SISTEMA SANITARIO REGIONALE
AZIENDA OSPEDALIERO-UNIVERSITARIA SANT'ANDREA

Cardio-TC/RM
WEBINAR FAD

Dal 16 maggio 2024 all'11 Luglio 2024

PROGRAMMA

16 Maggio – ore 17.00/18.00
Introduzione al Corso (A. Laghi)
Saluti Direzione Generale AOUSA (D. Donetti)
Tecnica di acquisizione della Cardio TC/Utilizzo del Mdc e Triple-rule-out (D. Caruso)

23 Maggio – ore 17.00/18.00
Anatomia coronarica (L. Pugliese)

30 Maggio – ore 17.00/18.00
Caratteristiche di placca: calcifica, non calcifica, vulnerabile (D. De Santis)

6 Giugno – ore 17.00/18.00
La definizione della stenosi secondo CAD-RADS v.2 (D. De Santis)

13 Giugno – ore 17.00/18.00
Indicazione alla Cardio RM, protocollo di acquisizione e sequenze principali (D. De Santis)

27 Giugno – ore 17.00/18.00
Patologia infiammatoria (miocarditi, pericarditi) (D. De Santis)

4 Luglio – ore 17.00/18.00
Cardiopatia ischemica (L. Pugliese)

11 Luglio – ore 17.00/18.00
Cardiomiopatie (ipertrofica, dilatativa, aritmogena) e patologie da Accumulo (L. Pugliese)

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Il **Corso Webinar CardioTC** e **CardioRM** del Sant'Andrea 2024 è un corso di Cardio TC (Tomografia Computerizzata) e Cardio RM (Risonanza Magnetica) progettato per fornire ai discenti una comprensione approfondita delle due principali tecniche di imaging cardiaco utilizzate nella pratica clinica moderna.
Questo corso mira a fornire una panoramica completa dei principi di base, delle applicazioni cliniche e delle sfide associate all'uso della TC e della RM nel contesto della valutazione cardiaca. Il corso inizia con una discussione delle tecniche di acquisizione della Cardio TC, compreso l'uso dei mezzi di contrasto e i protocolli come il "Triple-rule- out". I discenti impareranno a interpretare le immagini TC per valutare l'anatomia coronarica, identificare caratteristiche delle placche aterosclerotiche e definire stenosi coronariche secondo il sistema CAD-RADS.
Successivamente, il focus si sposta sulla Cardio RM, esplorando le indicazioni per questo tipo di imaging, i protocolli di acquisizione e le sequenze principali utilizzate per valutare la struttura e la funzione cardiaca per diagnosticare patologie cardiache, tra cui infiammazioni miocardiche, cardiomiopatie e malattie da accumulo.

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Segreteria Scientifica
Prof. Andrea Laghi – Dott. Damiano Caruso
U.O.C. di Radiologia
AOU Sant'Andrea Sapienza Università di Roma

GE HealthCare

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Patologia infiammatoria:
Miocarditi e Pericarditi

Dr. Tiziano Polidori, MD

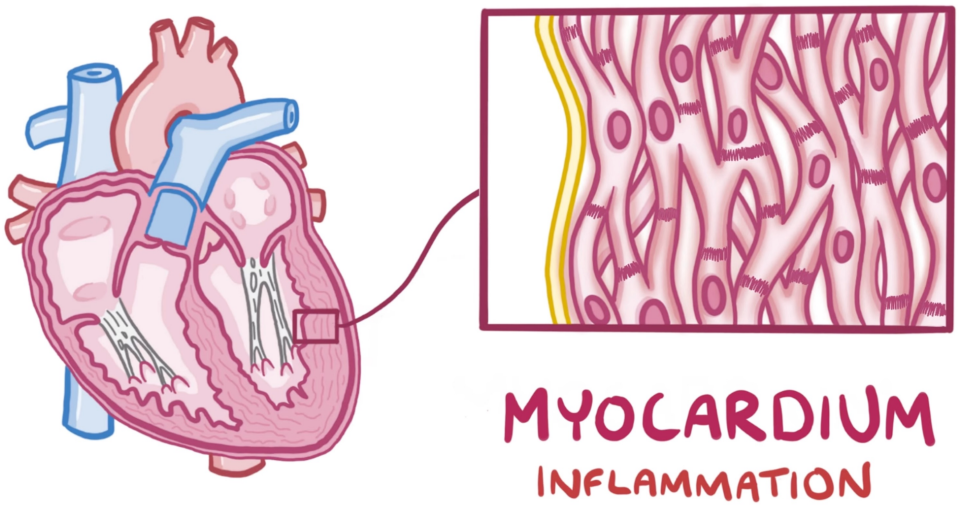
Dept of Medical-Surgical Science and Translational Imaging

Sapienza - University of Rome

tiziano.polidori@uniroma1.it

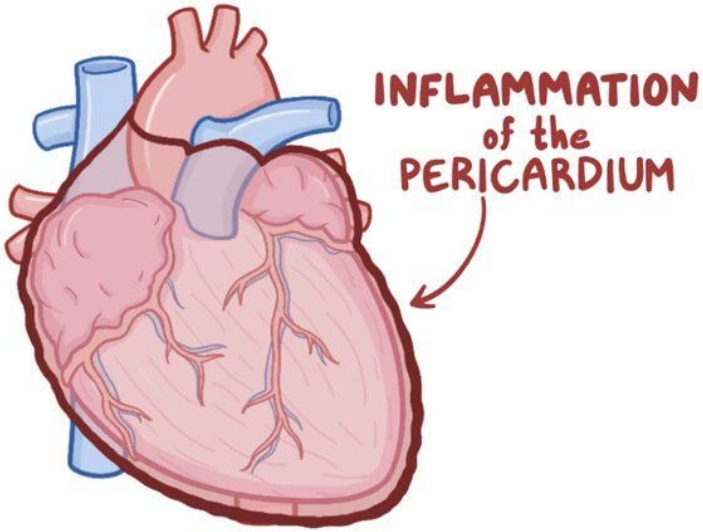
CARDIAC INFLAMMATORY DISEASE

MYOCARDITIS



Inflammatory condition of the heart muscle (myocardium).

PERICARDITIS



Inflammation of the pericardium, the thin, two-layered sac-like membrane that surrounds the heart.

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CARDIAC INFLAMMATORY DISEASE

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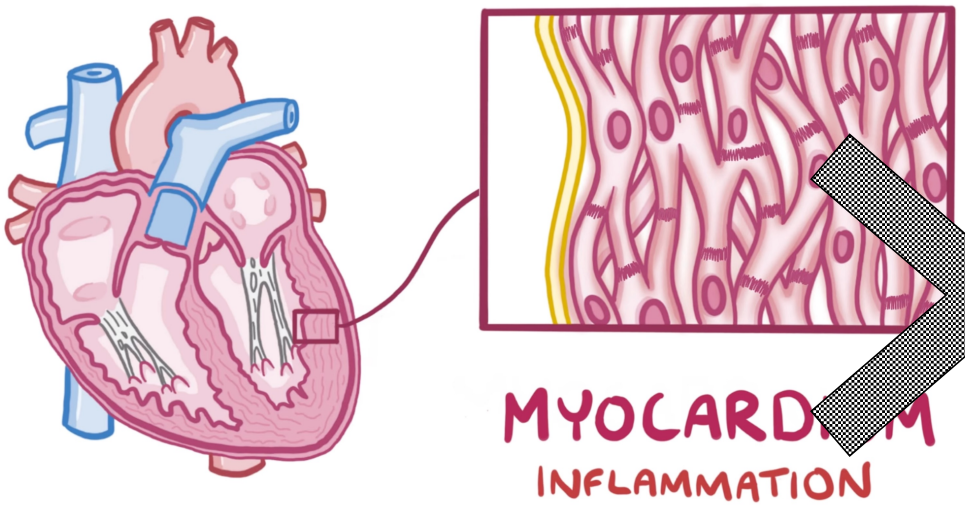
MYOCARDITIS



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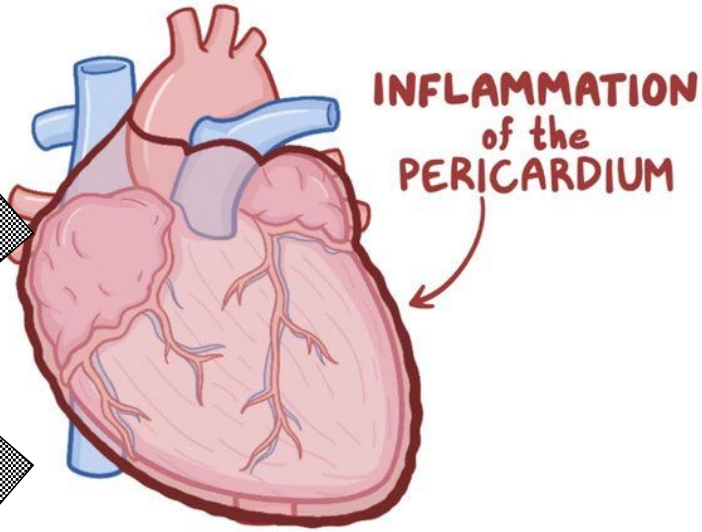
PERICARDITIS



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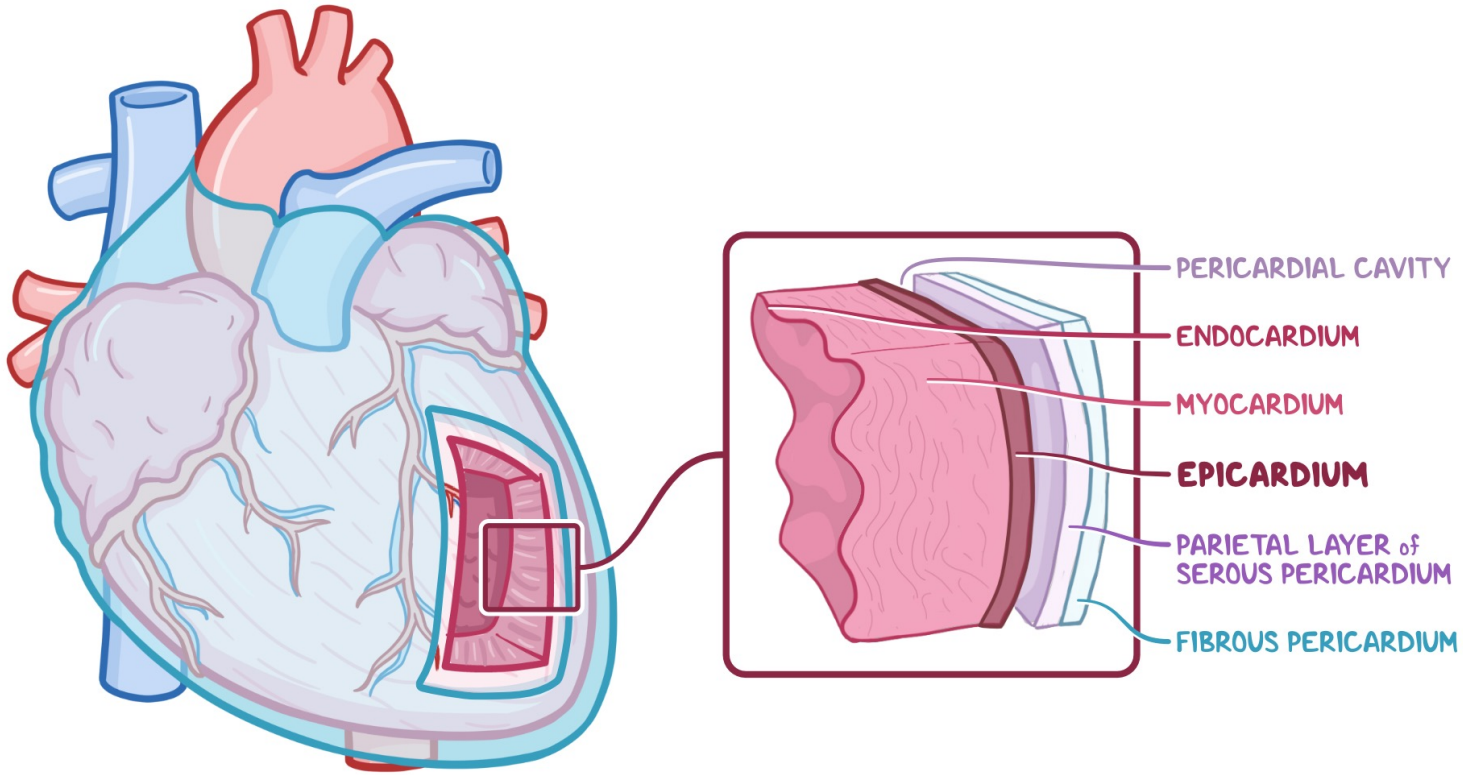

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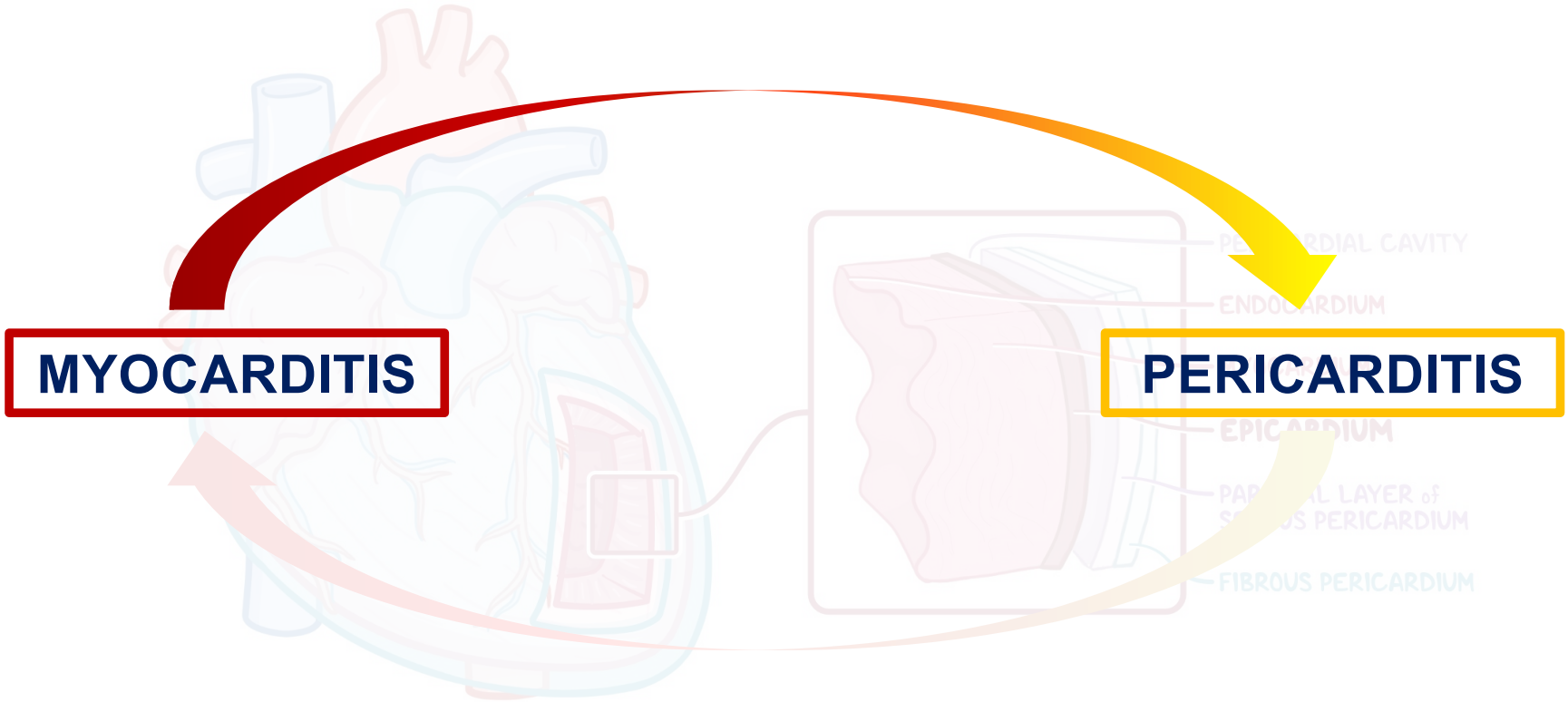

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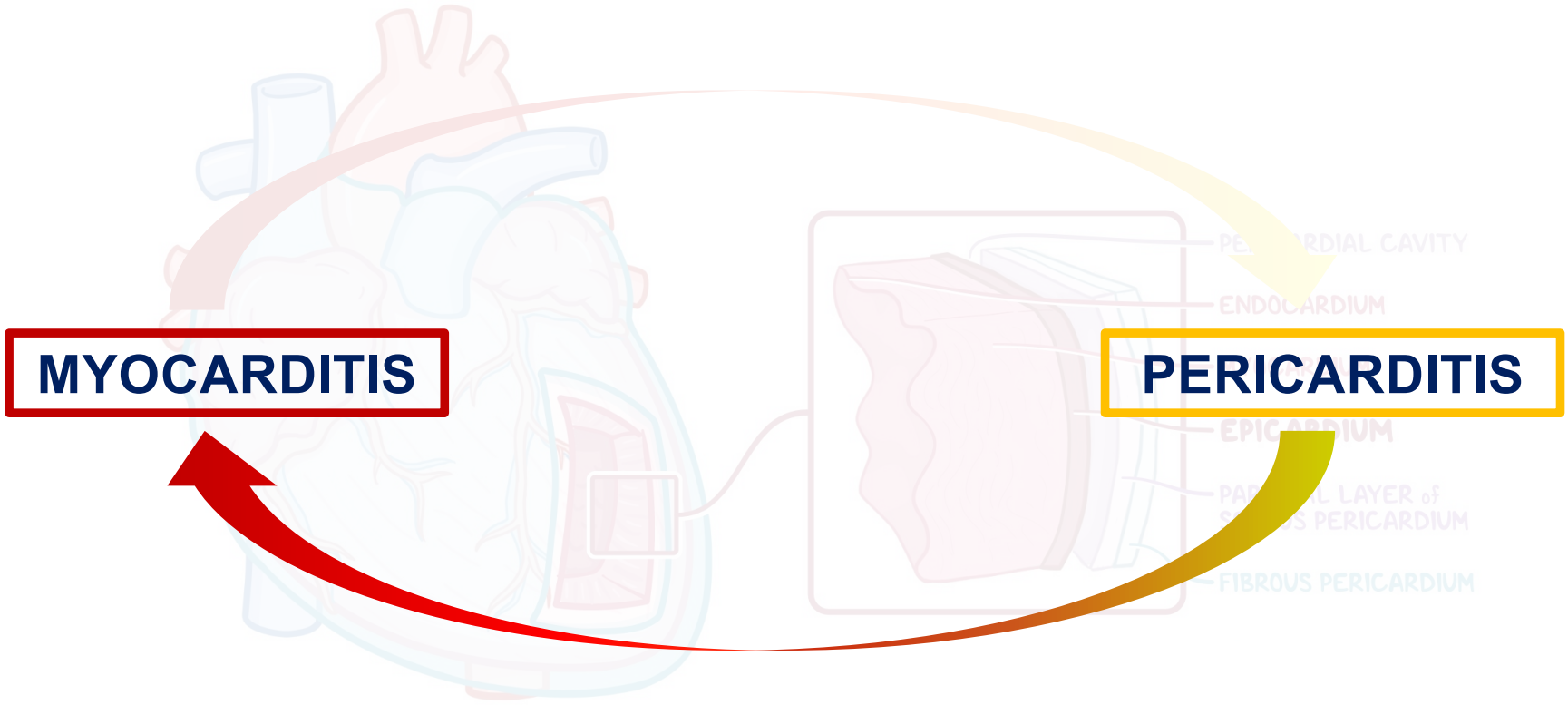

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CARDIAC INFLAMMATORY DISEASE

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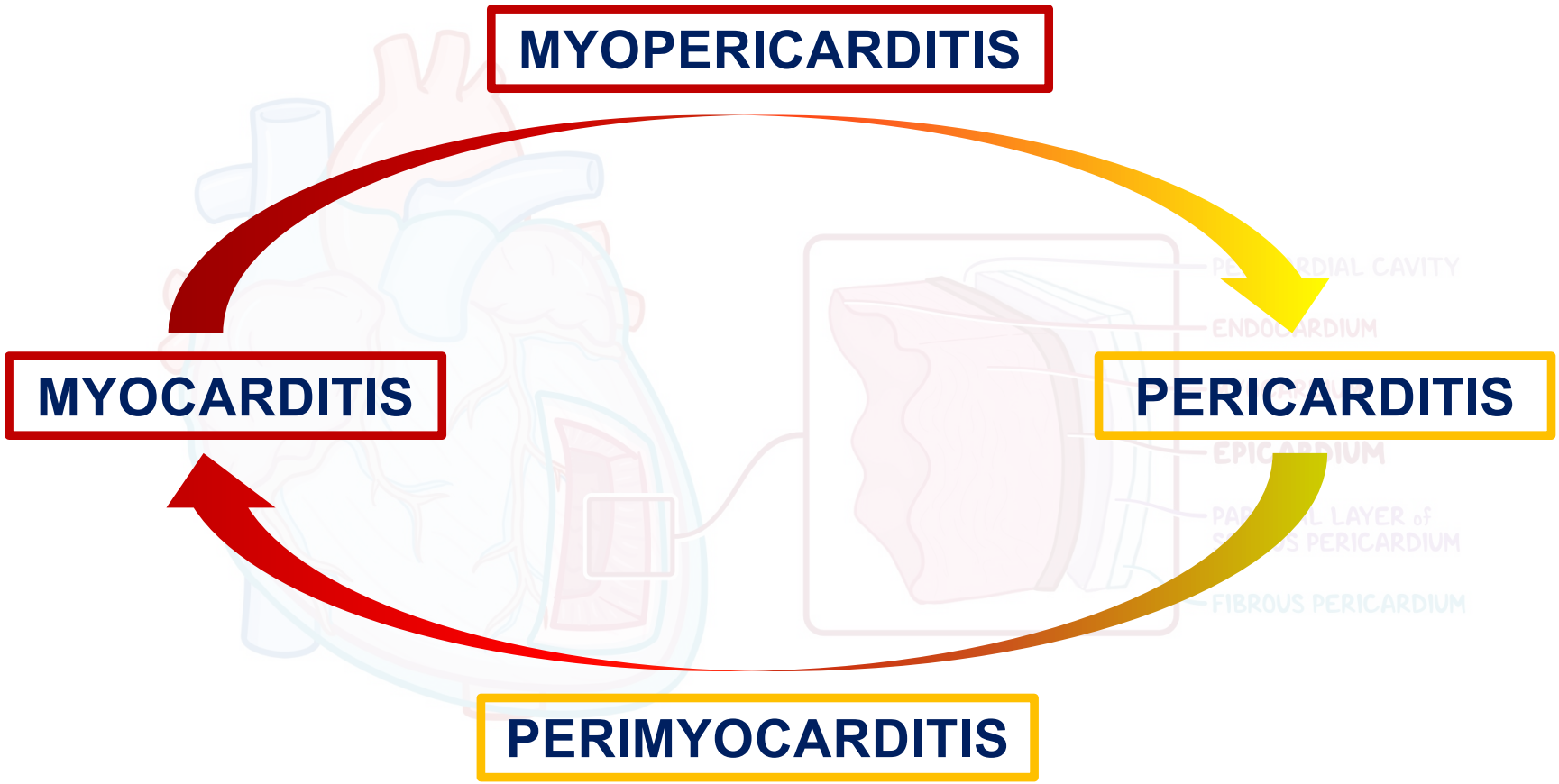
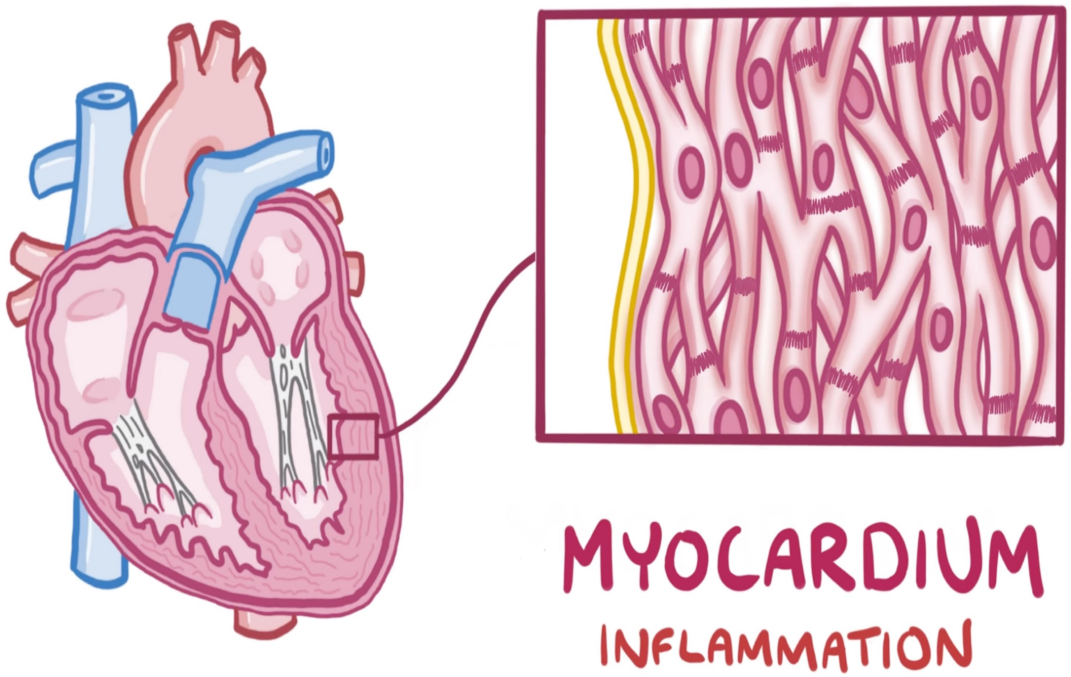


MYOCARDITIS

- 1 to 10 cases per 100,000 people per year.
- 12% of young adults (<40 y) who die suddenly.
- incidence increases following certain viral infections → 1-5% of cases following a viral infection (coxsackievirus, adenovirus, pB19).



