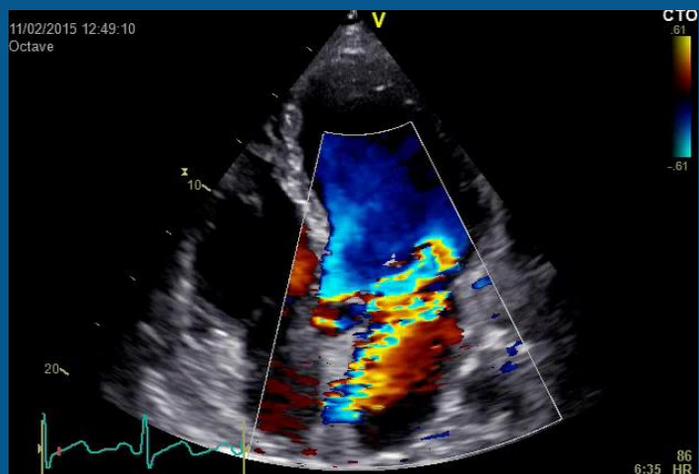
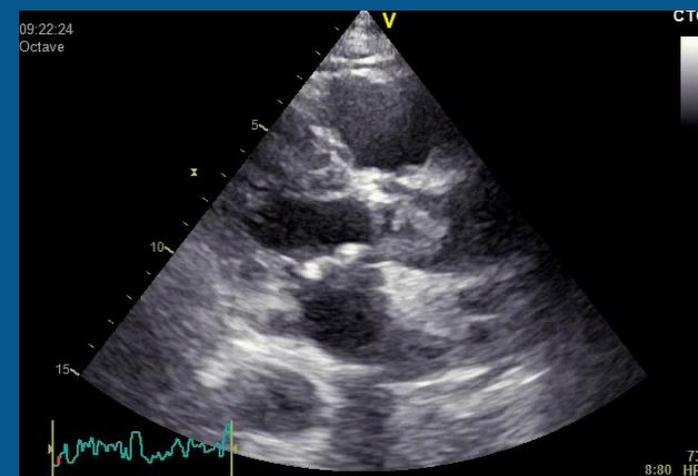
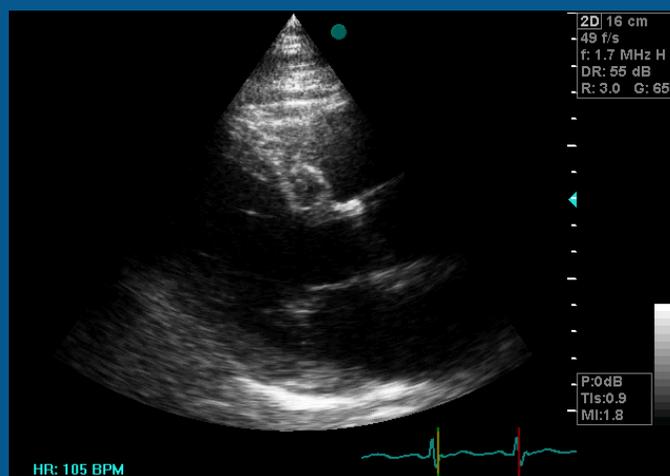
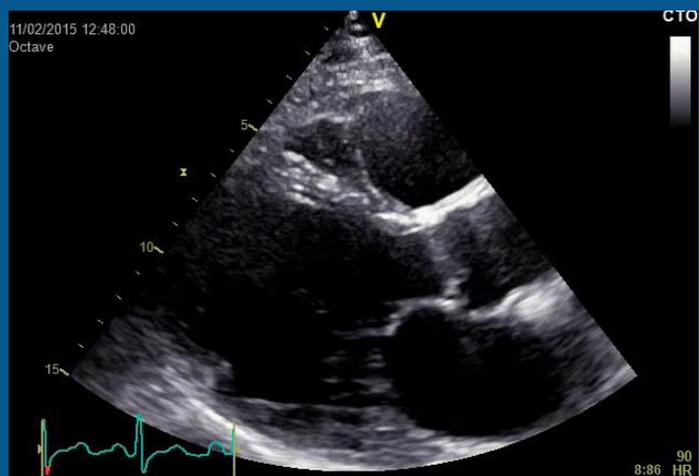
ACUTE CORONARY SYNDROME - AHF



