



UTIC | **ANMCO**
CLUB |
CRITICAL CARE COMMUNITY

Quando l'imaging avanzato guida alle scelte terapeutiche

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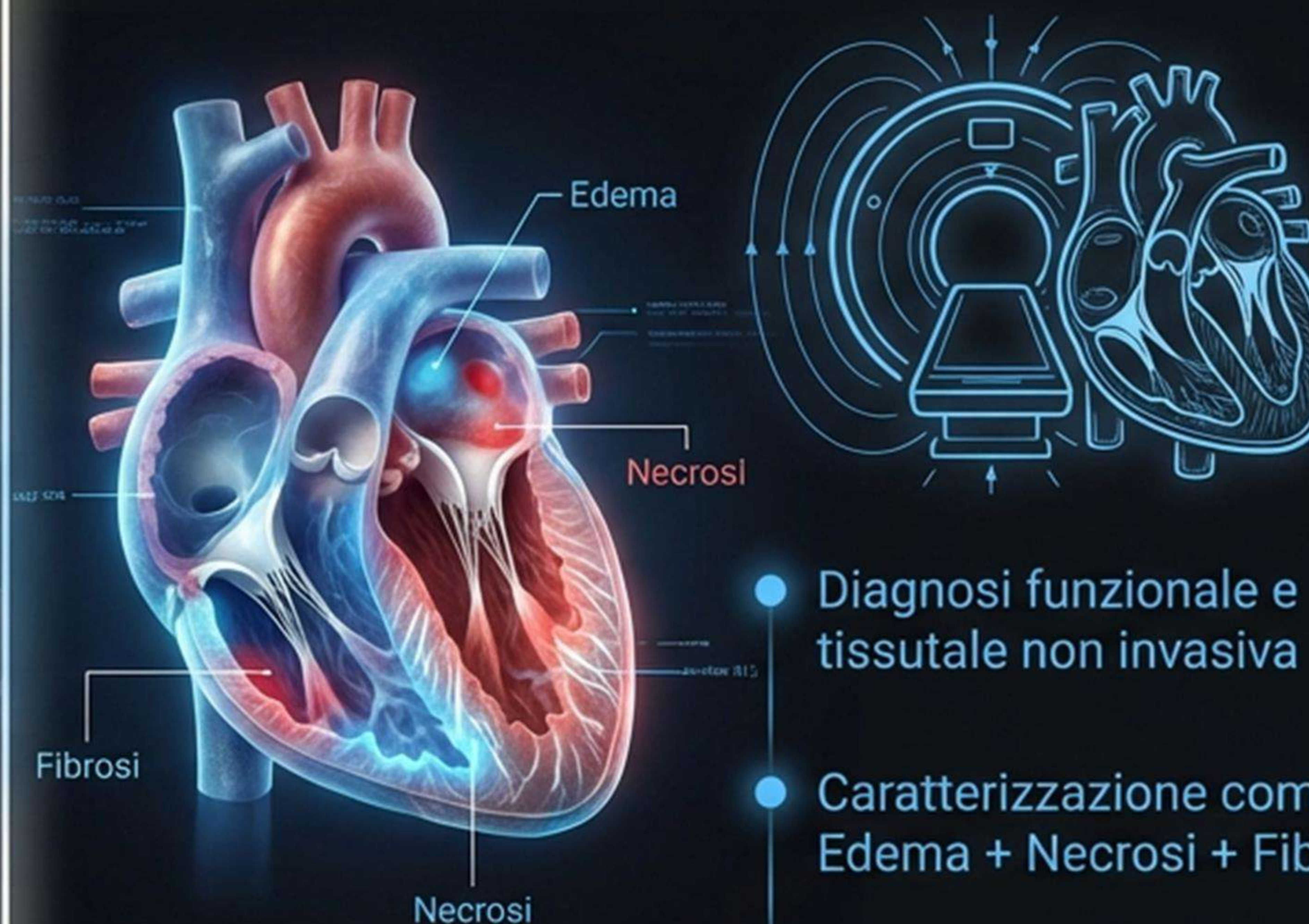
Il Cambio di Paradigma: 30 Anni di Evoluzione

Il Passato - Criteri di Dallas



- Diagnosi puramente istologica
- Alta invasività (Biopsia)
- Limiti: Sampling error, bassa sensibilità

Il Presente - Imaging Avanzato



- Diagnosi funzionale e tissutale non invasiva
- Caratterizzazione completa: Edema + Necrosi + Fibrosi
- Gold Standard attuale per il paziente stabile

2013 Position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases European Heart Journal

Biopsia Endomiocardica (BEM): Il “Gold Standard” Dimenticato?



Indicazioni di Classe I (ESC 2025):

Miocardite ad alto rischio e/o instabilità emodinamica
 Miocardite a rischio intermedio che non rispondono alla terapia convenzionale, per identificare il sottotipo istologico specifico e per la ricerca del genoma virale ai fini del trattamento (Classe I C, LG ESC 2025)

Realtà Clinica (EACVI)

5%

Solo il **5%** dei centri usa la BEM di routine. **47%** dei centri ha accesso alla metodica. **Rischio:** Mancata diagnosi di eziologie specifiche che richiedono terapie mirate.

Yohann Bohbot et al. *European Heart Journal - Imaging cardiovascolare* vol.25-7 luglio 2024

2025 ESC Guidelines for the management of myocarditis and pericarditis

Developed by the task force for the management of myocarditis and pericarditis of the European Society of Cardiology (ESC)

Co-developed by the Association for European Paediatric and Congenital Cardiology (AEPC) and the European Association of Cardiothoracic Surgery (EACTS)

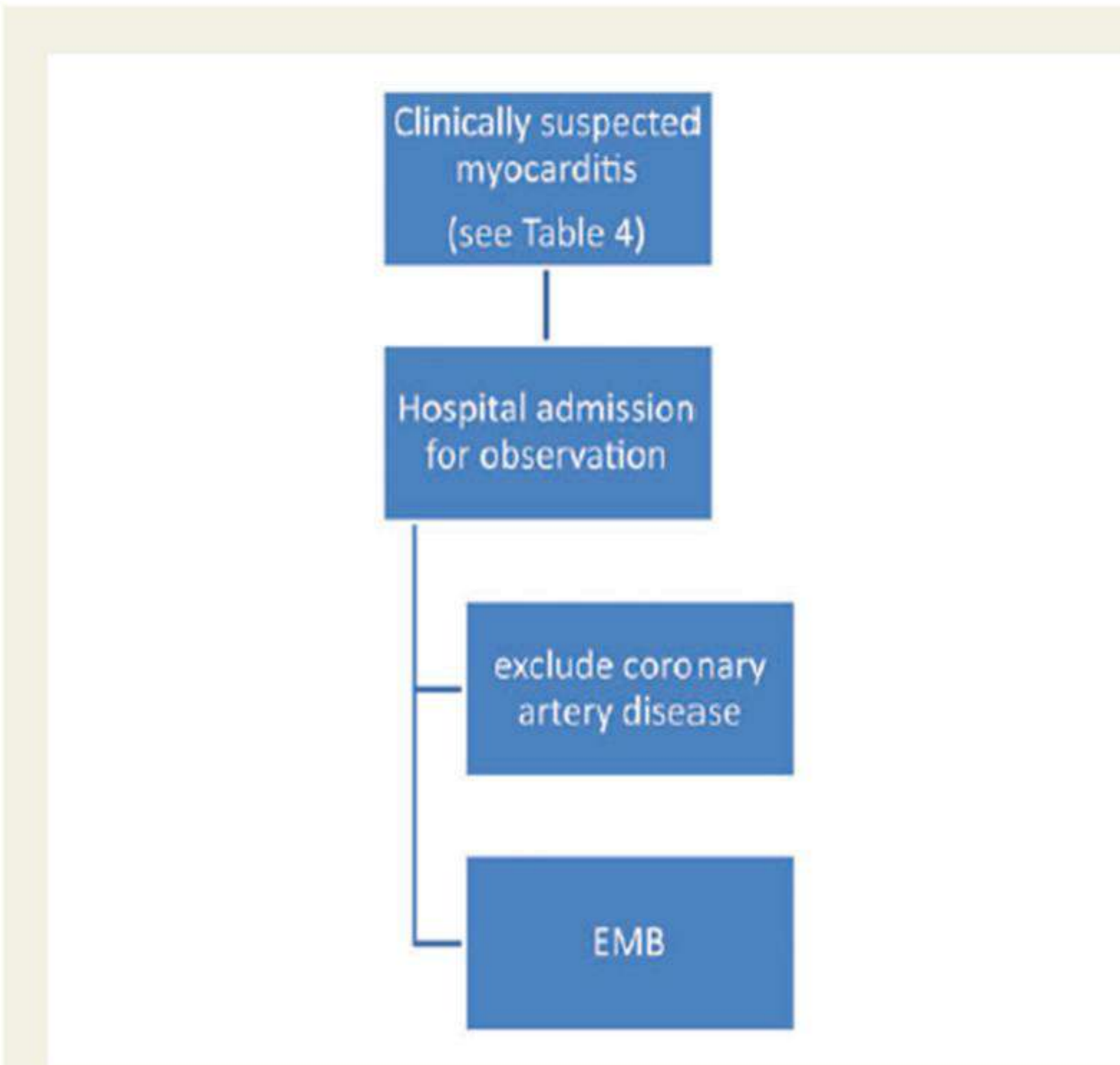
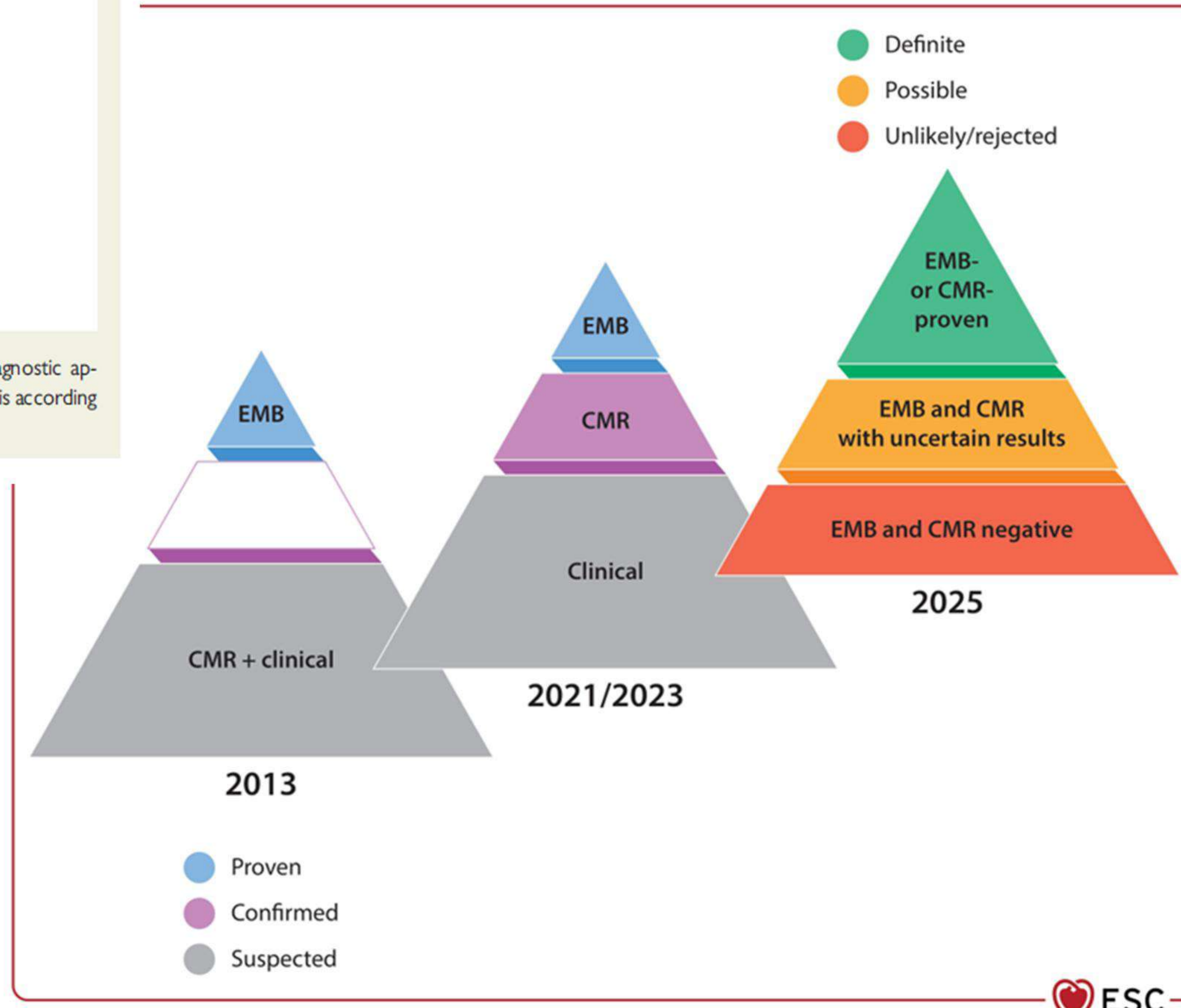
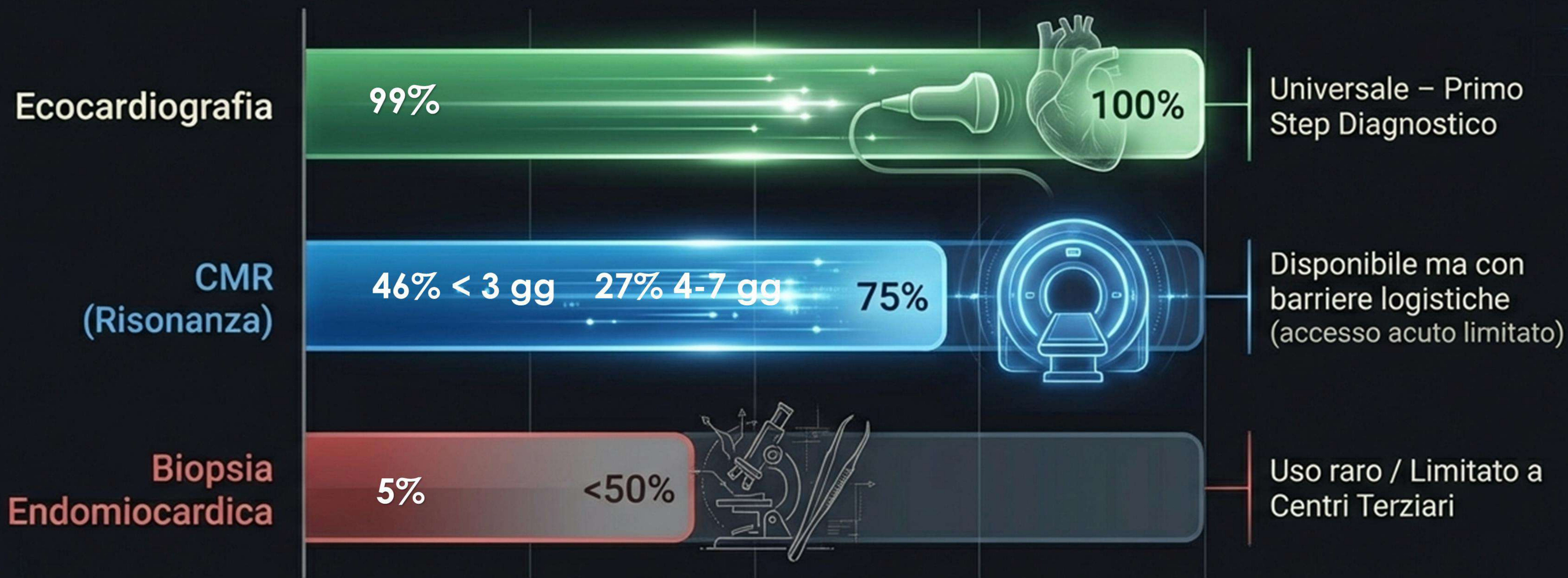


Figure 3 The flow chart shows the proposed diagnostic approach for patients with clinically suspected myocarditis according to Table 4.



La Realtà Clinica: Dati Registro EACVI (74 Paesi)

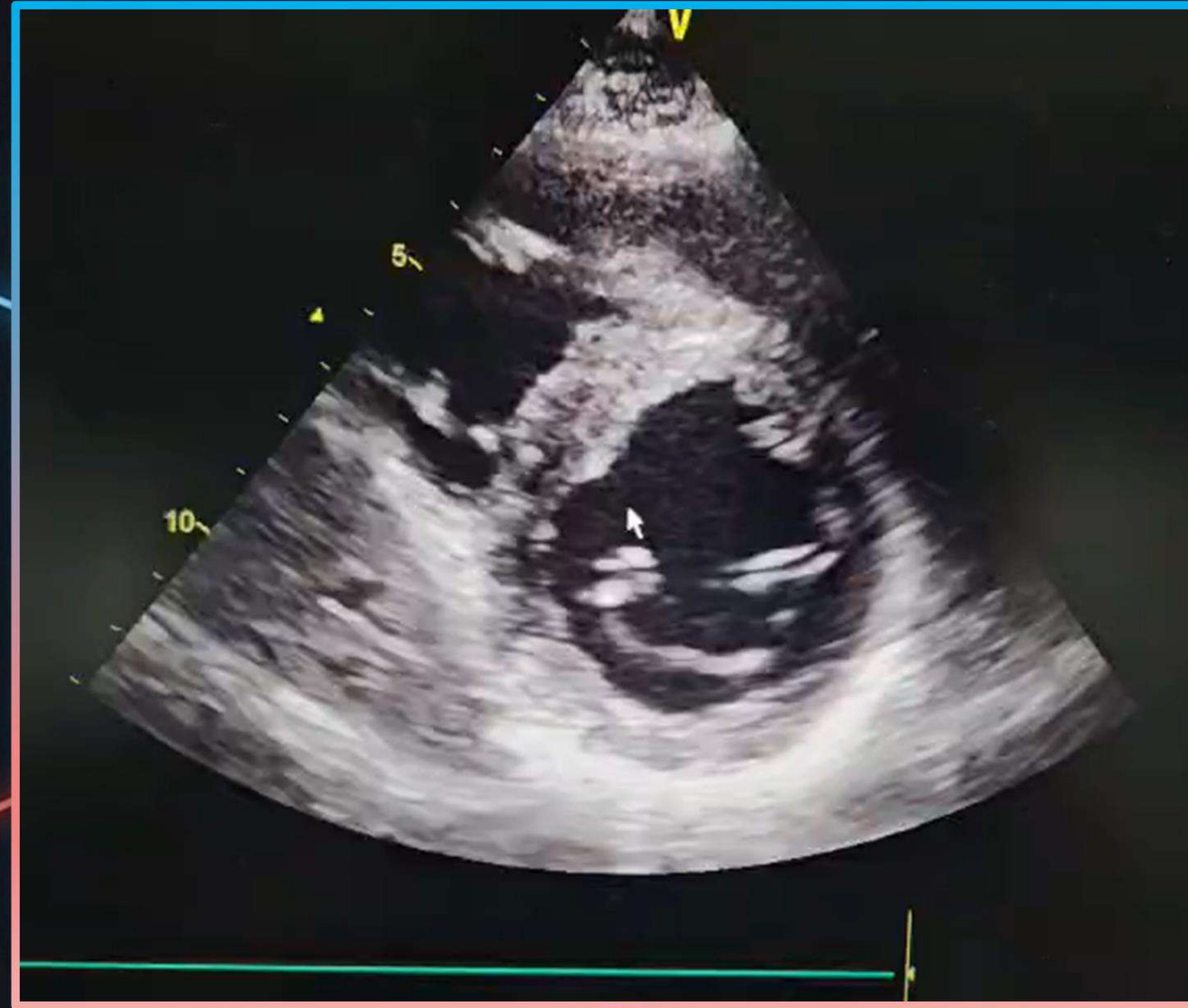


L'imaging avanzato è il target, ma le risorse locali dettano il percorso reale.

Il Primo Step in UTIC: Ecocardiografia ed Emodinamica

Ruolo:
Valutazione rapida
funzione ventricolare
e Strain Longitudinale

Red Flags:
Versamento
pericardico, trombi
intracavitari



- Rapida
- Efficace

Rule-out:
Esclusione cause
ischemiche
(WMA non coronariche)

- Pratica
- Ripetibile

Esclusione Ischemia: Coronarografia /
TC Coronarica come step mandatorio.

MIOCARDITE ACUTA IN UTIC: DASHBOARD ECOCARDIOGRAFICA

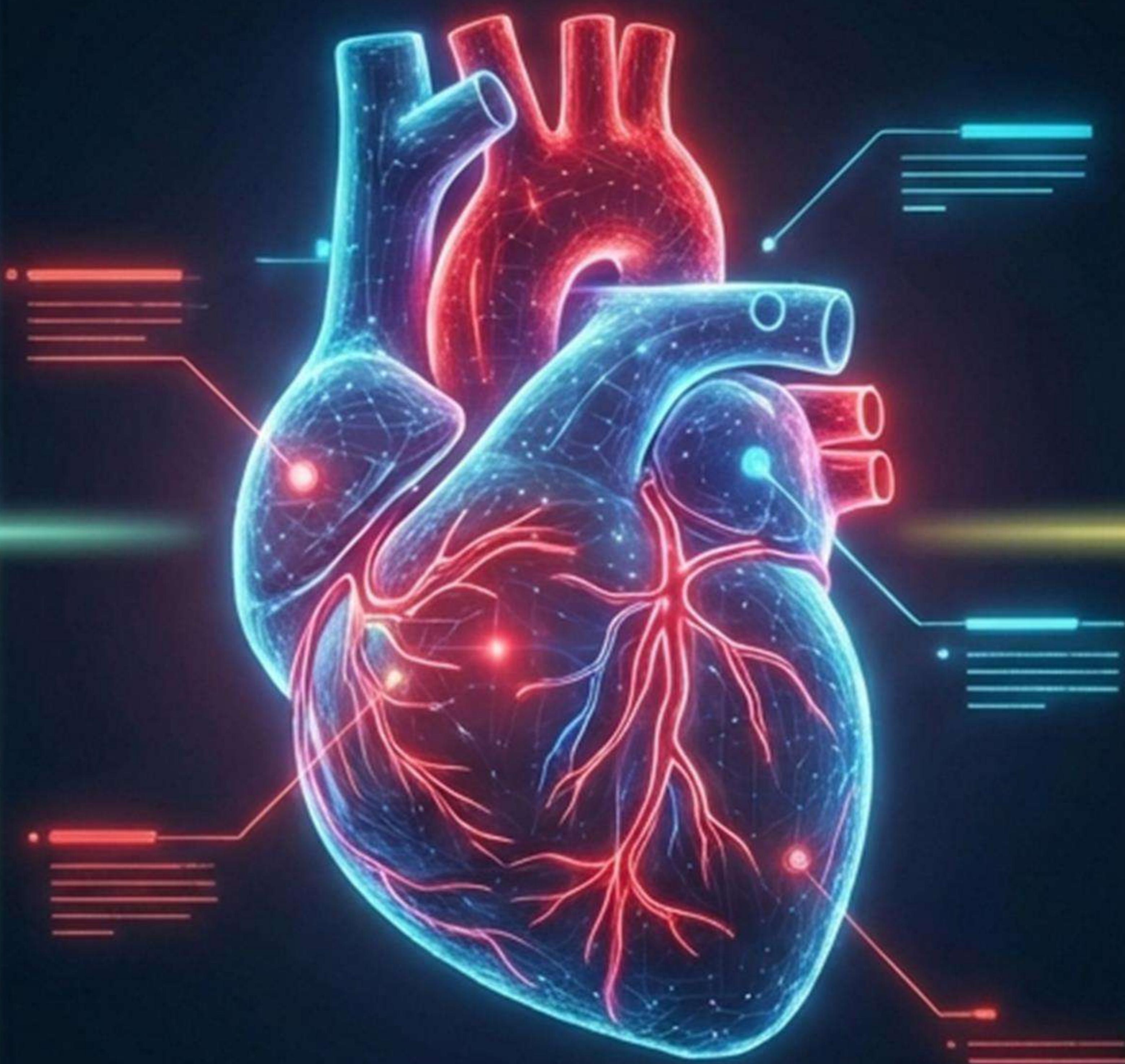
VENTRICOLO SINISTRO

- LVEF: da normale a severamente ridotta
- LV-GLS: CUT-OFF > -18% (Danno Subclinico)
- RWMA: Anomalie regionali
- Ispessimento parietale da edema

REPERTI AGGIUNTI

- Tamponamento cardiaco
- Trombosi intraventricolare
- Alterato strain atriale
- Iperecogenicità pericardica