Kindermann I, Barth C, Mahfoud F, et al. "Update on myocarditis." *Journal of the American College of Cardiology*. 2012;59(9):779-792.

MYOCARDITIS - ETIOLOGY

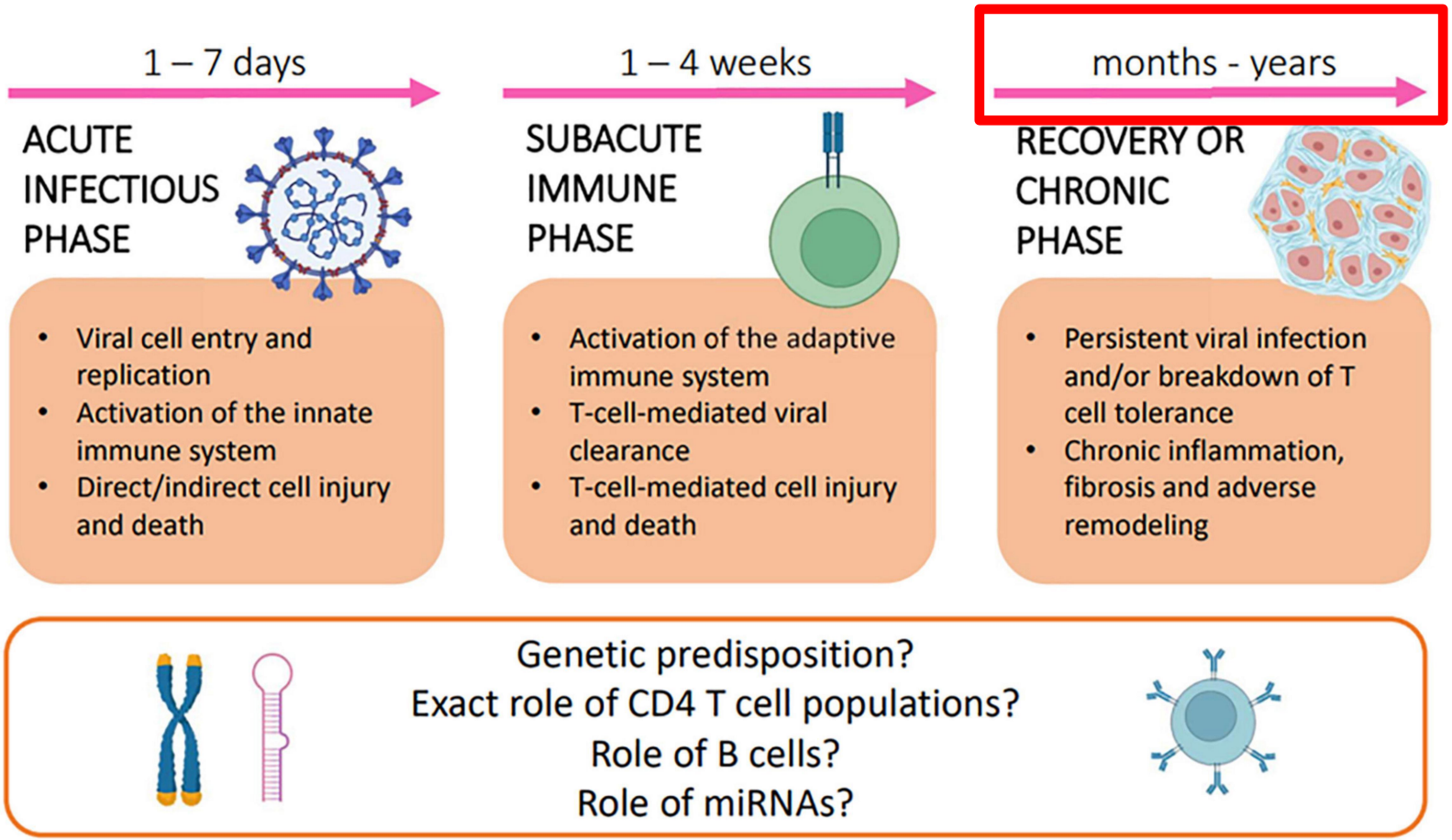
Table I Causes of myocarditis/inflammatory cardiomyopathy

1. Infectious myocarditis	
Bacterial	*Staphylococcus, Streptococcus, Pneumococcus, Meningococcus, Gonococcus, Salmonella, Corynebacterium diphtheriae, Haemophilus influenzae, Mycobacterium* (tuberculosis), *Mycoplasma pneumoniae, Brucella*
Spirochaetal	*Borrelia* (Lyme disease), *Leptospira* (Weil disease)
Fungal	*Aspergillus, Actinomyces, Blastomyces, Candida, Coccidioides, Cryptococcus, Histoplasma, Mucormycoses, Nocardia, Sporothrix*
Protozoal	*Trypanosoma cruzi, Toxoplasma gondii, Entamoeba, Leishmania*
Parasitic	*Trichinella spiralis, Echinococcus granulosus, Taenia solium*
Rickettsial	*Coxiella burnetii* (Q fever), *R. rickettsii* (Rocky Mountain spotted fever), *R. tsutsugamuschi*
Viral	RNA viruses: Coxsackieviruses A and B, echoviruses, polioviruses, influenza A and B viruses, respiratory syncytial virus, mumps virus, measles virus, rubella virus, hepatitis C virus, dengue virus, yellow fever virus, Chikungunya virus, Junin virus, Lassa fever virus, rabies virus, human immunodeficiency virus-1 DNA viruses: adenoviruses, parvovirus B19, cytomegalovirus, human herpes virus-6, Epstein-Barr virus, varicella-zoster virus, herpes simplex virus, variola virus, vaccinia virus
2. Immune-mediated myocarditis	
Allergens	Tetanus toxoid, vaccines, serum sickness Drugs: penicillin, cefaclor, colchicine, furosemide, isoniazid, lidocaine, tetracycline, sulfonamides, phenytoin, phenylbutazone, methyldopa, thiazide diuretics, amitriptyline
Alloantigens	Heart transplant rejection
Autoantigens	Infection-negative lymphocytic, infection-negative giant cell Associated with autoimmune or immune-oriented disorders: systemic lupus erythematosus, rheumatoid arthritis, Churg-Strauss syndrome, Kawasaki's disease, inflammatory bowel disease, scleroderma, polymyositis, myasthenia gravis, insulin-dependent diabetes mellitus, thyrotoxicosis, sarcoidosis, Wegener's granulomatosis, rheumatic heart disease (rheumatic fever)
3. Toxic myocarditis	
Drugs	Amphetamines, anthracyclines, cocaine, cyclophosphamide, ethanol, fluorouracil, lithium, catecholamines, hemetine, interleukin-2, trastuzumab, clozapine
Heavy metals	Copper, iron, lead (rare, more commonly cause intramyocyte accumulation)
Miscellaneous	Scorpion sting, snake, and spider bites, bee and wasp stings, carbon monoxide, inhalants, phosphorus, arsenic, sodium azide
Hormones	Phaeochromocytoma, vitamins: beri–beri
Physical agents	Radiation, electric shock

- Infectous (Viral)
- Immune-mediated (Autoimmune)
- Toxic

Caforio ALP, et al. Current state of knowledge on aetiology, diagnosis, management, and therapy of myocarditis: a position statement of the European Society of Cardiology Working Group on Myocardial and Pericardial Diseases. European Heart Journal. 2013;34(33):2636-2648. doi:10.1093/eurheartj/eht210

MYOCARDITIS - PATHOPHYSIOLOGY



Liu P, Mason J. Advances in the understanding of myocarditis. Circulation 2001;104:1076–82.

MYOCARDITIS - SIMPTOMS

Clinical Presentation

- Chest pain (up to 95% of cases);
- Dyspnea (up to 49% of cases);
- Other typical but non-specific symptoms (fatigue, palpitations, and syncope)

MYOCARDITIS

There are 3 more dramatic modes of presentation associated with acute myocarditis.

- Myocarditis may manifest as acute onset of **heart failure** in a previously healthy person.
- It may masquerade as an **acute coronary syndrome** (ACS).
- **Arrhythmias** including ventricular tachycardia may be the leading symptom, sometimes manifesting as sudden cardiac death.

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MYOCARDITIS – NON INVASIVE TEST

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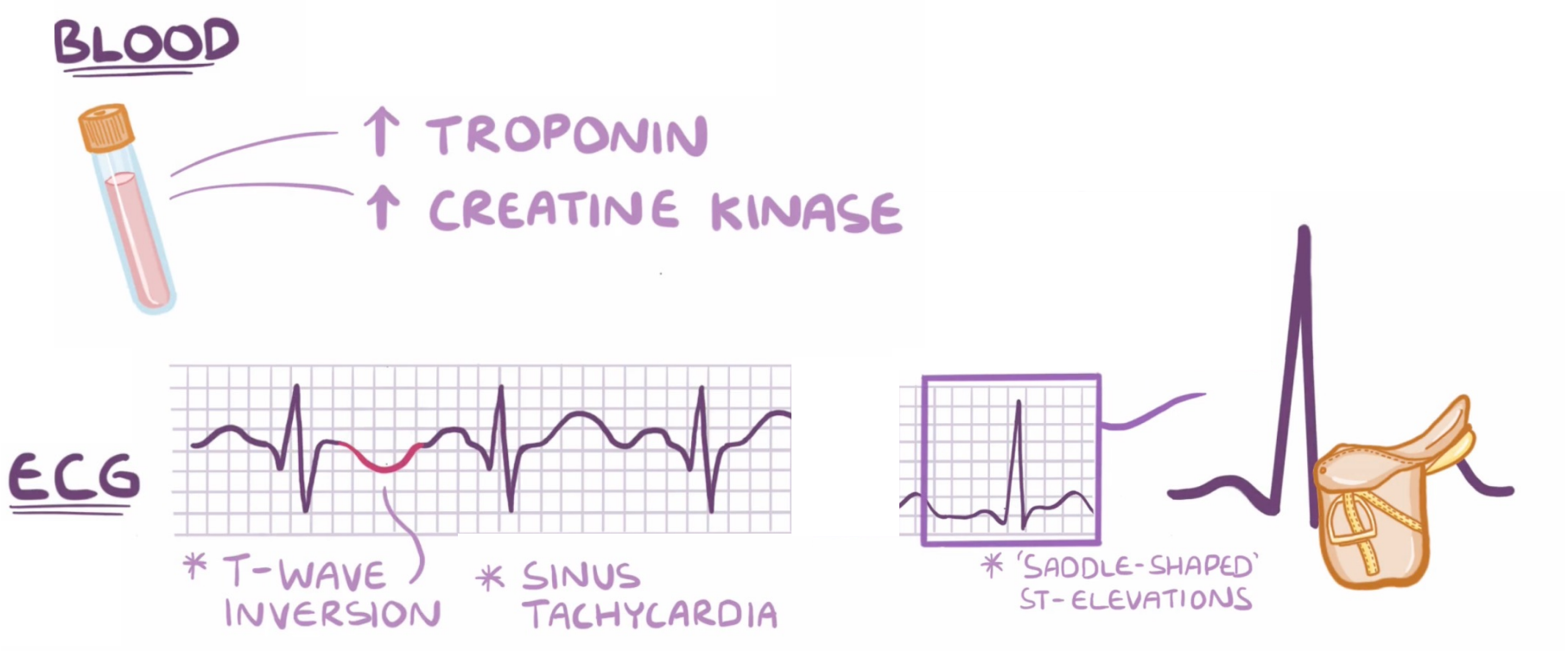
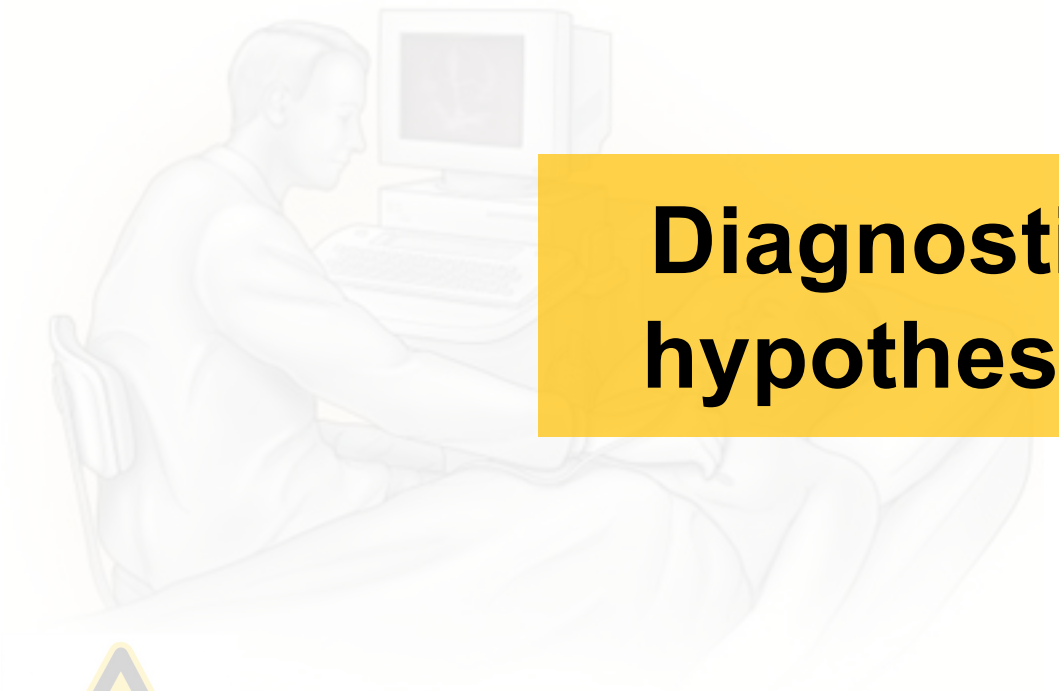


MYOCARDITIS - ECHOCARDIOGRAPHY

- Localized wall motion abnormalities including areas of **hypokinesia**, **akinesia**, and **dyskinesia**.

These nonspecific changes cannot be used to clearly differentiate acute myocardial infarction from myocarditis.

Goitein, Orly et al. “Acute myocarditis: noninvasive evaluation with cardiac MRI and transthoracic echocardiography.” AJR. American journal of roentgenology vol. 192,1 (2009): 254-8. doi:10.2214/AJR.08.1281



Diagnostic hypothesis

- Localized wall motion abnormalities including areas of **hypokinesia**, **akinesia**, and **dyskinesia**.

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MYOCARDITIS - ECHOCARDIOGRAPHY

Diagnosis

- Localized wall motion
- normalities including areas of
- **ookinesia**, **akinesia**, and
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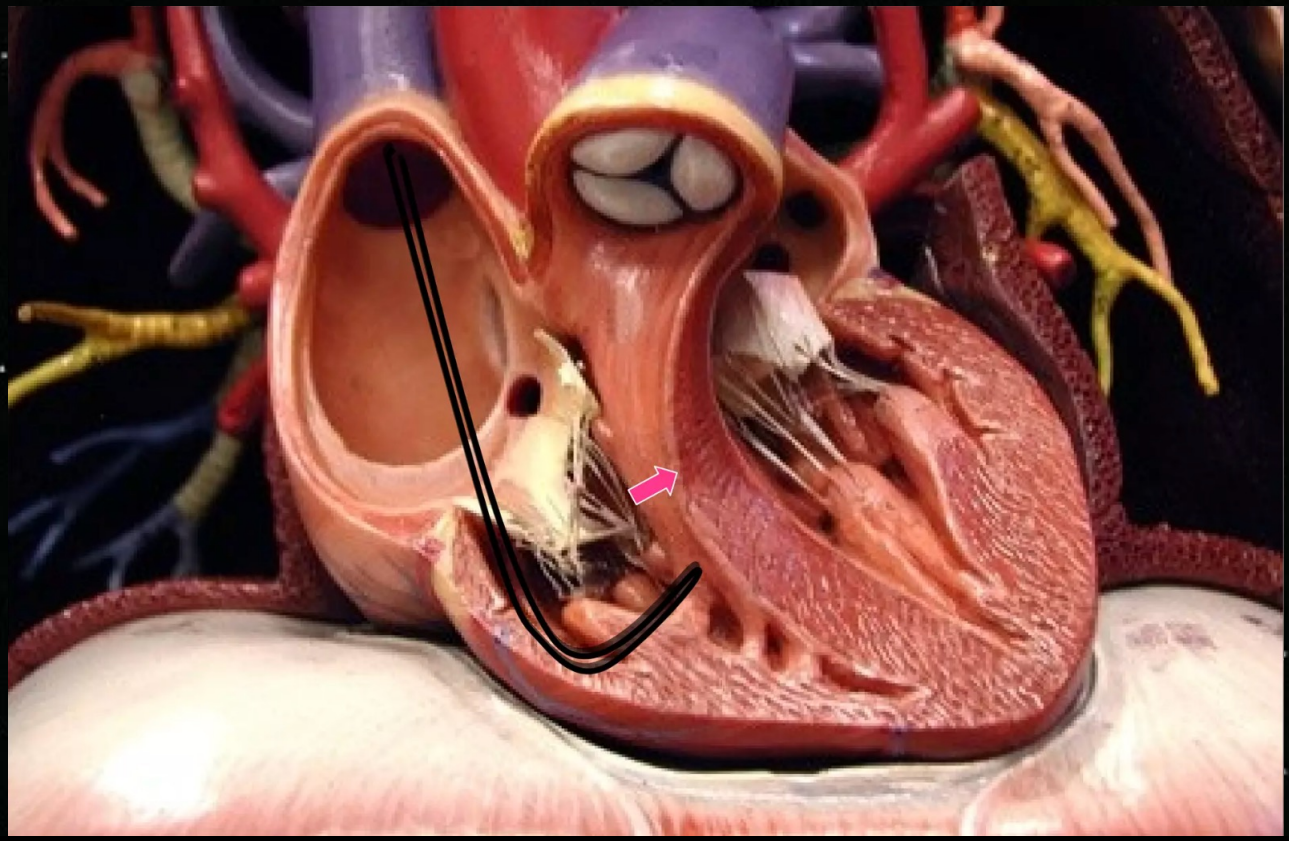

ENDOMYOCARDIAL BIOPSY

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MYOCARDITIS - CMR

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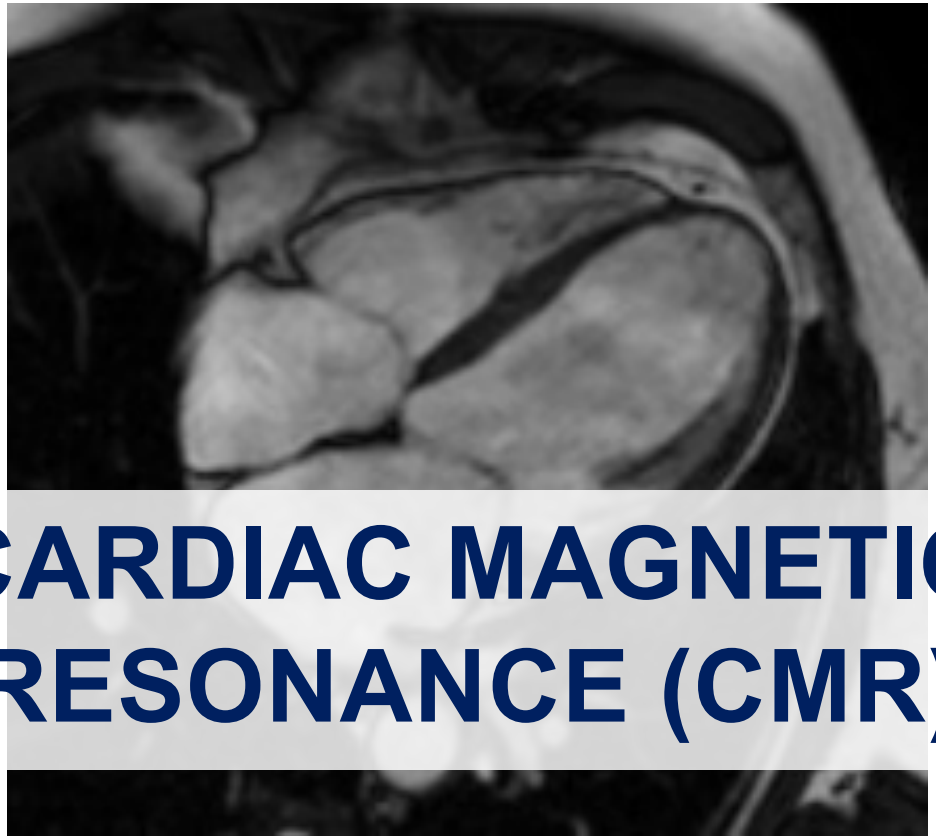


CARDIAC MAGNETIC RESONANCE (CMR)

MYOCARDITIS - CMR

ESC Guidelines

Table 33 Cardiac magnetic resonance in patients with suspected myocarditis[955,956]

Indication
Indicated at baseline, in all patients with clinical history + ECG, elevated troponin or echocardiographic abnormalities, and significant CAD excluded or unlikely.
Advised at follow-up in patients with persistent dysfunction at echocardiography, arrhythmias or ECG abnormalities.[a]

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure; European Heart Journal (2021), doi:10.1093/eurheartj/ehab368

MYOCARDITIS - CMR

Recommendations for specialized diagnostic tests for selected patients with chronic heart failure to detect reversible/treatable causes of heart failure

Recommendations	Class[a]	Level[b]
CMR		
CMR is recommended for the assessment of myocardial structure and function in those with poor echocardiogram acoustic windows.	I	C
CMR is recommended for the characterization of myocardial tissue in suspected infiltrative disease, Fabry disease, inflammatory disease (myocarditis), LV non-compaction, amyloid, sarcoidosis, iron overload/haemochromatosis.	I	C
CMR with LGE should be considered in DCM to distinguish between ischaemic and non-ischaemic myocardial damage.	IIa	C

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure; European Heart Journal (2021), doi:10.1093/eurheartj/ehab368

WHEN ENDOMYOCARDIAL BIOPSY?

