Scientific and Technological Advancements in Cardiac and Vascular Surgery

Magnetic Resonance versus Nuclear Medicine for Tissue Characterisation

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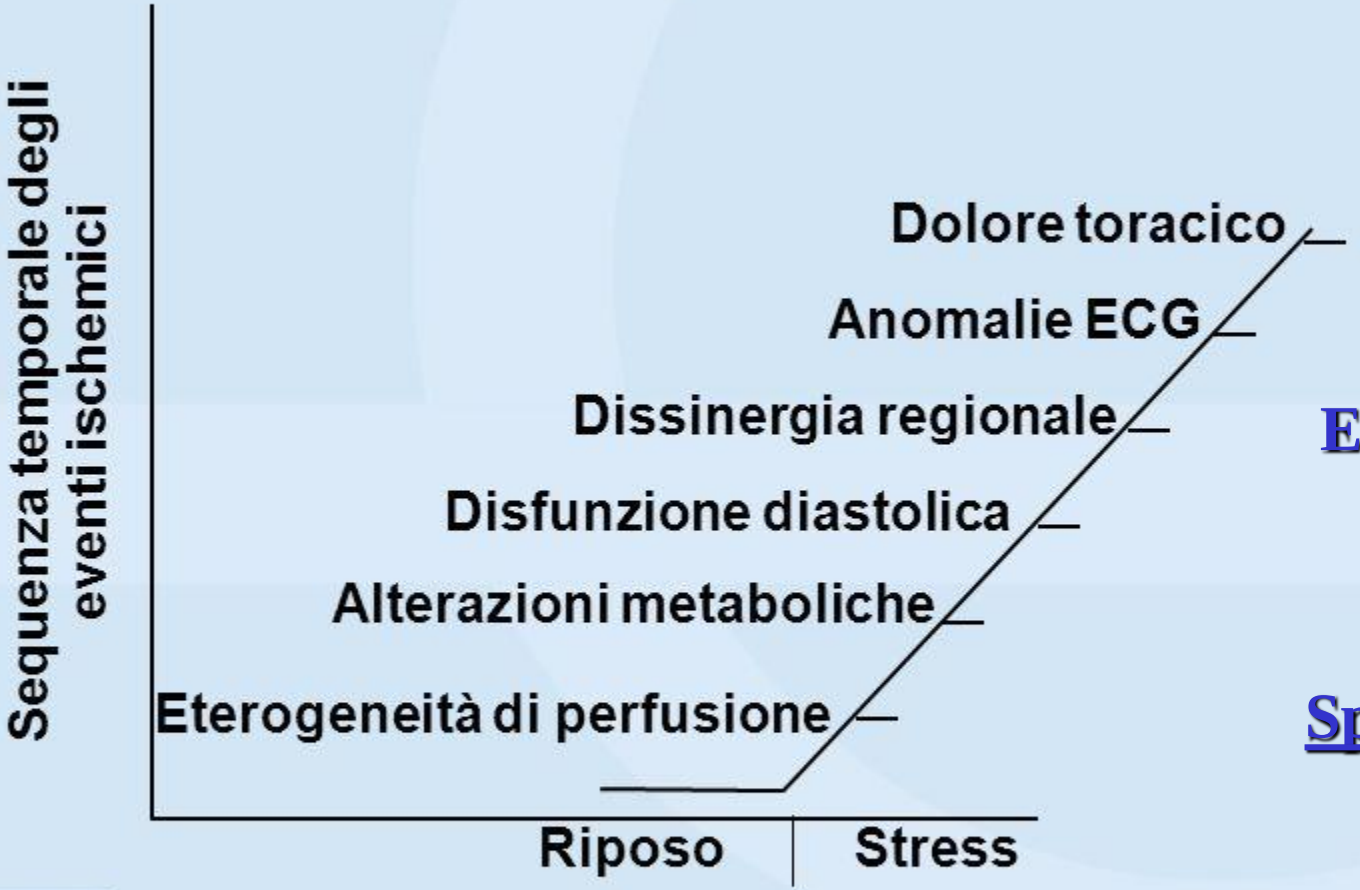
Erice – 30/4 - 6/5/2015