ECMO



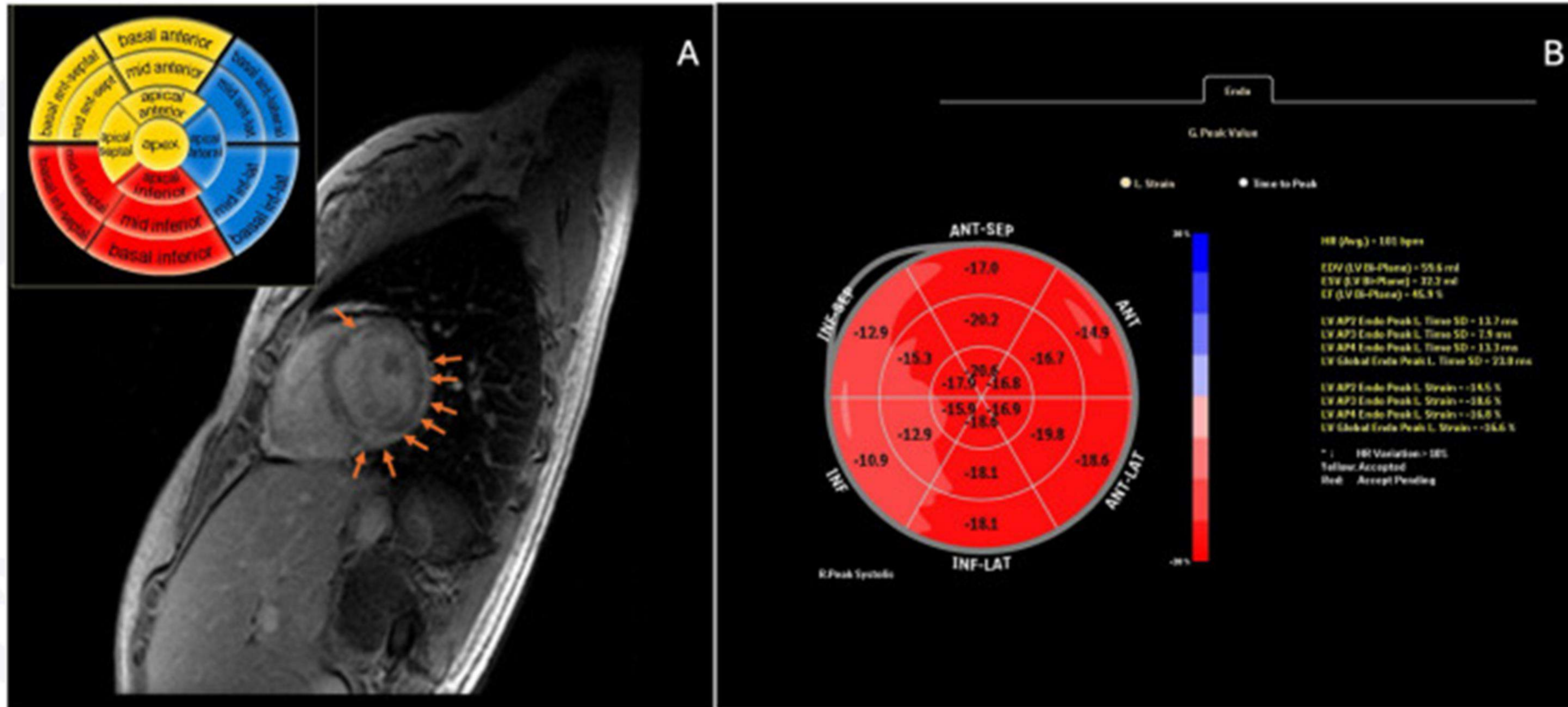
VENTRICOLO DESTRO

- Dimensioni
- Cinetica
- TAPSE
- FAC
- Strain longitudinale
- PAPs
- Setto

SEGNI DI SHOCK

- E/A
- DT
- Cardiac Output
- Cardiac Index
- Stroke Volume
- VTI LVOT
- E/E'
- VCI e collapsabilità
- PAPs
- Elastanza e accoppiamento

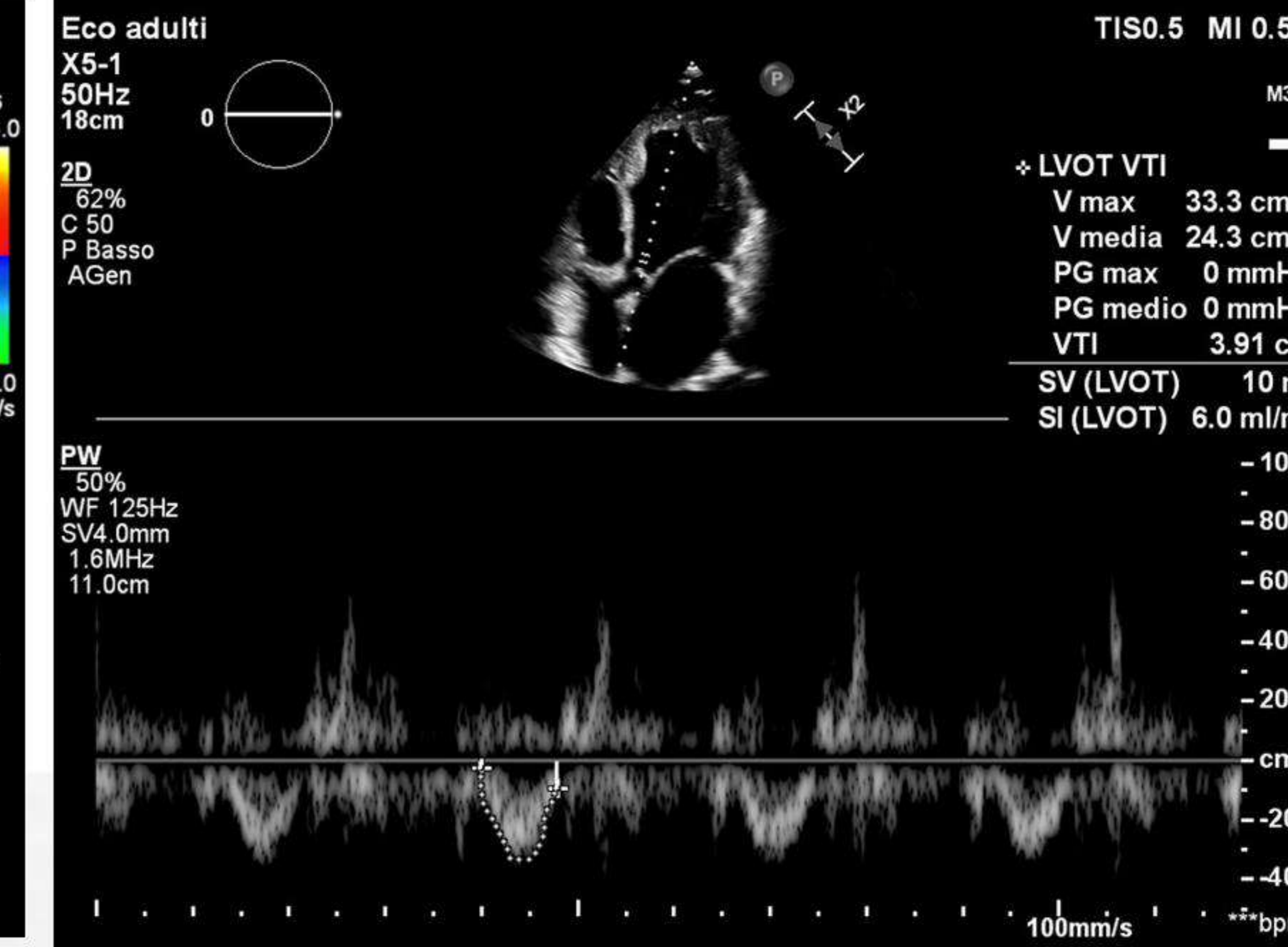
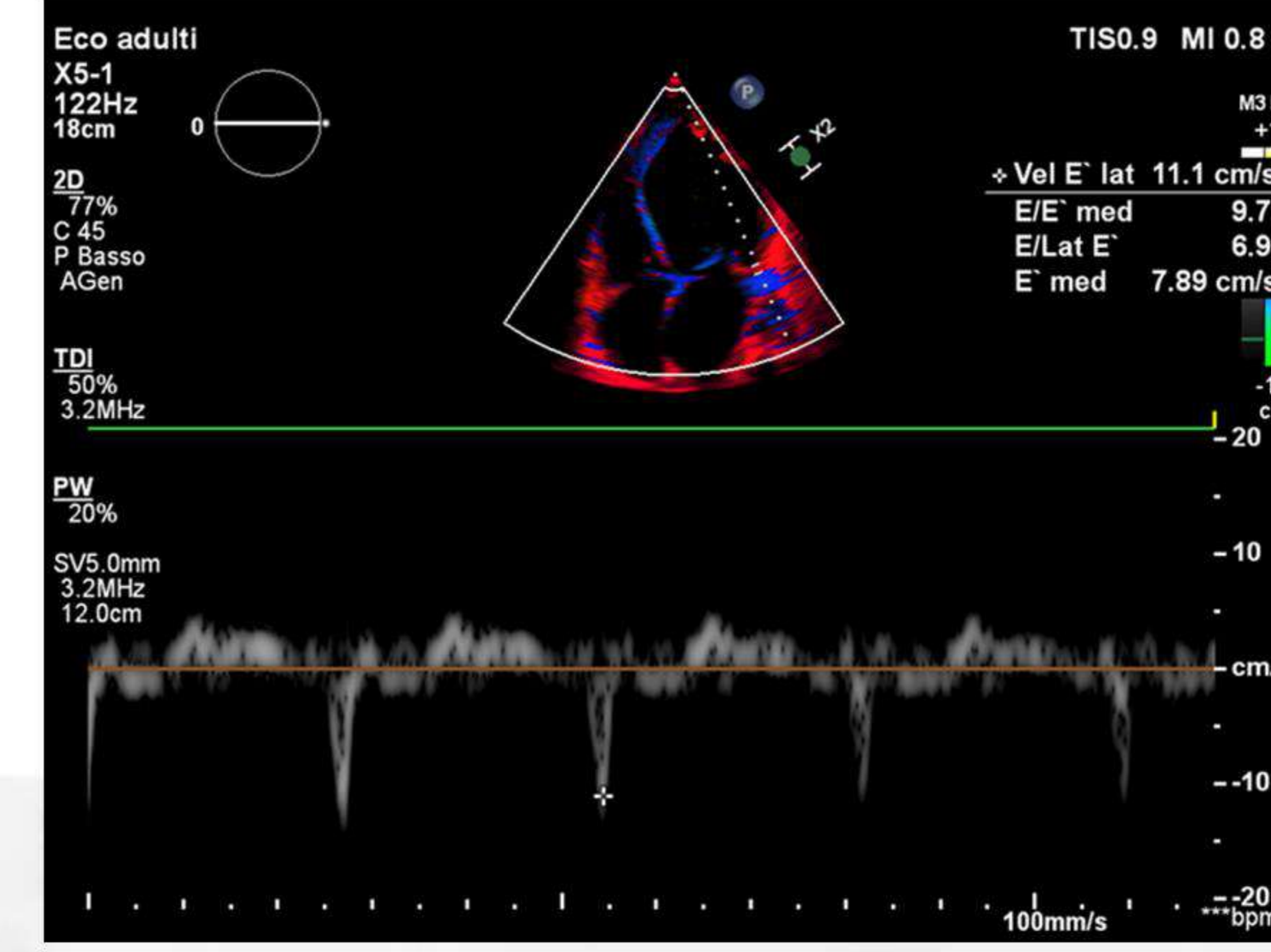
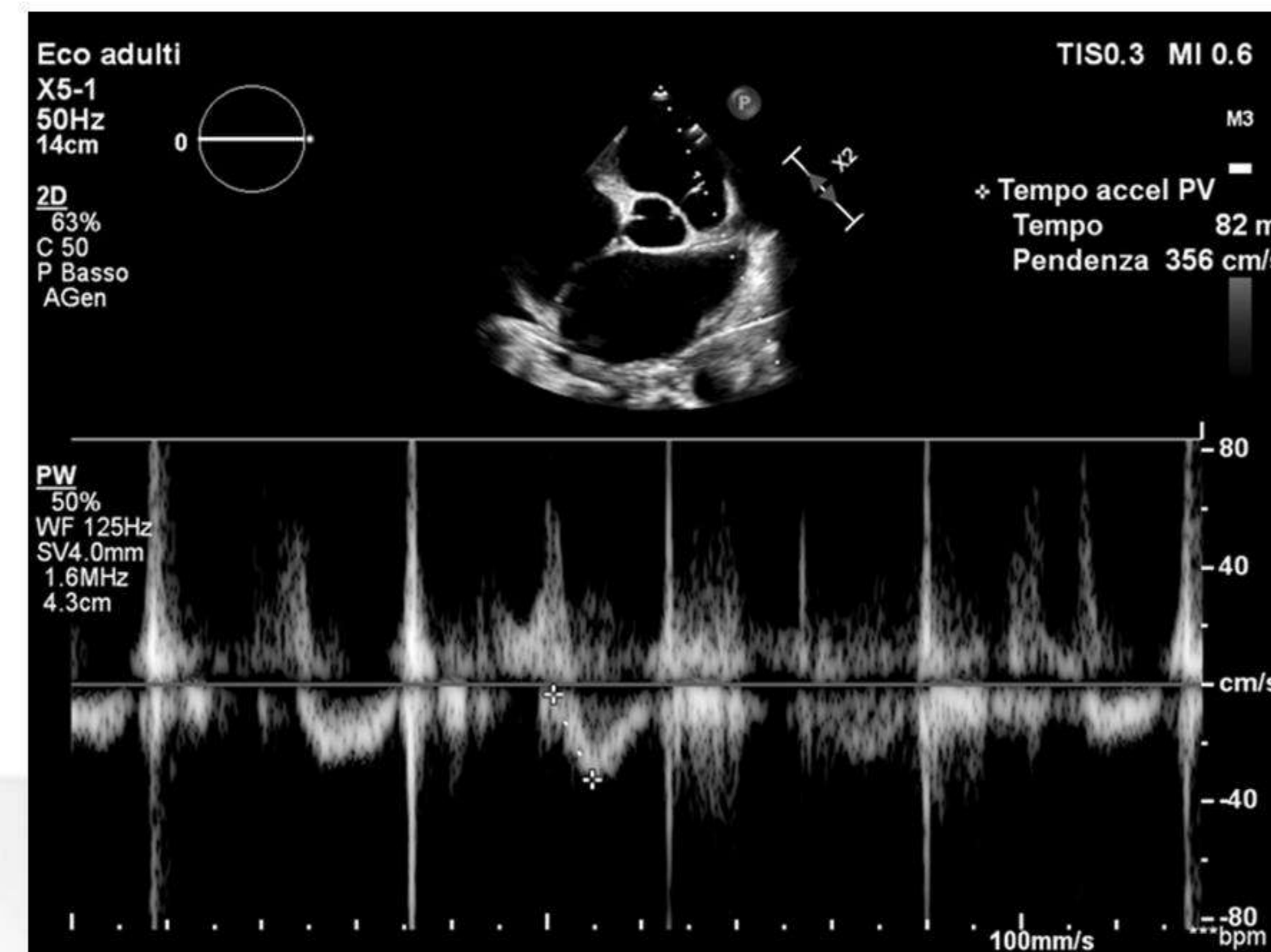
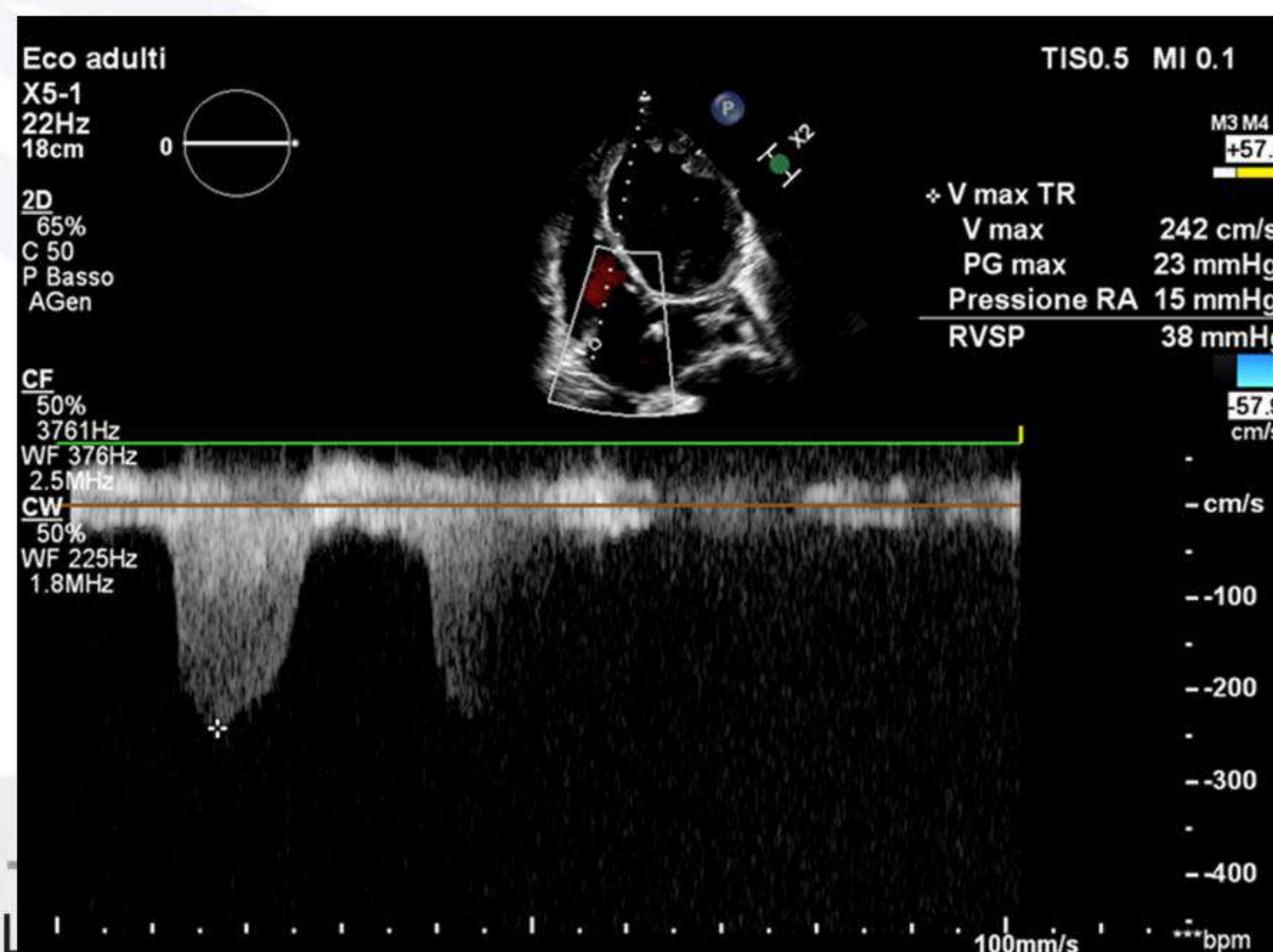
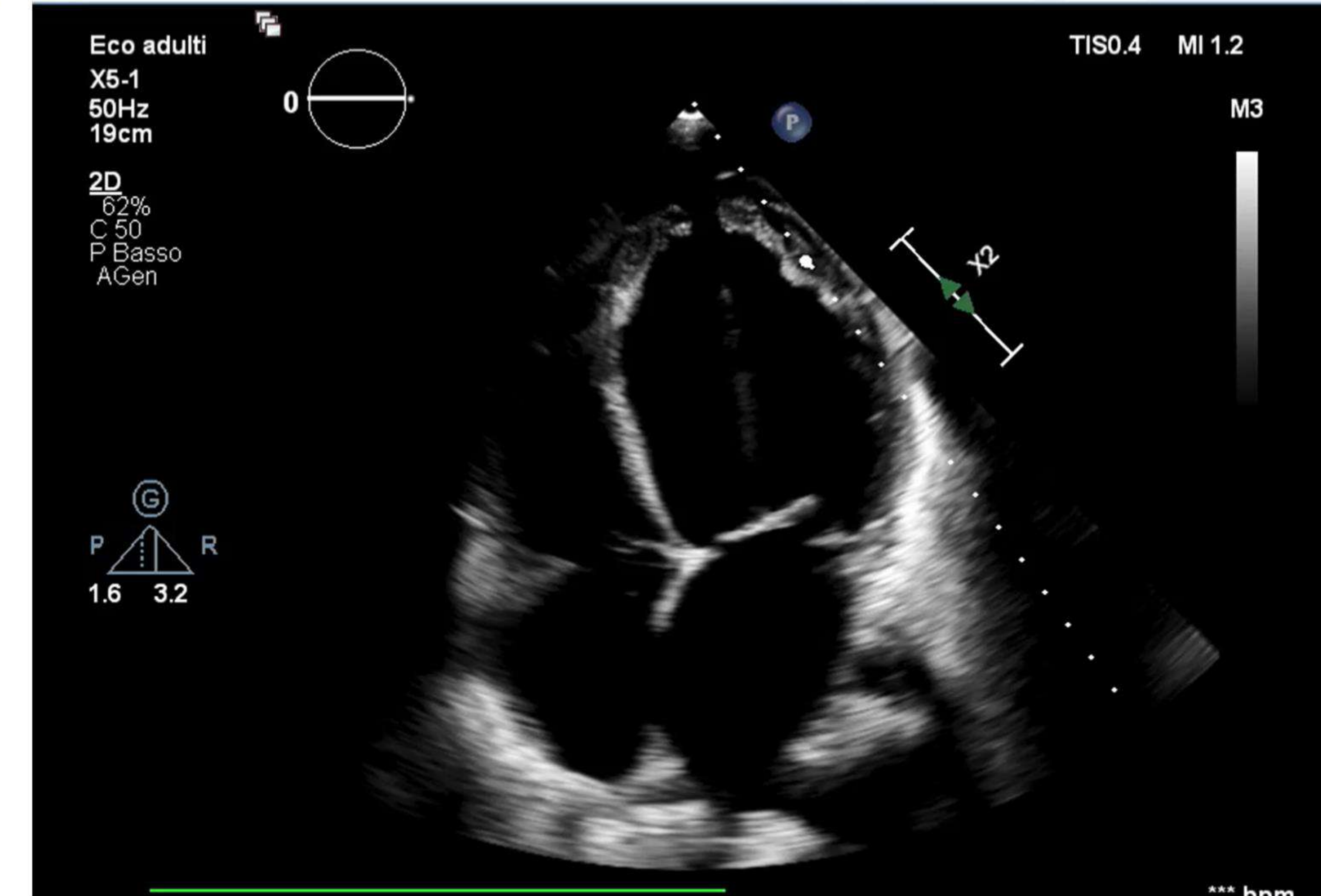
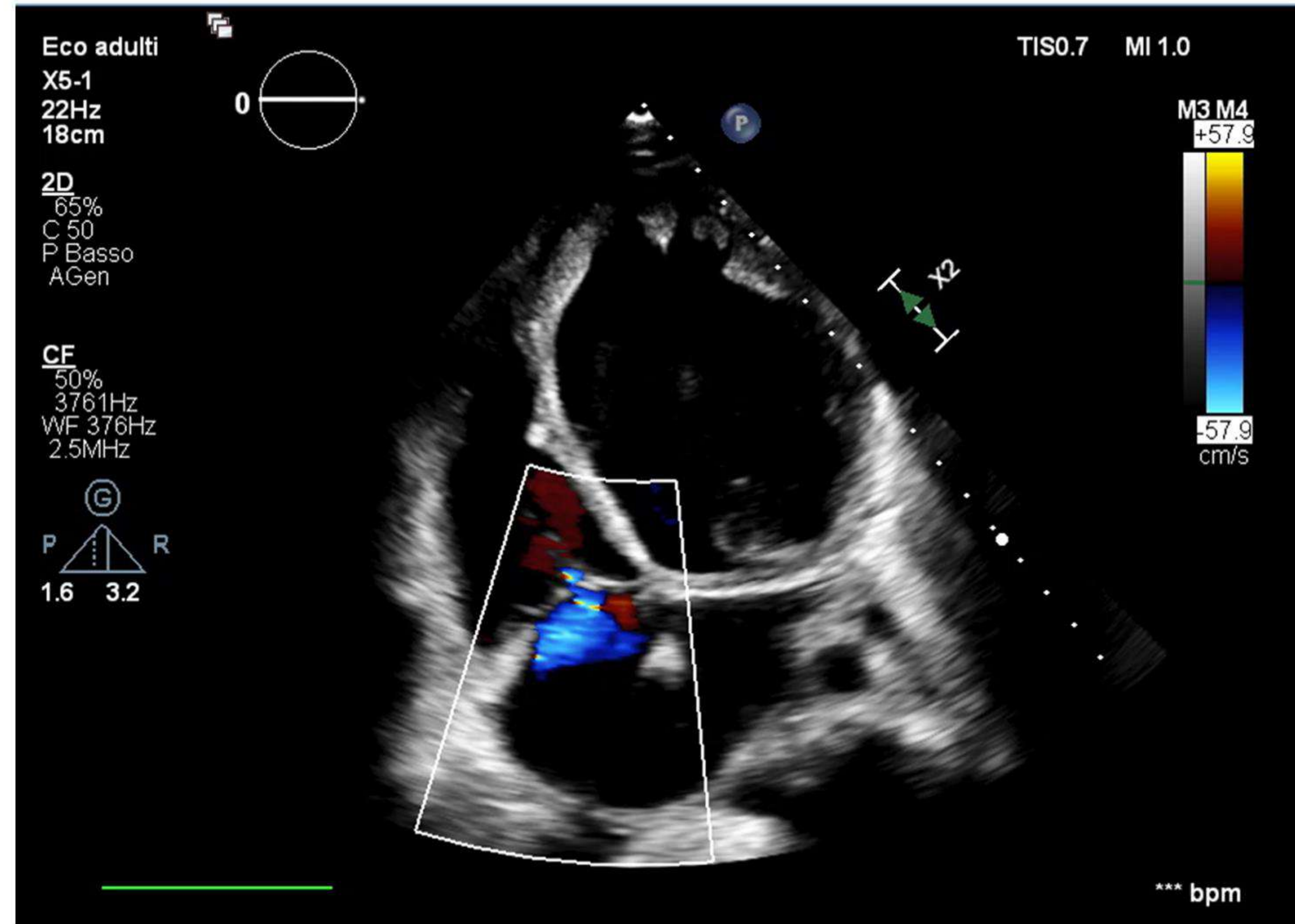
Gls ventricolare sx



Alkan, Fatos et al. "Comparison of cardiac magnetic resonance and speckle tracking echocardiography in cardiac evaluation of children with acute myocarditis with preserved left ventricular function." *BMC medical imaging* vol. 25,1 243. 1 Jul. 2025, doi:10.1186/s12880-025-01772-4

L'ecocardiografia è sufficiente?