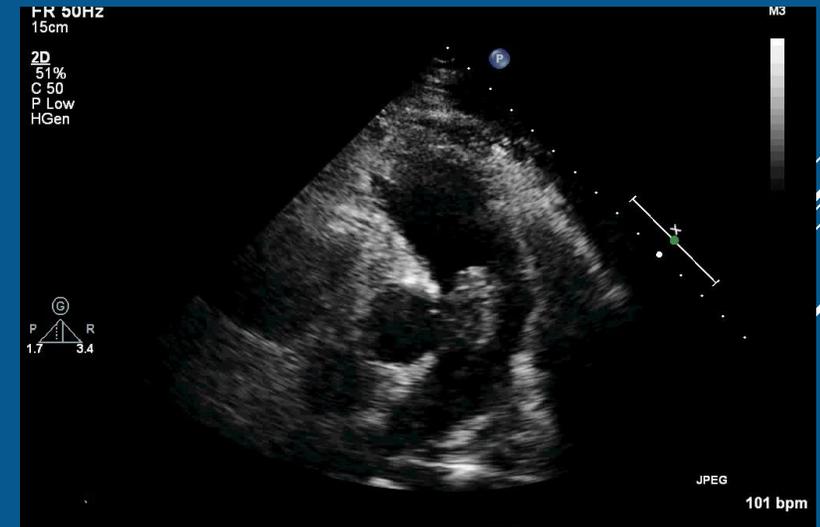
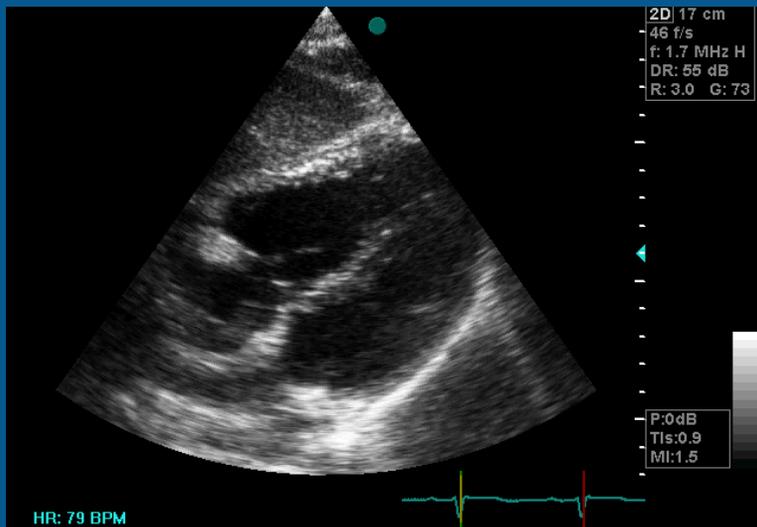
ACUTE CORONARY SYNDROME – MECHANICAL COMPLICATIONS