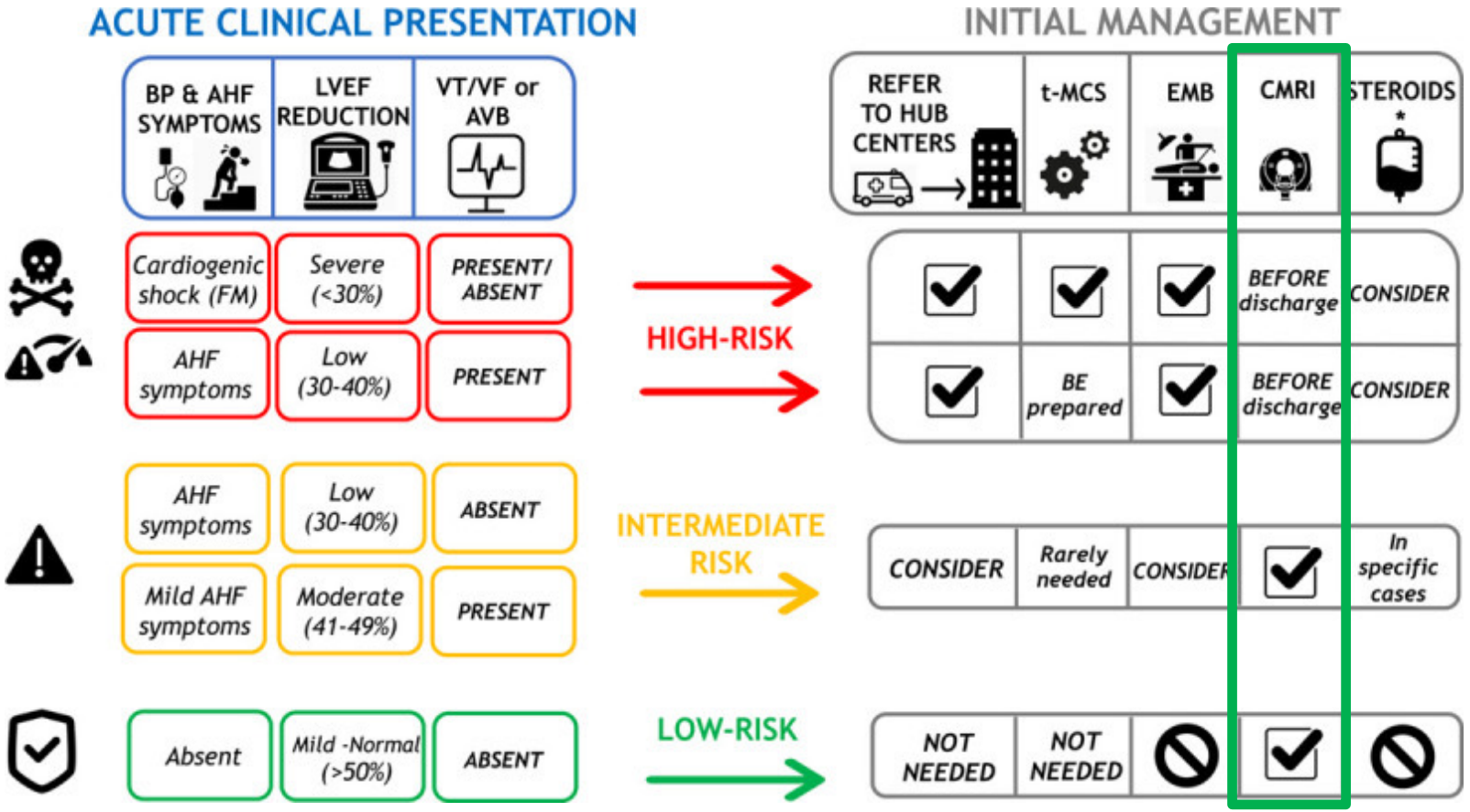
Table 32 **Endomyocardial biopsy in patients with suspected myocarditis**

Indication (see also section 4.3).
Progressive or persistent severe cardiac dysfunction and/or life-threatening ventricular arrhythmias and/or Mobitz type 2 second-degree or higher AV block with lack of short-term (<1-2 weeks) expected response to usual medical treatment.
The aim is to identify aetiology and to indicate specific treatment (e.g. giant cell myocarditis, eosinophilic myocarditis, cardiac sarcoidosis, systemic inflammatory disorders).[97,98,917,918,958]

EMB		
EMB should be considered in patients with rapidly progressive HF despite standard therapy when there is a probability of a specific diagnosis, which can be confirmed only in myocardial samples.[97,98]	IIa	C

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure; European Heart Journal (2021), doi:10.1093/eurheartj/ehab368

MYOCARDITIS - CMR



Ammirati E, et al. Management of Acute Myocarditis and Chronic Inflammatory Cardiomyopathy: An Expert Consensus Document. *Circ Heart Fail*. doi:10.1161/CIRCHEARTFAILURE.120.007405

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MYOCARDITIS - CMR

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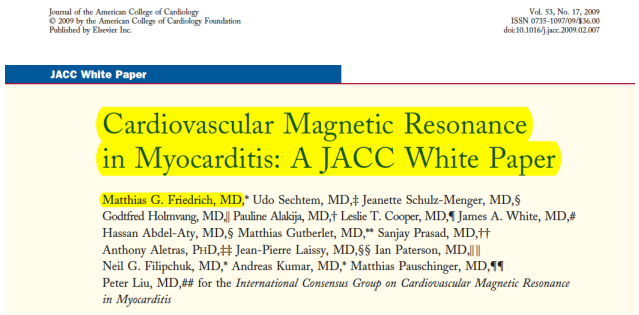

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doi:10.1016/j.jacc.2009.02.007

JACC White Paper

Cardiovascular Magnetic Resonance in Myocarditis: A JACC White Paper

Matthias G. Friedrich, MD,* Udo Sechtem, MD,† Jeanette Schulz-Menger, MD,§ 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*

Lake-Louise Criteria

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MYOCARDITIS - CMR

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JACC White Paper

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MYOCARDITIS - CMR

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Table 1

Published Controlled Studies on Cardiovascular Magnetic Resonance in Myocarditis

	Validation	No. of Patients	No. of Control Patients
Friedrich et al., *Circulation* 1998 (9)	Clinical	19	18
Laissy et al., *Chest* 2002 (11)	Clinical	20	7
Rieker et al., *Rofo* 2002 (36)	Clinical	11	10
Laissy et al., *Radiology* 2005 (37)*	Clinical	24	31
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	25	22
Mahrholdt et al., *Circulation* 2006 (40)	Histology	87	26
Gutberlet et al., *Radiology* 2008 (34)†	Histology	48	35
Yilmaz et al., *Heart* 2008 (43)†	Histology	55	30
Total		289	179

*Compared with patients with acute myocardial infarction. †Compared with patients with clinical evid… …histologic evidence for chronic myocarditis.

1998-2008

289 patients

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., *Circulation* 1998 (9)	Clinical	84	89	86	89	84
Laissy et al., *Chest* 2002 (11)	Clinical	85	100	89	100	70
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	80	68	74	74	75
Gutberlet et al., *Radiology* 2008 (34)	Histology	63	86	72	86	63
Pooled data (n = 194)		74	83	78	86	70
T2						
Rieker et al., *Rofo* 2002 (36)	Clinical	100	50	76	69	100
Laissy et al., *Chest* 2002 (11)	Clinical	45	100	59	100	39
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	84	74	79	78	81
Gutberlet et al., *Radiology* 2008 (34)	Histology	67	69	67	74	60
Pooled data (n = 178)		70	71	70	77	63
Late enhancement						
Rieker et al., *Rofo* 2002 (36)	Clinical	45	60	52	56	50
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (18)	Clinical	44	100	71	78	62
Mahrholdt et al., *Circulation* 2006 (40)	Histology	95	96	96	99	81
Gutberlet et al., *Radiology* 2008 (34)	Histology	27	80	49	65	44
Yilmaz et al., *Heart* 2008 (43)	Histology	35	83	51	81	38
Pooled data (n = 336)		59	86	68	89	53

MYOCARDITIS - CMR

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Pooled data (n = 336)		59	86	68	89	53

MYOCARDITIS - CMR

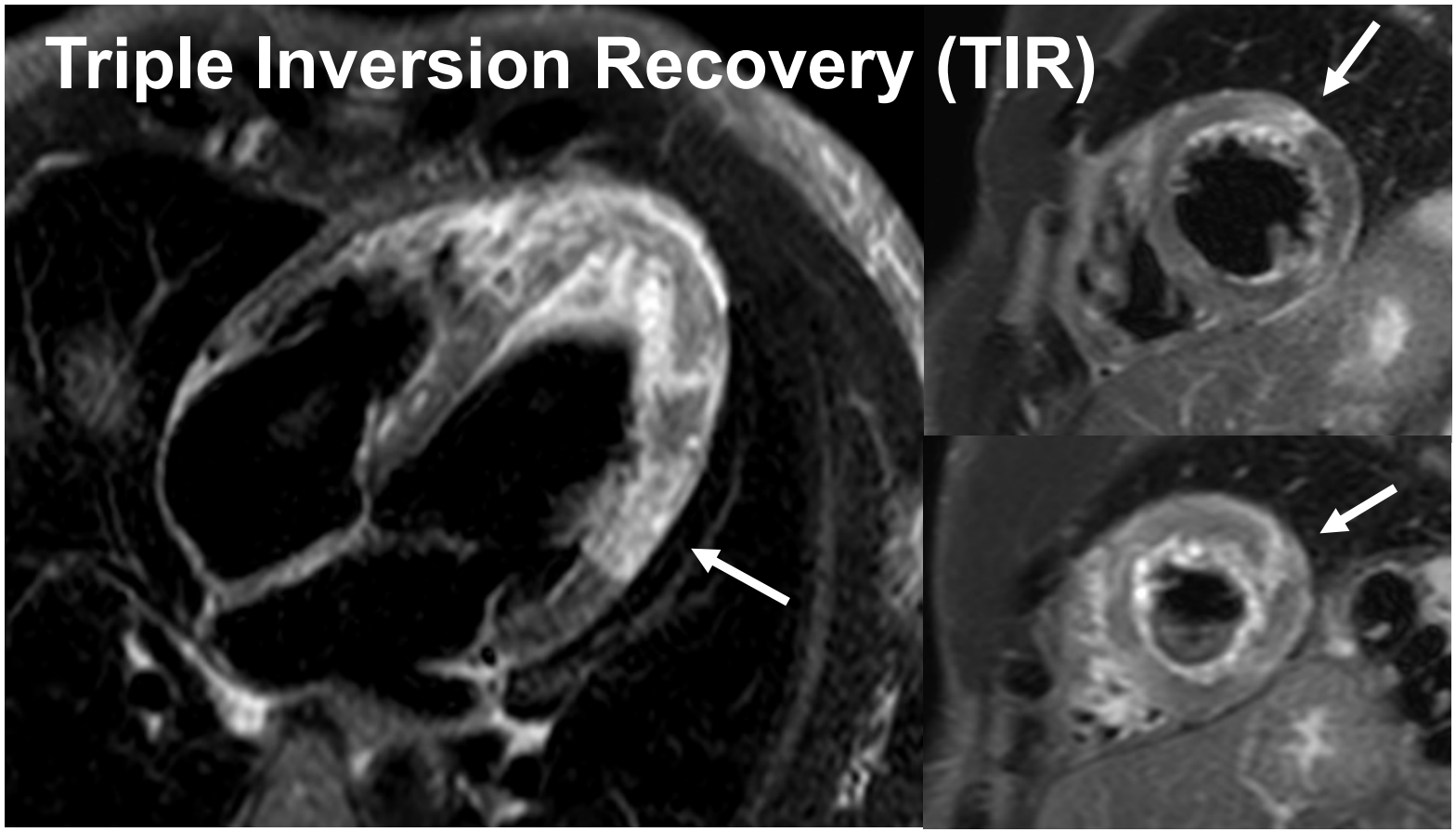
T2 (before CM)

T2-weighted triple inversion recovery (TIR) pulse sequence showed a significantly higher global myocardial signal intensity

Edema

MYOCARDITIS - CMR

T2 (before CM)



T2-W non cine sequences:

- ***Black Blood***
- ***Black Fat***
- ***Black Myocardium (soft tissue)***

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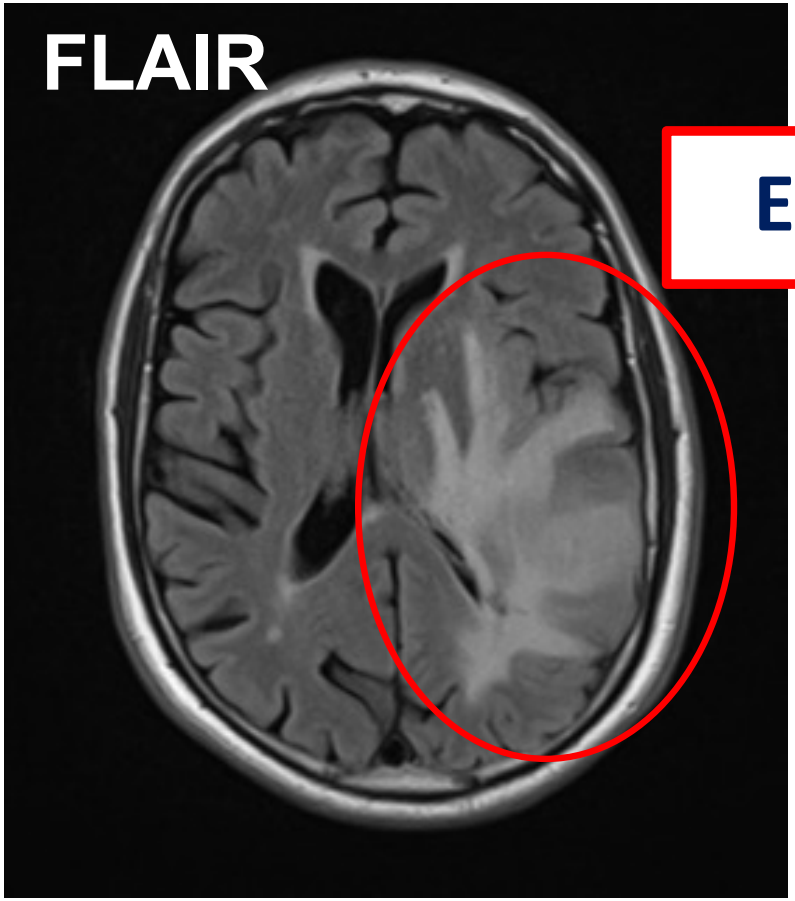
MYOCARDITIS - CMR

T2 (before CM)



Edema

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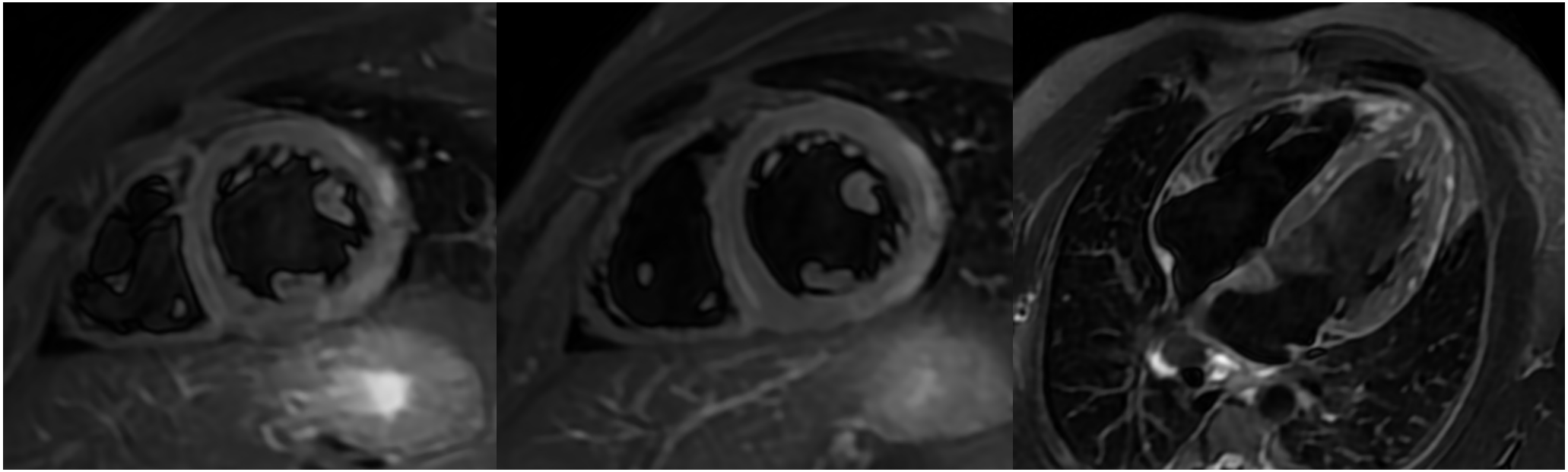
T2 (before CM)



Lateral and infero-lateral subepicardial edema

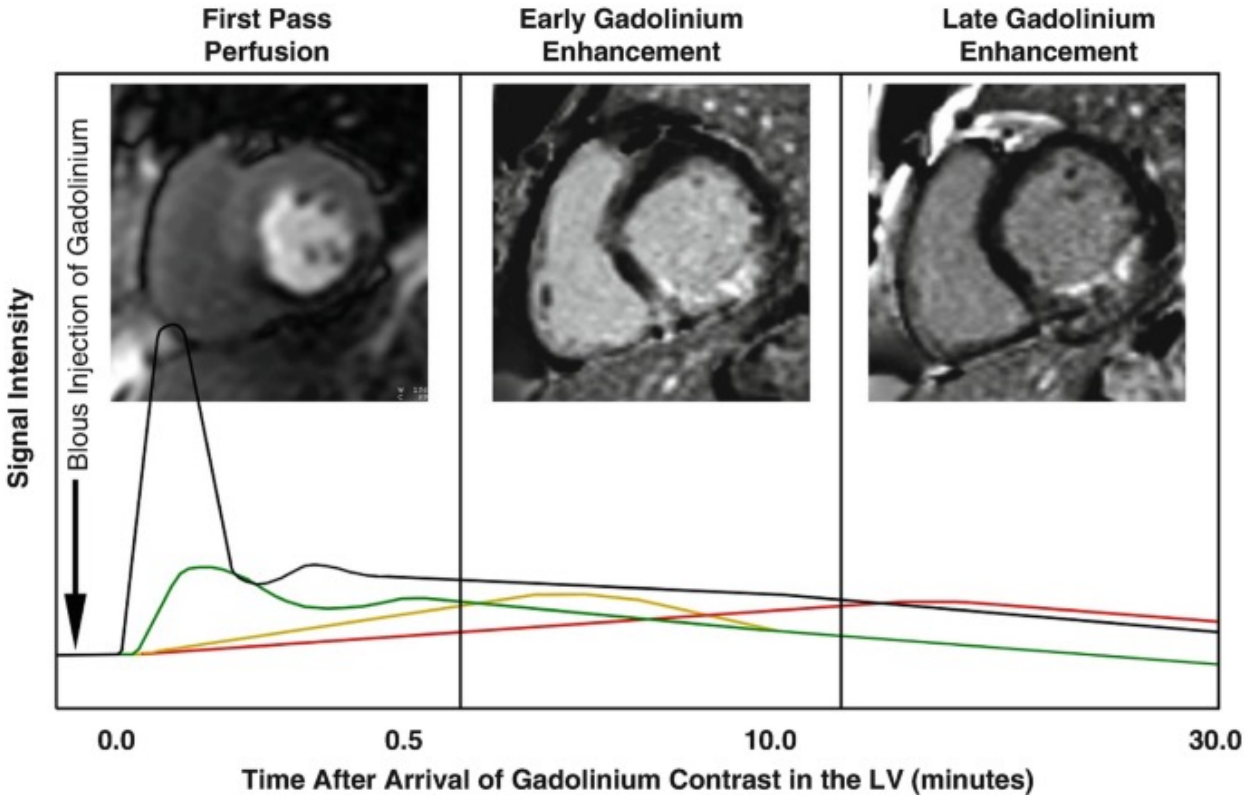
MYOCARDITIS - CMR

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., *Circulation* 1998 (9)	Clinical	84	89	86	89	84
Laissy et al., *Chest* 2002 (11)	Clinical	85	100	89	100	70
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	80	68	74	74	75
Gutberlet et al., *Radiology* 2008 (34)	Histology	63	86	72	86	63
Pooled data (n = 194)		74	83	78	86	70
T2						
Rieker et al., *Rofo* 2002 (36)	Clinical	100	50	76	69	100
Laissy et al., *Chest* 2002 (11)	Clinical	45	100	59	100	39
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	84	74	79	78	81
Gutberlet et al., *Radiology* 2008 (34)	Histology	67	69	67	74	60
Pooled data (n = 178)		70	71	70	77	63
Late enhancement						
Rieker et al., *Rofo* 2002 (36)	Clinical	45	60	52	56	50
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (18)	Clinical	44	100	71	78	62
Mahrholdt et al., *Circulation* 2006 (40)	Histology	95	96	96	99	81
Gutberlet et al., *Radiology* 2008 (34)	Histology	27	80	49	65	44
Yilmaz et al., *Heart* 2008 (43)	Histology	35	83	51	81	38
Pooled data (n = 336)		59	86	68	89	53

Early Gadolinium Enhancement (EGE)