- Maschio, 27 anni
- 10 anni prima diagnosi di sarcoma
- Dolore toracico e dispnea, blandi sintomi influenzali
- Apiretico
- PCR 4,74 mg/dl (<0.60)
- Troponina in incremento
- Transaminasi in incremento
- PAM 65
- Lac 2-> 4 mmol/l



Miocardite acuta: ruolo prognostico dell'ecocardiografia speckle tracking e confronto con le caratteristiche della risonanza magnetica cardiaca

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Affiliazioni Espandere

PMID: 34175961 DOI: 10.1007/s00380-021-01893-0

Astratto

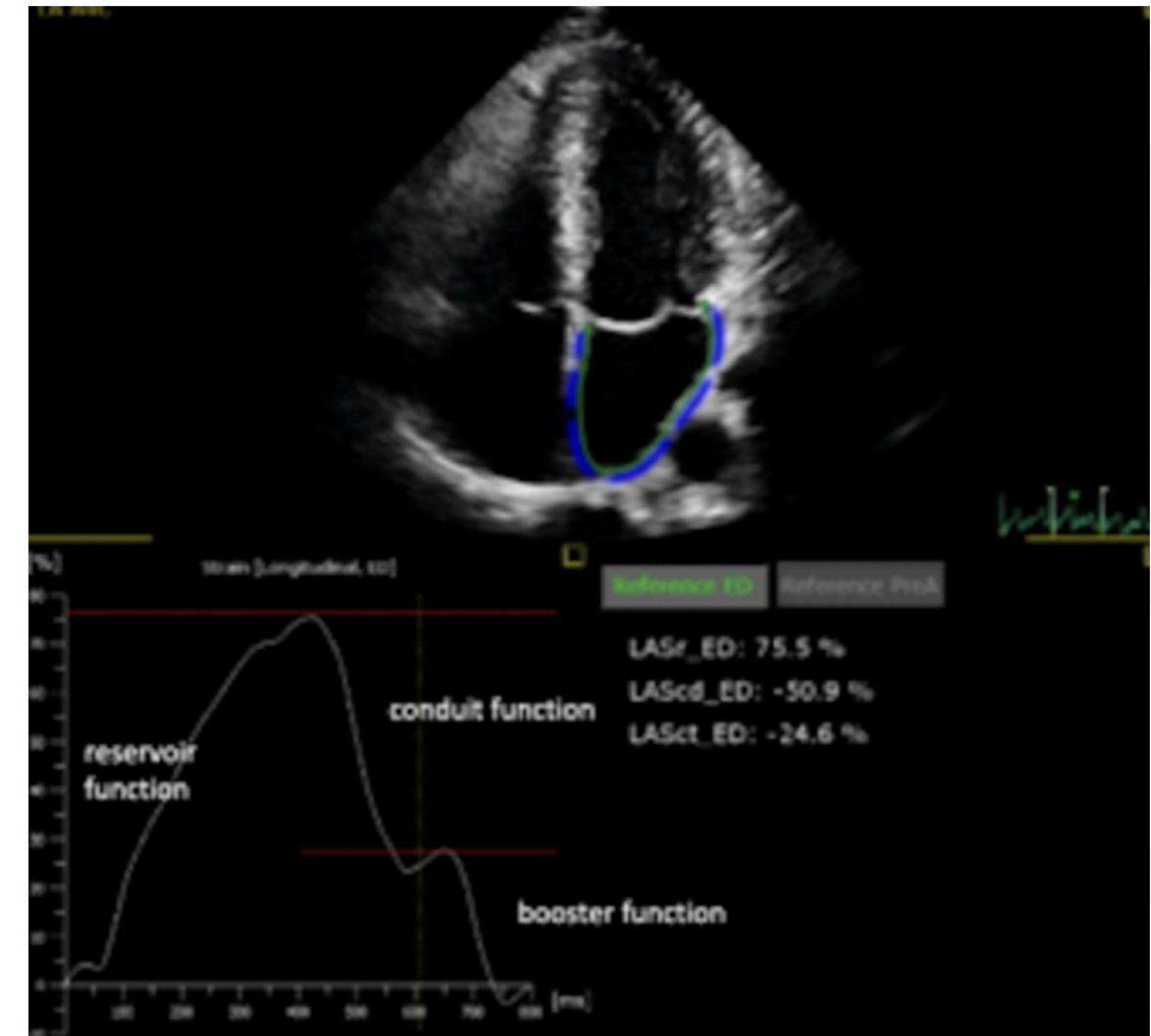
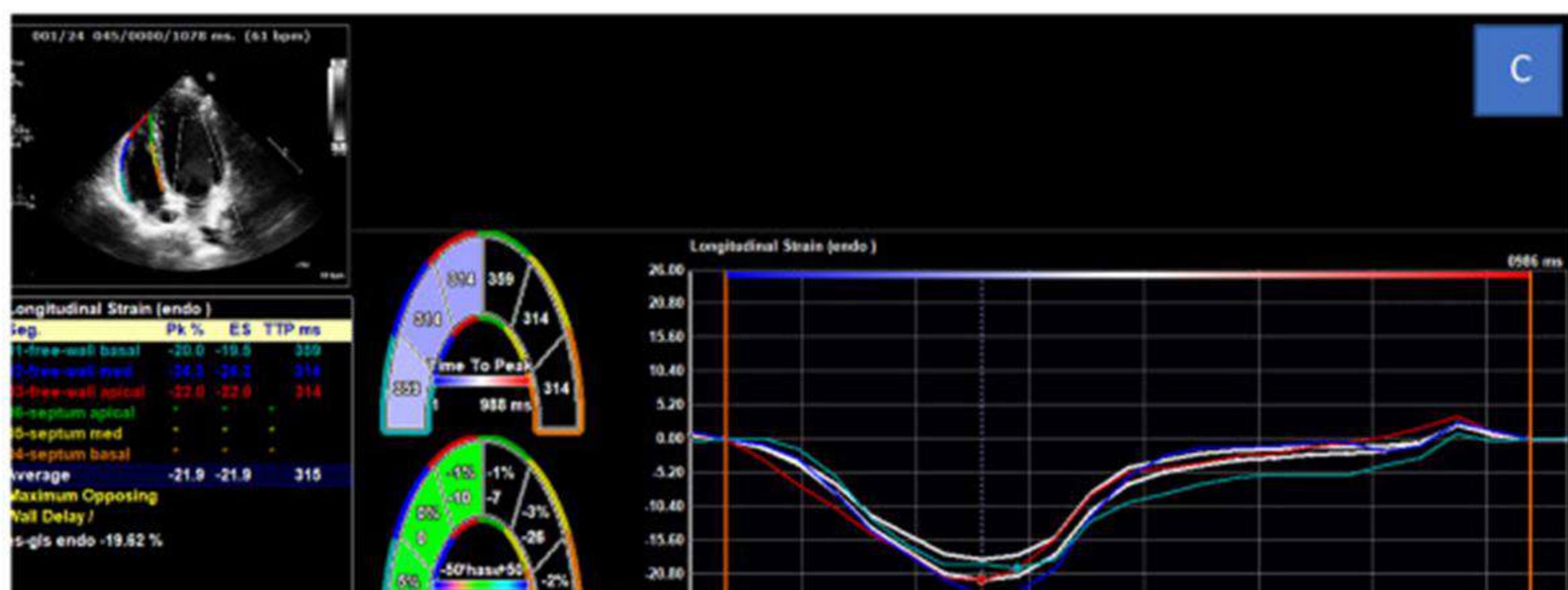
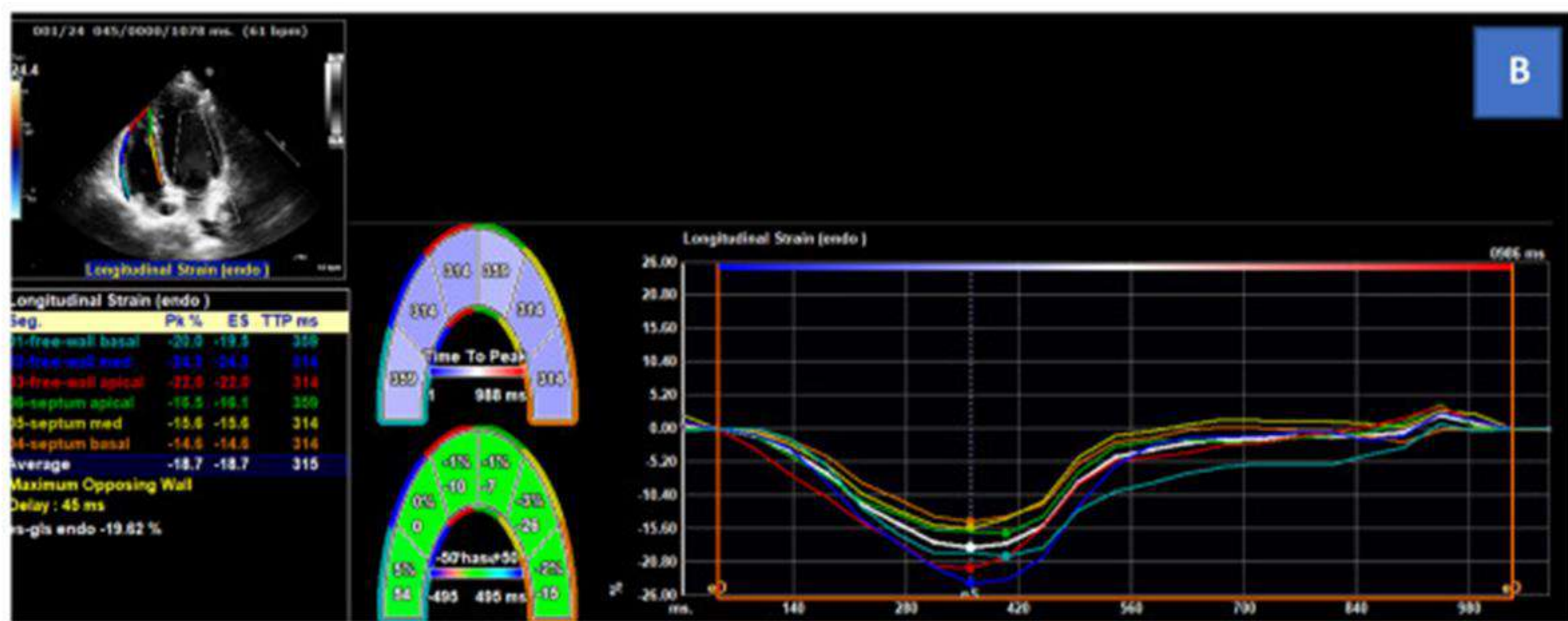
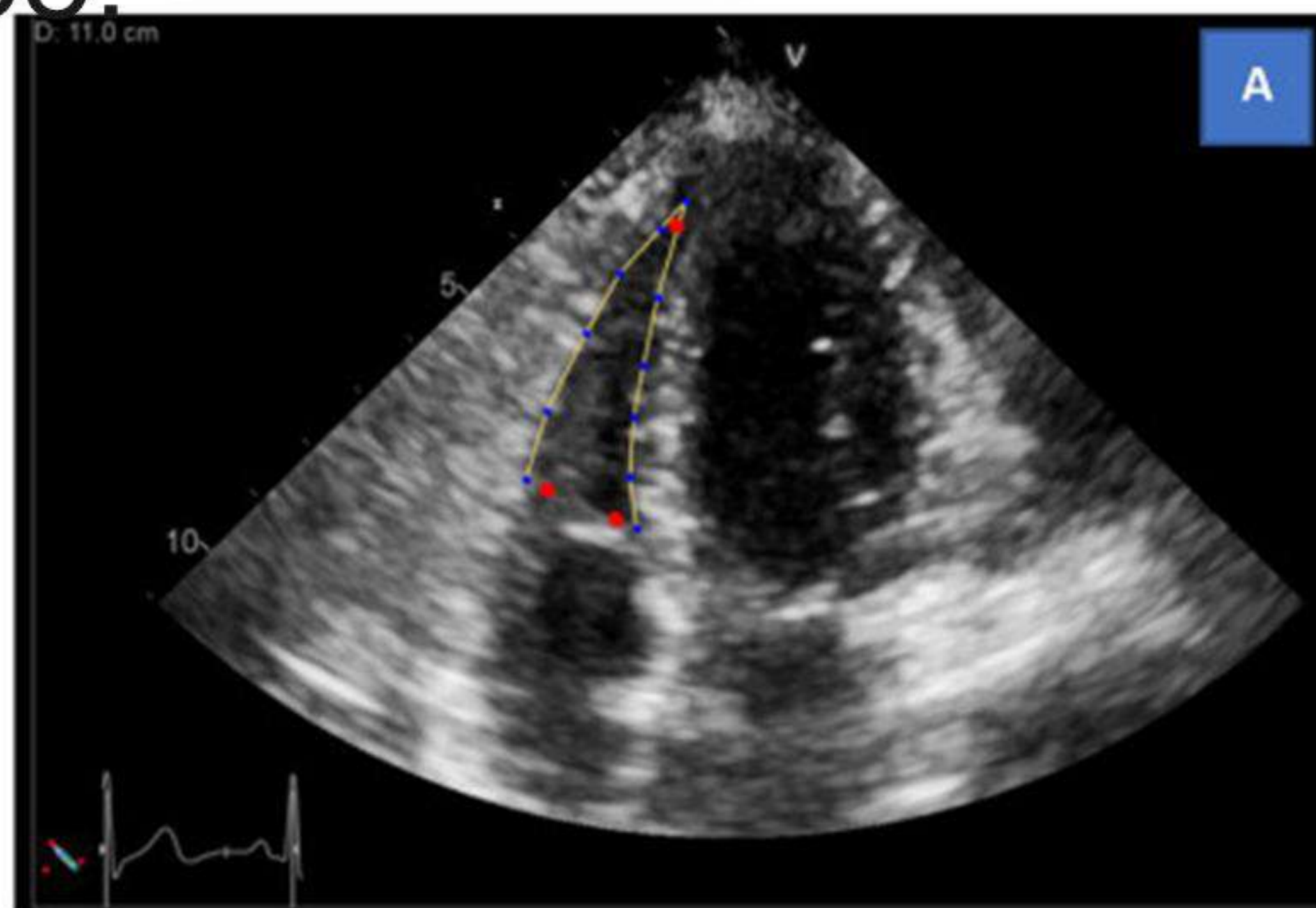
Valutare la funzione sistolica longitudinale in pazienti con miocardite, la sua correlazione con le caratteristiche della risonanza magnetica cardiaca (RMC) e il suo valore predittivo nel recupero funzionale e nell'insorgenza di aritmie durante il follow-up (FU) con terapia medica ottimizzata (OMT). Sono stati arruolati pazienti con miocardite acuta, confermata tramite criteri RMC, e controlli sani abbinati per età e sesso. L'ecocardiografia transtoracica bidimensionale (2D), inclusa l'analisi speckle tracking, è stata eseguita al momento del ricovero e dopo 6 mesi di FU. I pazienti del gruppo con miocardite sono stati inoltre sottoposti a monitoraggio ECG Holter delle 24 ore durante la FU. Sono stati arruolati 115 pazienti con miocardite (età media 41 ± 17 , 70% maschi) e 70 soggetti sani. La deformazione longitudinale globale (GLS) e la deformazione subepicardica erano notevolmente inferiori nel gruppo con miocardite rispetto ai controlli (GLS% media: $-14,1 \pm 5,1$ vs $-23,1 \pm 3,6$, $p < 0,001$). È stata riscontrata una forte correlazione positiva tra il carico cicatriziale totale (TSB) alla CMR e il GLS basale del ventricolo sinistro ($r = 0,67$, $p < 0,0001$). Il GLS è migliorato dopo 6 mesi di FU nella miocardite sottoposta a OMT (GLS% media: $-14,1 \pm 5,1$ vs $-16,5 \pm 4,8$, $p < 0,01$). Mediante analisi di correlazione bivariata, la FEVS basale, il GLS e il TSB erano tutti associati alla FEVS a 6 mesi di FU. Inoltre, mediante analisi di regressione lineare multivariata, questi parametri si sono confermati predittori indipendenti del recupero funzionale a 6 mesi (LVEF β 0,38, $p < 0,01$; GLS β - 0,35, $p < 0,01$; carico cicatriziale totale β - 0,52, $p < 0,0001$). Lo strain sistolico di picco segmentale era significativamente diverso tra i segmenti con e senza potenziamento tardivo del gadolinio alla CMR ($-13,2 \pm 3,1\%$ vs $-18,1 \pm 3,5\%$, $p < 0,001$). **Uno strain segmentale del -12% ha identificato la cicatrice con una sensibilità del 79% e una specificità dell'84%** (AUC = 0,91; IC 95% 0,73-0,97; $p < 0,001$). Inoltre, il GLS del ventricolo sinistro basale nella miocardite è risultato predittivo di tachicardie ventricolari non sostenute (valore di cut-off $> -12\%$; sensibilità 84%; specificità 74,4%; AUC = 0,75). I parametri di deformazione longitudinale miocardica sono significativamente associati alla presenza di una cicatrice alla RMC e sono predittori di esito funzionale e aritmie ventricolari nei pazienti con miocardite acuta. La loro valutazione durante l'esame ecografico dovrebbe essere presa in considerazione per ottenere maggiori informazioni sulla prognosi e sulla stratificazione del rischio di questo sottogruppo di pazienti.

Parole chiave: Miocardite acuta; Risonanza magnetica cardiaca; Prognosi; Ecocardiografia speckle tracking; Aritmie ventricolari.

Strain gls ventricolare atriale e dx

Meindl, Christine et al. "Left atrial strain parameters derived by echocardiography are impaired in patients with acute myocarditis and preserved systolic left ventricular function." *The international journal of cardiovascular imaging* vol. 39,6 (2023): 1157-1165. doi:10.1007/s10554-023-02827-9

Ben-Joya, Daniel et al. "The prevalence of abnormal right ventricle speckle strain in the setting of acute myocarditis and preserved left ventricle function." *The international journal of cardiovascular imaging* vol. 39,7 (2023): 1231-1238.



Esempio di imaging di deformazione atriale sinistra che include tre fasi: serbatoio LA (LASr), condotto LA (LAScd) e funzione di richiamo LA (LASct)