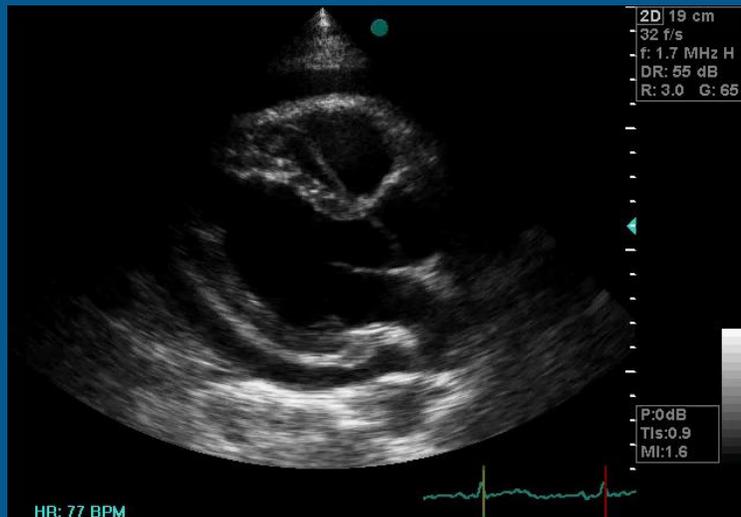
ACUTE VALVULAR HEART DISEASE - AHF



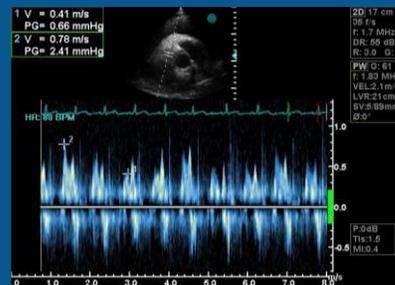
ACUTE PULMONARY EMBOLISM - ARHF



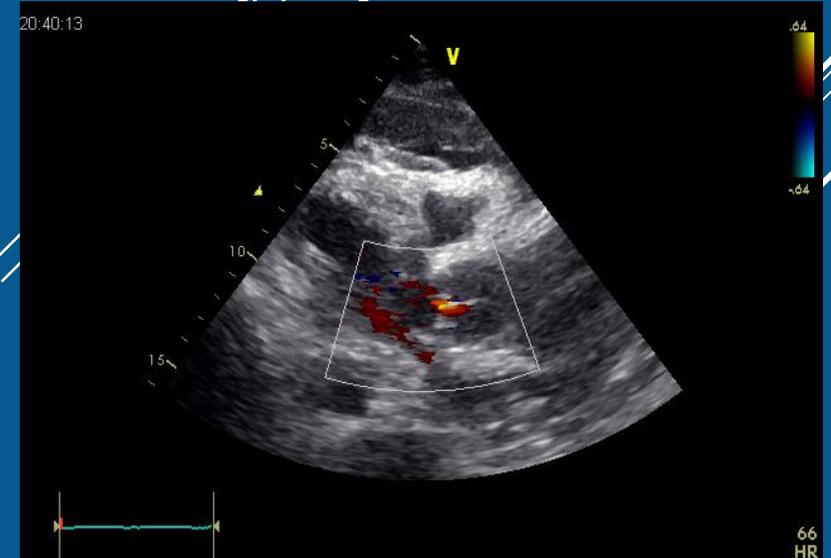
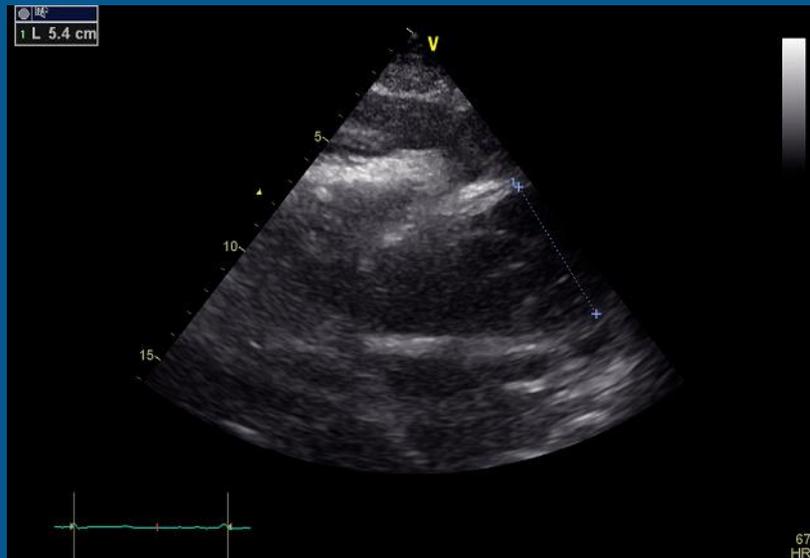
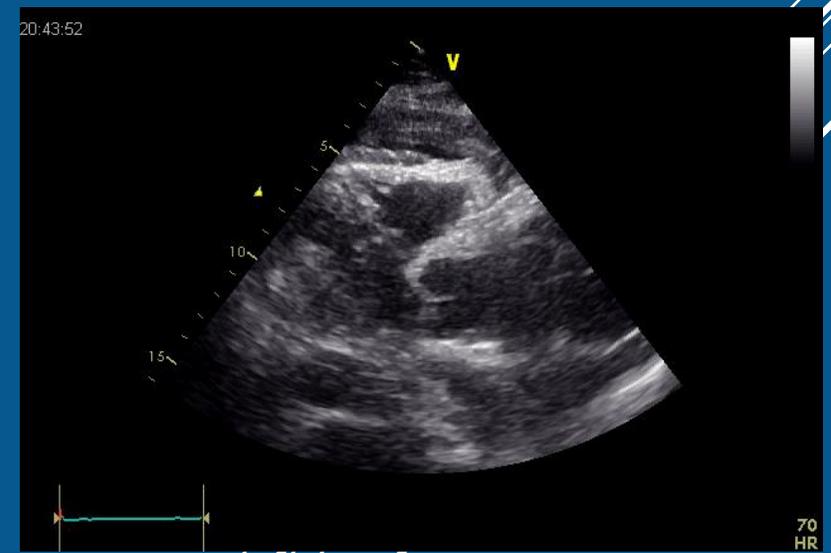
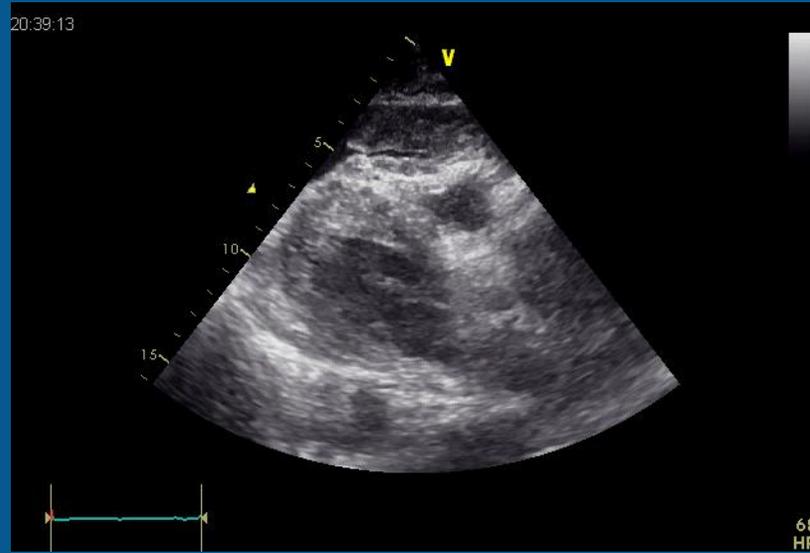
ACUTE (PERI) MYOCARDITIS -AHF