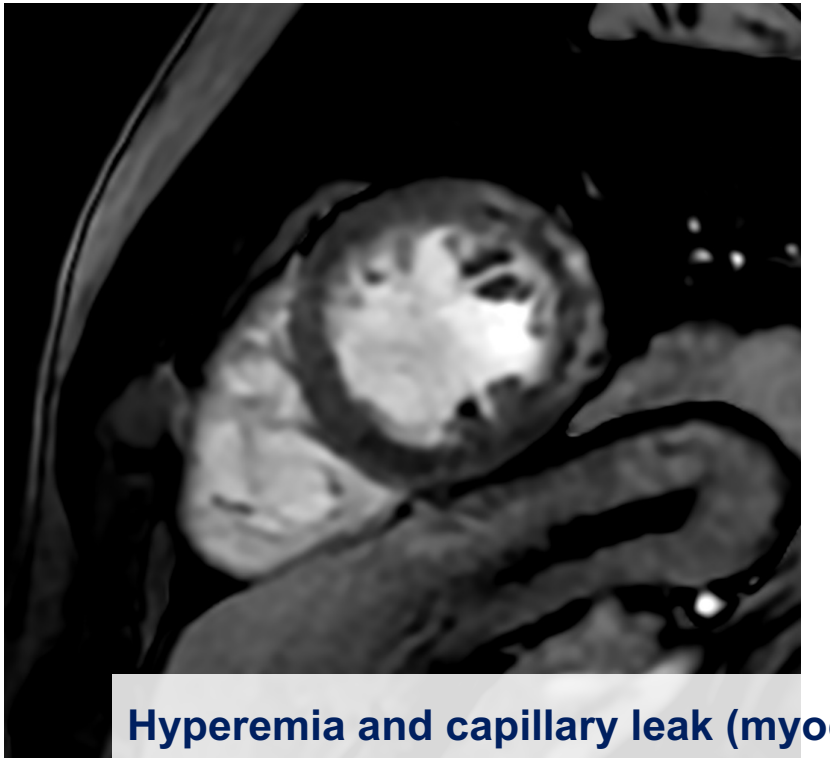


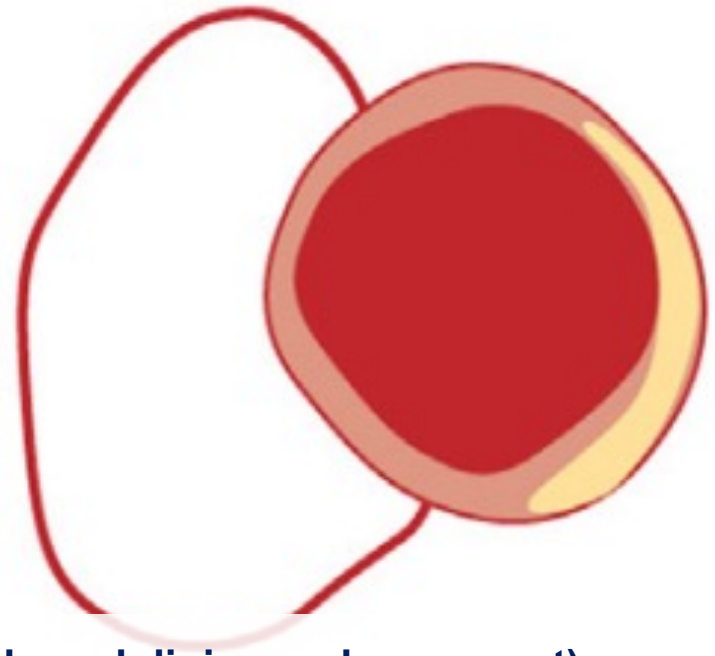
1 – 4 min after C.M.

Fixed TI

MYOCARDITIS - CMR

Early Gadolinium Enhancement





Hyperemia and capillary leak (myocardial early gadolinium enhancement)

Bière, Loïc et al. “Imaging of myocarditis and inflammatory cardiomyopathies.” *Archives of cardiovascular diseases* vol. 112,10 (2019): 630-641. doi:10.1016/j.acvd.2019.05.007

Table 3

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Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	80	68	74	74	75
Gutberlet et al., *Radiology* 2008 (34)	Histology	63	86	72	86	63
Pooled data (n = 194)		74	83	78	86	70
T2						
Rieker et al., *Rofo* 2002 (36)	Clinical	100	50	76	69	100
Laissy et al., *Chest* 2002 (11)	Clinical	45	100	59	100	39
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	84	74	79	78	81
Gutberlet et al., *Radiology* 2008 (34)	Histology	67	69	67	74	60
Pooled data (n = 178)		70	71	70	77	63
Late enhancement						
Rieker et al., *Rofo* 2002 (36)	Clinical	45	60	52	56	50
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (18)	Clinical	44	100	71	78	62
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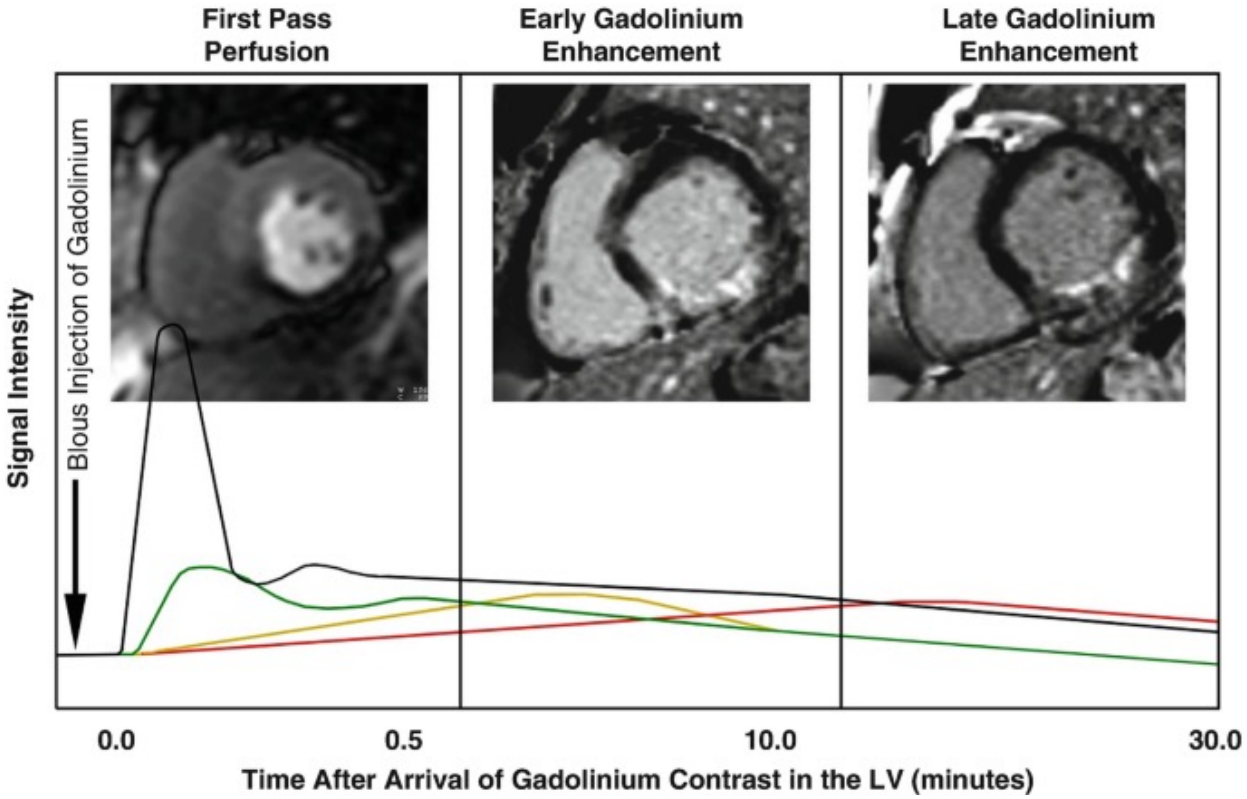
Yilmaz et al., *Heart* 2008 (43)	Histology	35	83	51	81	38
Pooled data (n = 336)		59	86	68	89	53

Late Gadolinium Enhancement



>10 min after C.M.

Identification optimal TI for LGE (TI-SCOUT)

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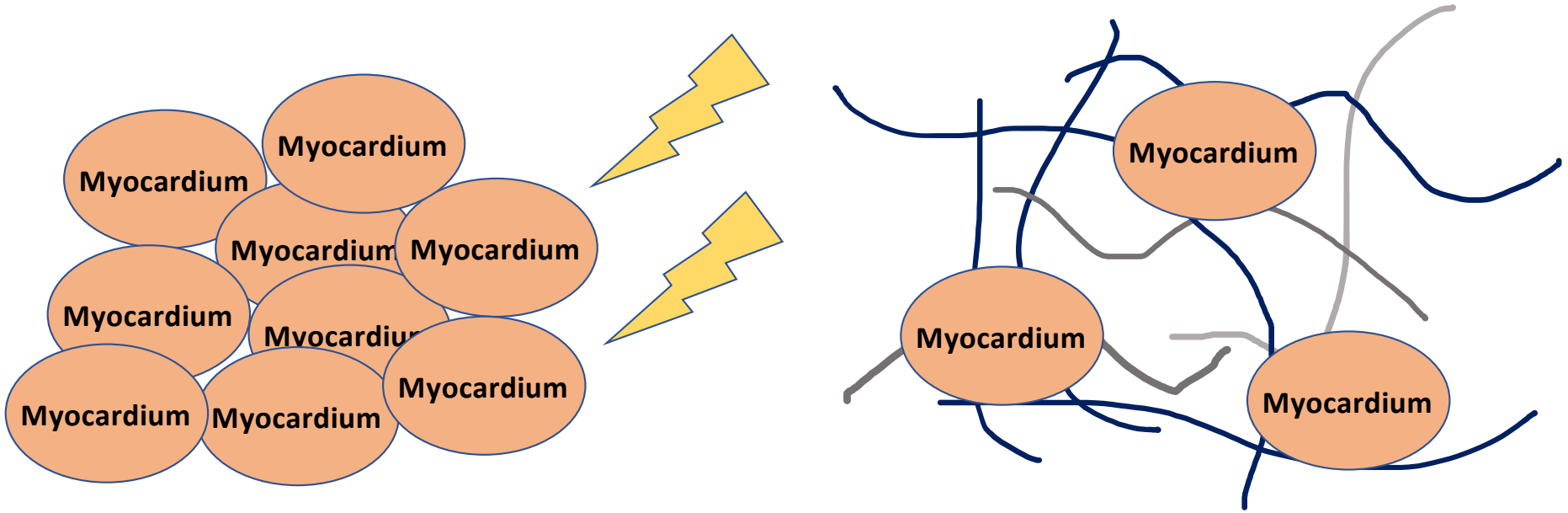
Late Gadolinium Enhancement

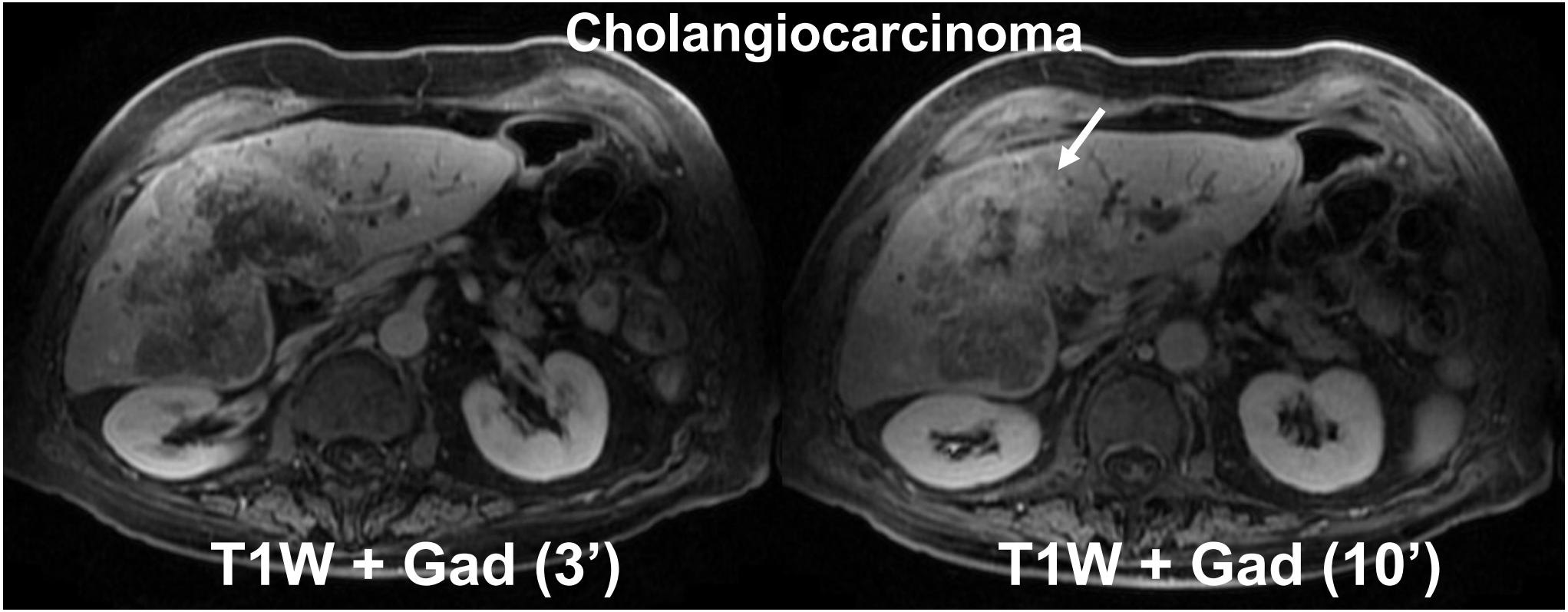


Healthy Myocardium

Fibrosis/Edema

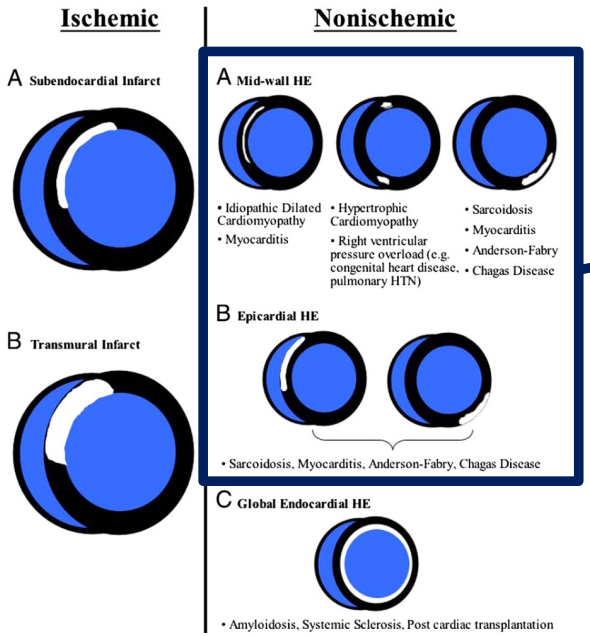
MYOCARDITIS - CMR

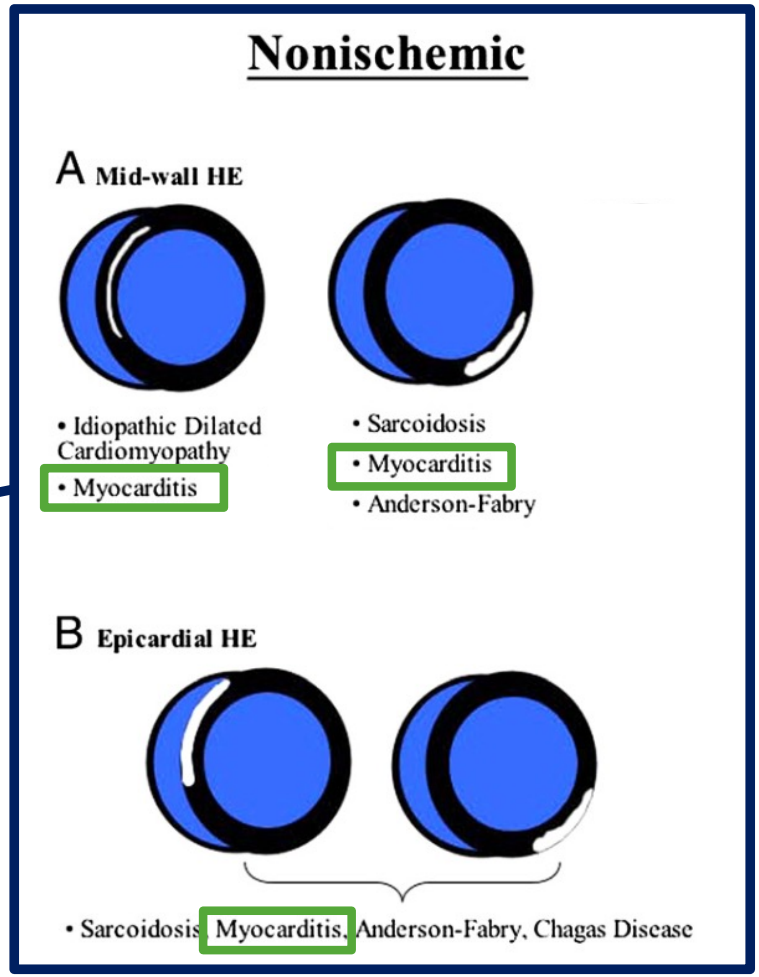
Late Gadolinium Enhancement



MYOCARDITIS - CMR

Late Gadolinium Enhancement





Schulz-Menger J et al. J Cardiovasc Magn Reson. 2020 Mar 12;22(1):19. doi: 10.1186/s12968-020-00610-6

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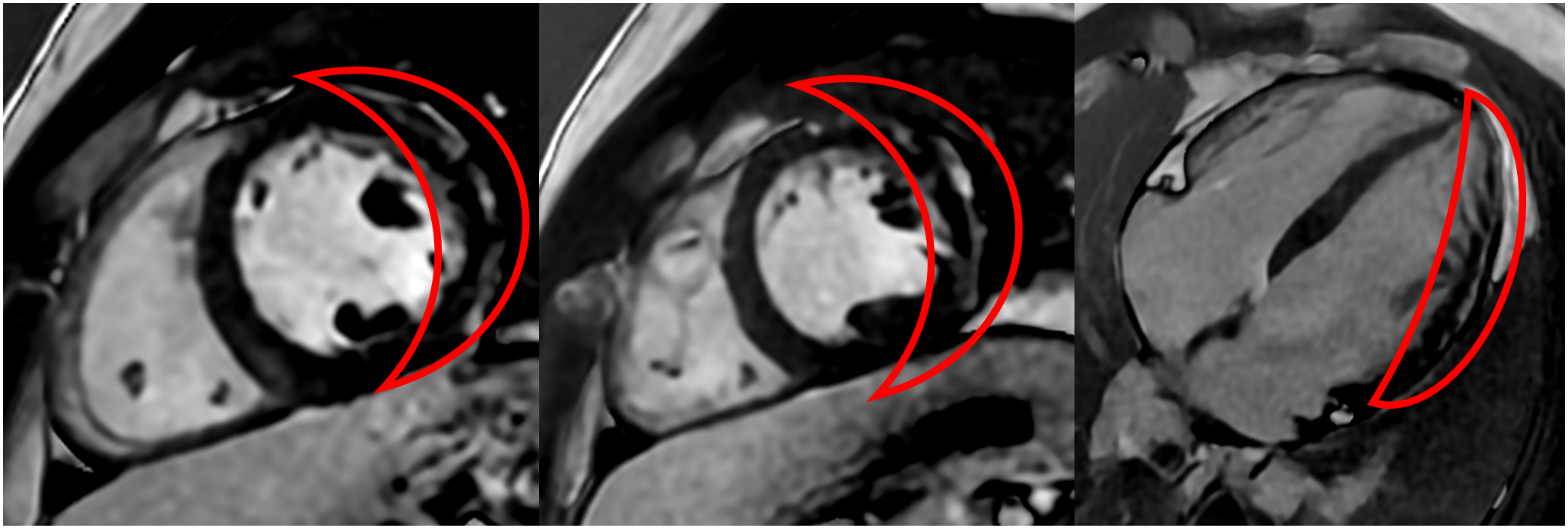
Late Gadolinium Enhancement



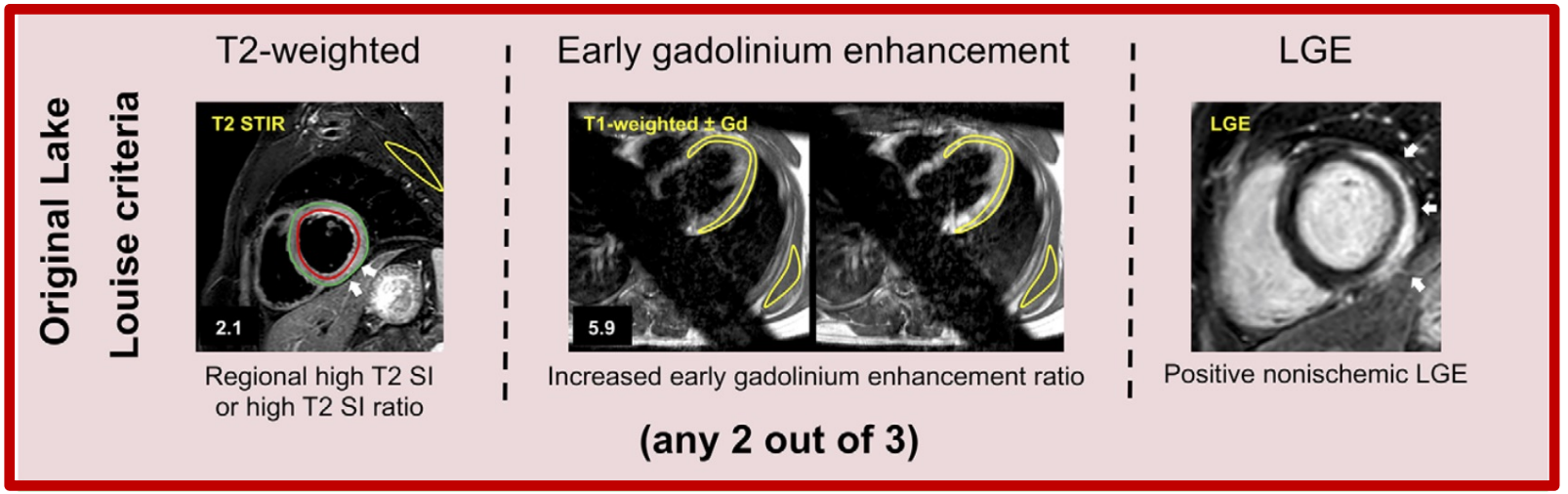
Lateral and infero-lateral subepicardial LGE

Table 4

Overview of the Diagnostic Accuracy of Several Combinations of Tissue Criteria

	Validation	Sensitivity (%)	Specificity (%)	Accuracy (%)	PPV (%)	NPV (%)
T2 + LGE						
Abdel-Aty et al., *J Am Coll Cardiol* 2005 (13)	Clinical	40	100	69	100	61
Gutberlet et al., *Radiology* 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., *J Am Coll Cardiol* 2005 (13)	Clinical	88	74	81	100	85
Gutberlet et al., *Radiology* 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., *J Am Coll Cardiol* 2005 (13)	Clinical	100	48	75	68	100
Gutberlet et al., *Radiology* 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., *J Am Coll Cardiol* 2005 (13)	Clinical	76	96	85	95	79
Gutberlet et al., *Radiology* 2008 (34)	Histology	63	89	73	88	63
Pooled data (n = 130)		67	91	78	91	69