MIOCARDITE ACUTA IN UTIC

DASHBOARD ECOCARDIOGRAFICA

VENTRICOLO SINISTRO

LVEF
LV-GLS
RWMA
Ispessimento parietale

REPERTI AGGIUNTI

Tamponamento cardiaco
Trombosi
Alterato strain atriale
Iperecogenicità

ECMO

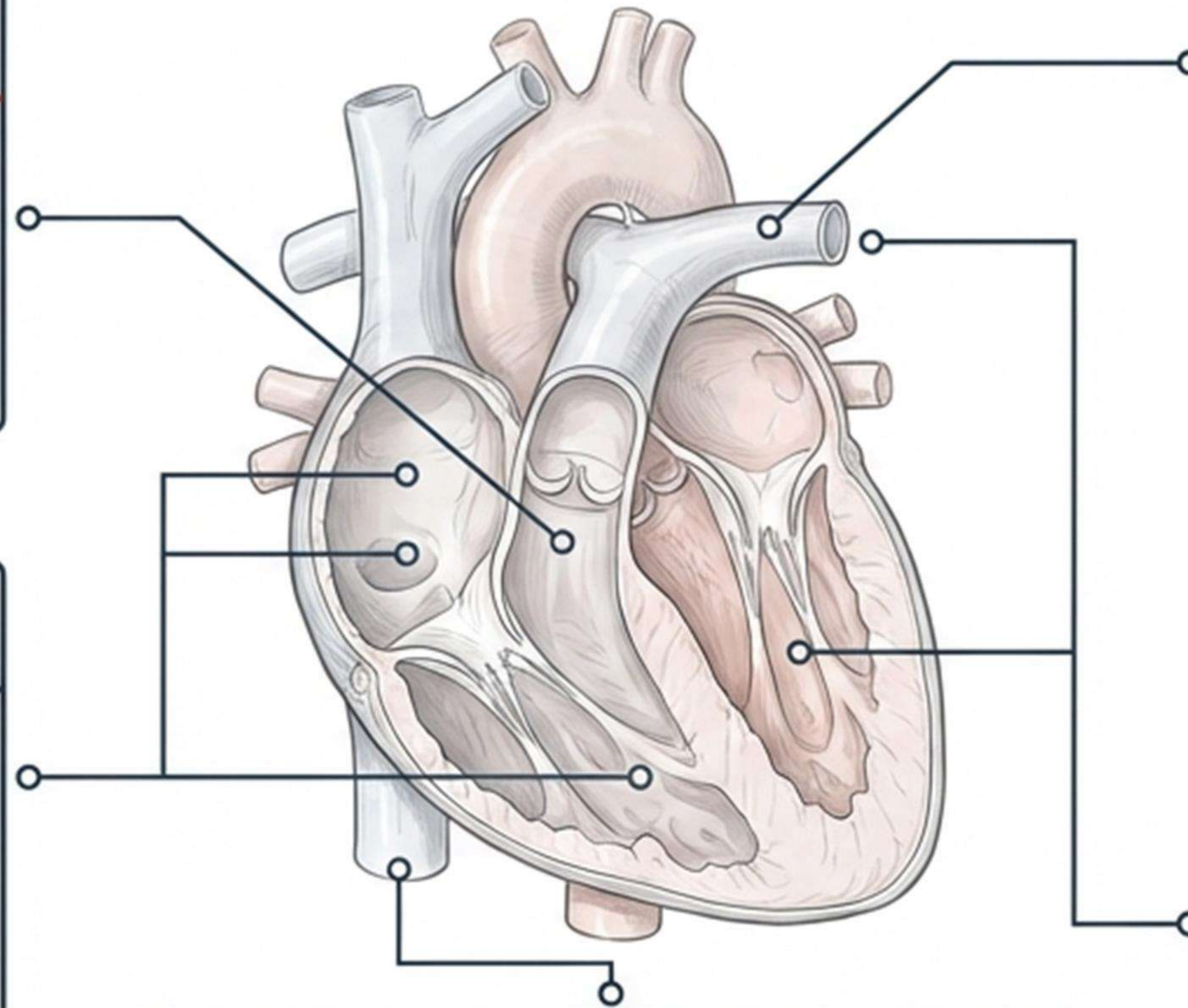
ECMO
Weaning ECMO

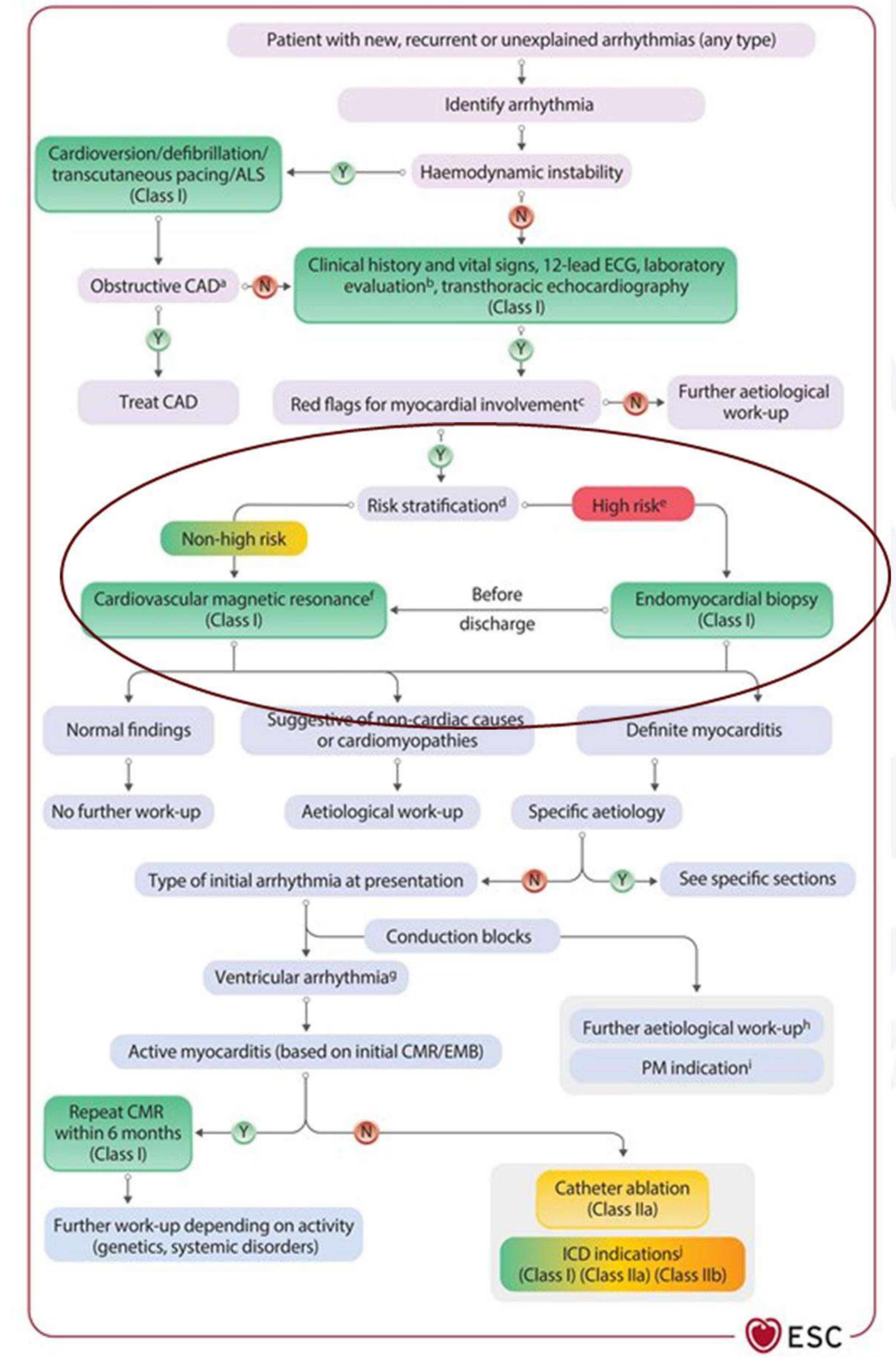
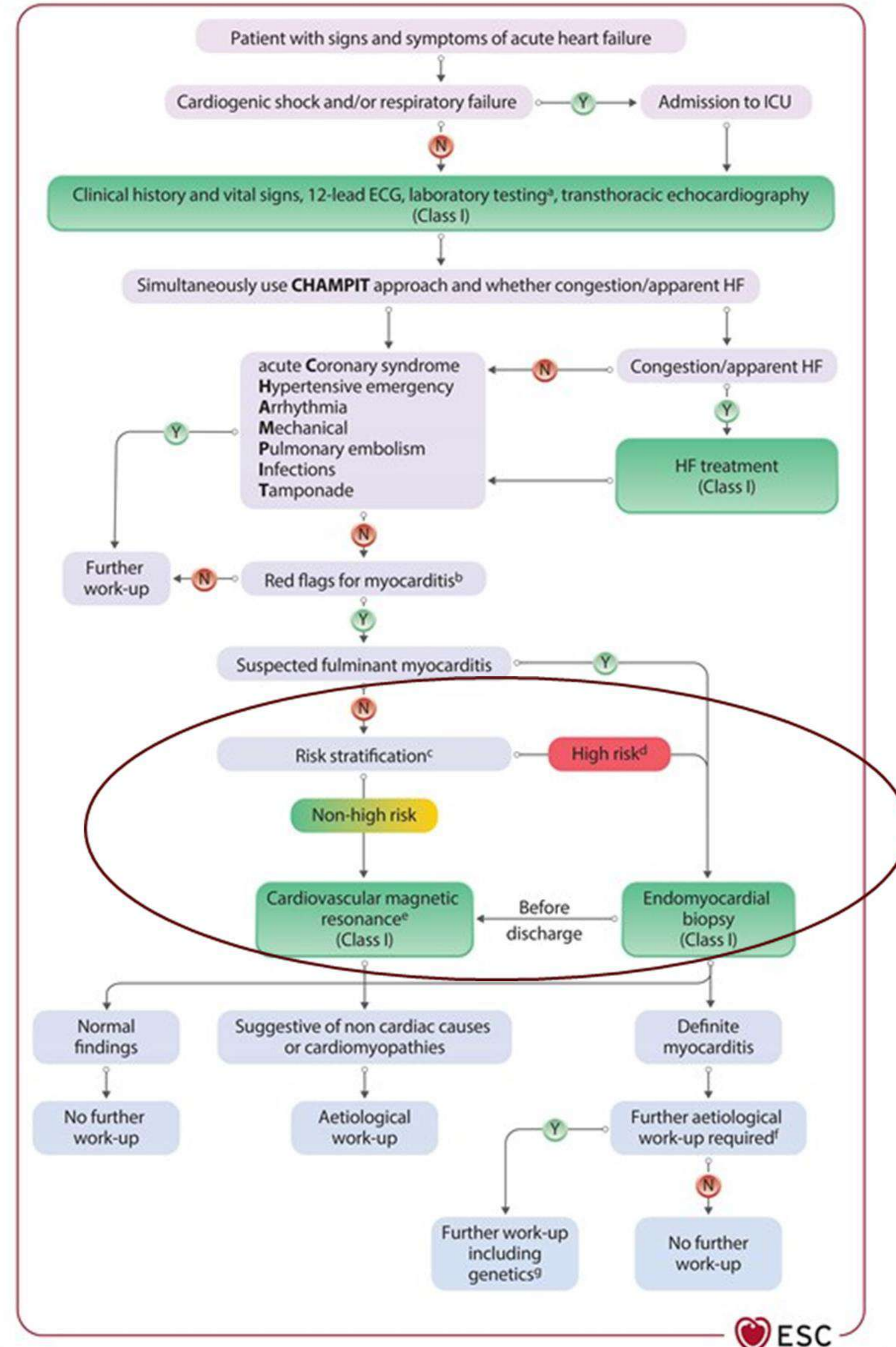
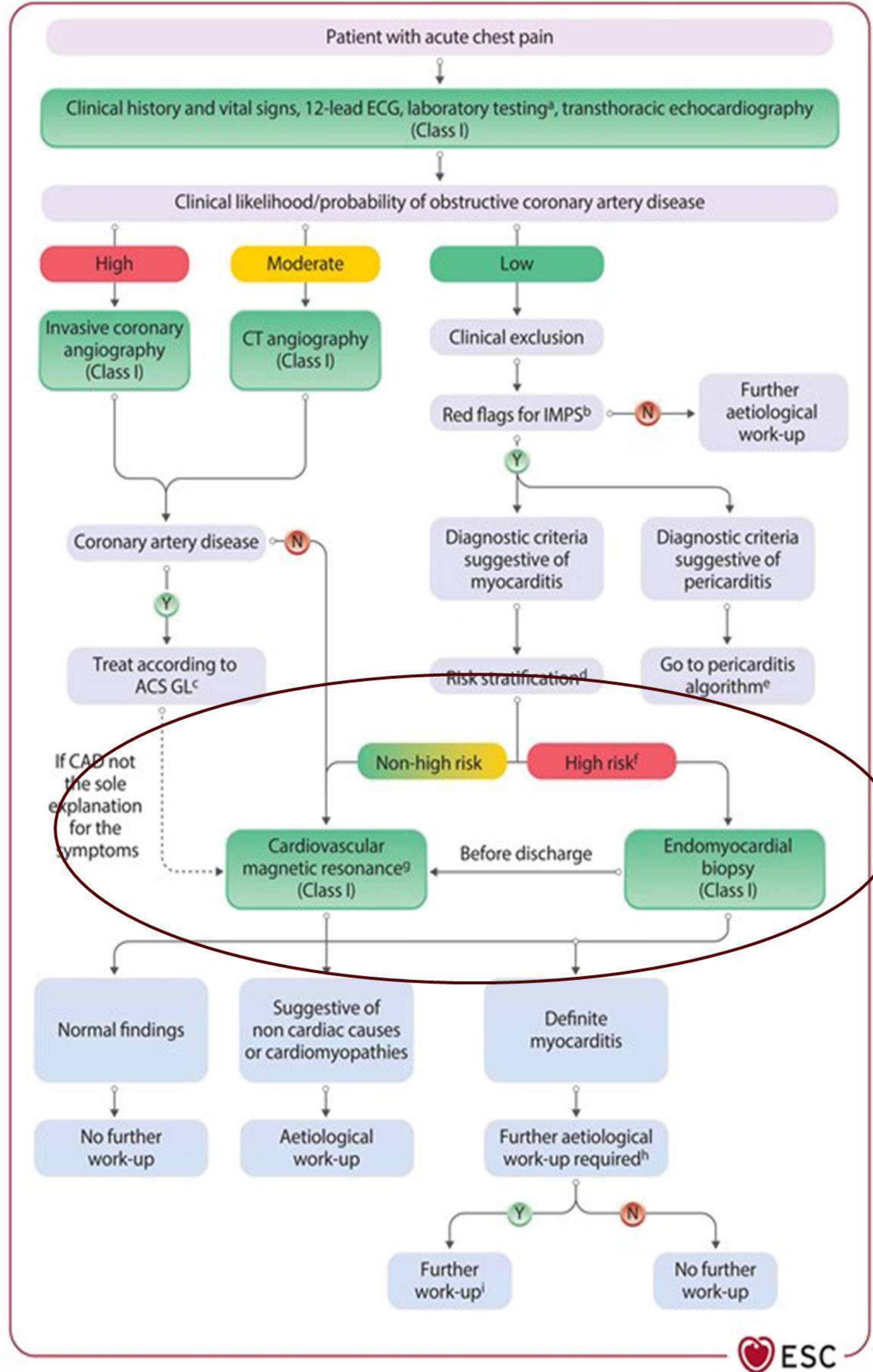
VENTRICOLO DESTRO

Dimensioni
Cinetica
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Strain longitudinale
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SEGNI DI SHOCK

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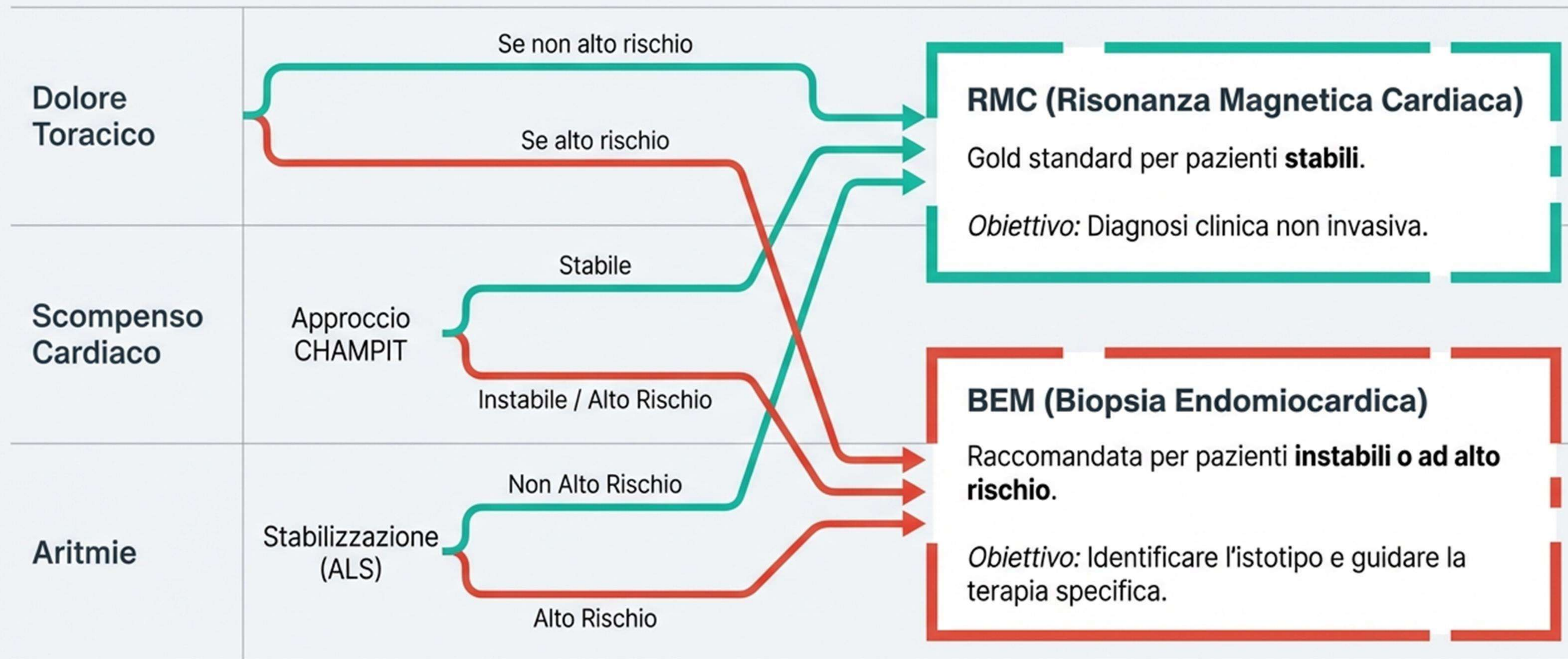




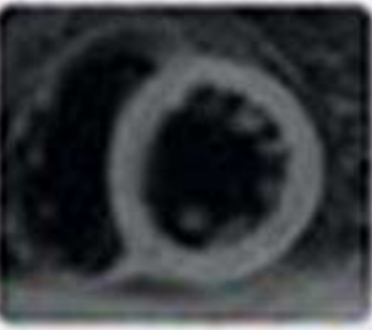





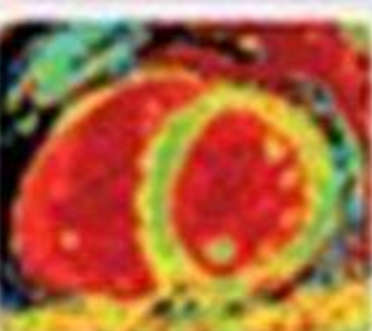
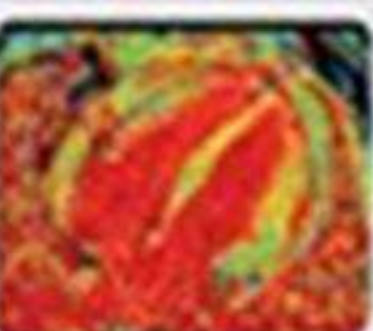

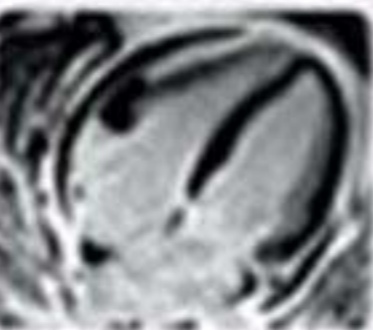


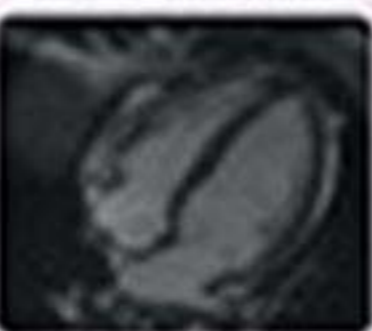
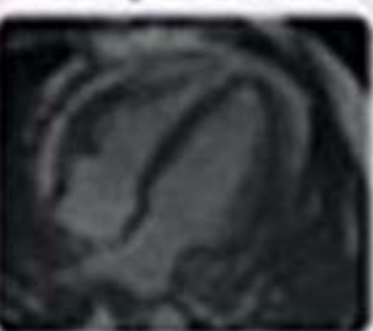
STRATIFICAZIONE DEL RISCHIO

Risk	High risk	Intermediate risk	Low risk
Myocarditis	<ul style="list-style-type: none"> • Acute HF/cardiogenic shock • Dyspnoea NYHA III–IV refractory to medical therapy • Cardiac arrest/syncope^a • Ventricular fibrillation/sustained ventricular tachycardia^a • High-level AV block^a 	<ul style="list-style-type: none"> • New/progressive dyspnoea • Non-sustained ventricular arrhythmias • Persistent release or relapsing troponin 	Stable symptoms or oligosymptomatic
	Imaging criteria:	Imaging criteria:	Imaging criteria:
	<ul style="list-style-type: none"> • Newly reduced LVEF (<40%)^a • Extensive LGE on CMR^a 	<ul style="list-style-type: none"> • Newly mildly reduced LVEF (41%–49%) and/or WMA • Preserved LVEF (≥50%) and LGE ≥2 segments on CMR 	<ul style="list-style-type: none"> • Preserved LVEF (≥50%) without LGE or limited LGE (<2 segments) on CMR

Algoritmi Diagnostici: Il Bivio tra RMC e BEM nei 3 Scenari



La caratterizzazione tissutale non invasiva

Criterion	Methods	Example images and pathology		Parameters for reporting	
				For myocarditis	For pericardial involvement
T2-based criterion	T2-weighted imaging or T2 mapping	Myocardial oedema 	Pericardial oedema 	<ul style="list-style-type: none"> • Presence, extent, and location of oedema (T2 weighted) • Regional high T2 SI or global high T2 SI (T2-weighted) • Regional or global increase of myocardial T2 times 	<ul style="list-style-type: none"> • High signal intensity of the pericardium in T2-mapping or T2-weighted imaging
					
T1-based criterion	Native T1 mapping/post-contrast T1 mapping (ECV)/ T1-weighted imaging	Myocardial oedema/diffuse fibrosis 	Pericardial oedema/diffuse fibrosis 	<ul style="list-style-type: none"> • Description of focal increases • Regional or global increase of native myocardial T1 times • Regional or global increase ECV values 	<ul style="list-style-type: none"> • High signal intensity of the pericardium in T1-mapping
					
T1-based criterion	Late gadolinium enhancement	Focal myocardial fibrosis/scar 	Pericardial inflammation/scar 	<ul style="list-style-type: none"> • Presence, pattern, extent, and location of LGE (positive if areas with high SI in a nonischaemic distribution pattern) • Thrombi (if present) • Total LGE/LV mass (%) (no routine) 	<ul style="list-style-type: none"> • High signal intensity of the pericardium in LGE images
					
Supportive criterion	Cine imaging	Functional and wall motion abnormalities 	Haemodynamic compromise 	<ul style="list-style-type: none"> • Regional wall-motion abnormalities • Cardiac function (e.g. LVEF, RVEF) and volume parameters 	<ul style="list-style-type: none"> • Presence, composition, and extent of pericardial effusion • Haemodynamic relevance of pericardial effusion • Diameter of pericardial effusion

Updated Lake Louise Criteria (LLC) for myocarditis			
CMR-proven myocarditis= 2 out of 2 updated LLC main criteria fulfilled	T2-based criterion Myocardial oedema	Abnormal T2-mapping or T2-weighted imaging	Pericardial abnormalities
	Main criteria		Supportive criteria
CMR-uncertain myocarditis= only 1 out of 2 updated LLC main criteria fulfilled	T1-based criterion Non-ischaemic myocardial injury	Abnormal T1-mapping, ECV or LGE	Systolic LV-dysfunction



JACC White Paper

Cardiovascular Magnetic Resonance in Myocarditis: A JACC White Paper

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 Godtfred Holmvang, MD,|| Pauline Alakija, MD,† Leslie T. Cooper, MD,¶ James A. White, MD,#
 Hassan Abdel-Aty, MD,§ Matthias Gutberlet, MD,** Sanjay Prasad, MD,††
 Anthony Aletras, PhD,‡‡ Jean-Pierre Laissy, MD,§§ Ian Paterson, MD,|||
 Neil G. Filipchuk, MD,* Andreas Kumar, MD,* Matthias Pauschinger, MD,¶¶
 Peter Liu, MD,## for the International Consensus Group on Cardiovascular Magnetic Resonance in Myocarditis

Table 7

Proposed Diagnostic Criteria

In the setting of clinically suspected myocarditis:
 Regional or global myocardial SI increase in T2-weighted images.†
 Increased global myocardial early gadolinium enhancement ratio between myocardium and skeletal muscle in gadolinium-enhanced T1-weighted images.‡
 There is at least 1 focal lesion with nonischemic regional distribution in inversion recovery-prepared gadolinium-enhanced T1-weighted images (“late gadolinium enhancement”).§

A CMR study is consistent

A repeat CMR study between 1 and 2 weeks after the initial CMR study is recommended if

- None of the criteria are present, but the onset of symptoms has been very recent and there is strong clinical evidence for myocardial inflammation.
- One of the criteria is present.

The presence of LV dysfunction or pericardial effusion provides additional, supportive evidence for myocarditis.

*The clinical suspicion for active myocarditis should be based on the criteria listed in Table 5. †Images should be obtained using a body coil or a surface coil with an effective surface coil intensity correction algorithm; global signal intensity (SI) increase has to be quantified by an SI ratio of myocardium over skeletal muscle of ≥ 2.0 . If the edema is more subendocardial or transmural in combination with a colocalized ischemic (including the subendocardial layer) pattern of late gadolinium enhancement, acute myocardial infarction is more likely and should be reported. ‡Images should be obtained using a body coil or a surface coil with an effective surface coil intensity correction algorithm; a global SI enhancement ratio of myocardium over skeletal muscle of ≥ 4.0 or an absolute myocardial enhancement of $\geq 45\%$ is consistent with myocarditis. §Images should be obtained at least 5 min after gadolinium injection; foci typically exclude the subendocardial layer, are often multifocal, and involve the subepicardium. If the late gadolinium enhancement pattern clearly indicates myocardial infarction and is colocalized with a transmural regional edema, acute myocardial infarction is more likely and should be reported.

Abbreviations as in Table 6.

In the setting of clinically suspected myocarditis,* CMR findings are consistent with myocardial inflammation, if at least 2 of the following criteria are present:

Regional or global myocardial SI increase in T2-weighted images.†

Increased global myocardial early gadolinium enhancement ratio between myocardium and skeletal muscle in gadolinium-enhanced T1-weighted images.‡

There is at least 1 focal lesion with nonischemic regional distribution in inversion recovery-prepared gadolinium-enhanced T1-weighted images (“late gadolinium enhancement”).§

Table 3

Overview of the Diagnostic Accuracy of Individual Tissue Criteria as Assessed in Controlled Trials

	Validation	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
Early myocardial gadolinium enhancement						
Friedrich et al., <i>Circulation</i> 1998 (9)	Clinical	84	89	86	89	84
Laissy et al., <i>Chest</i> 2002 (11)	Clinical	85	100	89	100	70
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	80	68	74	74	75
Gutberlet et al., <i>Radiology</i> 2008 (34)	Histology	63	86	72	86	63
Pooled data (n = 194)		74	83	78	86	70
T2						
Rieker et al., <i>Rofo</i> 2002 (36)	Clinical	100	50	76	69	100
Laissy et al., <i>Chest</i> 2002 (11)	Clinical	45	100	59	100	39
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	84	74	79	78	81
					74	60
					77	63
					56	50
					78	62
					99	81
					65	44
					81	38
					89	53
T2 + LGE						
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	40	100	69	100	61
Gutberlet et al., <i>Radiology</i> 2008 (34)	Histology	17	91	48	73	44
Pooled data (n = 130)		25	95	56	86	50
T2 and/or LGE						
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	88	74	81	100	85
Gutberlet et al., <i>Radiology</i> 2008 (34)	Histology	50	57	52	80	25
Pooled data (n = 130)		60	66	62	79	43
Any 1 of 3						
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	100	48	75	68	100
Gutberlet et al., <i>Radiology</i> 2008 (42)	Histology	81	49	67	68	65
Pooled data (n = 130)		88	48	70	68	76
Any 2 of 3						
Abdel-Aty et al., <i>J Am Coll Cardiol</i> 2005 (13)	Clinical	76	96	85	95	79
Gutberlet et al., <i>Radiology</i> 2008 (34)	Histology	63	89	73	88	63
Pooled data (n = 130)		67	91	78	91	69

LGE = late gadolinium enhancement; other abbreviations as in Table 2.