CARDIAC TAMPONADE



AORTIC DISSECTION



Male, 60 years old
History of hypertension,
Presented with acute chest
pain and dyspnea

CHOICE OF ECHO IMAGING TECHNIQUE IN AHF SETTING



European Heart Journal – Cardiovascular Imaging (2013) 14, 1–11
doi:10.1093/ehjci/ies193

RECOMMENDATIONS

Emergency echocardiography: the European Association of Cardiovascular Imaging recommendations

Aleksandar N. Neskovic^{1*}, Andreas Hagendorff², Patrizio Lancellotti³, Fabio Guarracino⁴, Albert Varga⁵, Bernard Cosyns⁶, Frank A. Flachskampf⁷, Bogdan A. Popescu⁸, Luna Gargani⁹, Jose Luis Zamorano¹⁰, and Luigi P. Badano¹¹, on behalf of the European Association of Cardiovascular Imaging[†]



European Heart Journal – Cardiovascular Imaging (2015) 16, 119–146
doi:10.1093/ehjci/jeu210

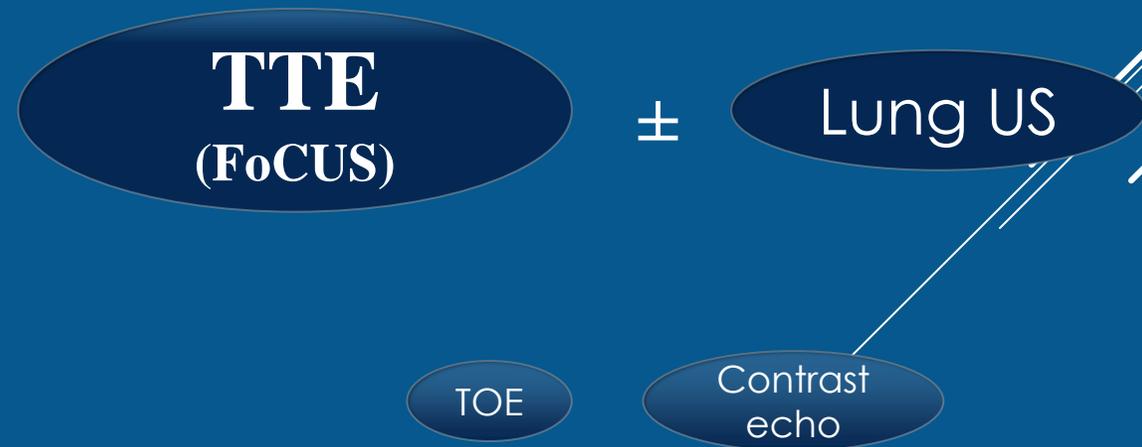
The use of echocardiography in acute cardiovascular care: Recommendations of the European Association of Cardiovascular Imaging and the Acute Cardiovascular Care Association

Patrizio Lancellotti^{1*}, Susanna Price^{2*}, Thor Edvardsen³, Bernard Cosyns⁴, Aleksandar N. Neskovic⁵, Raluca Dulgheru¹, Frank A. Flachskampf⁶, Christian Hassager⁷, Agnes Pasquet⁸, Luna Gargani⁹, Maurizio Galderisi¹⁰, Nuno Cardim¹¹, Kristina H. Haugaa³, Arnaud Ancion¹, Jose-Luis Zamorano¹², Erwan Donal¹³, Héctor Bueno¹⁴, and Gilbert Habib¹⁵