MYOCARDITIS - CMR



Lake-Louise Criteria
2009

Luetkens, Julian A et al. "Comparison of Original and 2018 Lake Louise Criteria for Diagnosis of Acute Myocarditis: Results of a Validation Cohort." *Radiology. Cardiothoracic imaging* vol. 1,3 e190010. 25 Jul. 2019, doi:10.1148/ryct.2019190010

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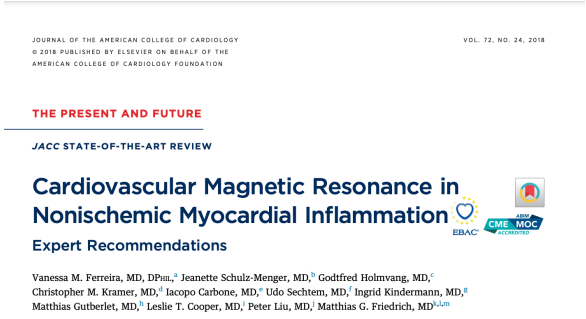
Revised Lake-Louise Criteria


JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION

VOL. 72, NO. 24, 2018

THE PRESENT AND FUTURE

JACC STATE-OF-THE-ART REVIEW

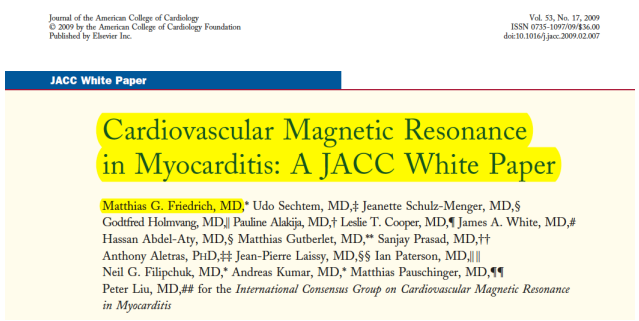
Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation

Expert Recommendations

Vanessa M. Ferreira, MD, DPhil,[a] Jeanette Schulz-Menger, MD,[b] Godtfred Holmvang, MD,[c] Christopher M. Kramer, MD,[d] Iacopo Carbone, MD,[e] Udo Sechtem, MD,[f] Ingrid Kindermann, MD,[g] Matthias Gutberlet, MD,[h] Leslie T. Cooper, MD,[i] Peter Liu, MD,[j] Matthias G. Friedrich, MD[k,l,m]

2009

2024


Journal of the American College of Cardiology
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Vol. 53, No. 17, 2009
ISSN 0735-1097/09/$36.00
doi:10.1016/j.jacc.2009.02.007

JACC White Paper

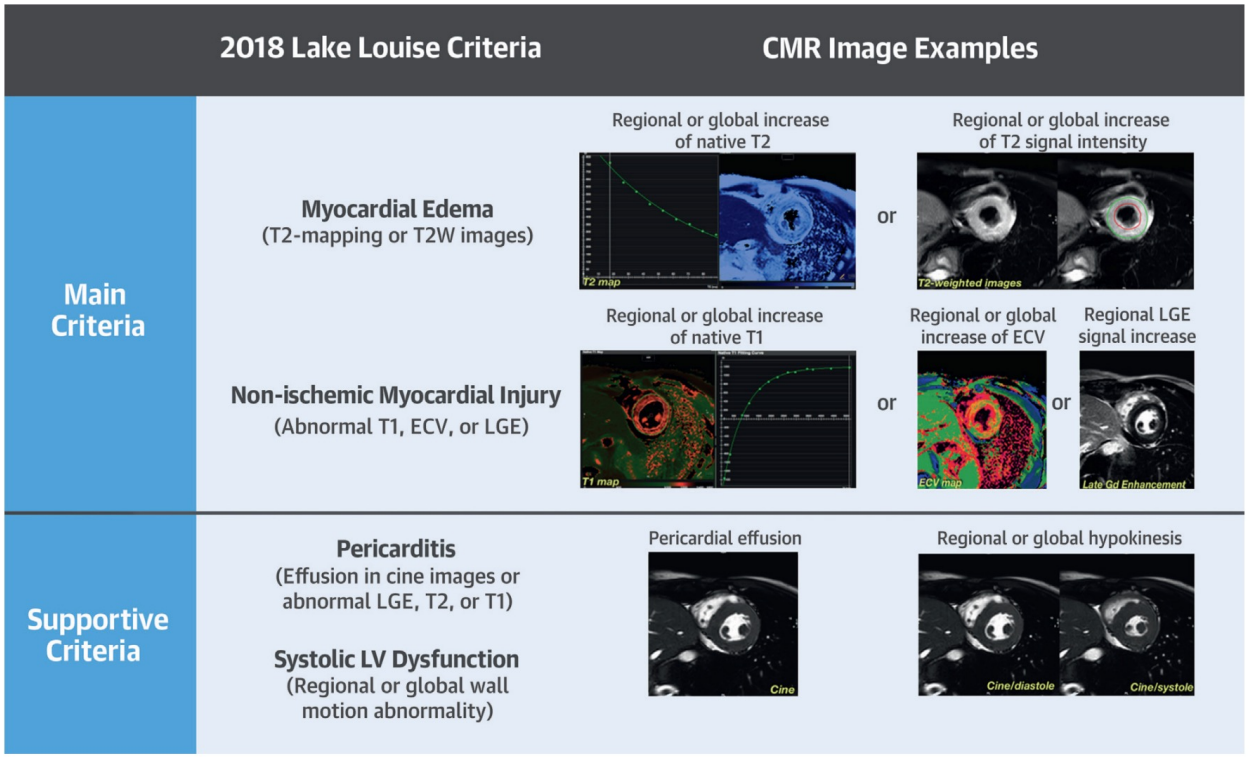
Cardiovascular Magnetic Resonance in Myocarditis: A JACC White Paper

Matthias G. Friedrich, MD,* Udo Sechtem, MD,† Jeanette Schulz-Menger, MD,‡ 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*

Lake-Louise Criteria

MYOCARDITIS - CMR

CENTRAL ILLUSTRATION **Overview of the Updated Lake Louise Criteria**



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

ECV = extracellular volume; LGE = late gadolinium enhancement; T2W = T2-weighted.

Ferreira, Vanessa M et al. "Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation: Expert Recommendations." *Journal of the American College of Cardiology* vol. 72,24 (2018): 3158-3176. doi:10.1016/j.jacc.2018.09.072

MYOCARDITIS - CMR

TABLE 3 Updated Recommendations of CMR Criteria of Myocardial Inflammation

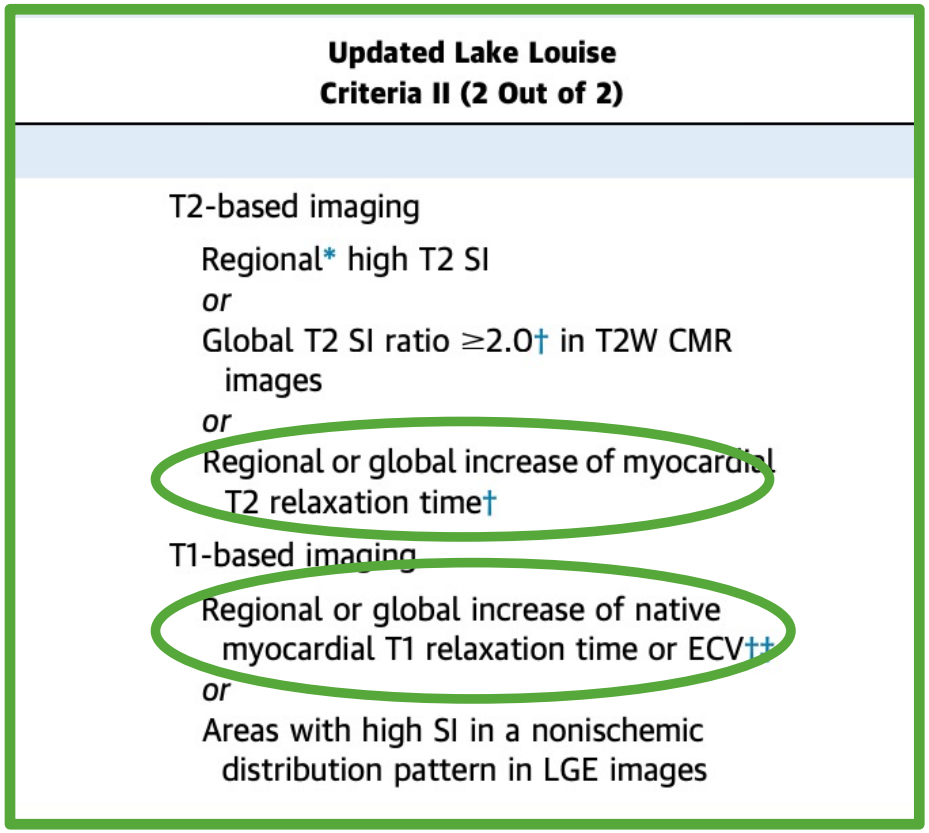
Original Lake Louise Criteria I (Any 2 Out of 3)	Updated Lake Louise Criteria II (2 Out of 2)	Diagnostic Targets
Main criteria		
T2-weighted imaging Regional* high T2 SI *or* Global T2 SI ratio ≥2.0† in T2W CMR images	T2-based imaging Regional* high T2 SI *or* Global T2 SI ratio ≥2.0† in T2W CMR images *or* Regional or global increase of myocardial T2 relaxation time†	Myocardial edema
Early gadolinium enhancement SI ratio myocardium/skeletal muscle (EGE ratio) of ≥4.0† in EGE images Late gadolinium enhancement Areas with high SI in a nonischemic distribution pattern in LGE images	T1-based imaging Regional or global increase of native myocardial T1 relaxation time or ECV†‡ *or* Areas with high SI in a nonischemic distribution pattern in LGE images	↑ T1 – edema (intra or extra-cellular), hyperemia/capillary leak, necrosis, fibrosis EGE – hyperemia, capillary leak LGE – necrosis, fibrosis, (extracellular acute edema) ↑ ECV – edema (extracellular), hyperemia/capillary leak, necrosis, fibrosis
Supportive criteria		
Pericardial effusion in cine CMR images	Pericardial effusion in cine CMR images *or* High signal intensity of the pericardium in LGE images, T1-mapping or T2-mapping *or* T1 mapping or T2 mapping	Pericardial inflammation
Systolic LV wall motion abnormality in cine CMR images	Systolic LV wall motion abnormality in cine CMR images	LV dysfunction

*"Regional" refers to an area of at least 10 contiguous pixels. †Published or local normal values, LV coverage and proper analysis tools must be acknowledged. ‡T1 mapping is highly sensitive to detecting both acute and chronic forms of increased free water content within the myocardium, and thus, the Consensus Group recommends treating it as an alternative criterion to EGE. If paired with LGE to diagnose myocarditis, the areas of T1 abnormality should be beyond that detected by LGE imaging.

↑ = increased; ECV = extracellular volume; other abbreviations as in Tables 1 and 2.

Ferreira, Vanessa M et al. "Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation: Expert Recommendations." *Journal of the American College of Cardiology* vol. 72,24 (201 3158-3176. doi:10.1016/j.jacc.2018.09.072

MYOCARDITIS - CMR



Updated Lake Louise Criteria II (2 Out of 2)

T2-based imaging

- Regional* high T2 SI
- *or*
- Global T2 SI ratio ≥2.0† in T2W CMR images
- *or*
- Regional or global increase of myocardial T2 relaxation time†

T1-based imaging

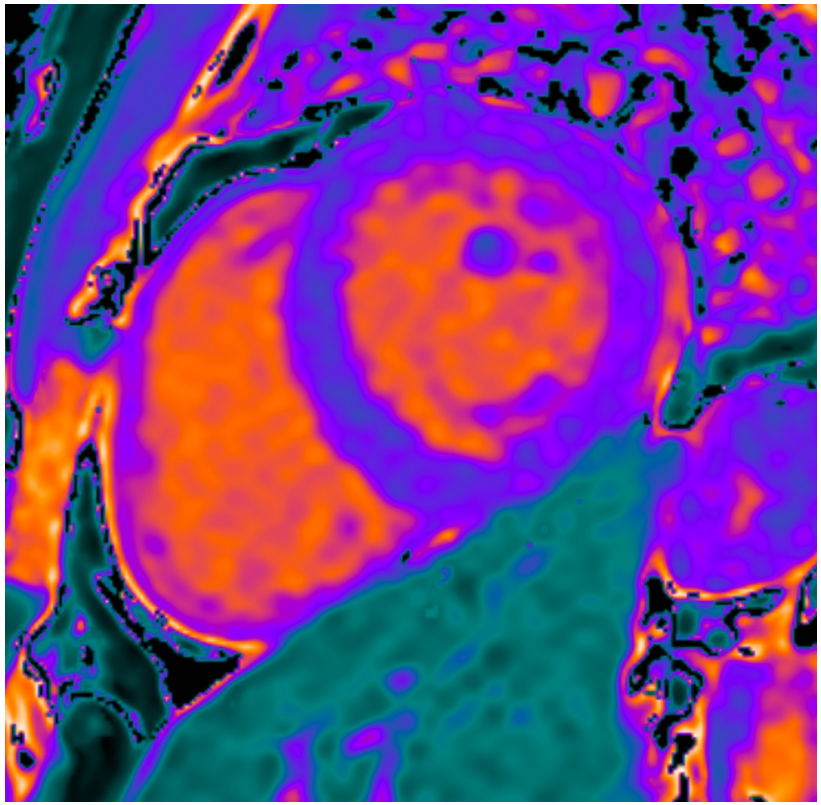
- Regional or global increase of native myocardial T1 relaxation time or ECV††
- *or*
- Areas with high SI in a nonischemic distribution pattern in LGE images

CMR parametric mapping

Ferreira, Vanessa M et al. "Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation: Expert Recommendations." *Journal of the American College of Cardiology* vol. 72,24 (2018): 3158-3176. doi:10.1016/j.jacc.2018.09.072

MYOCARDITIS - CMR

Native T1 Mapping



		T1 (native)	ECV	T2	T2*
Infiltration	Iron	+	?	+	++
	Amyloid	++	++	?	–
	Anderson-Fabry	++	–	+	–
Acute myocardial injury	Edema	++	+	++	?
	Necrosis	++	++	+	++
	Hemorrhage	+	?	+	++
Fibrosis	Diffuse/global*	+	++	?	–
	Focal/regional*	+	++	–	–

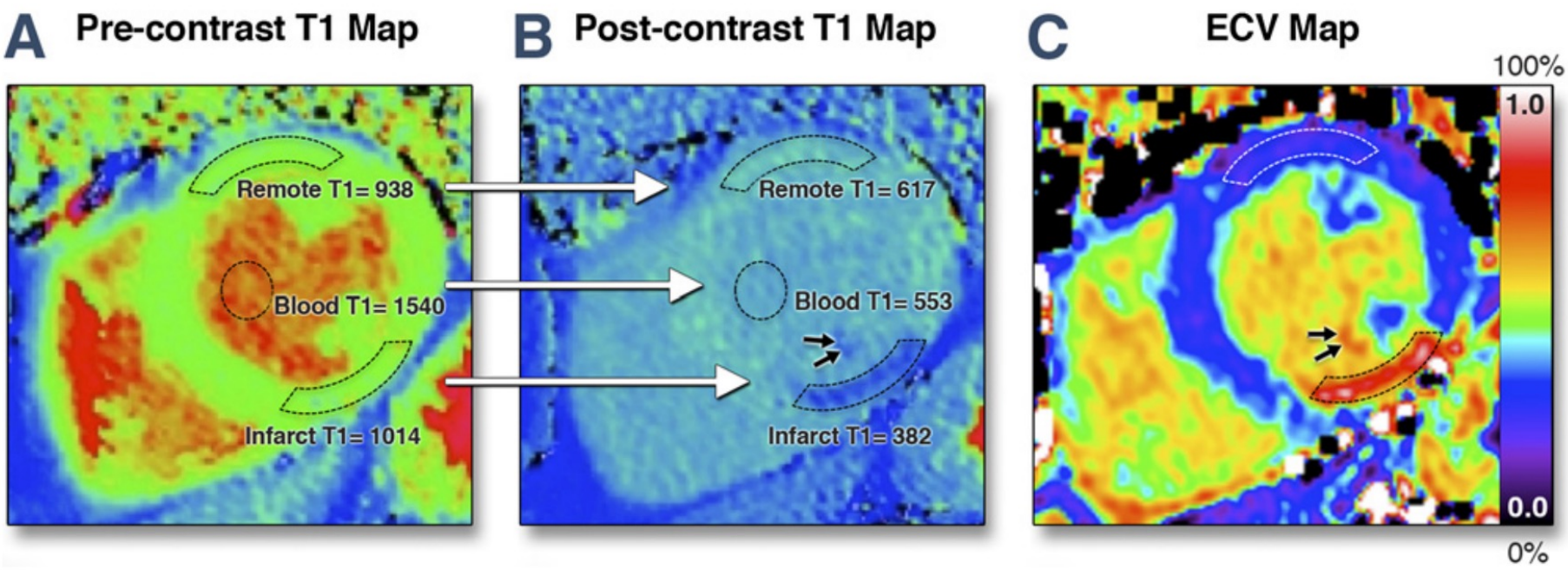
Increased Native T1	Decreased Native T1
Edema	↑ Lipid
↑ Interstitial space	↑ Iron

Haaf P et al. J Cardiovasc Magn Reson. 2016 Nov 30;18(1):89. doi: 10.1186/s12968-016-0308-4

Kramer CM et al. J Cardiovasc Magn Reson. 2020 Feb 24;22(1):17. doi: 10.1186/s12968-020-00607-1

MYOCARDITIS - CMR

ECV



$$ECV = (1 - \text{hematocrit}) \times (\Delta R1_{myocardium} / \Delta R1_{blood})$$

White, Steven K et al. “T1 mapping for myocardial extracellular volume measurement by CMR: bolus only versus primed infusion technique.” JACC. Cardiovascular imaging vol. 6,9 (2013): 955-62. doi:10.1016/j.jcmg.2013.01.011

MYOCARDITIS - CMR

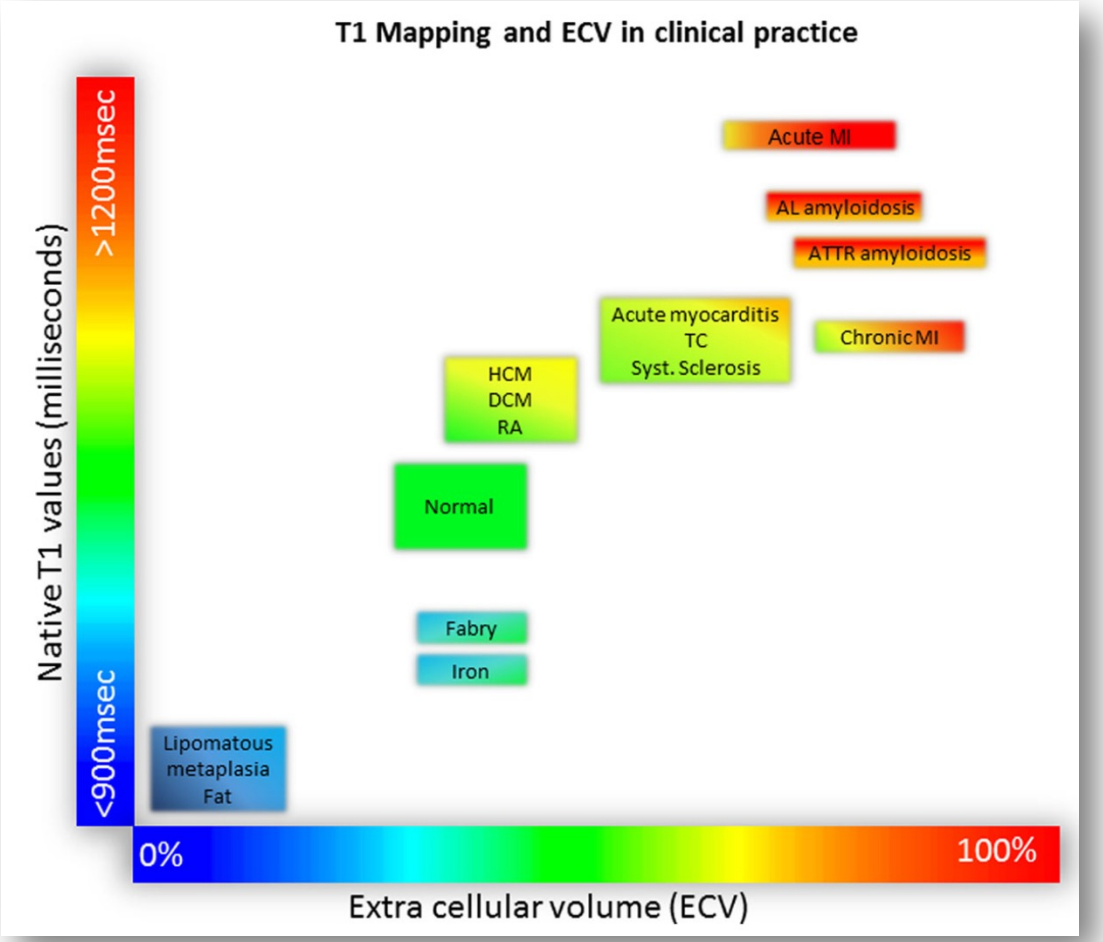
ECV

Normal ECV: 25.3% ± 3.5%

Increased ECV	Decreased ECV
Amyloid	Fat/lipomatous metaplasia
Collagen (fibrosis) Edema	Thrombus

White, Steven K et al. “T1 mapping for myocardial extracellular volume measurement by CMR: bolus only versus primed infusion technique.” JACC. Cardiovascular imaging vol. 6,9 (2013): 955-62. doi:10.1016/j.jcmg.2013.01.011

MYOCARDITIS - CMR

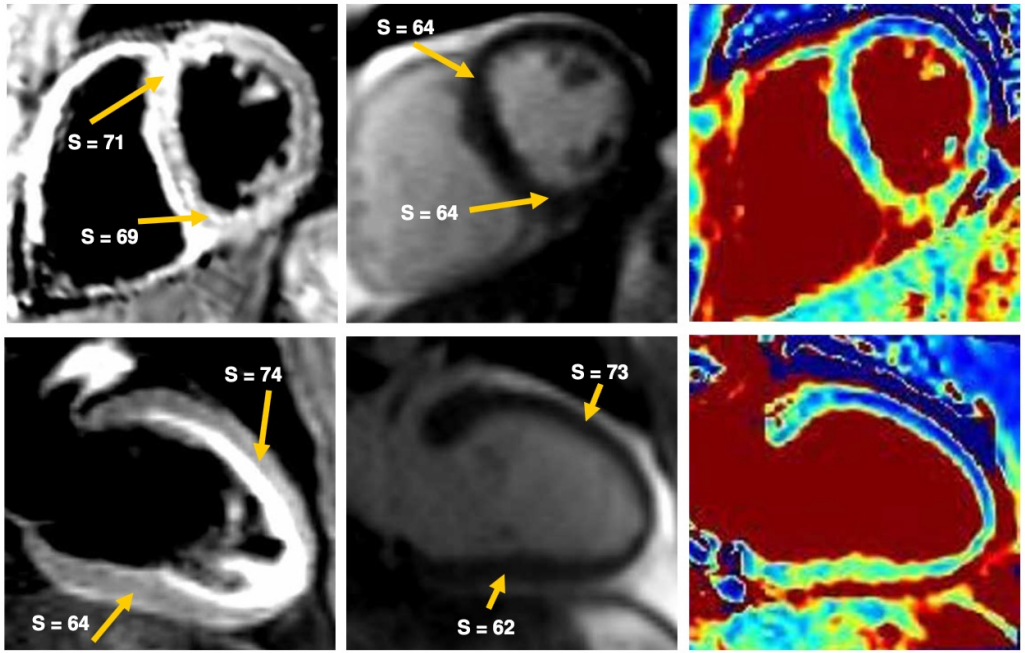


Haaf P et al. J Cardiovasc Magn Reson. 2016 Nov 30;18(1):89. doi: 10.1186/s12968-016-0308-4

T2 Mapping

- T2-prepared single-shot bSSFP sequences acquired with different T2 prep time, gradient and spin echo (GraSE) or FSE-based pulse sequences.