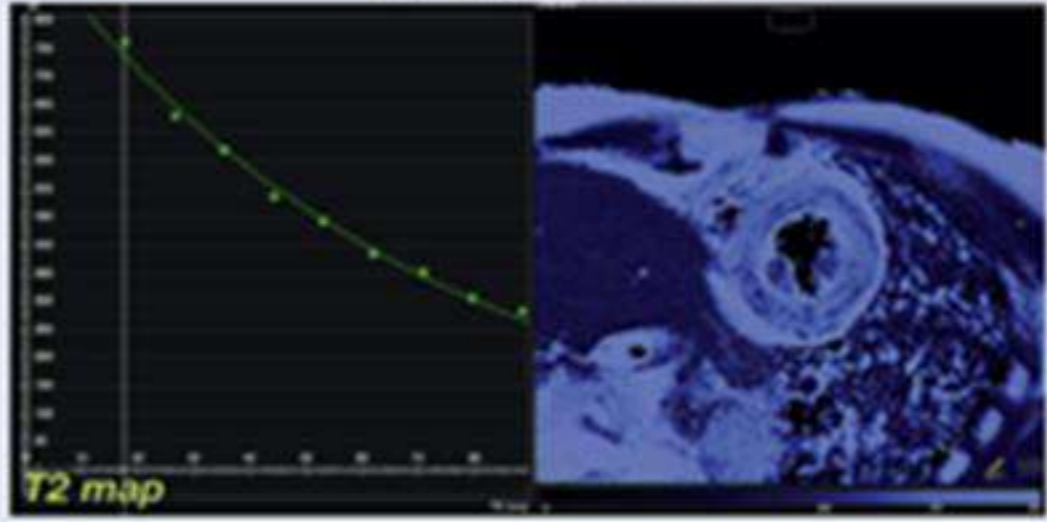
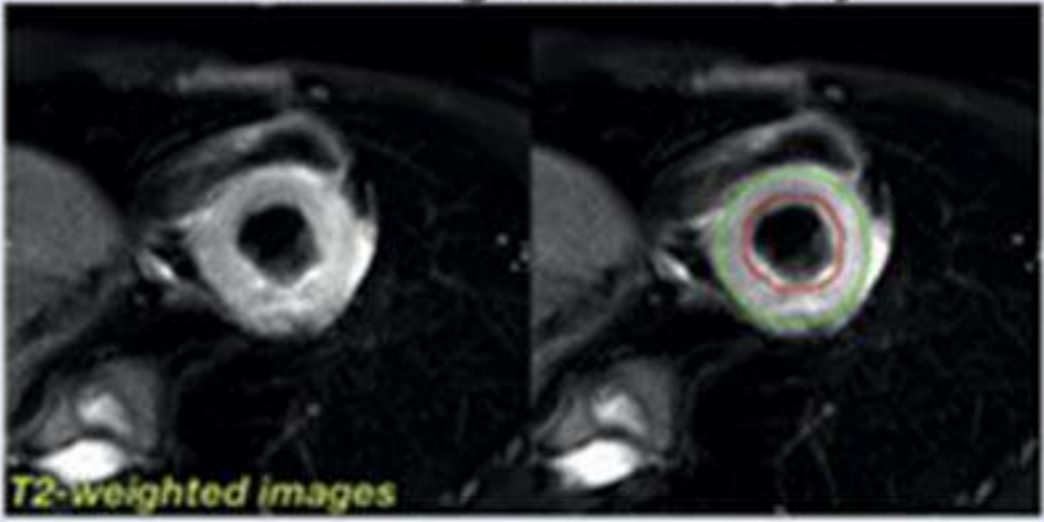
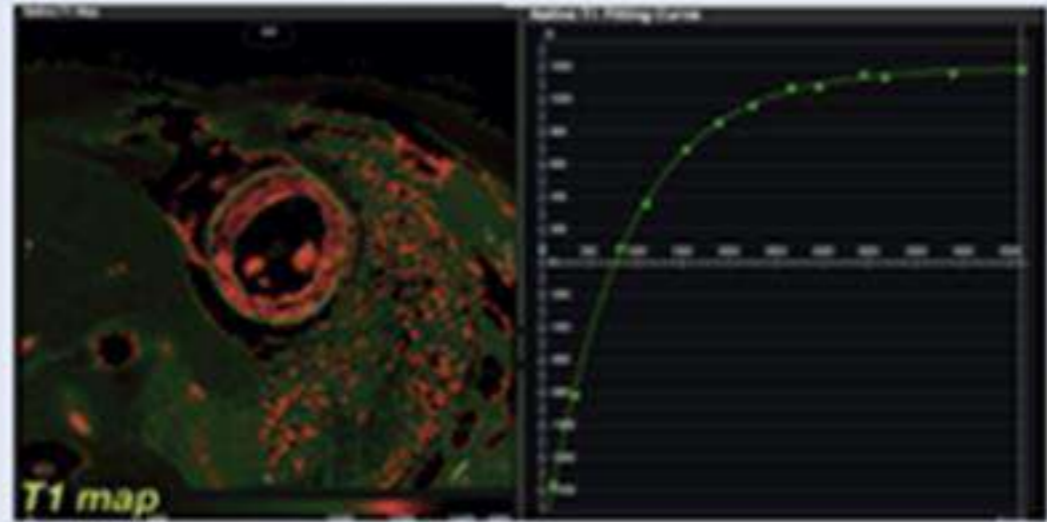
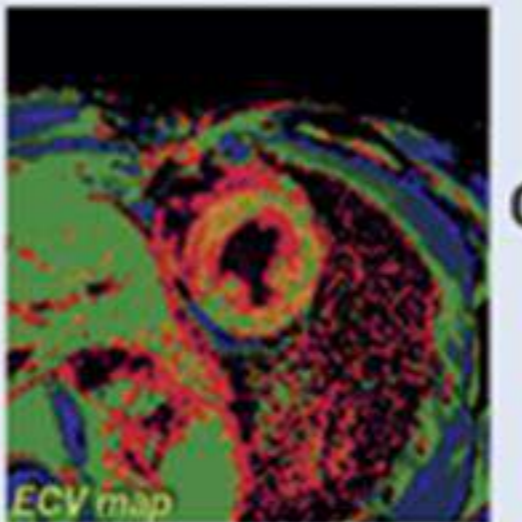
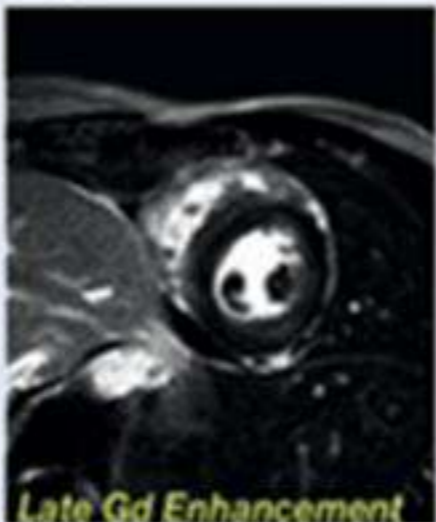
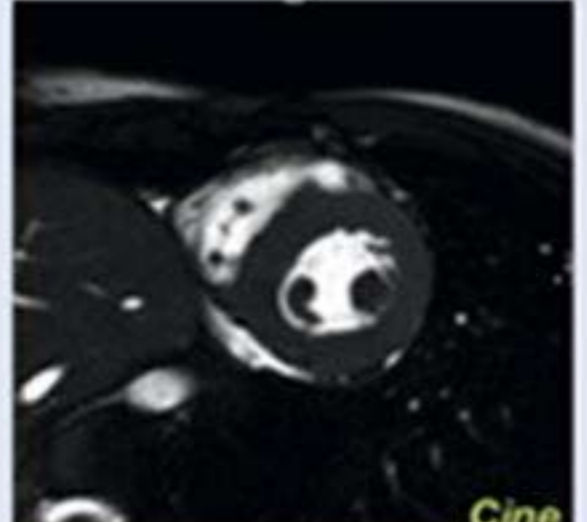
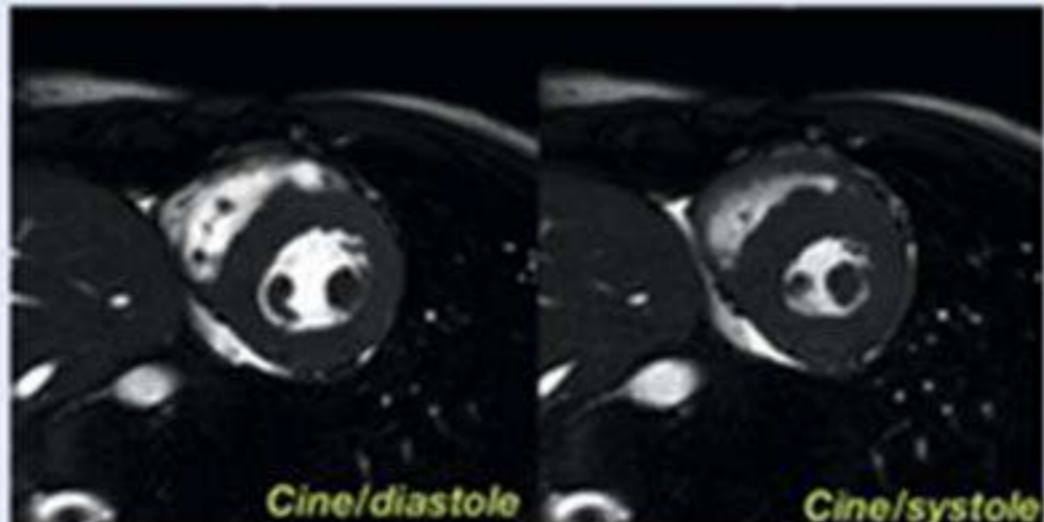
Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation

Expert Recommendations

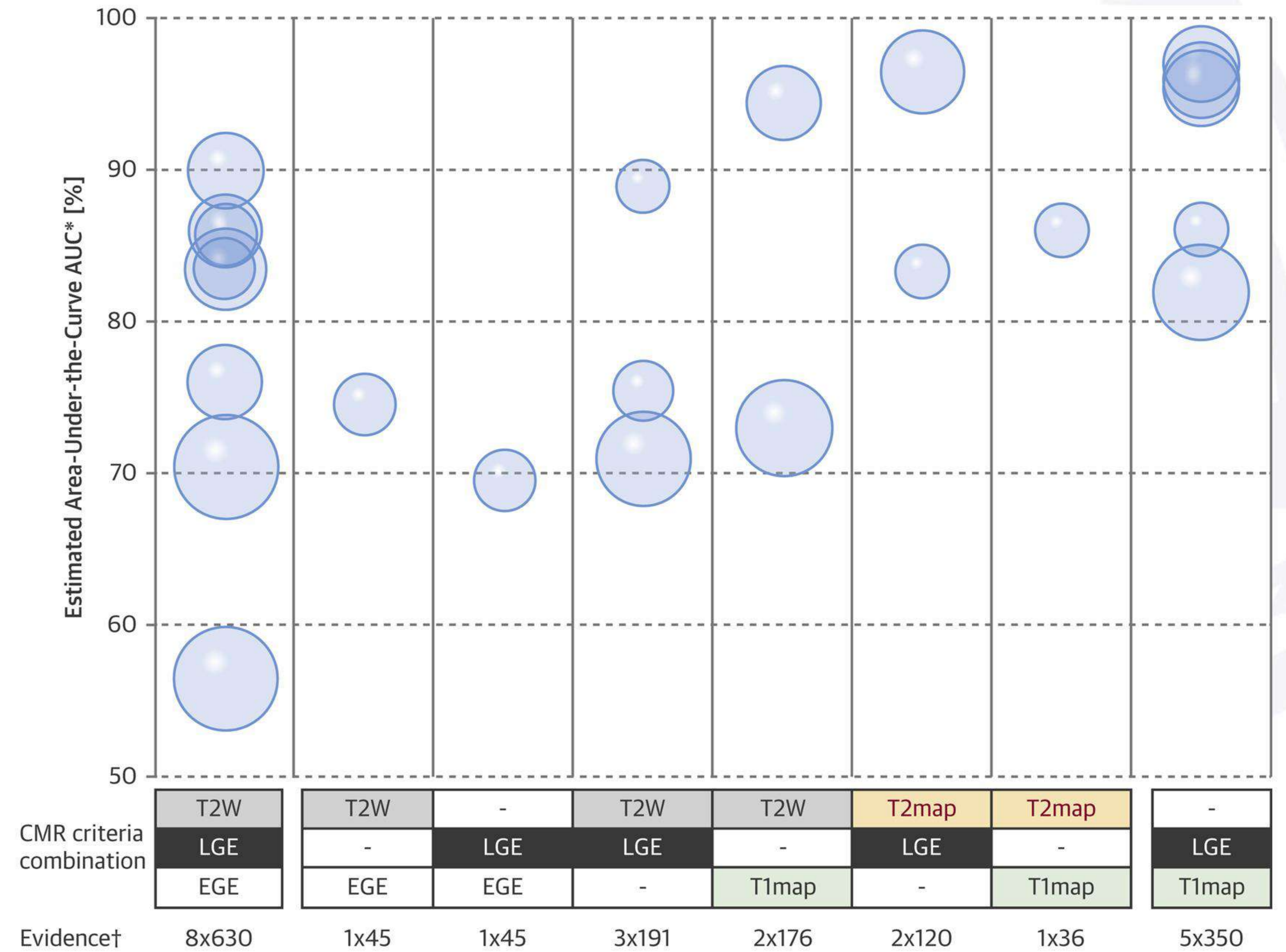
Vanessa M. Ferreira, MD, DPM,² Jeanette Schulz-Menger, MD,³ Godtfred Holmvang, MD,⁵ Christopher M. Kramer, MD,⁴ Jacopo Carbone, MD,⁶ Udo Sechtem, MD,⁷ Ingrid Kindermann, MD,⁸ Matthias Gutberlet, MD,³ Leslie T. Cooper, MD,¹ Peter Liu, MD,¹ Matthias G. Friedrich, MD^{2,1,9}

JACC JOURNAL CME/MOC/ECME

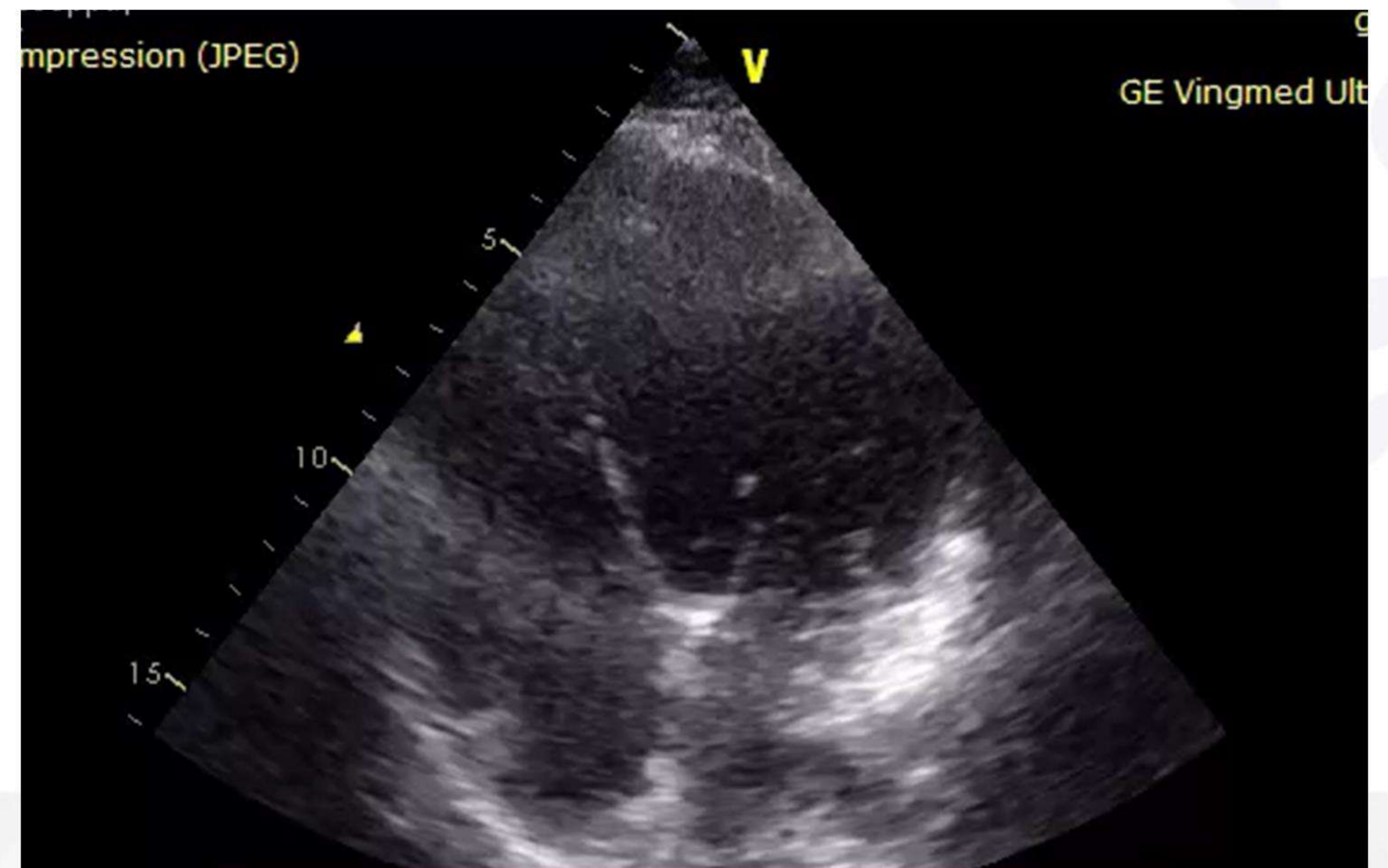
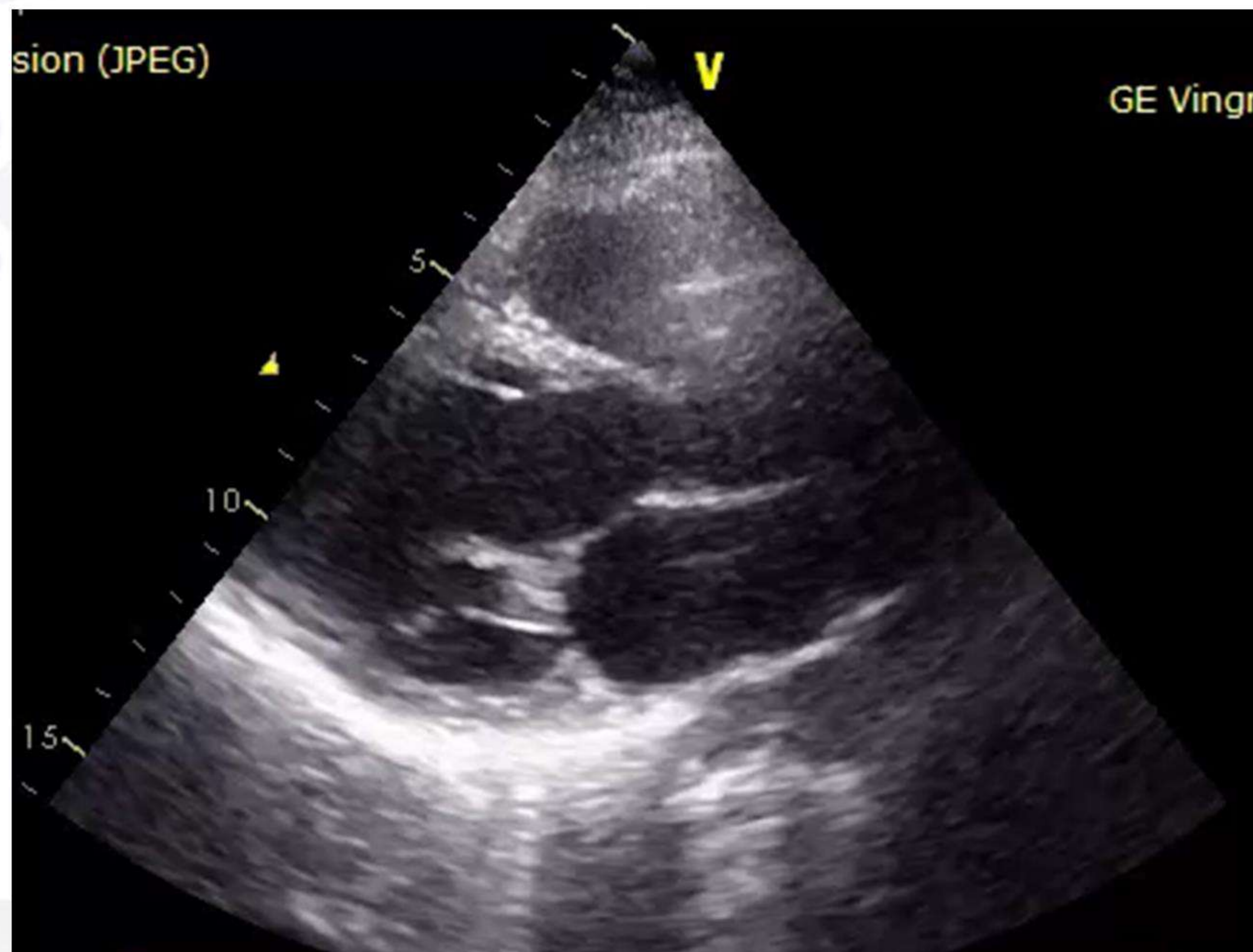
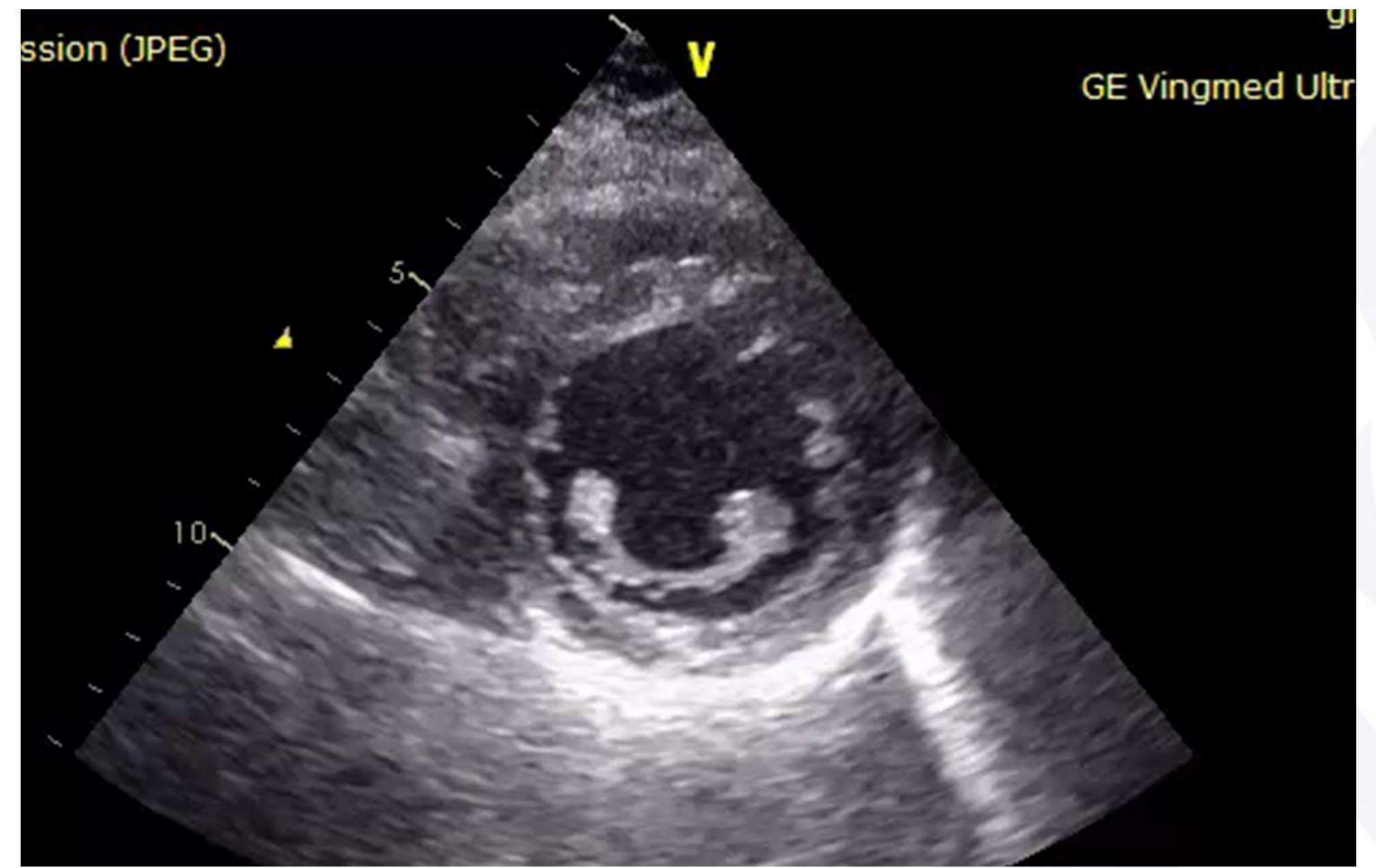
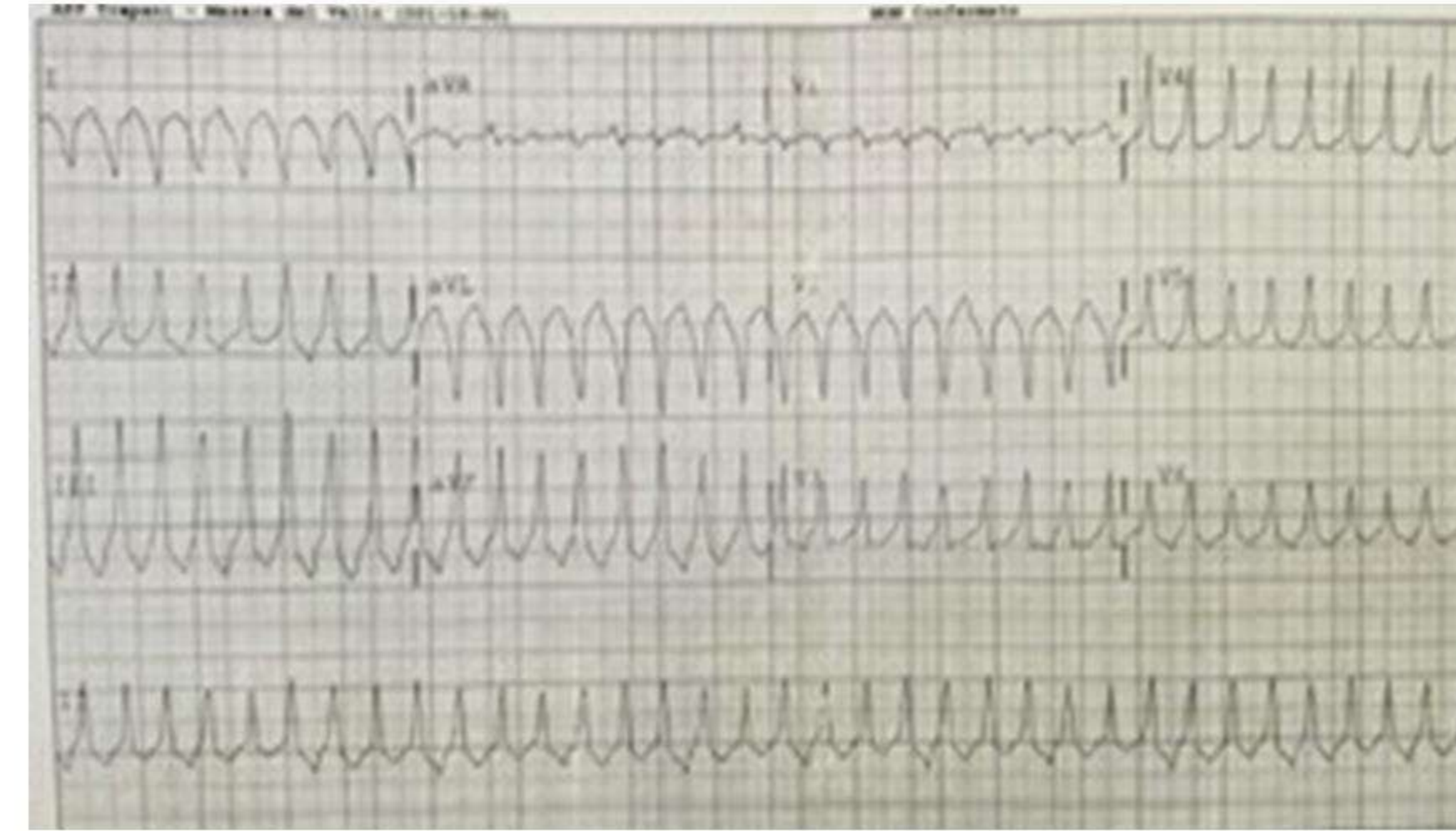
CENTRAL ILLUSTRATION: Overview of the Updated Lake Louise Criteria