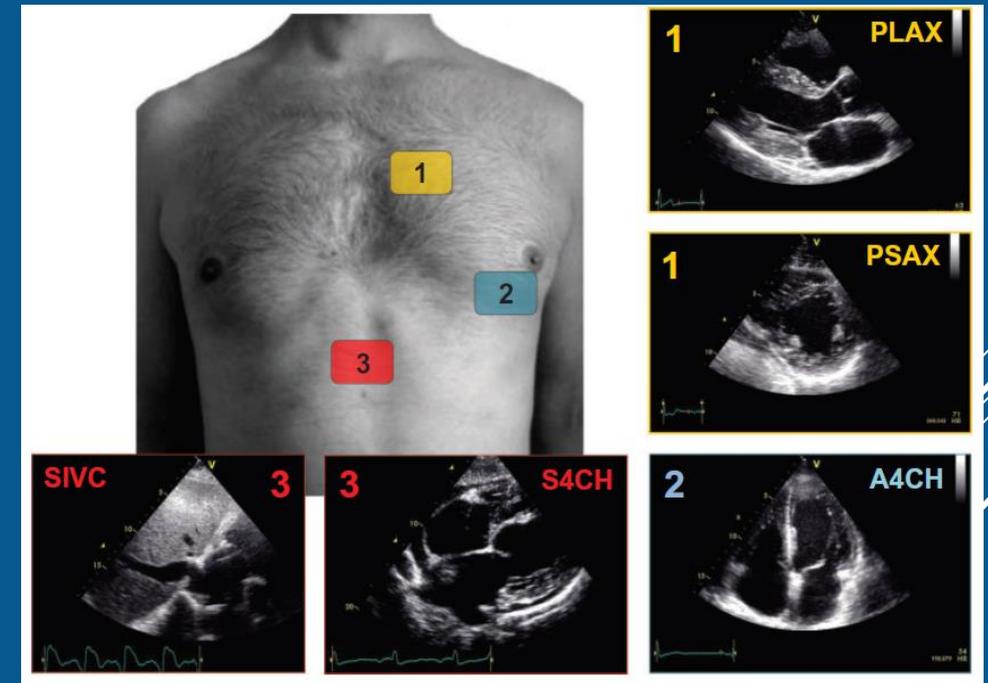
Acute Cardiovascular Care Association
ACCA
A Registered Branch of the ESC

- Acute heart failure
- Cardiac arrest
- Acute chest pain
- Acute coronary syndrome
- Suspected tamponade
- Complications of MI
- Acute valvular heart disease
- Acute aortic syndrome



FoCUS examination

- ▶ A rapid, problem-oriented, point-of-care examination
- ▶ According to standardized but restricted scanning protocol
- ▶ As an adjunct to physical examination,
- ▶ Based on two-dimensional and colour-Doppler limited views
- ▶ Portable or handheld devices are used
- ▶ Immediate bedside availability



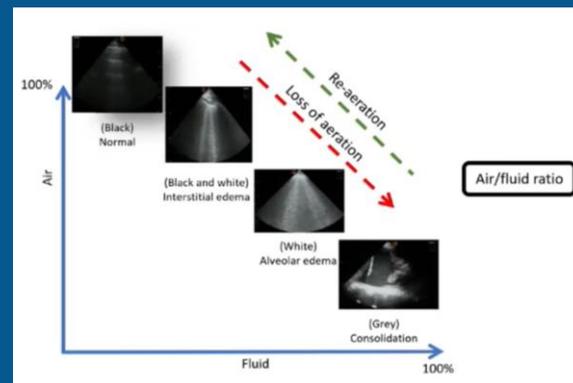
- Ferre RM, et al. Eur J Heart Fail 2015;17:1223–1227.
- Cardim N, et al Eur Heart J Cardiovasc Imaging 2019;20:245–252
- Neskovic A, et al. European Heart Journal - Cardiovascular Imaging (2018) 19, 475–481

LUNG ULTRASOUND

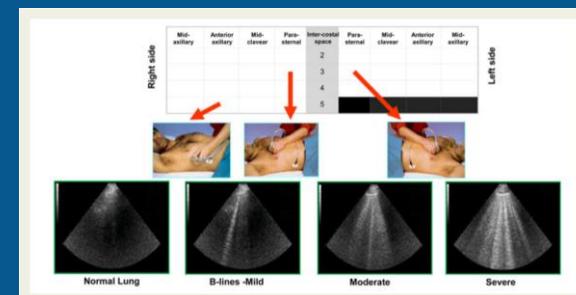
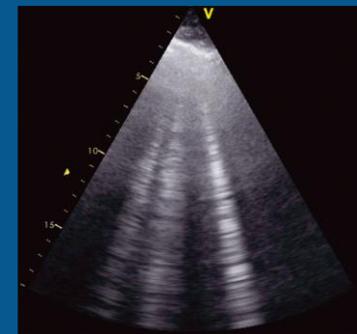
Fast, Reliable and
Easy-to-learn method

Table 1 Primer of lung ultrasound for cardiologists

Sign	Description	Meaning
A-lines	Horizontal, parallel lines beyond the pleura	Normal artefacts
B-lines	Vertical, comet-tail-like lines fanning out from pleural line	EVLW accumulation
Pleural line	Echo dense line	Parietal and visceral pleura
Pleural effusion	Echo-free pleura-lung space	Pleural effusion