Edema = Increased T2

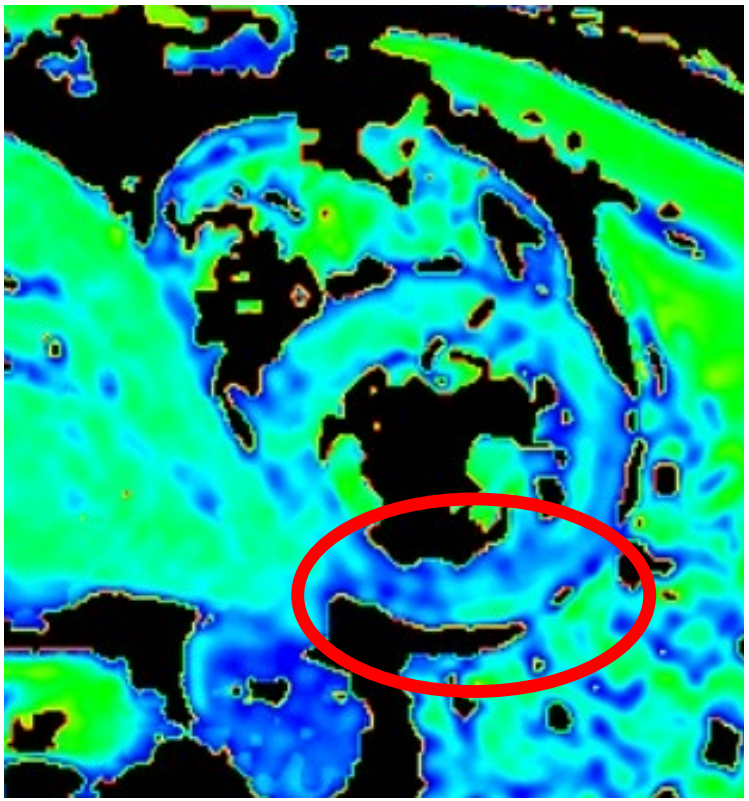


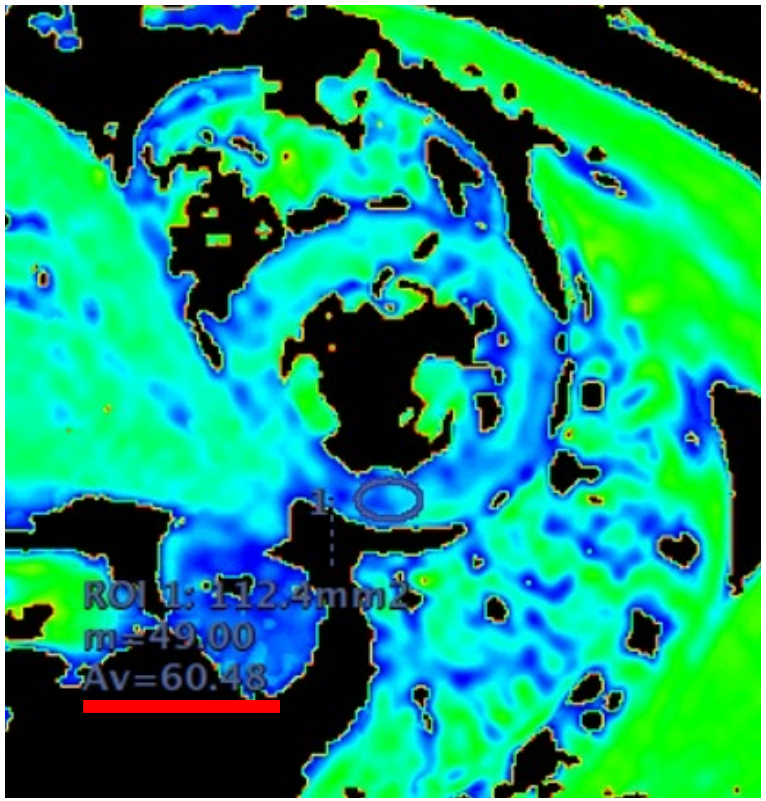
Normal T2: 49.3% ± 4.5%

Kramer CM et al. J Cardiovasc Magn Reson. 2020 Feb 24;22(1):17. doi: 10.1186/s12968-020-00607-1
Giri S et al. J Cardiovasc Magn Reson. 2009 Dec 30;11(1):56. doi: 10.1186/1532-429X-11-56

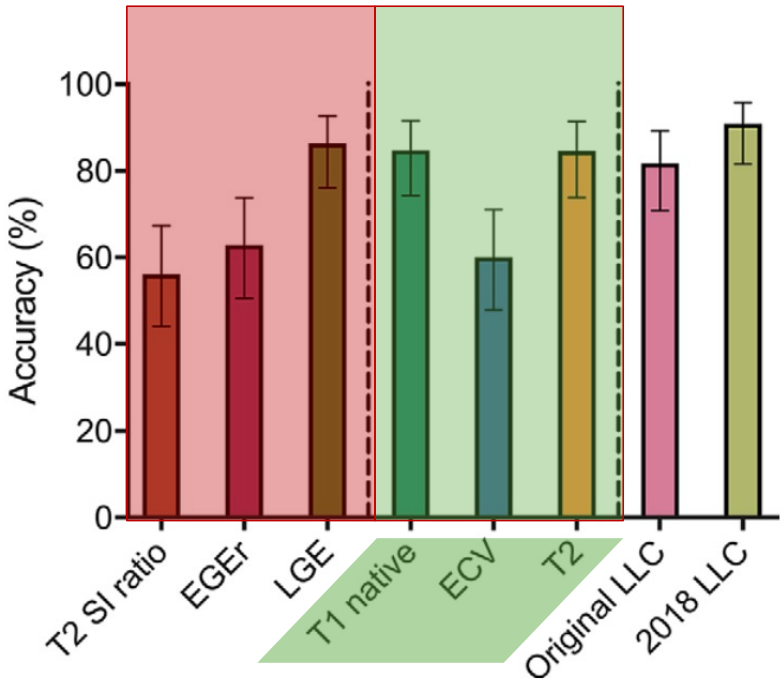
MYOCARDITIS - CMR

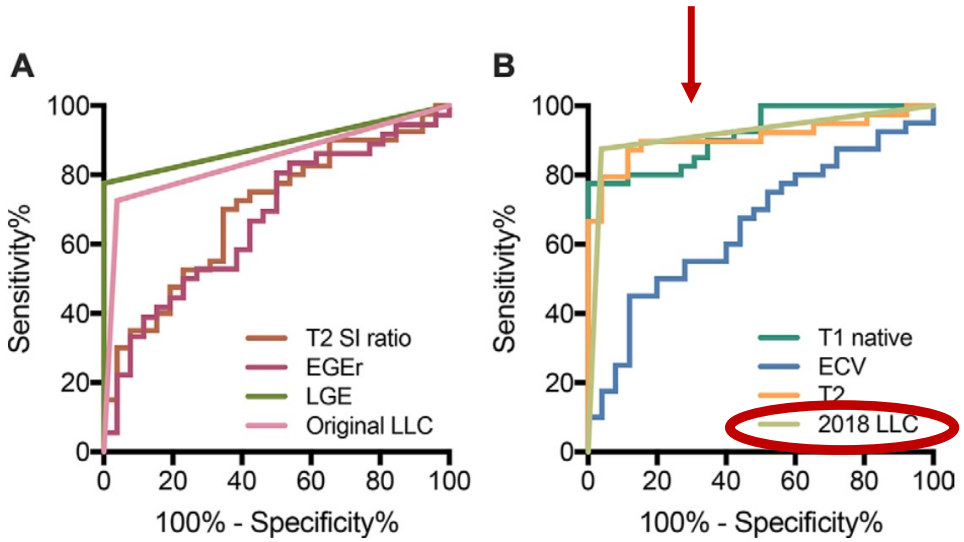
T2 Mapping





MYOCARDITIS - CMR

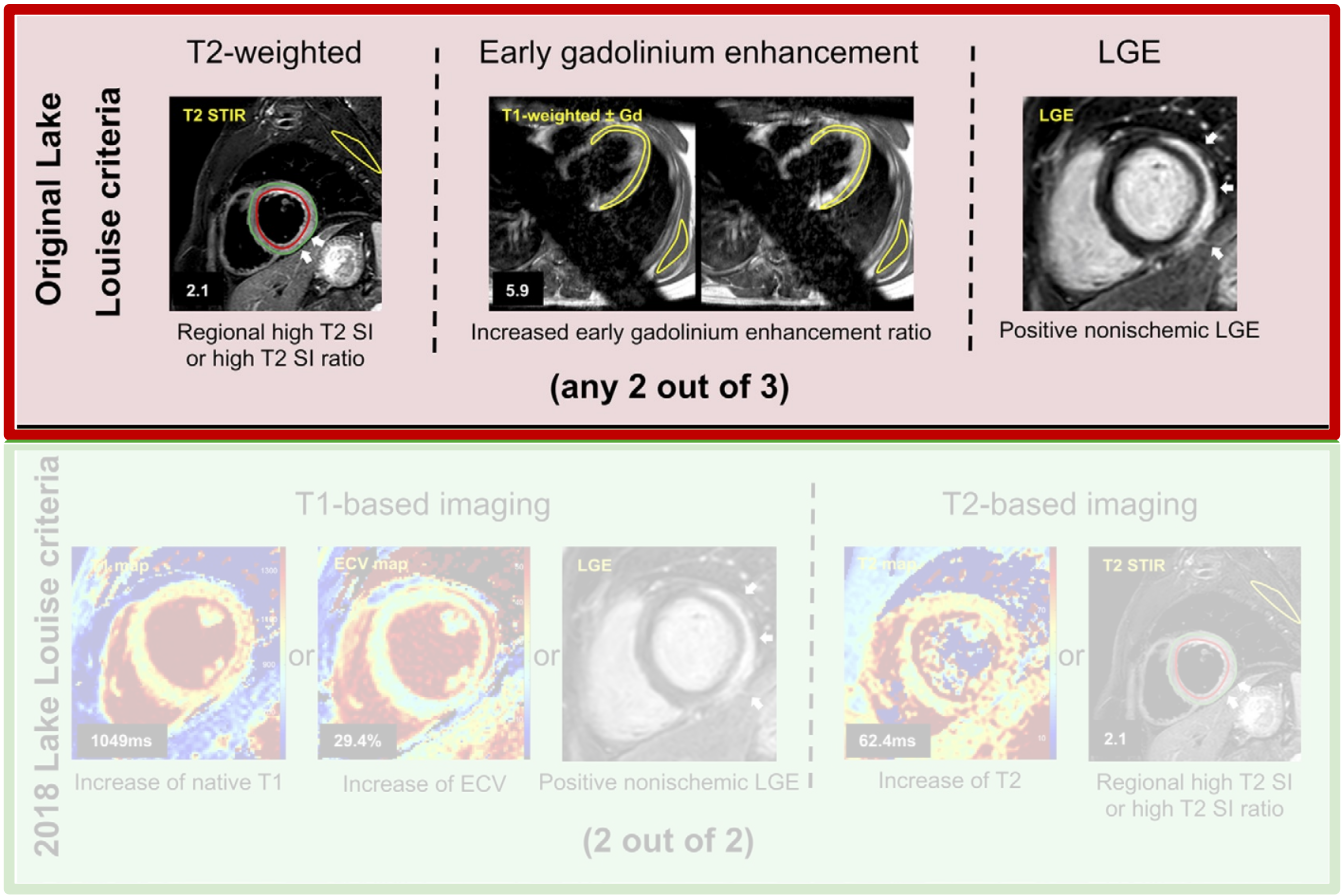




PARAMETRIC IMAGING

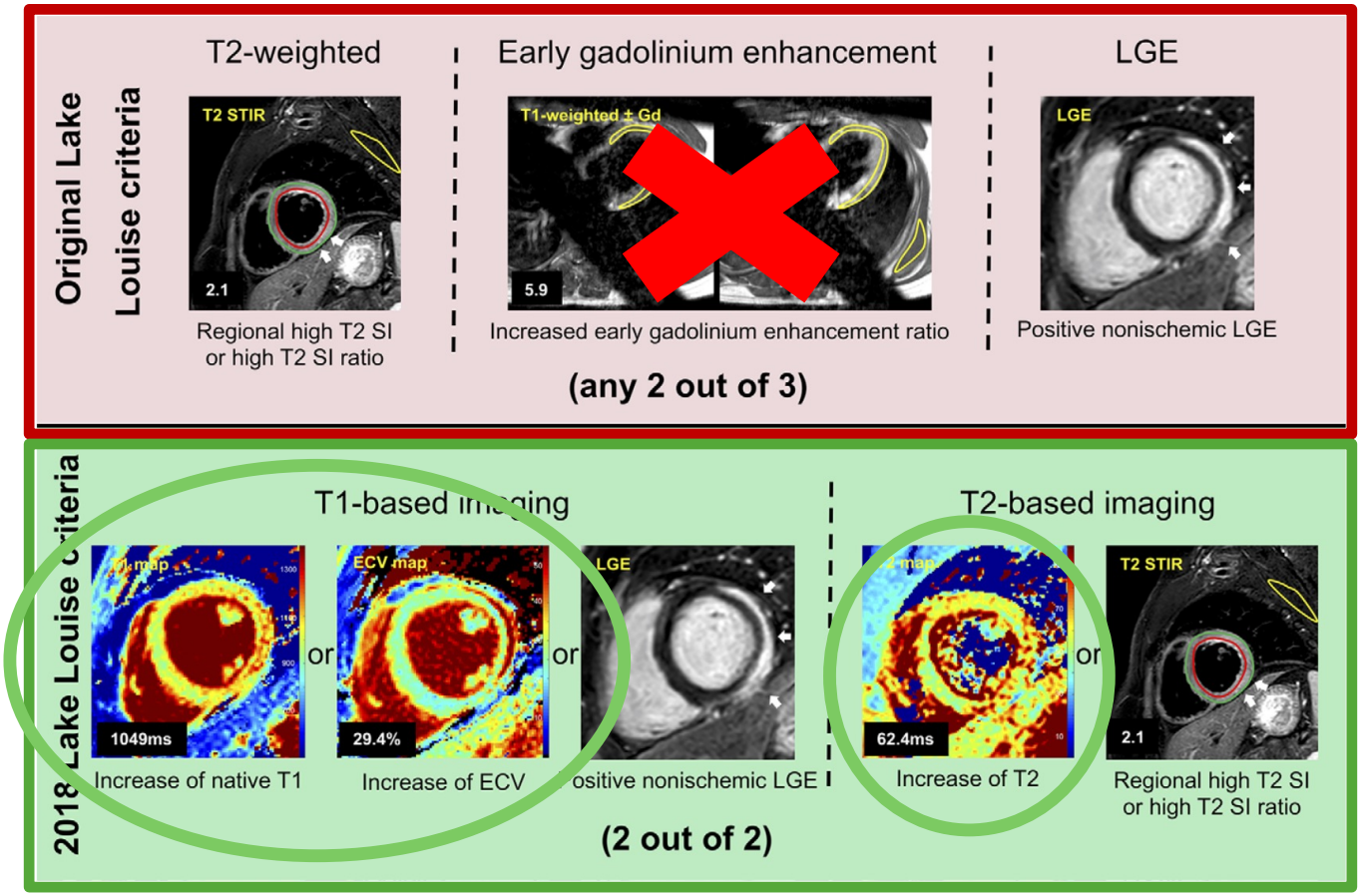
Luetkens, Julian A et al. "Comparison of Original and 2018 Lake Louise Criteria for Diagnosis of Acute Myocarditis: Results of a Validation Cohort." *Radiology. Cardiothoracic imaging* vol. 1,3 e190010. 25 Jul. 2019, doi:10.1148/ryct.2019190010

MYOCARDITIS - CMR



Luetkens, Julian A et al. "Comparison of Original and 2018 Lake Louise Criteria for Diagnosis of Acute Myocarditis: Results of a Validation Cohort." *Radiology. Cardiothoracic imaging* vol. 1,3 e190010. 25 Jul. 2019, doi:10.1148/ryct.2019190010

MYOCARDITIS - CMR

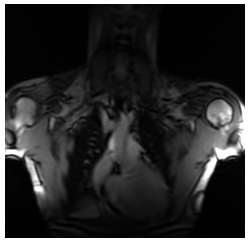


Luetkens, Julian A et al. "Comparison of Original and 2018 Lake Louise Criteria for Diagnosis of Acute Myocarditis: Results of a Validation Cohort." *Radiology. Cardiothoracic imaging* vol. 1,3 e190010. 25 Jul. 2019, doi:10.1148/ryct.2019190010

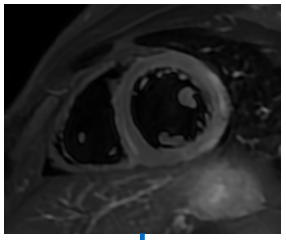
MYOCARDITIS - CMR

CMR - PROTOCOL

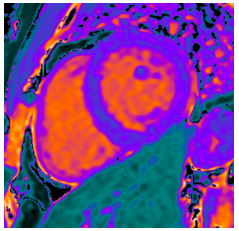
Localizer



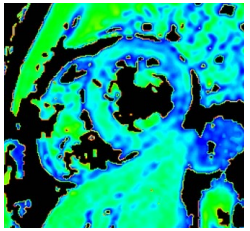
T2-TIR



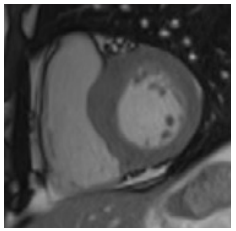
T1-Native



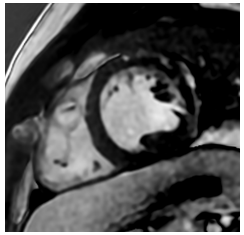
T2-Map



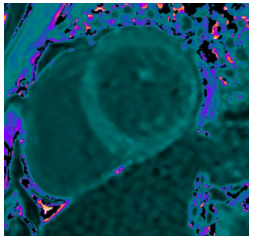
Post-contrast Cine-SSFP



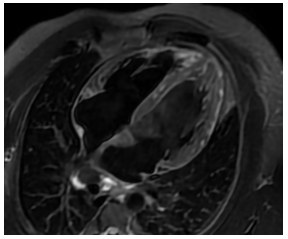
Multiplanar LGE

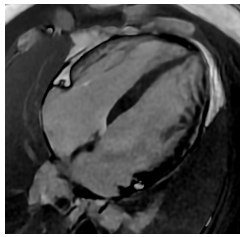


T1-post contrast ECV



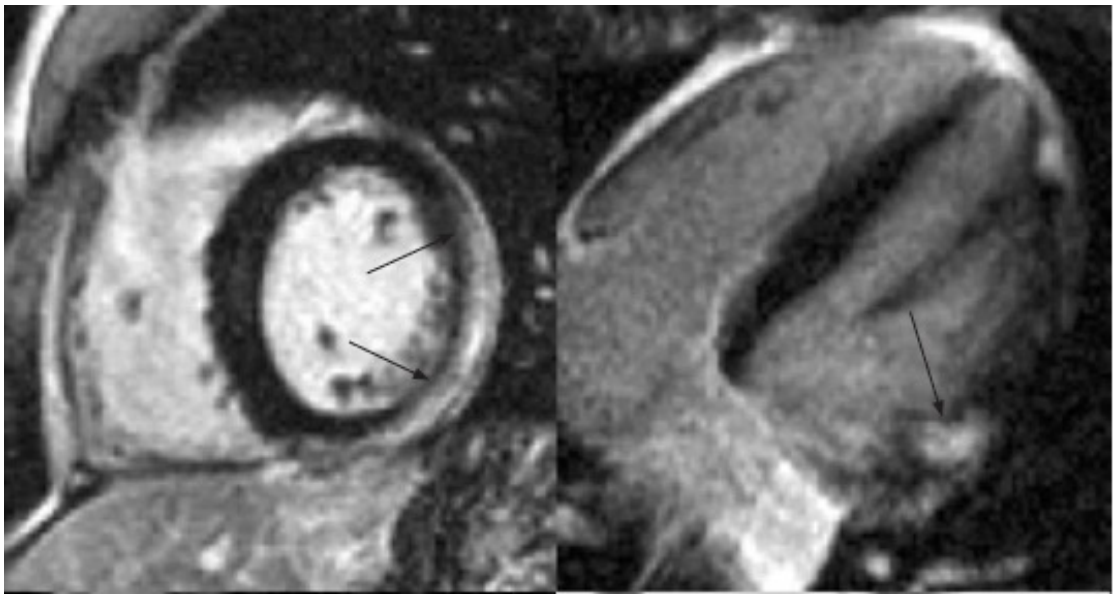
Consider multiplanar





MYOCARDITIS - CMR

Specific pattern – Parvovirus B19



Parvovirus B19 associated myocarditis often shows LGE of the epicardial portions of the free lateral wall of the LV

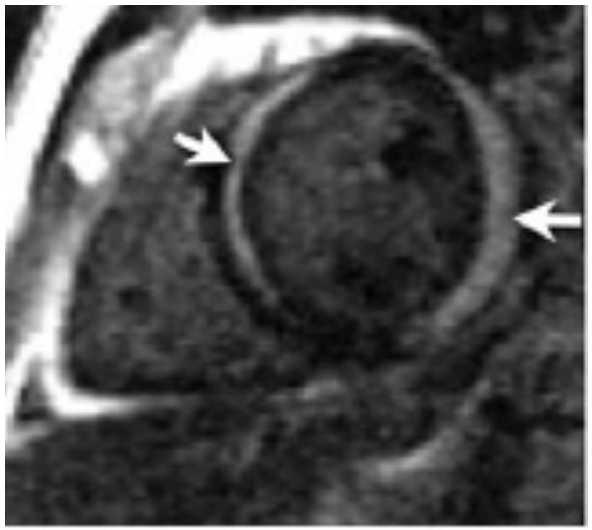
.