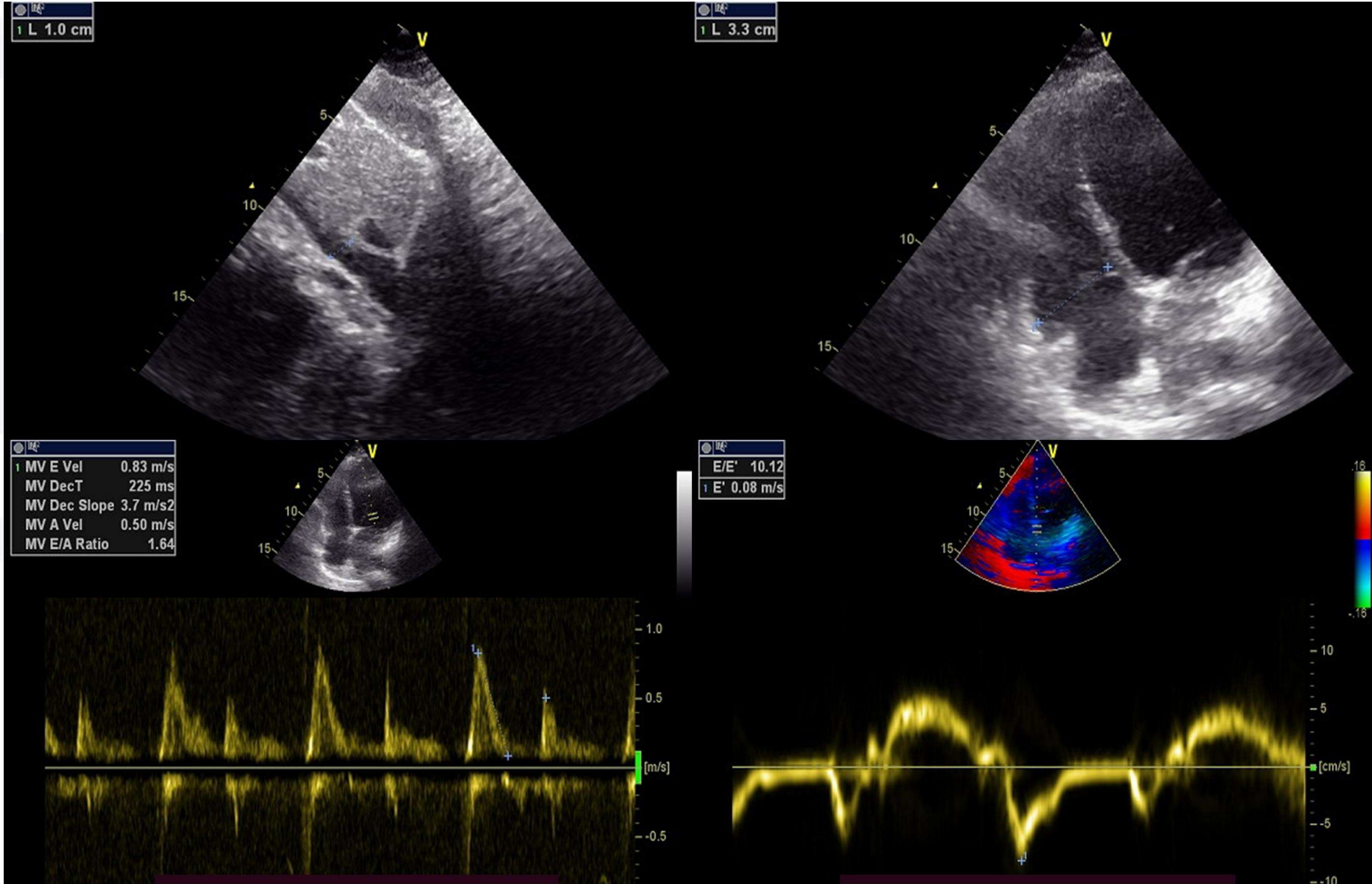
	2018 Lake Louise Criteria	CMR Image Examples
Main Criteria	Myocardial Edema (T2-mapping or T2W images)	Regional or global increase of native T2  or Regional or global increase of T2 signal intensity 
	Non-ischemic Myocardial Injury (Abnormal T1, ECV, or LGE)	Regional or global increase of native T1  or Regional or global increase of ECV  or Regional LGE signal increase 
Supportive Criteria	Pericarditis (Effusion in cine images or abnormal LGE, T2, or T1)	Pericardial effusion 
	Systolic LV Dysfunction (Regional or global wall motion abnormality)	Regional or global hypokinesis 

Ferreira, V.M. et al. J Am Coll Cardiol. 2018;72(24):3158-76.



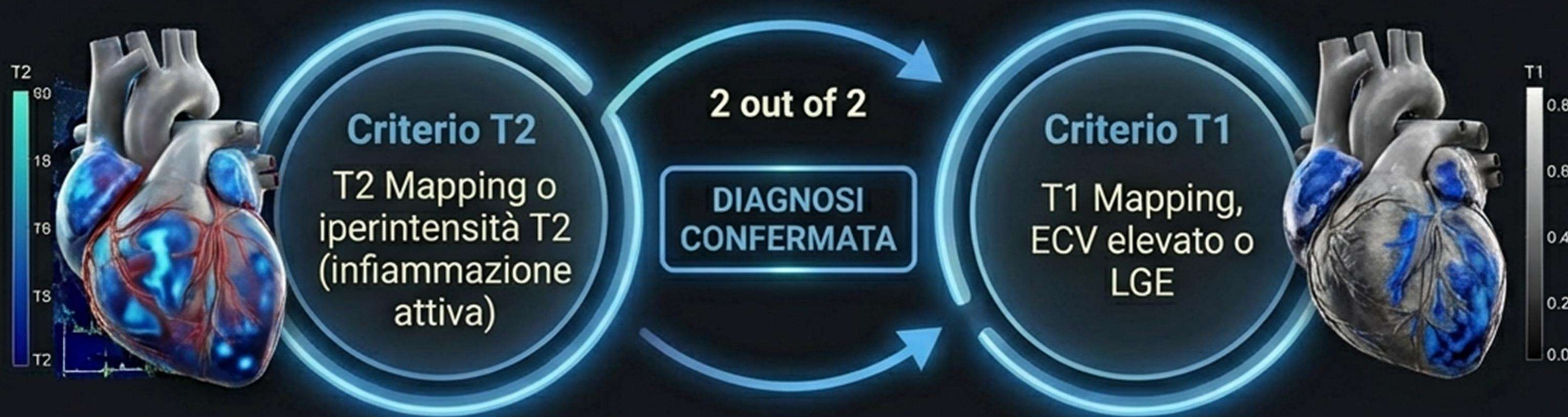
- Donna di 40 anni, fumatrice, familiarità per CAD
- Pregresso aborto
- Dolore toracico e cardiopalmo
- ECG TV
- PAO 110/70 mmHg
- PCR 10 mg/dl (<0.60)
- Troponina 475 ng/l
- TC torace addensamenti flogistici e versamento pleurico
- CVG negativa





La Diagnosi Tissutale Non Invasiva: CMR

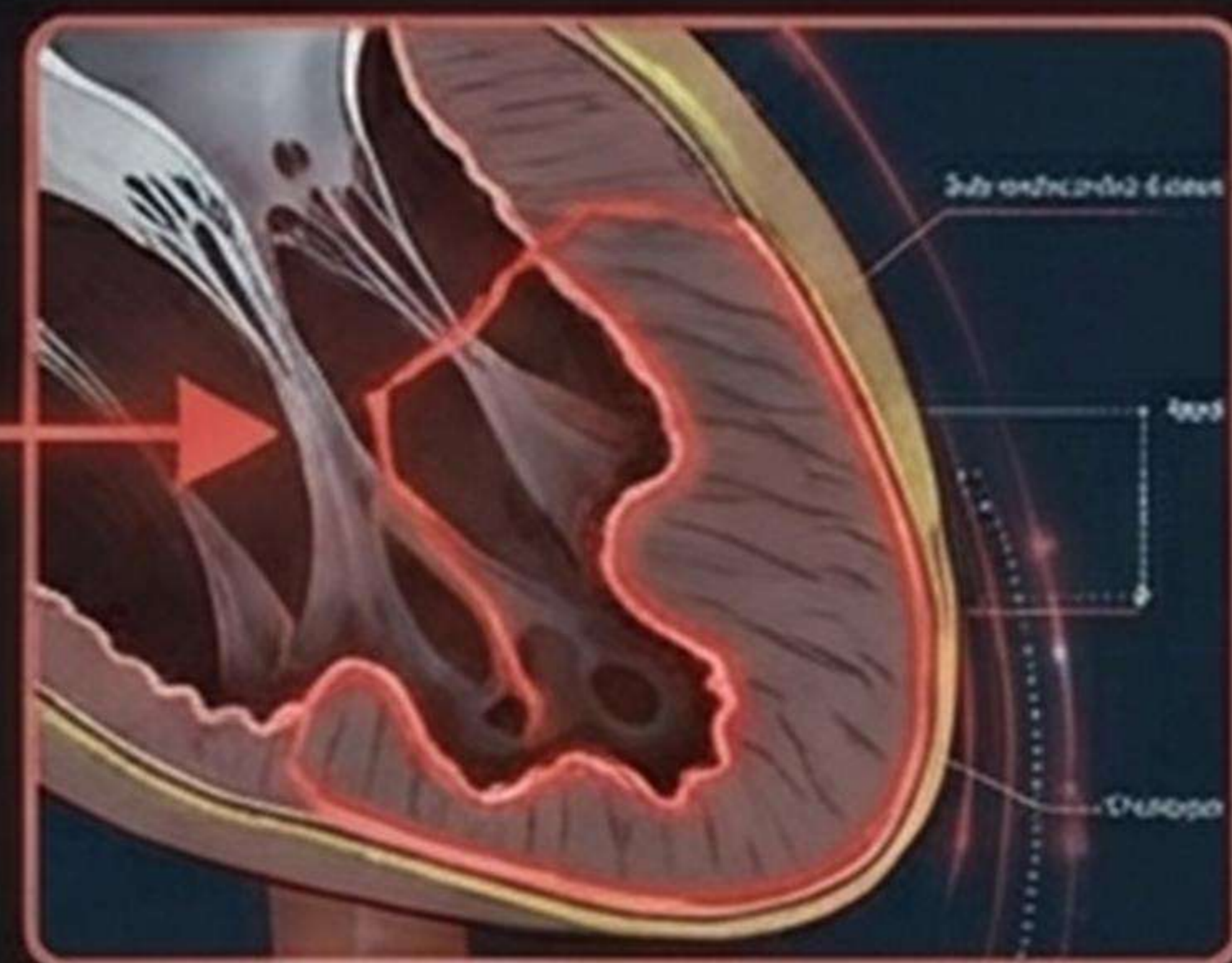
Criteri di Lake Louise (Revisione 2018)



Sub-endocardial



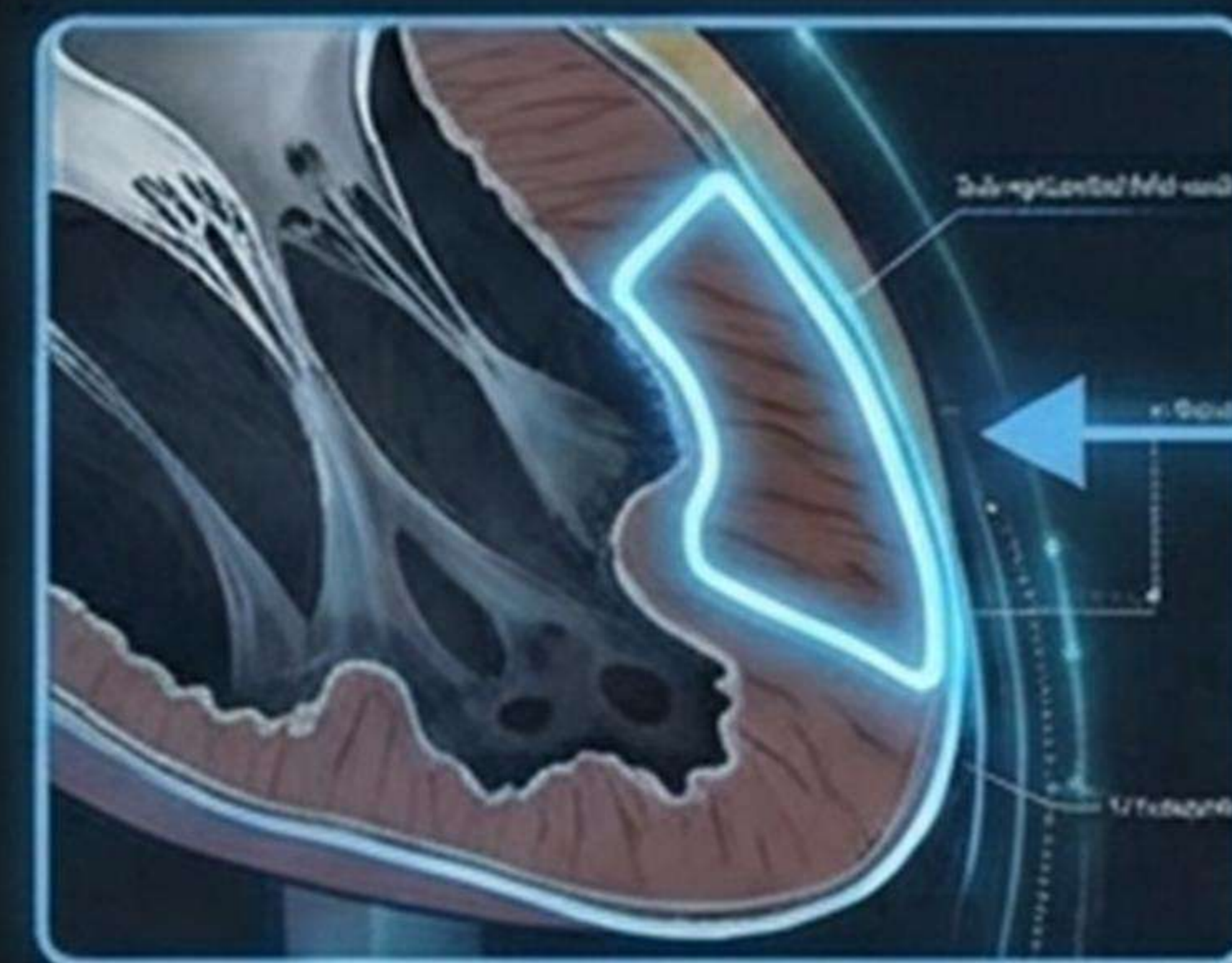
Ischemico



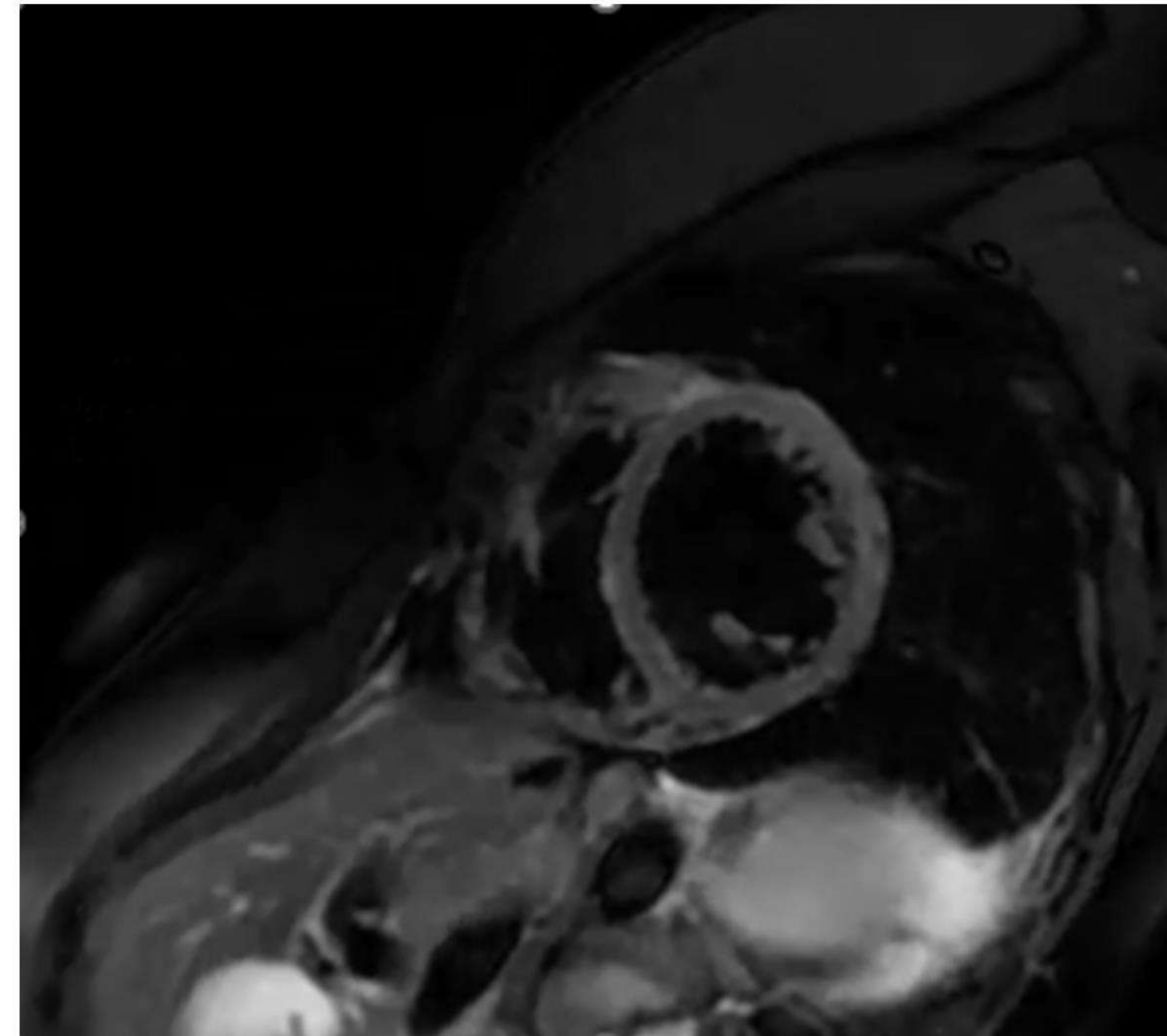
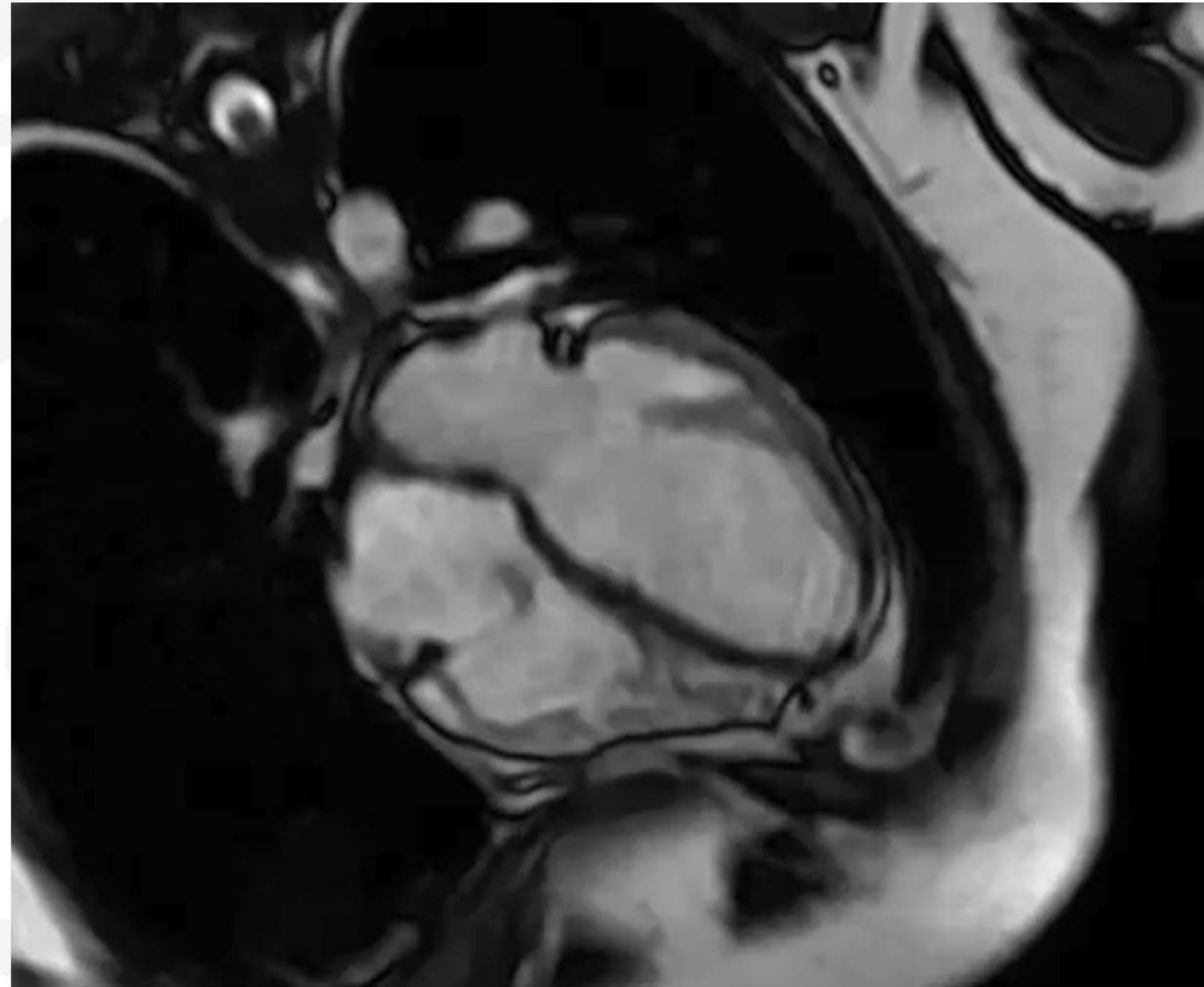
Sub-epicardial/Mid-wall