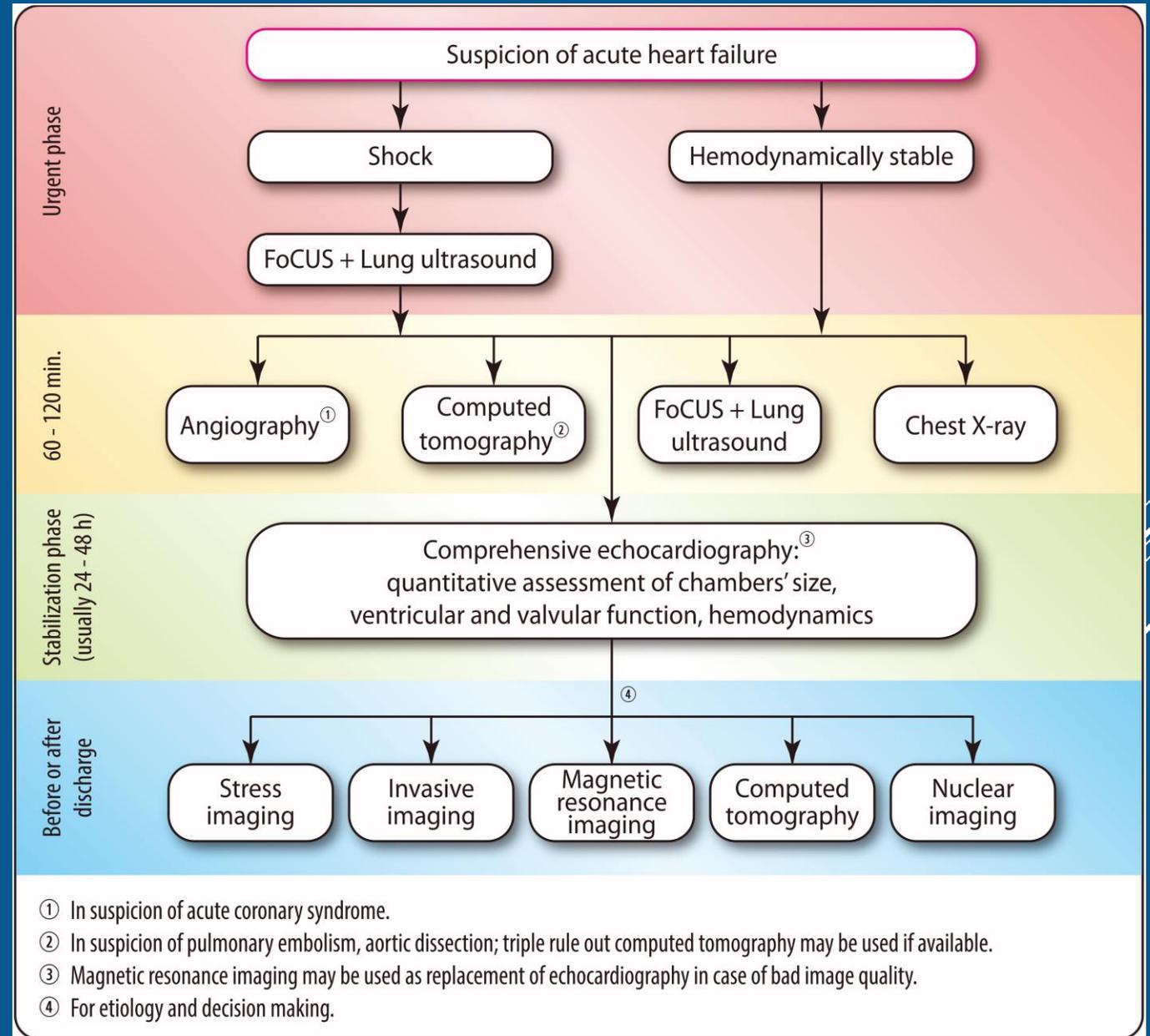
B-Lines



Pleural effusion



Use of imaging modalities in consecutive phases of AHF



Čelutkienė J et al. Imaging in patients with suspected AHF: timeline approach position statement on behalf of the Heart Failure Association of the European Society of Cardiology European Journal of Heart Failure (2020) 22, 181–195

PREFERABLE ECHO MACHINES IN AHF SETTING?



Echo machines

Capabilities

Stationary high-end systems

Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE), and advanced modalities (3D, contrast)

Mobile (smaller machines on wheels, middle range technology)

Full range of standard echo modalities and measurements (MM, 2D, PW, CW, Colour, TVI, TEE)

Portable (small machines that can be carried by a person)

Basic, standard echo modalities and measurements (MM, 2D, PW, CW, Colour)

Hand-held or pocket-size imaging devices

Limited functions (2D, Colour) and measurement package

2D, two-dimensional; 3D, three-dimensional; Colour, colour Doppler; CW, continuous Doppler; MM, M-mode; PW, pulsed Doppler; TVI, tissue velocity imaging.