Mahrholdt H, Wagner A, Deluigi C, et al. Presentation, patterns of myocardial damage and clinical course of viral myocarditis. Circulation 2006;114:1581–90

MYOCARDITIS - CMR

Specific pattern - HSV

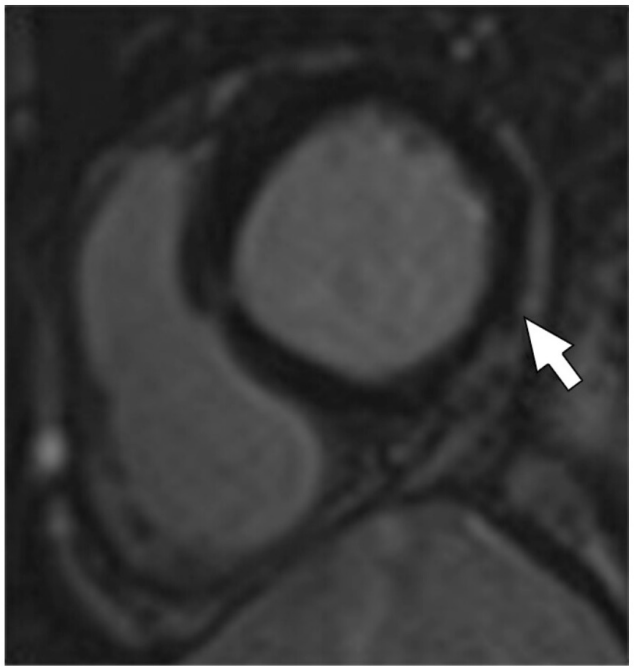
In contrast, the peculiar pattern of a sandwiched stripe of late enhancement within the interventricular septum is more frequently found in **herpes virus.**



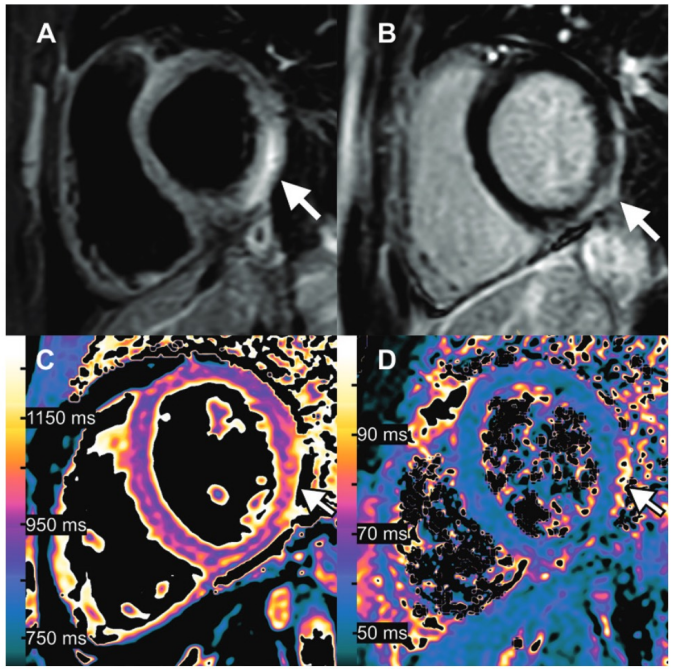
Mahrholdt H, Wagner A, Deluigi C, et al. Presentation, patterns of myocardial damage and clinical course of viral myocarditis. Circulation 2006;114:1581–90

Specific pattern – SarS-CoV2/Vaccine

SarS-CoV2 infection



SarS-CoV2 vaccine

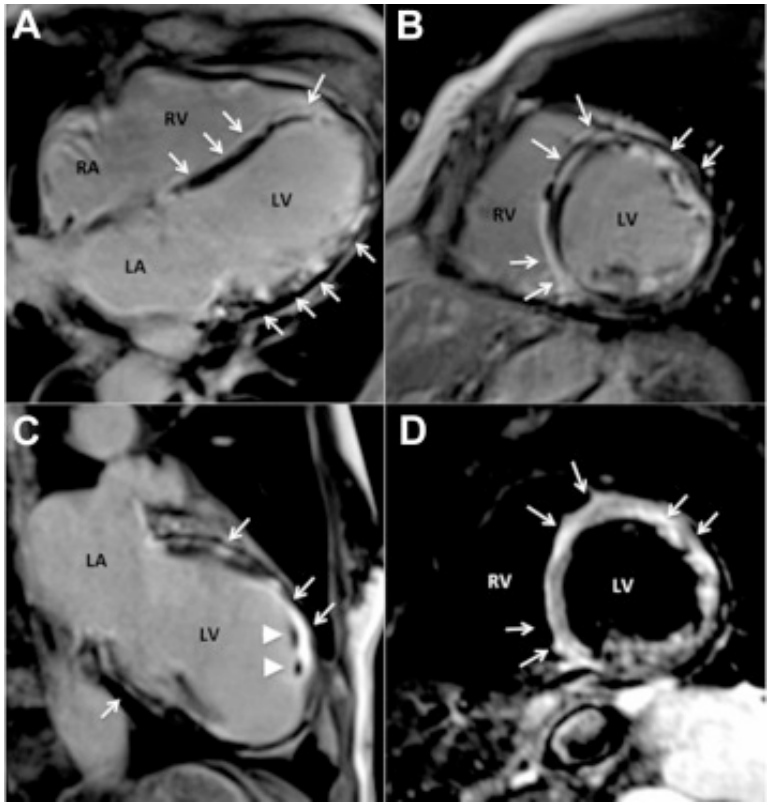


Abdeldayem EH, Raief Mosaad BM, Yassin A, Abdelrahman AS. Cardiac MRI in patients with COVID-19 infection. Eur Radiol. 2023;33(6):3867-3877. doi:10.1007/s00330-022-09325-x
Bozkurt B, Kamat I, Hotez PJ. Myocarditis With COVID-19 mRNA Vaccines. Circulation. 2021;144(6):471-484. doi:10.1161/CIRCULATIONAHA.121.056135

MYOCARDITIS - CMR

Specific pattern - Immune Check-point Inhibitor

- Myocarditis is an uncommon but potentially fatal complication of **IMMUNE CHECK-POINT INHIBITOR (ICI)** therapy.
- Lower rate of LGE and the lower sensitivity of the 2018-LL criteria in ICI-M than in viral myocarditis; LGE more commonly involves the mid-wall of the basal and mid septum.
- A retrospective analysis of 79 patients with ICI-myocarditis and mapping data showed that 100% of patients met at least one of the revised LLC on MRI and 48% met both T1 and T2-based criteria.



Cadour F, Cautela J, Rapacchi S, et al. Cardiac MRI features and prognostic value in immune checkpoint inhibitor–induced myocarditis. Radiology. 2022;303:512-521. Crossref
Thavendiranathan P, Zhang L, Zafar A, et al. Myocardial T1 and T2 mapping by magnetic resonance in patients with immune checkpoint inhibitor-associated myocarditis. J Am Coll Cardiol. 2021;77:1503-1516. Crossref

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MYOCARDITIS - CMR

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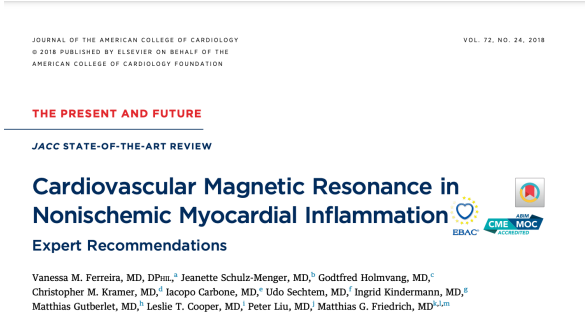
Revised Lake-Louise Criteria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VOL. 72, NO. 24, 2018

THE PRESENT AND FUTURE

JACC STATE-OF-THE-ART REVIEW

Cardiovascular Magnetic Resonance in Nonischemic Myocardial Inflammation

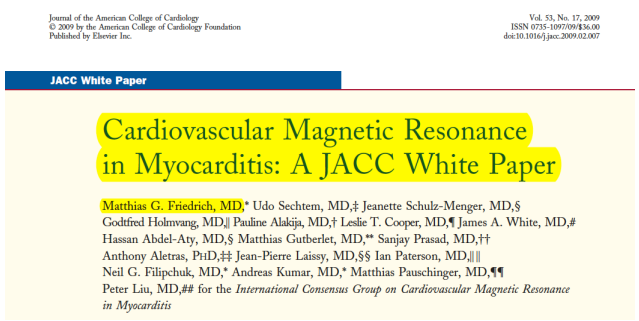
Expert Recommendations

Vanessa M. Ferreira, MD, DPhil,[a] Jeanette Schulz-Menger, MD,[b] Godtfred Holmvang, MD,[c] Christopher M. Kramer, MD,[d] Iacopo Carbone, MD,[e] Udo Sechtem, MD,[f] Ingrid Kindermann, MD,[g] Matthias Gutberlet, MD,[h] Leslie T. Cooper, MD,[i] Peter Liu, MD,[j] Matthias G. Friedrich, MD[k,l,m]

2009

2024

2018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Vol. 53, No. 17, 2009
ISSN 0735-1097/09/$36.00
doi:10.1016/j.jacc.2009.02.007

JACC White Paper

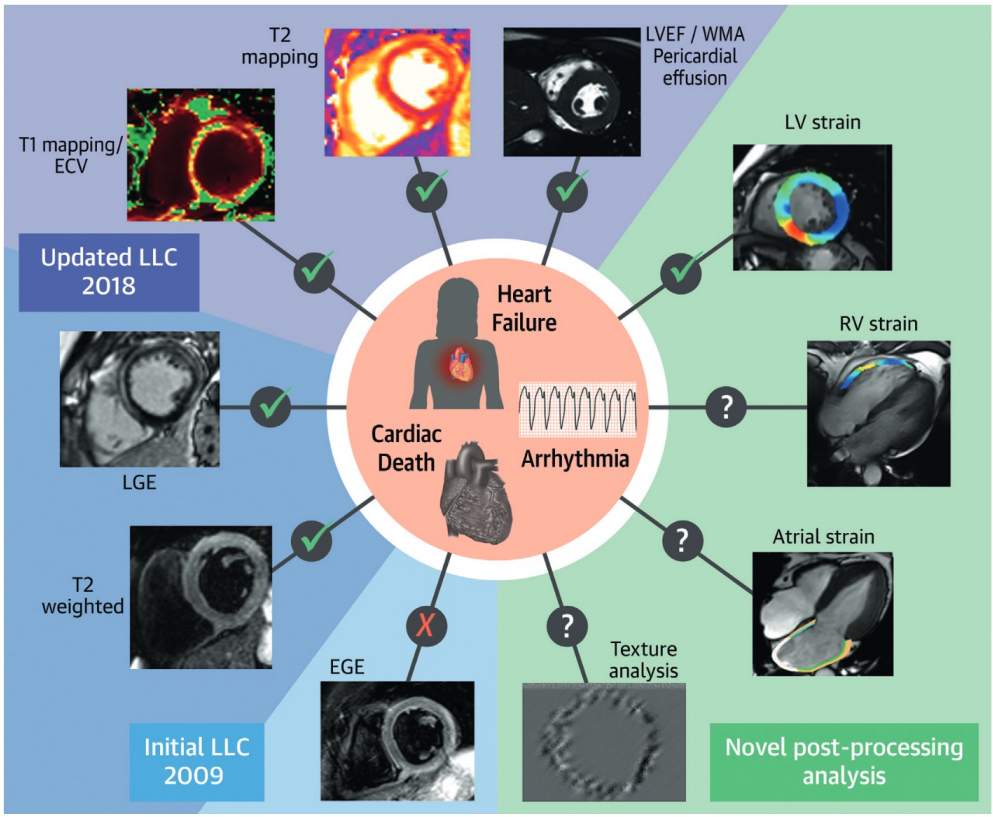
Cardiovascular Magnetic Resonance in Myocarditis: A JACC White Paper

Matthias G. Friedrich, MD,* Udo Sechtem, MD,† Jeanette Schulz-Menger, MD,‡ 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*

Lake-Louise Criteria

MYOCARDITIS - CMR

CENTRAL ILLUSTRATION **Association of CMR Parameters With Outcome in Patients With Clinically Suspected Myocarditis**



Eichhorn C, et al. J Am Coll Cardiol Img. 2022;15(7):1325-1338.

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MYOCARDITIS - CMR

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Diagnosis → **Prognosis**

3-6 months follow-up

ESC European Society of Cardiology
European Heart Journal (2021) 42, 3599–3726
doi:10.1093/eurheartj/ehab368

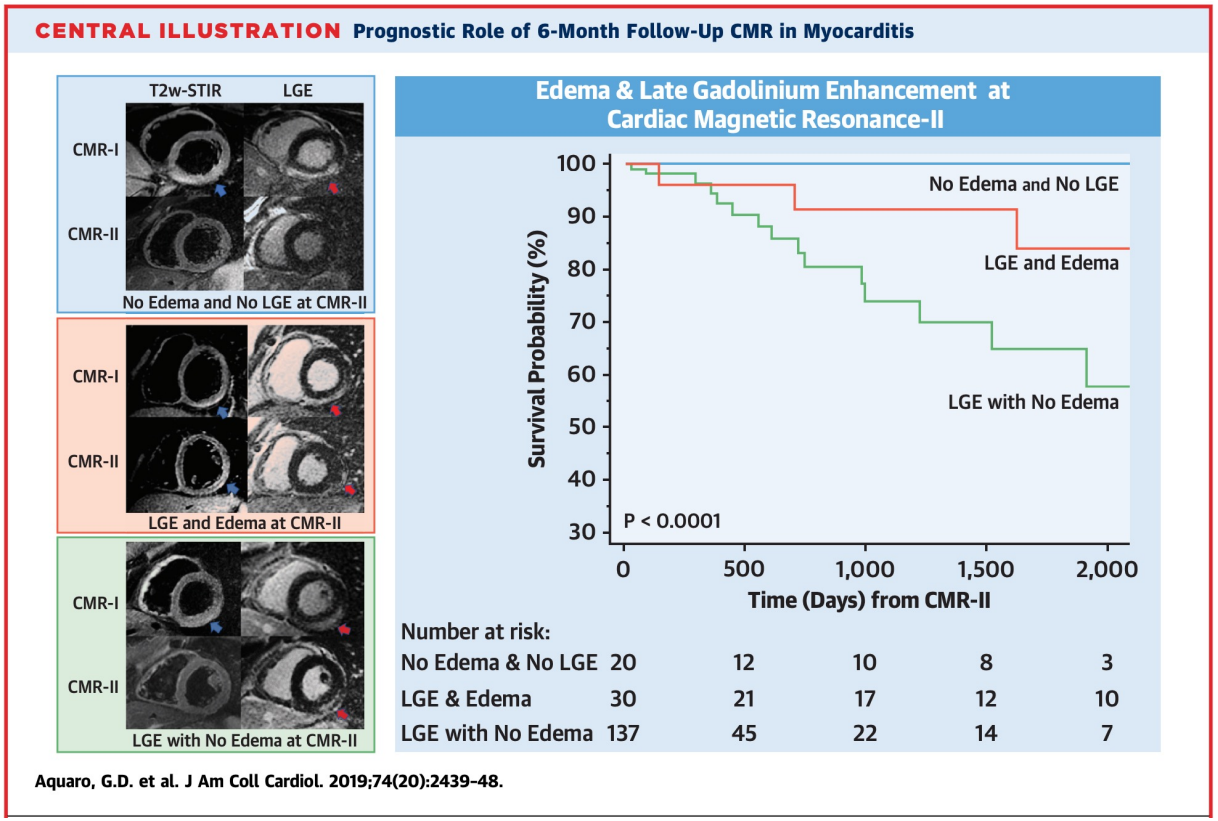
ESC GUIDELINES

2021 ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure

Developed by the Task Force for the diagnosis and treatment of acute and chronic heart failure of the European Society of Cardiology (ESC)

With the special contribution of the Heart Failure Association (HFA) of the ESC

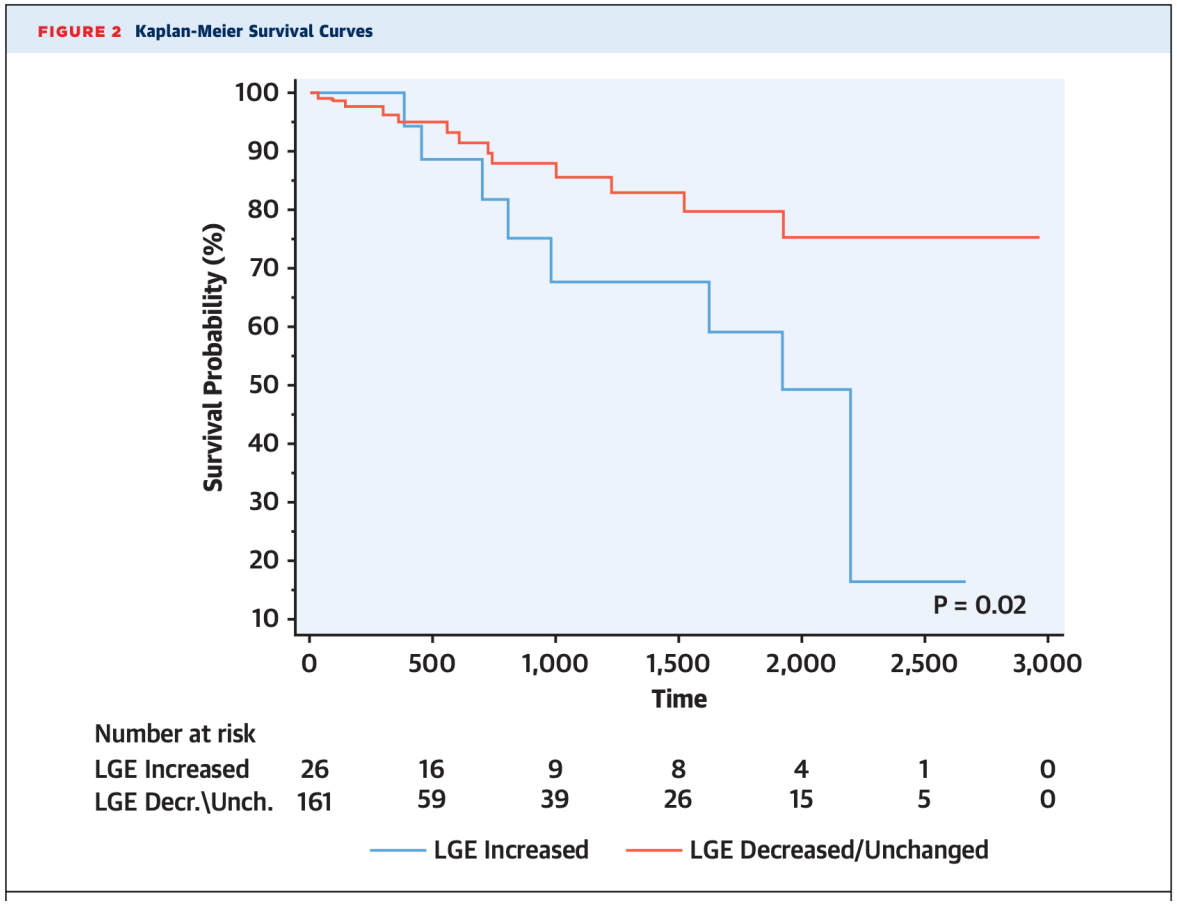
MYOCARDITIS - CMR



- LGE is not a marker of irreversible myocardial damage
- in patients with LGE and edema there was active inflammation with the potential to heal in the future, whereas in those without edema, LGE represents a definite fibrosis.

Aquaro, Giovanni Donato et al. “Prognostic Value of Repeating Cardiac Magnetic Resonance in Patients With Acute Myocarditis.” Journal of the American College of Cardiology vol. 74,20 (2019): 2439-2448. doi:10.1016/j.jacc.2019.08.1061

MYOCARDITIS - CMR

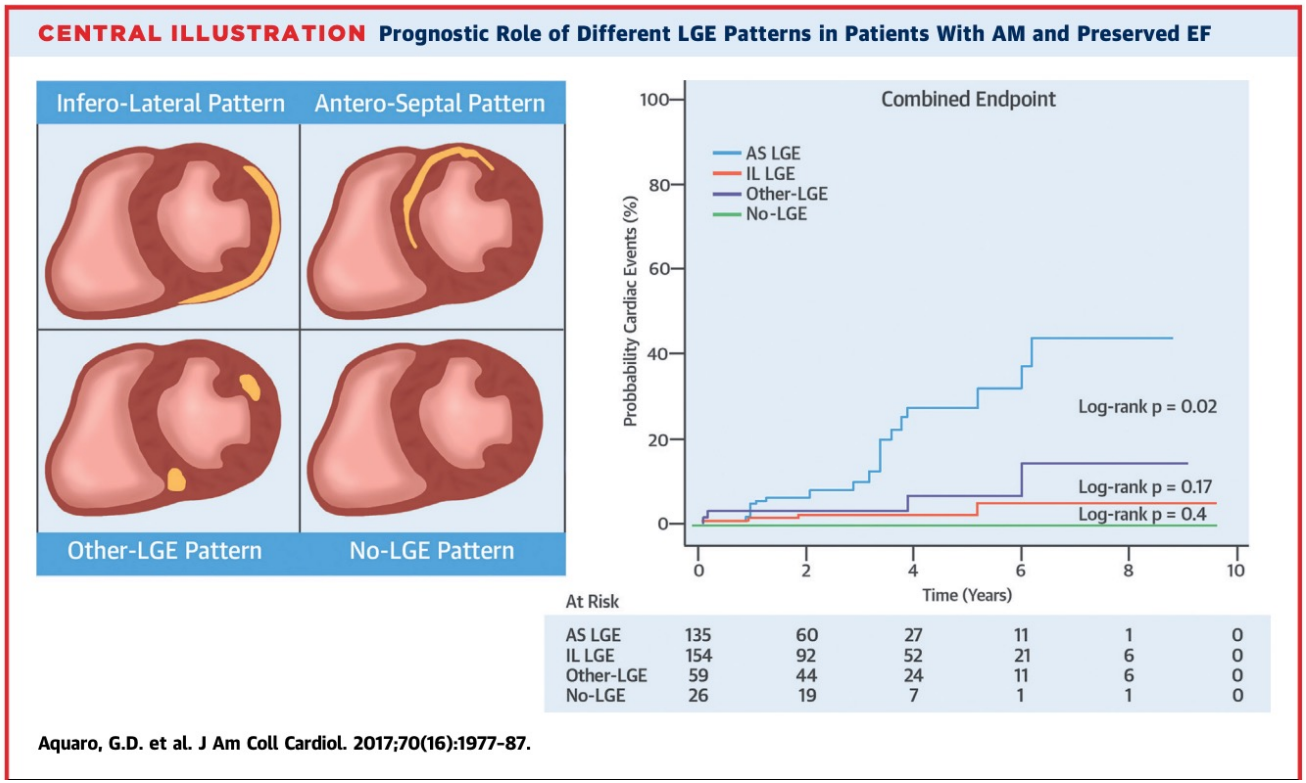


- Myocardial damage might continue as the result of an autoimmune response or multiple relapse of myocarditis

Disease progression and worse outcome

Aquaro, Giovanni Donato et al. "Prognostic Value of Repeating Cardiac Magnetic Resonance in Patients With Acute Myocarditis." Journal of the American College of Cardiology vol. 74,20 (2019): 2439-2448. doi:10.1016/j.jacc.2019.08.1061

MYOCARDITIS - CMR



- in the ITAMY registry, the midwall septal pattern of LGE was associated with a worse prognosis than the inferior and/or lateral subepicardial pattern.