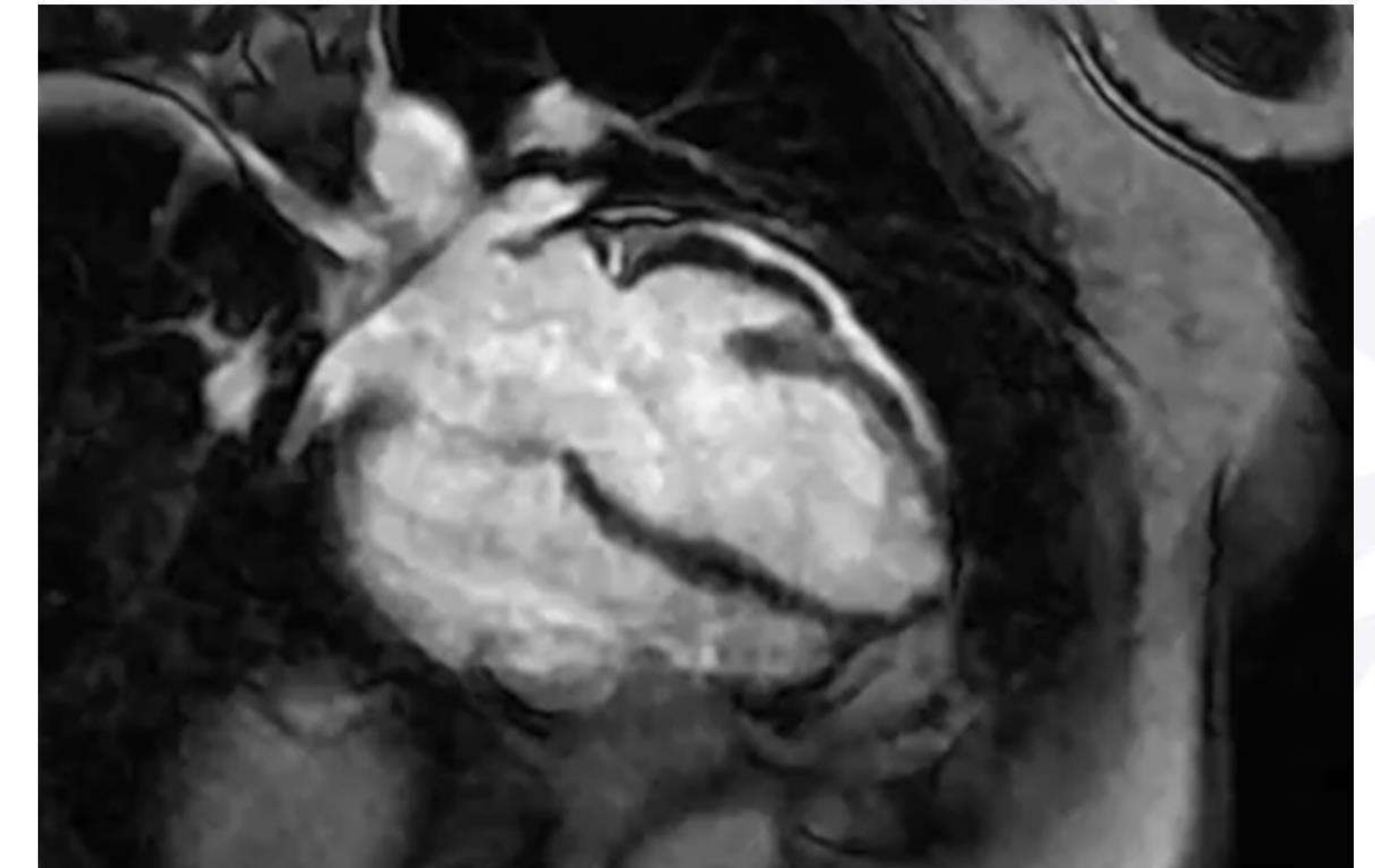
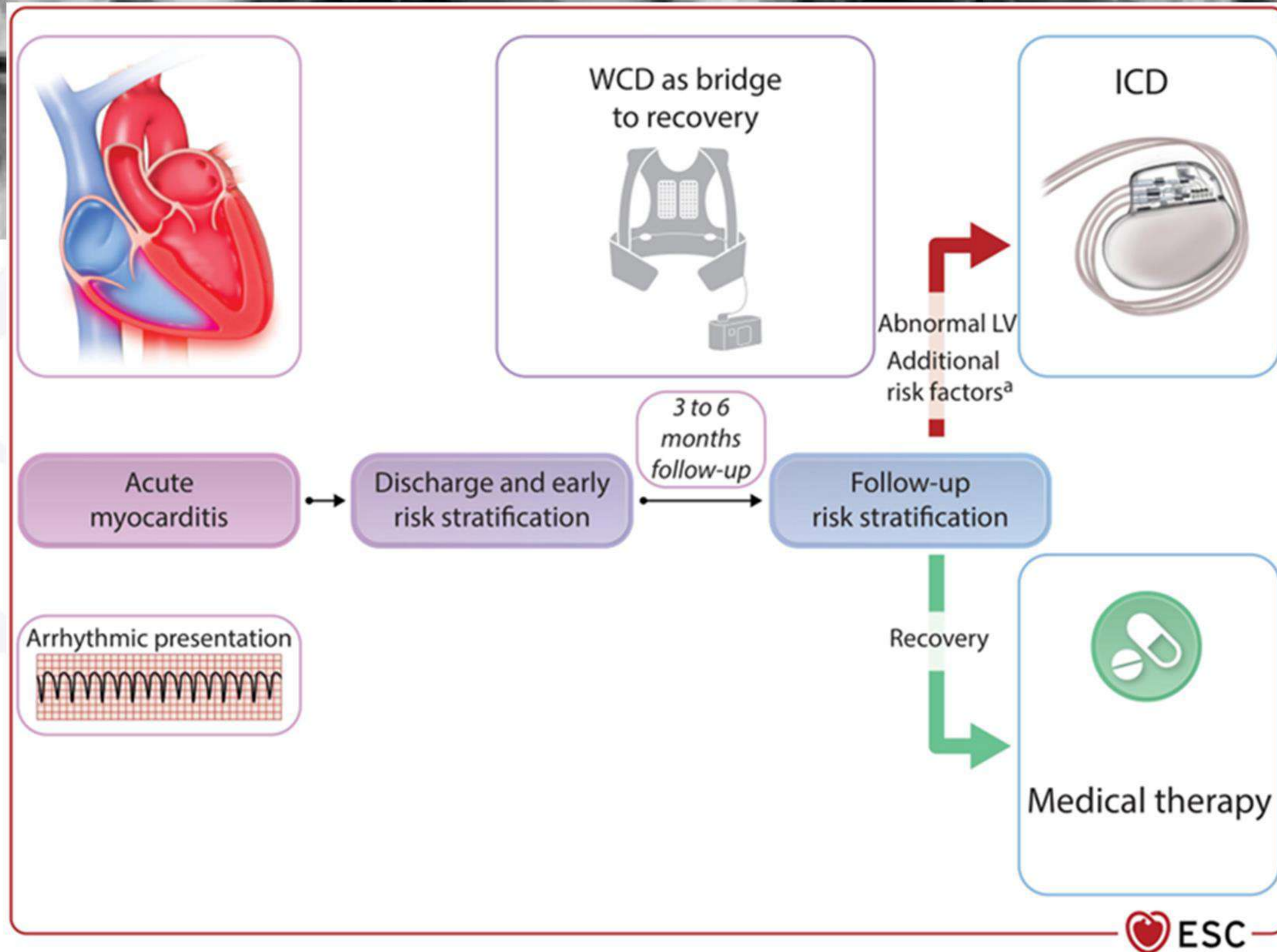
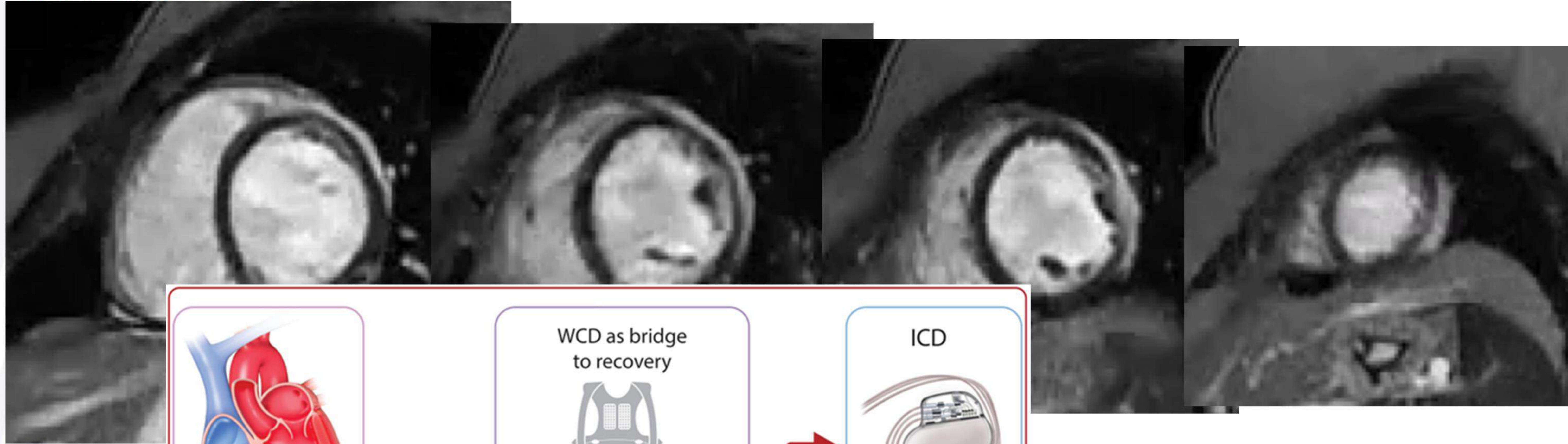
Non-Ischemico



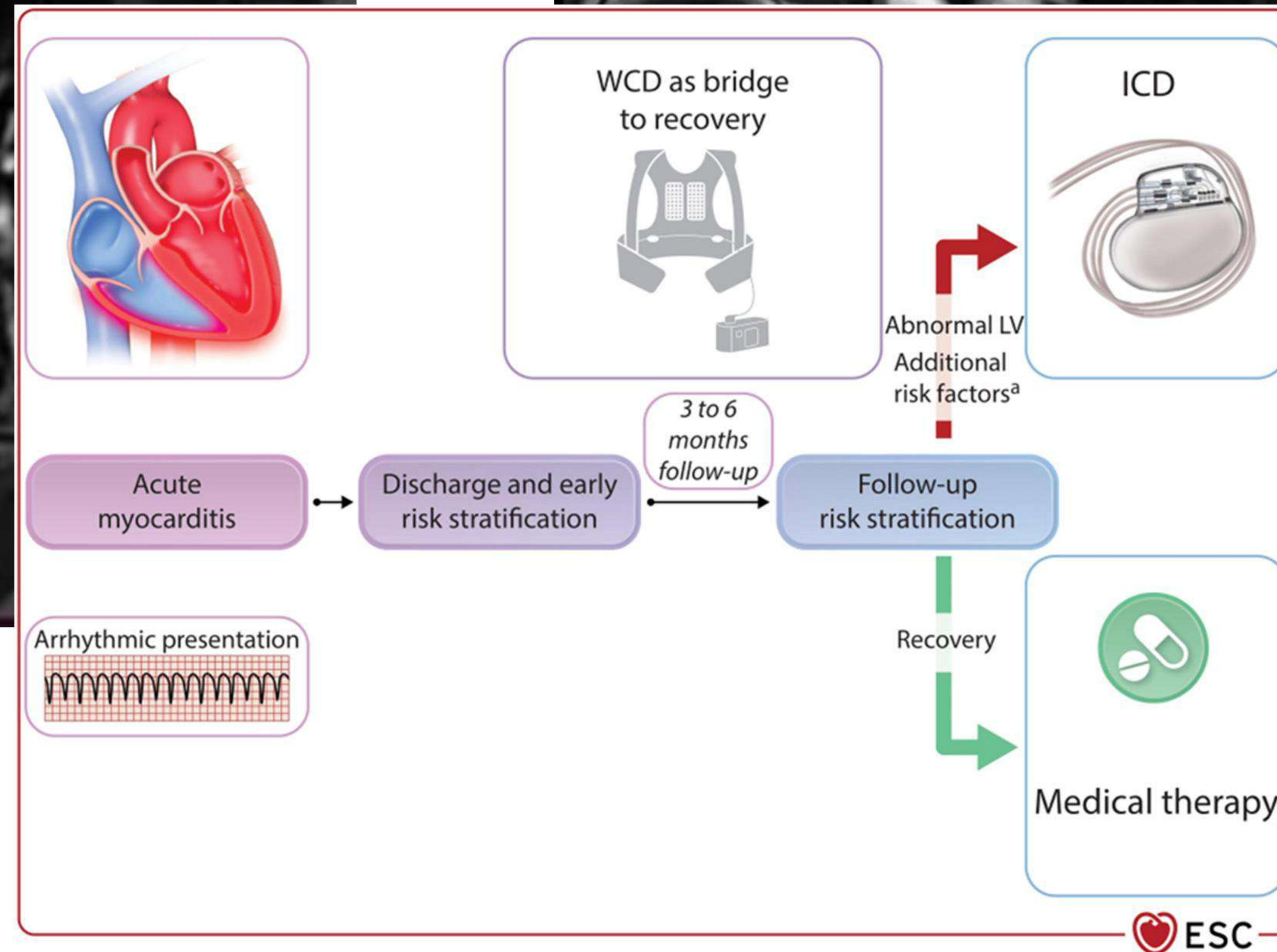
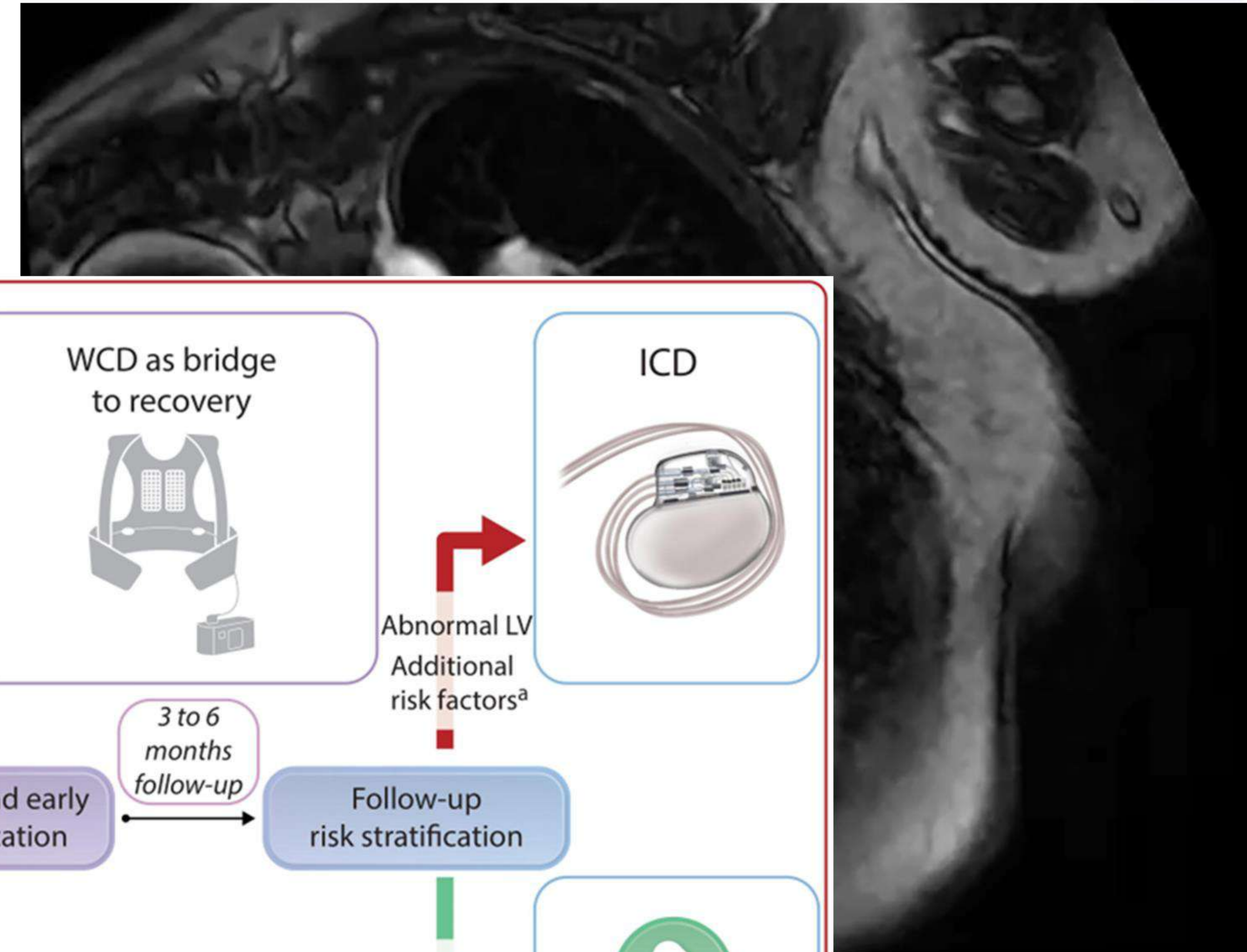
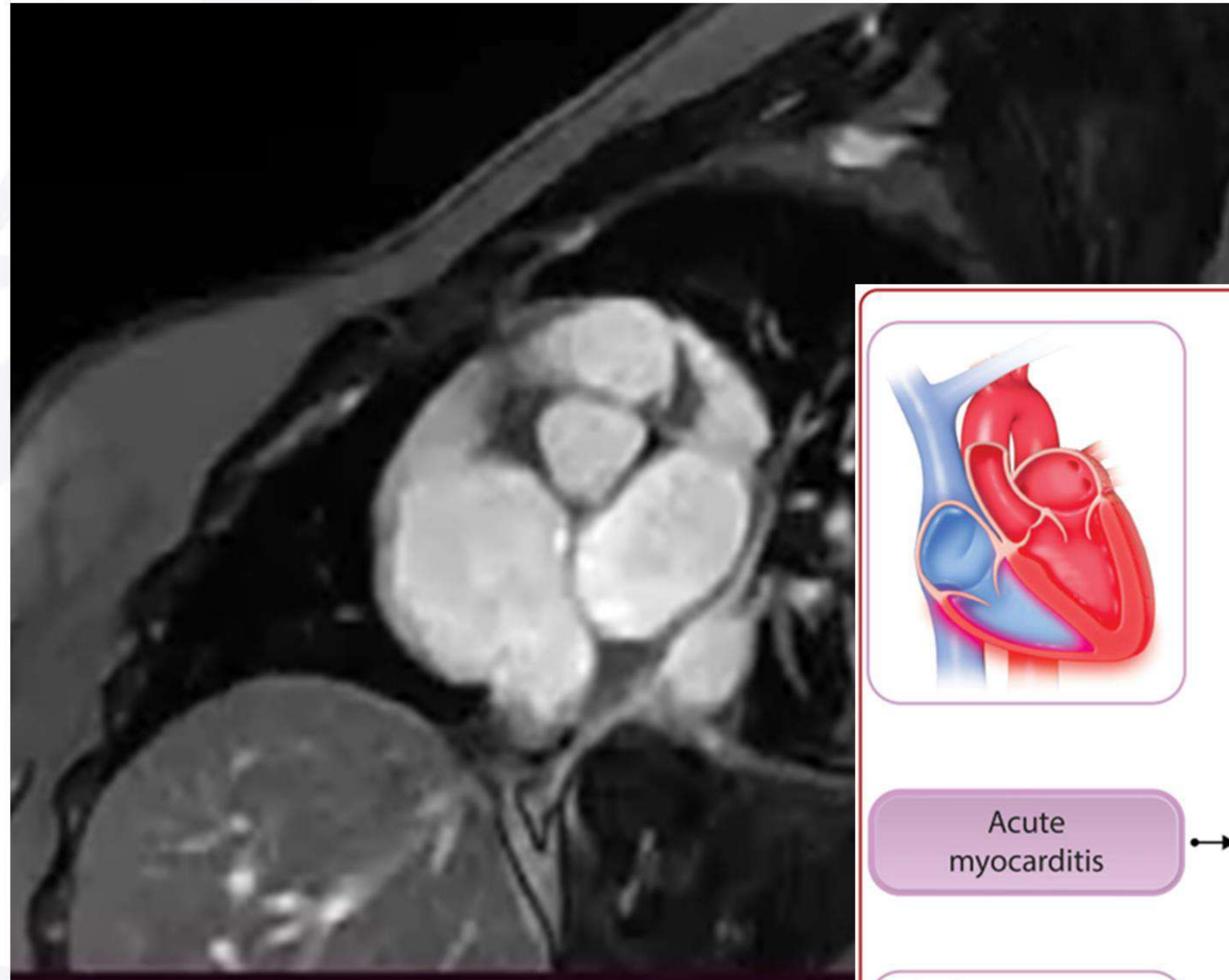
RMN cine, T2W