- Sicari et al. *Eur J Echocardiogr* 2011;12:85-7
- Neskovic A et al. *Eur Heart J* 2013;14:1-11
- Cardim N et al. *EHI-CVI* (2018) 0, 1-8

WHO SHOULD PERFORM THE ECHO IN AHF SETTING?

- Echo examination: challenging
- Quick decisions
- Limited time for consultations
- Stressful situation
- Difficulties in acquiring good images
- Suboptimal studies

Echo in AHF setting, if not personally performed and interpreted, **should at least be supervised** by an expert physician with advanced level of competence in echocardiography

Table 3 Minimal requirements for training and expertise for cardiologists and non-cardiologists^a for unaided performing/interpretation of adult echocardiography in emergency settings (modified from Popescu et al.¹)

Level of competence in emergency echocardiography	Profile of individual performing emergency echocardiography	Minimal number of examinations performed to become competent ^b	Achieved level of expertise according to EAE recommendations	Level of competence to be achieved according to ESC Core Curriculum ^c	Additional education/training requirements
Independent operator	Cardiologists (completed training according to ESC Core Curriculum requirements for general training for cardiologists)	350 (TTE)	Basic echocardiography	<ul style="list-style-type: none"> • Level III in general adult TTE • Level II in TEE • Level I in stress echocardiography 	Highly recommended <ul style="list-style-type: none"> • 150 emergency cases interpreted/reported
	Non-cardiologists ^a (completed training in their own specialties, but not in cardiology)	350 ^d (TTE)	Basic echocardiography	<ul style="list-style-type: none"> • Level III in general adult TTE • Level II in TEE • Level I in stress echocardiography 	Mandatory <ul style="list-style-type: none"> • Theoretical: specific knowledge on emergency cardiovascular diseases/conditions (see list, Table 4), • Practical skills: 150 emergency cases interpreted/reported; 50 of which personally performed and documented
Expert operator	Cardiologists (completed training appropriate for cardiologists with subspecialty interest in echocardiography)	750 (TTE) 75 (TEE) 100 (stress echo)	Advanced echocardiography	<ul style="list-style-type: none"> • Level III in general adult TTE • Level III in complex adult TTE • Level III in TEE • Level III in stress echocardiography 	No additional training required (expert operators in emergency echocardiography provides: education, training, and supervision)

^aAnaesthesiologists, intensive care specialist, emergency physicians, and cardiac surgeons. Sonographers and fellows are not included.

^bProgramme directors directly involved in education and training process in emergency echocardiography must have advanced level of expertise in echocardiography (according to EAE recommendations¹), and achieved Level III of competence in general adult TTE, TEE, and stress echocardiography (according to ESC Core Curriculum⁵).

^cThe ESC Core Curriculum⁵. See text.

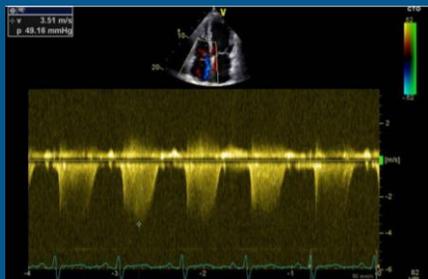
^dAdditional training is mandatory.

B. ECHOCARDIOGRAPHY IN THE STABILIZATION PHASE – Comprehensive examination

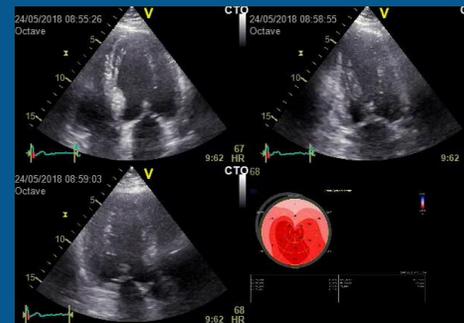
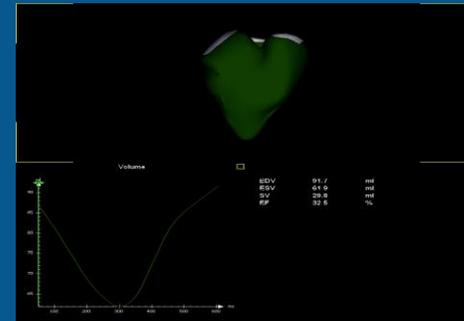
- ▶ Preferably within the first 48 h after admission
- ▶ At least before discharge in most patients
- ▶ Haemodynamically stable patient (Symptoms recession, able to lie in decubitus position, more accurate evaluation of cardiac valves / function)
- ▶ Better Echo machine
- ▶ More experienced colleagues