Aquaro, Giovanni Donato et al. “Cardiac MR With Late Gadolinium Enhancement in Acute Myocarditis With Preserved Systolic Function: ITAMY Study.” Journal of the American College of Cardiology vol. 70,16 (2017): 1977-1987. doi:10.1016/j.jacc.2017.08.044

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MYOCARDITIS - CMR

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Protocolli cardiologici per il giudizio di idoneità allo sport agonistico (COCIS) 2023

	Classe	LDE
I soggetti con diagnosi di miocardite certa o probabile devono sospendere l'attività sportiva agonistica, finché il processo morboso non sia totalmente guarito e comunque per un periodo non inferiore a 3 - 6 mesi dall'esordio della malattia.	III	B
Nei soggetti considerati guariti da una miocardite senza esiti * dopo 3-6 mesi non vi sono controindicazioni a partecipare ad attività sportive agonistiche. Un caso particolare rappresenta la persistenza di LGE alla RM nonostante la normalizzazione di tutti gli altri esami: tale circostanza è trattata nel capitolo sulla cicatrice non ischemica del ventricolo sinistro.	I	C

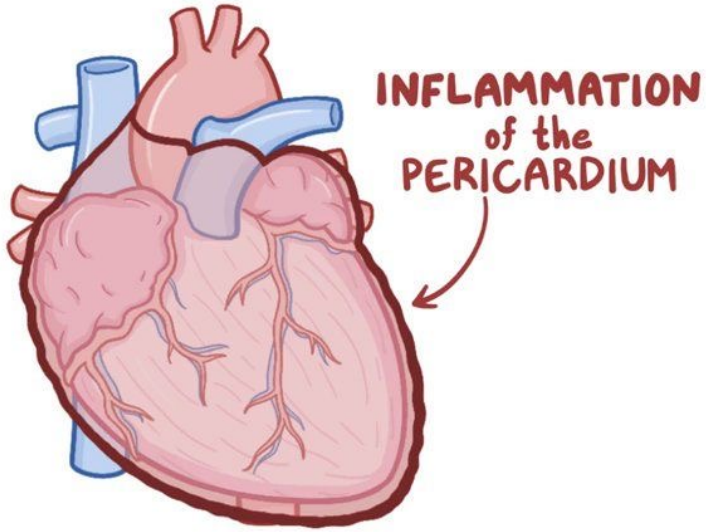
	Classe	LDE
Gli atleti con cicatrice non ischemica del ventricolo sinistro associata a disfunzione ventricolare sinistra (FE <50% ECO, <45% RM) e/o alterazioni dell'ECG (bassi voltaggi del QRS nelle periferiche e/o onde T invertite) e/o aritmie ventricolari significative (BPV indotti dallo sforzo frequenti, polimorfi o ripetitivi) non devono partecipare ad attività sportive agonistiche.	III	C
Gli atleti con cicatrice non ischemica *circoscritta* (<3 segmenti) localizzata alla parete libera del ventricolo sinistro, con normale funzione sistolica dello stesso, normale ECG e assenza di aritmie ventricolari significative (TE massimale e Holter con allenamento) potrebbero svolgere attività sportiva agonistica in tutti gli sport dopo accurata valutazione del rischio (vedi testo), caso per caso e condotta in centri di riferimento di provata esperienza Gli atleti con cicatrice non ischemica del ventricolo sinistro *estesa* (3 o più segmenti) anche in assenza di marker di rischio non dovrebbero partecipare ad attività sportive agonistiche, con la possibile eccezione delle attività sportive del Gruppo A, dopo accurata valutazione del rischio caso per caso e condotta in centri di riferimento di provata esperienza.	II	C

CARDIAC INFLAMMATORY DISEASE

MYOCARDITIS

Inflammatory condition of the heart muscle (myocardium).

PERICARDITIS



Inflammation of the pericardium, the thin, two-layered sac-like membrane that surrounds the heart.

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PERICARDITIS

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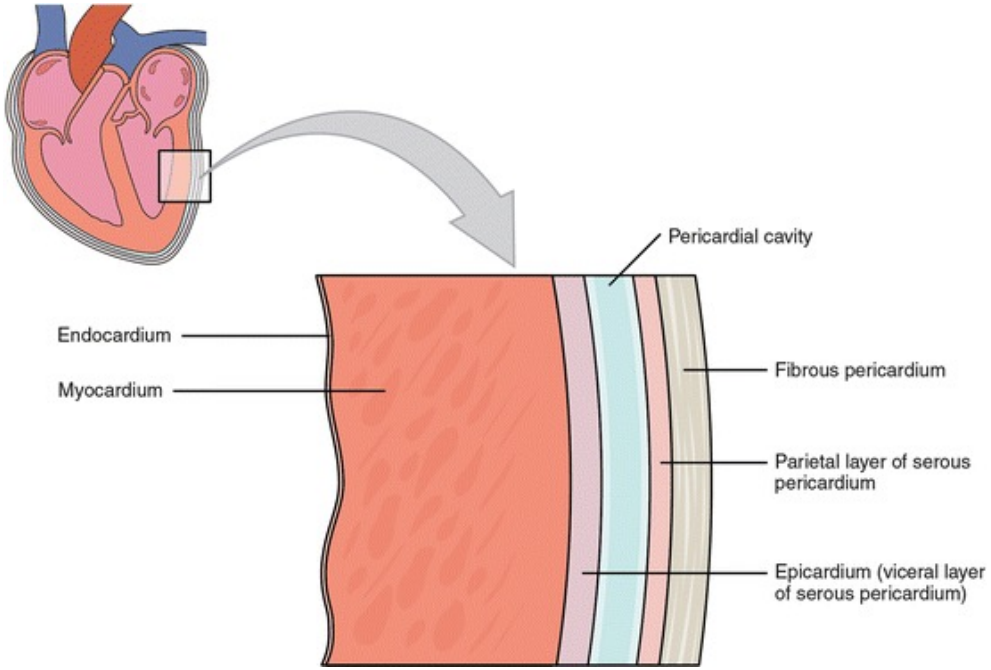


Normal thickness → < 2 mm

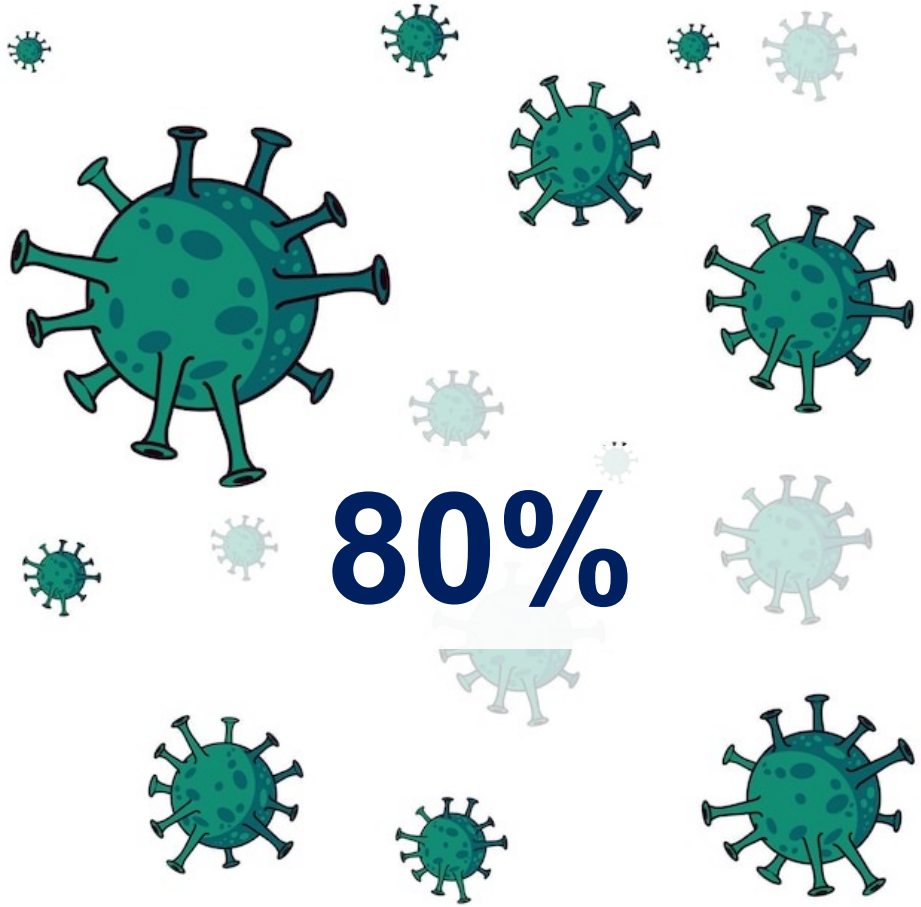
Abnormal thickness → 4 mm

Risk of constriction → >5-6 mm

PERICARDITIS - CMR

Table 2. Etiologies of Acute Pericarditis

Infectious	Noninfectious	Hypersensitivity- or autoimmunity-related
Viral*	Acute idiopathic*	Medication induced (select drugs)*
Adenovirus	Acute myocardial infarction*	Anticoagulants
Coxsackie virus A and B	Neoplastic*	Hydralazine
Echovirus	Primary tumors	Isoniazid
Epstein-Barr virus	Fibroma	Minoxidil
Hepatitis	Lipoma	Phenytoin (Dilantin)
Human immunodeficiency virus	Mesothelioma	Procainamide
Influenza	Sarcoma	Metabolic disorders*
Mumps	Metastatic tumors	Gout
Bacterial*	Breast	Myxedema
Haemophilus	Leukemia	Renal insufficiency (i.e., dialysis pericarditis)
Legionella	Lung	Uremia
Meningococcus	Lymphoma	Postcardiac injury
Neisseria	Melanoma	Postmyocardial infarction (Dressler syndrome)
Pneumococcus	Sarcoma	Postpericardiotomy syndrome
Salmonella	Trauma	Posttraumatic
Staphylococcus	Direct pericardial injury	Collagen vascular disease
Streptococcus	Cardiac injury (e.g., cardiac surgery, catheterization)	Ankylosing spondylitis
Streptococcus pneumoniae (in children)	Pericardial perforation (e.g., gastric/esophageal perforation, chest trauma)	Dermatomyositis
Syphilis	Indirect pericardial injury	Familial Mediterranean fever
Tuberculosis	Blunt chest trauma	Polyarteritis nodosa
Whipple disease	Radiation	Rheumatoid arthritis
Fungal	Aortic dissection (with leakage into pericardial sac)	Sarcoidosis
Aspergillosis	Chylopericardium	Scleroderma
Blastomycosis	Familial pericarditis	Sjögren syndrome
Candida	Pregnancy	Systemic lupus erythematosus
Coccidioidomycosis		Wegener granulomatosis
Histoplasmosis		Rheumatic fever
Other		
Parasitic		
Protozoal		



Snyder, Matthew J et al. “Acute pericarditis: diagnosis and management.” American family physician vol. 89,7 (2014): 553-60.

Diagnosis

- The use of CMR remains limited;
- Ability to provide information when hemodynamic assessment with echocardiography is difficult and the diagnosis remains unclear.

Table 4 Criteria for acute pericarditis (the presence of two criteria is considered diagnostic)

Typical chest pain
Pericardial friction rub
ECG changes consistent with pericarditis
New or worsening PEff
*Elevated C-reactive protein or ultrasensitive C-reactive protein/ Westergren sedimentation rate is a confirmatory finding
*LGE on CMR may be a new confirmatory finding

Adapted from Imazio.[4]

Klein, Allan L et al. "American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography." Journal of the American Society of Echocardiography doi:10.1016/j.echo.2013.06.023

PERICARDITIS - CMR

- Pericardial thickening
- Pericardial enhancement
- Pericardial effusion characterization:
  - Trasudate: low T1, high T2
  - Essudate: low-intermed T1, intermed T2
  - Chilous: high T1
  - Blood: variable T1 and T2 (age-dependent)

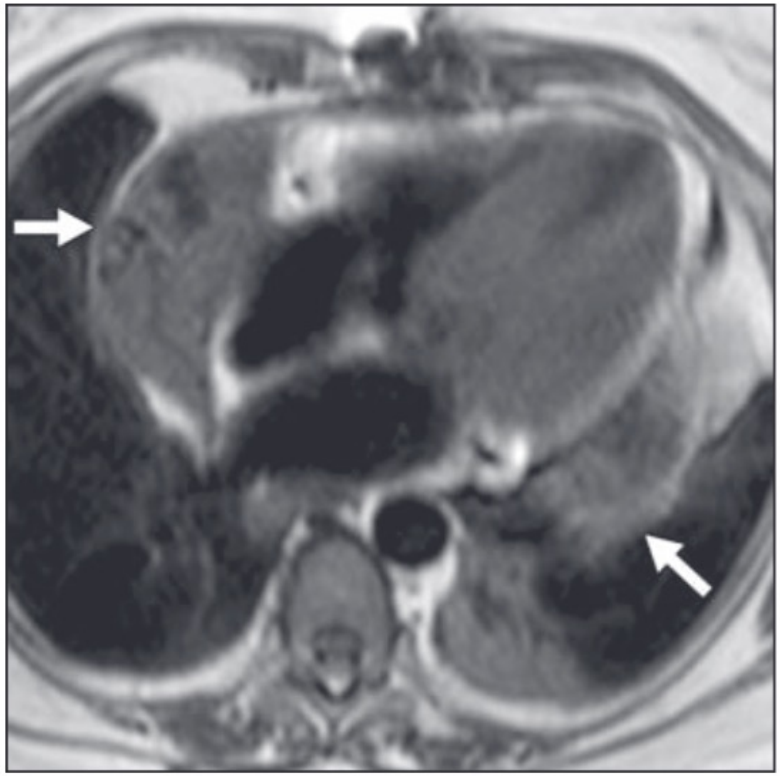
Table 1 A summary comparing different kinds of pericardial effusions according to the signal intensity (S.I) on T1 weighted imaging (T1W), T2 weighted imaging (T2W), and the T1 time in milliseconds (ms) in T1 mapping sequence

	T1W(S.I)	T2W(S.I)	T1 mapping
Exudates	Medium	Medium	> 3013 ms
Transudates	Low	High	< 3013 ms
Hemorrhagic	High	High	–
Proteinaceous	High	Low	–

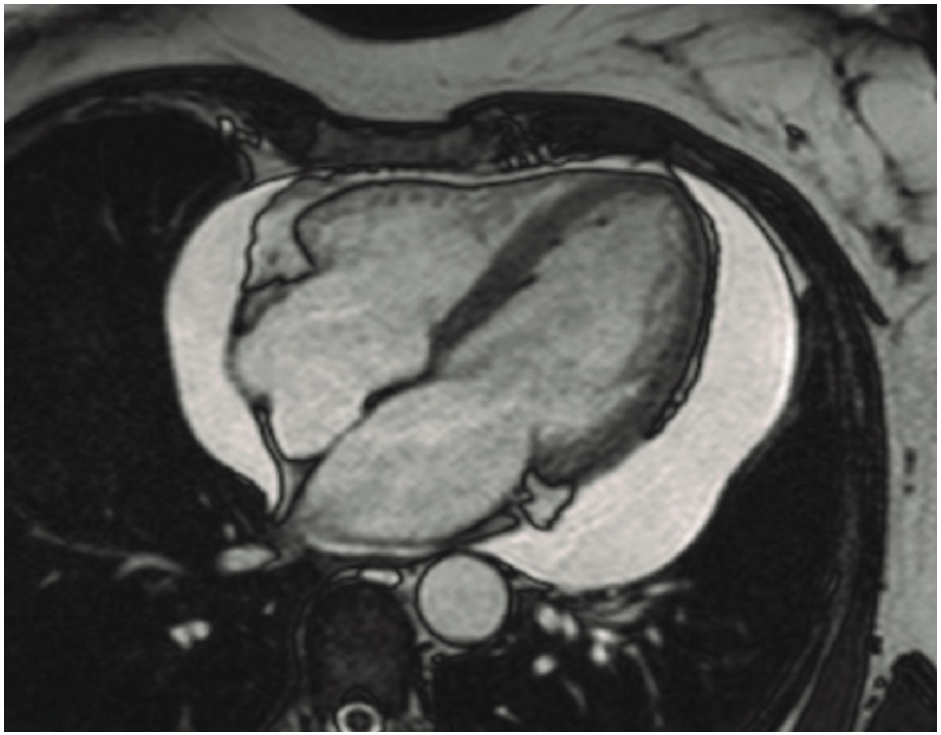
Klein, Allan L et al. “American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography.” Journal of the American Society of Echocardiography doi:10.1016/j.echo.2013.06.023

PERICARDITIS - CMR

Essudate



Trasudate



Klein, Allan L et al. “American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography.” Journal of the American Society of Echocardiography doi:10.1016/j.echo.2013.06.023

PERICARDITIS

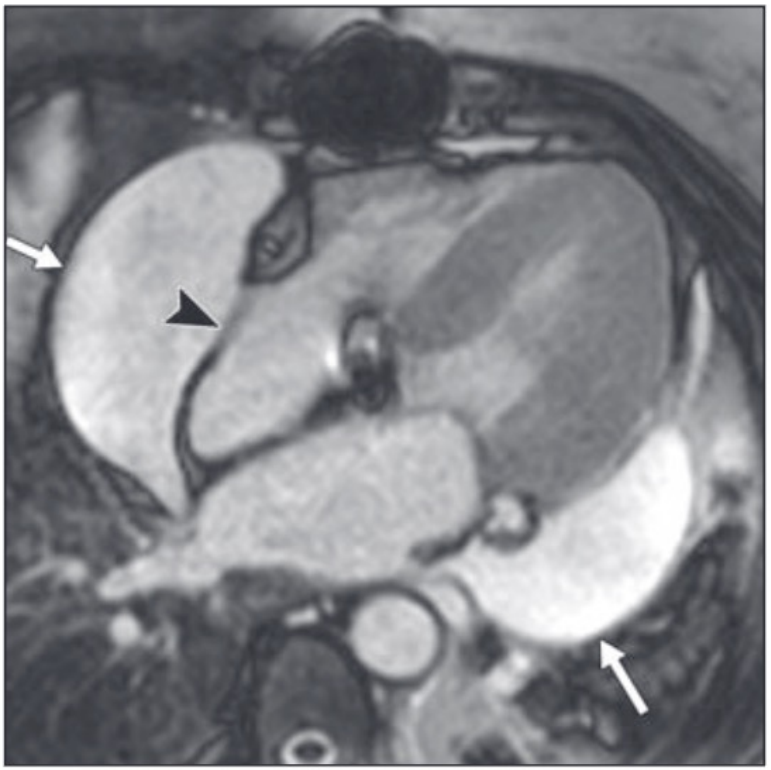
Pericardial enhancement

Klein, Allan L et al. “American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography.” Journal of the American Society of Echocardiography doi:10.1016/j.echo.2013.06.023

PERICARDITIS

Pericardial tamponade

With cine SSFP imaging and real-time cine CMR imaging, flattening of the interventricular septum, compression of the coronary sinus, distention of the superior vena cava, and the respiratory ventricular interdependence can be imaged.



Klein, Allan L et al. "American Society of Echocardiography clinical recommendations for multimodality cardiovascular imaging of patients with pericardial disease: endorsed by the Society for Cardiovascular Magnetic Resonance and Society of Cardiovascular Computed Tomography." Journal of the American Society of Echocardiography doi:10.1016/j.echo.2013.06.023

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TAKE HOME MESSAGE

SISTEMA SANITARIO REGIONALE
AZIENDA OSPEDALIERO-UNIVERSITARIA SANT'ANDREA

- Myocarditis and pericarditis are connected;
- MRI is fundamental for diagnosis (Lake Louise criteria 2.0) and prognosis (3-6 months)
- Evaluate LGE pattern and evolution of LGE
- Higher accuracy and sensivity of Parametric imaging compared to standard sequences
- MRI is only supportive in pericarditis

SISTEMA SANITARIO REGIONALE
AZIENDA OSPEDALIERO-UNIVERSITARIA SANT'ANDREA

Cardio-TC/RM WEBINAR FAD

Dal 16 maggio 2024 all'11 Luglio 2024

PROGRAMMA

16 Maggio – ore 17.00/18.00
Introduzione al Corso (A. Laghi)
Saluti Direzione Generale AOUSA (D. Donetti)
Tecnica di acquisizione della Cardio TC/Utilizzo del Mdc e Triple-rule-out (D. Caruso)

23 Maggio – ore 17.00/18.00
Anatomia coronarica (L. Pugliese)

30 Maggio – ore 17.00/18.00
Caratteristiche di placca: calcifica, non calcifica, vulnerabile (D. De Santis)

6 Giugno – ore 17.00/18.00
La definizione della stenosi secondo CAD-RADS v.2 (D. De Santis)

13 Giugno – ore 17.00/18.00
Indicazione alla Cardio RM, protocollo di acquisizione e sequenze principali (D. De Santis)

27 Giugno – ore 17.00/18.00
Patologia infiammatoria (miocarditi, pericarditi) (D. De Santis)

4 Luglio – ore 17.00/18.00
Cardiopatia ischemica (L. Pugliese)

11 Luglio – ore 17.00/18.00
Cardiomiopatie (ipertrofica, dilatativa, aritmogena) e patologie da Accumulo (L. Pugliese)

SAPIENZA UNIVERSITÀ DI ROMA

Il **Corso Webinar CardioTC** e **CardioRM** del Sant'Andrea 2024 è un corso di Cardio TC (Tomografia Computerizzata) e Cardio RM (Risonanza Magnetica) progettato per fornire ai discenti una comprensione approfondita delle due principali tecniche di imaging cardiaco utilizzate nella pratica clinica moderna.
Questo corso mira a fornire una panoramica completa dei principi di base, delle applicazioni cliniche e delle sfide associate all'uso della TC e della RM nel contesto della valutazione cardiaca. Il corso inizia con una discussione delle tecniche di acquisizione della Cardio TC, compreso l'uso dei mezzi di contrasto e i protocolli come il "Triple-rule- out". I discenti impareranno a interpretare le immagini TC per valutare l'anatomia coronarica, identificare caratteristiche delle placche aterosclerotiche e definire stenosi coronariche secondo il sistema CAD-RADS.
Successivamente, il focus si sposta sulla Cardio RM, esplorando le indicazioni per questo tipo di imaging, i protocolli di acquisizione e le sequenze principali utilizzate per valutare la struttura e la funzione cardiaca per diagnosticare patologie cardiache, tra cui infiammazioni miocardiche, cardiomiopatie e malattie da accumulo.

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AZIENDA OSPEDALIERO-UNIVERSITARIA SANT'ANDREA

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