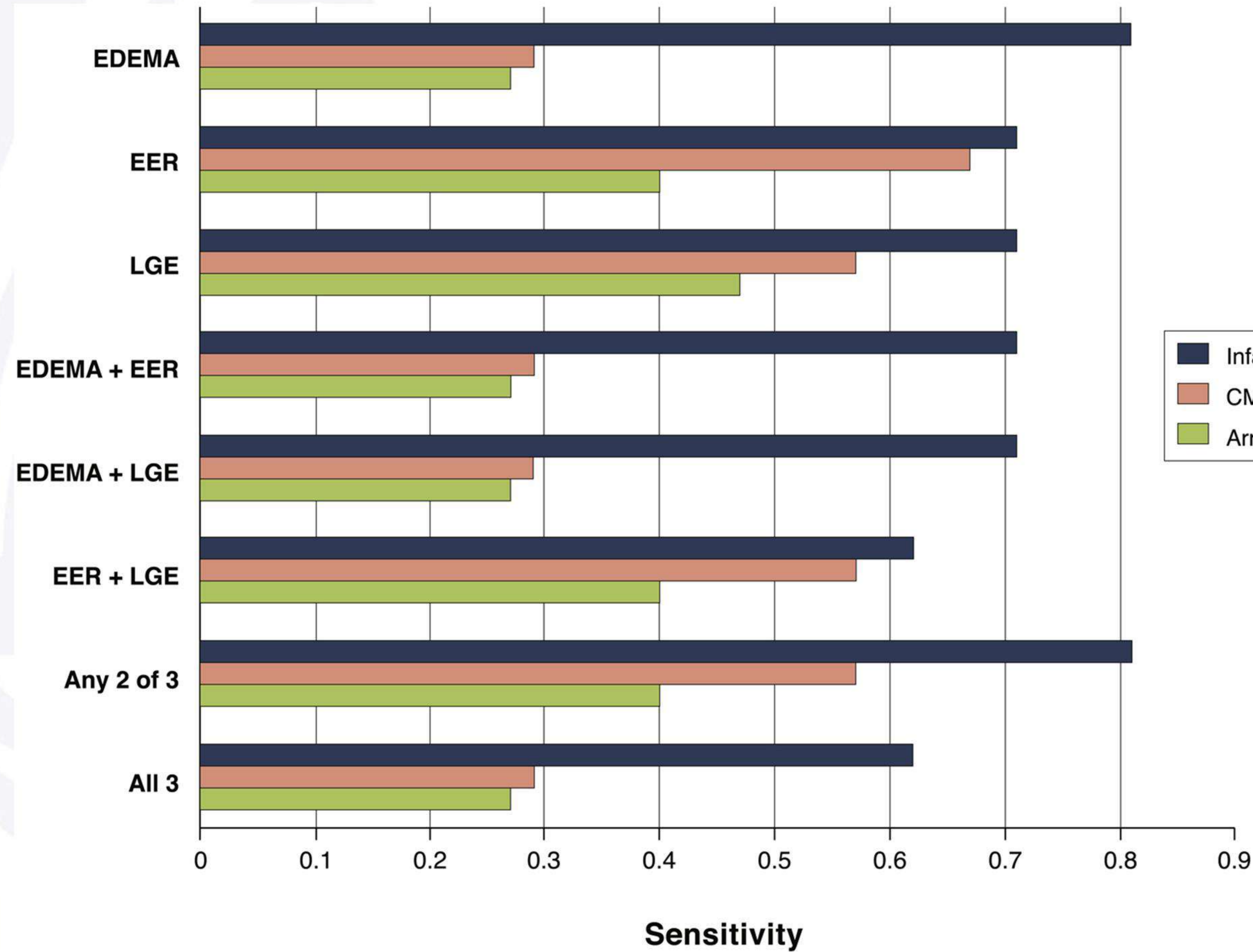
RMN LGE



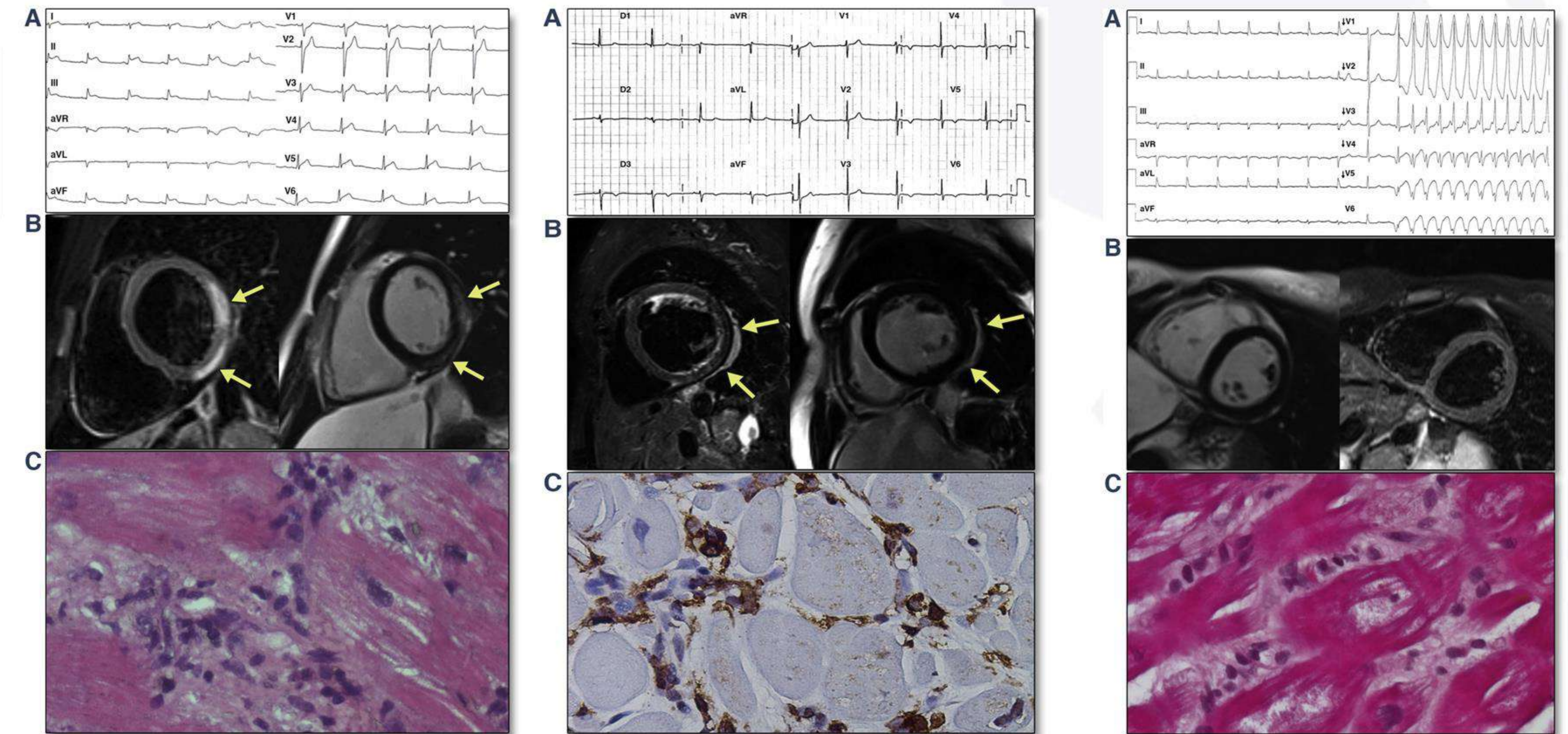
RMN LGE



Sensibilità diagnostica dell'edema e dell'enhancement precoce e tardivo del gadolinio alla CMR nei 3 modelli di miocardite acuta

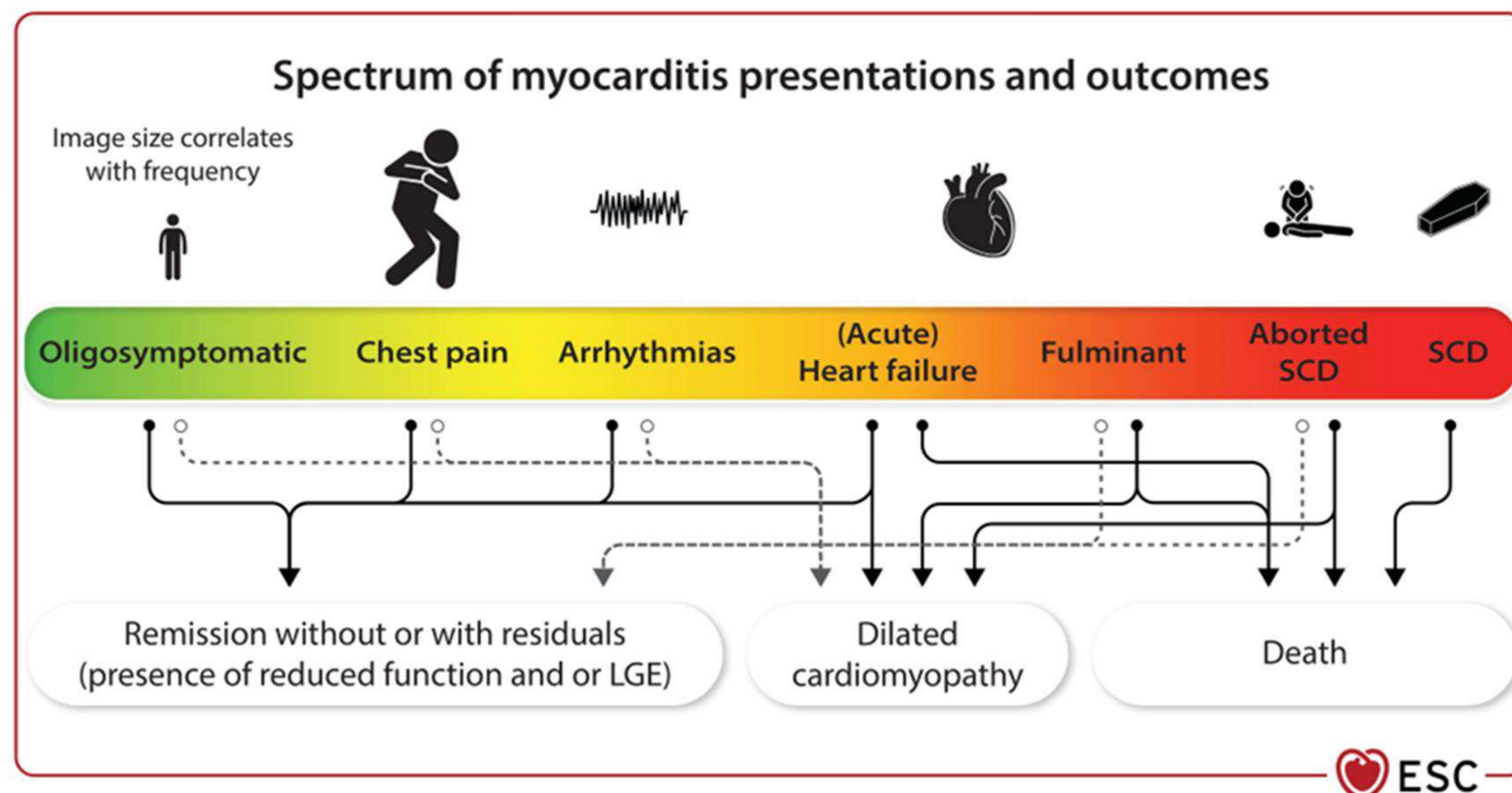


L'esecuzione della rmn in questi pz è difficile inoltre bisogna ricordare i limiti della metodica in questi paziente ricordare lo studio di Francone che dimostrava la minore sensibilità nei paz con presentazione sc rispetto alle altre. Fare un accenno alle tempistiche.



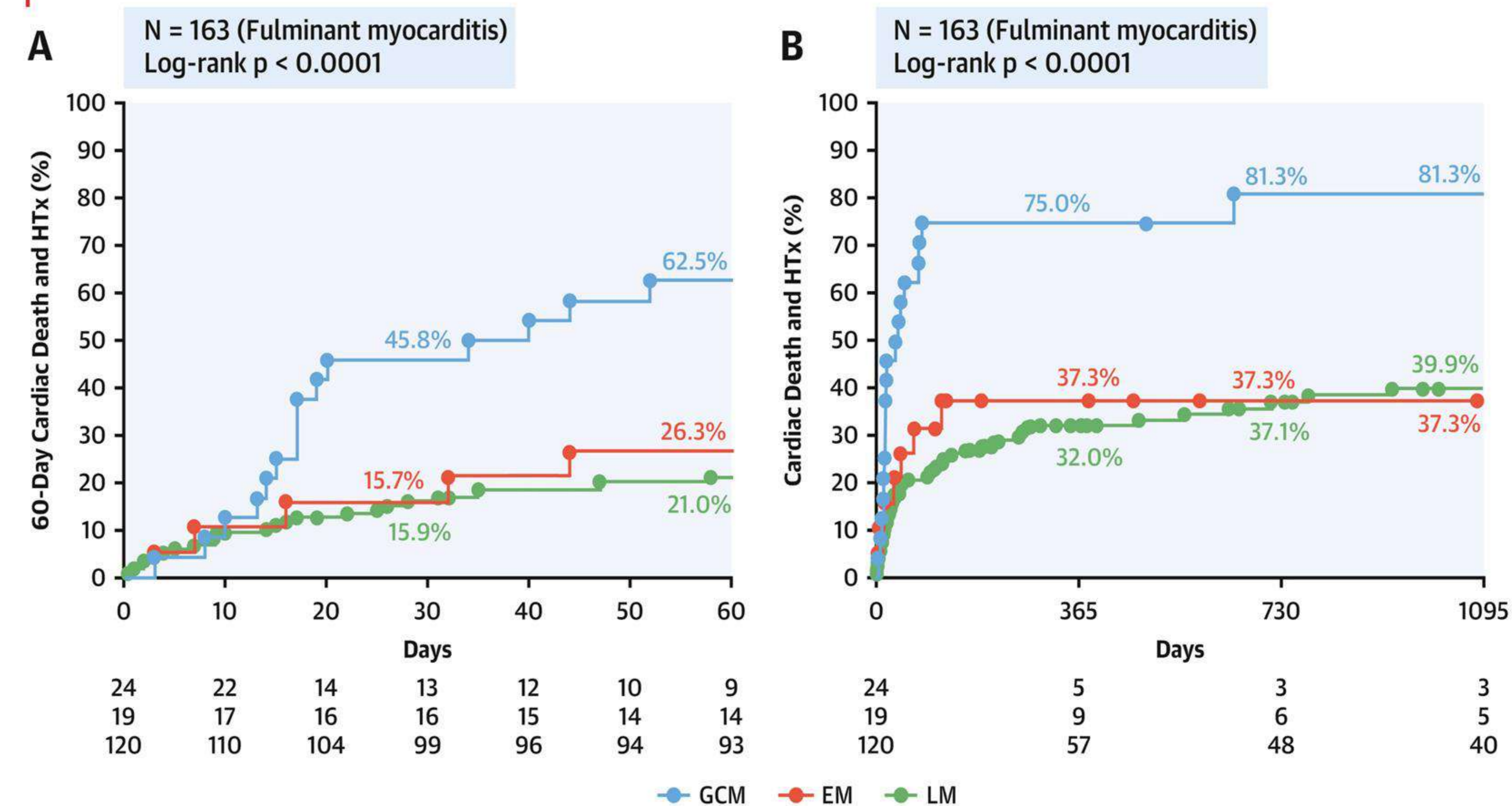
Franconi M et al J Am Coll Cardiol Img 2014 ;7:254-63

Cosa vogliamo di più?

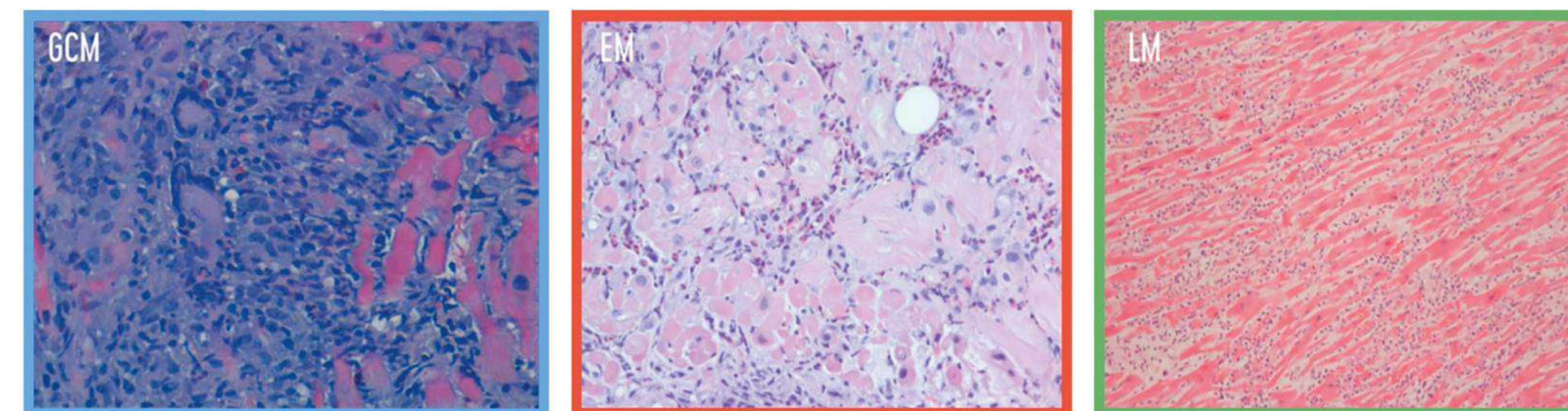


- 50% guarigione spontanea
- 25% disfunzione cardiaca stabile persistente
- 10%-25% presenta una disfunzione ventricolare progressiva, che potrebbe portare a cardiomiopatia dilatativa allo stadio terminale, trapianto di cuore o morte

CENTRAL ILLUSTRATION: Outcome in Histologically Proven Fulminant Myocarditis Versus Acute Nonfulminant Myocarditis With Left Ventricular Systolic Dysfunction

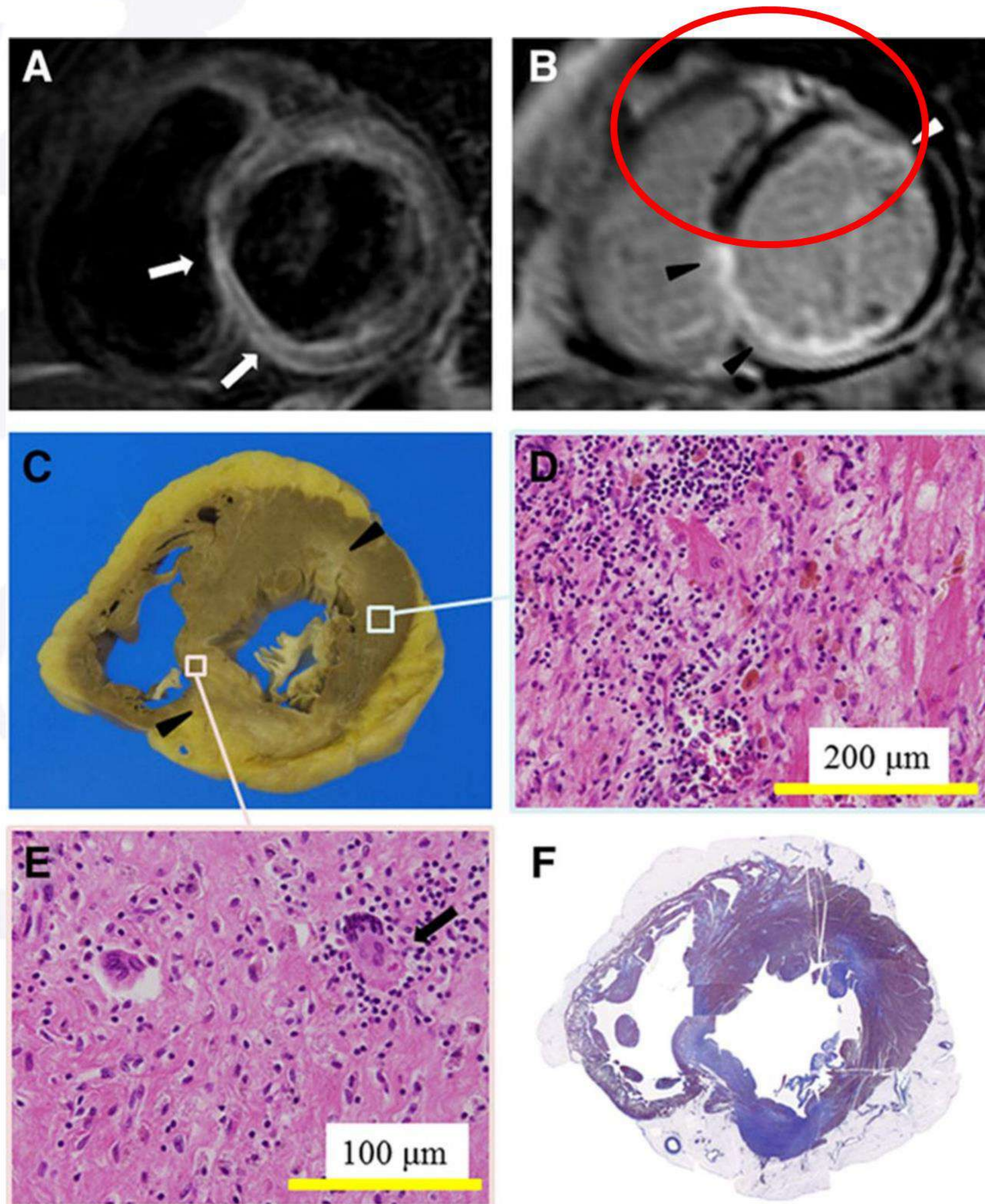


C

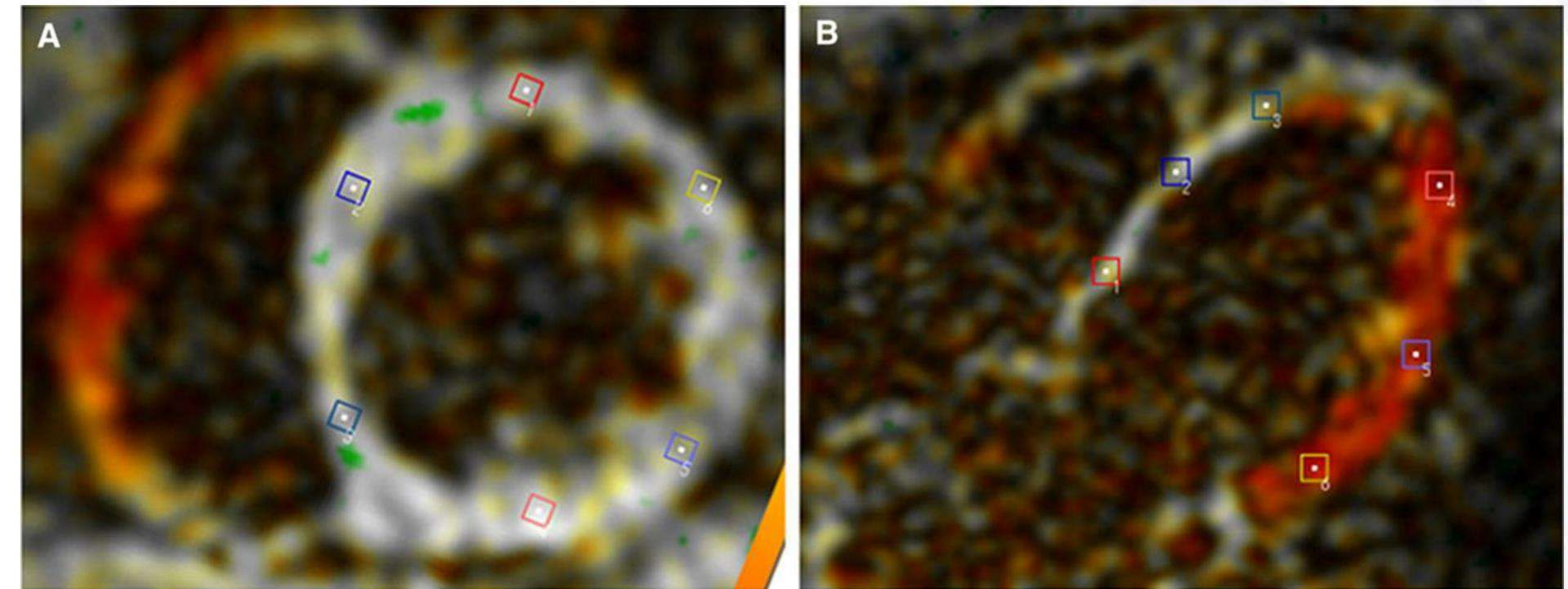


Ammirati, E. et al. J Am Coll Cardiol. 2019;74(3):299-311.

Miocardite a Cellule Giganti



Strain



Cardiac MRI in giant cell myocarditis: interesting associations with clinical and pathological features. Yasumori Sujino et al. *Circulation*, Volume 129 , Number 17