Full / detailed echocardiographic investigation

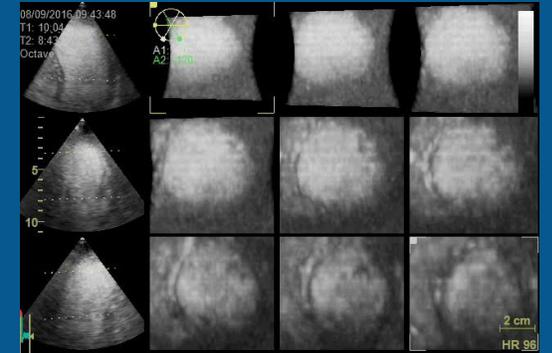
- Chamber quantification,
- Systolic and diastolic function,
- Haemodynamics
- Valvular assessment
- Advanced Echo techniques



3D



Strain



Contrast Echo



TOE

PROGNOSTIC ROLE OF ECHOCARDIOGRAPHY DURING THE HOSPITALIZATION

- ▶ Pre-discharge values appear to be better for long-term prognosis (≥ 6 months)
- ▶ LVEF, Elevated end-diastolic pressures (E/e'), and tricuspid annular velocities

Table 2. Echocardiographic Indices as Prognostic Indicators in Acute Heart Failure Studies

Trial	Patients	Timing of echo	N	Mean FU	Outcome
Echocardiography performed early during admission (≤ 48 hr)					
EFICA study, 2007 ³⁹	AHF	At admission	355	4 weeks	Mortality: LVEF [OR (95% CI), 1.27 (1.05-1.53)]
Arques et al, 2007 ⁴¹	AHF, Older adults, HFpEF	≤ 6 hr of admission	75	Hospitalization period	Mortality: No association with septal E/Ea or LVEF
BIO-HF study, 2014 ⁴⁰	AHF, older adults	Within 48hr of admission	401	405 days	Mortality: TR>30mmHg [HR (95% CI), 1.60 (1.03-2.49) in multivariable analysis]
Echocardiography performed close to discharge					
Logeart et al, 2004 ⁴⁵	AHF	Before discharge	114	6 months	HF-related readmission + mortality: No echocardiographic variable was predictive in multivariable analysis when pre-discharge BNP levels included in the analysis
Seo et al, 2008 ⁴⁴	AHF	Before discharge	58	36 months	HF-related readmission + CV mortality: E/A [HR (95% CI), 1.99 (1.31-2.76)] DT [HR (95% CI), 0.99 (0.98-0.99)] PVAAd-Ad [HR (95% CI), 1.02 (1.00-1.04)] E/Vp [HR (95% CI), 2.34 (1.31-4.18)] All in univariate analysis
Hirata et al, 2009 ³⁷	AHF	24h before discharge	108	351 days	HF-related readmission + CV mortality: LVEF $\leq 40\%$ and E/e' ≥ 15 [HR (95% CI), 12.6 (2.2-74.2) in multivariable analysis] CV mortality: LVEF $\leq 40\%$ and E/e' ≥ 15 [HR (95% CI), 21.2 (1.2-363.4) in multivariable analysis]
Ho et al, 2011 ⁴²	AHF	≤ 24 hr before discharge	87	191 days*	MACE: E/e' [HR (95% CI), 1.047 (1.006-1.090) in multivariable analysis]
Olson et al, 2012 ⁴³	AHF, LVEF $\leq 40\%$	Before discharge in a stable clinical	156	829 days*	HF-related readmission + CV mortality: S'+E' at the tricuspid annulus <18.5 cm/sec [HR (95% CI),

C. ECHOCARDIOGRAPHIC EXAMINATION (FOCUS STUDY) DURING THE HOSPITALIZATION

- ▶ In the patient's room (on ward rounds)
- ▶ Mostly handheld machine used
- ▶ Closer monitoring
- ▶ Volume status assessment
- ▶ Response to treatment, decision for therapy, time of discharge
- ▶ Educational tool
- ▶ Echo indices: LV dimensions, mitral inflow velocities, IVC diameter, TR gradient , RVSP.

CONCLUSIONS

Echocardiography in Acute Heart Failure

- Adjunct diagnostic tool in the clinical setting of new-onset or decompensated HF
- Less well defined, both in clinical practice and in clinical trials, than CHF
- Integration of focused cardiac study and LUS into acute phase and during the hospitalization
- Comprehensive echo examination when patient is stable
- Confirm or differentiate diagnosis,
- Identify the underlying causes,

Help cardiologist to make the optimal clinical decision