La cascata ischemica

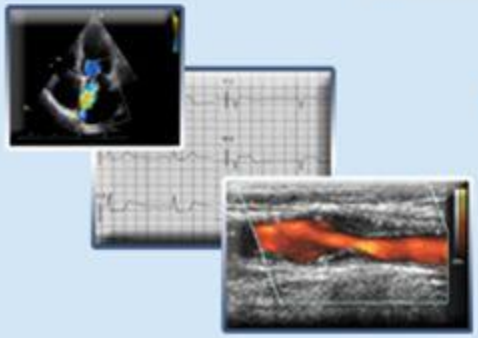


TE

ECO e RM

PET

Spect e RM



E. Picano, Stress Echocardiography 1994 (mod)

European Heart Journal (2013) **34**, 2949–3003
doi:10.1093/eurheartj/eht296

ESC GUIDELINES

2013 ESC guidelines on the management of stable coronary artery disease

The Task Force on the management of stable coronary artery disease of the European Society of Cardiology

Task Force Members: Gilles Montalescot* (Chairperson) (France), Udo Sechtem* (Chairperson) (Germany), Stephan Achenbach (Germany), Felicita Andreotti (Italy), Chris Arden (UK), Andrzej Budaj (Poland), Raffaele Bugiardini (Italy), Filippo Crea (Italy), Thomas Cuisset (France), Carlo Di Mario (UK), J. Rafael Ferreira (Portugal), Bernard J. Gersh (USA), Anselm K. Gitt (Germany), Jean-Sebastien Hulot (France), Nikolaus Marx (Germany), Lionel H. Opie (South Africa), Matthias Pfisterer (Switzerland), Eva Prescott (Denmark), Frank Ruschitzka (Switzerland), Manel Sabaté (Spain), Roxy Senior (UK), David Paul Taggart (UK), Ernst E. van der Wall (Netherlands), Christiaan J.M. Vrints (Belgium).

Table 19 Risk stratification using ischaemia testing

Recommendations	Class [a]	Level [b]	Ref. [c]
Risk stratification is recommended based on clinical assessment and the result of the stress test initially employed for making a diagnosis of SCAD.	I	B	109, 206–209
Stress imaging for risk stratification is recommended in patients with a non-conclusive exercise ECG[d]	I	B	210
Risk stratification using stress ECG (unless they cannot exercise or display ECG changes which make the ECG non evaluable) or preferably stress imaging if local expertise and availability permit is recommended in patients with stable coronary disease after a significant change in symptom level.	I	B	210–212
Stress imaging is recommended for risk stratification in patients with known SCAD and a deterioration in symptoms if the site and extent of ischaemia would influence clinical decision making.	I	B	146, 213–215
Pharmacological stress with echocardiography or SPECT should be considered in patients with LBBB.	IIa	B	216–218
Stress echocardiography or SPECT should be considered in patients with paced rhythm.	IIa	B	219, 220

ECG = electrocardiogram; LBBB = left bundle branch block; SCAD = stable coronary artery disease; SPECT = single photon emission computed tomography.

[a] Class of recommendation.

[b] Level of evidence.

[c] Reference(s) supporting levels of evidence.

[d] Stress imaging has usually been performed for establishing a diagnosis of SCAD in most of these patients.

6.4.3.3 Stress perfusion scintigraphy (single photon emission computed tomography and positron emission tomography)

Myocardial perfusion imaging using single photon emission computed tomography (SPECT) is a useful method of non-invasive risk stratification, readily identifying those patients at greatest risk for subsequent death and MI. Large studies have found that a normal stress perfusion study is associated with a subsequent rate of cardiac death and MI of $<1\%$ per year, which is nearly as low as that of the general population.[195] In contrast, large stress-induced perfusion defects, defects in multiple coronary artery territories, transient post-stress ischaemic LV dilatation and increased lung uptake of ^{201}Tl on post-stress images are all adverse prognostic indicators.[196] Patients with stress-induced reversible perfusion deficits $>10\%$ of the total LV myocardium (≥ 2 of the 17 segments) represent a high-risk subset.[194,197] Early coronary arteriography should be considered in these patients.

The extent and severity of ischaemia and scar on PET MPI in patients with known or suspected CAD also provides incremental event risk estimates of cardiac death and all-cause death, compared with traditional coronary risk factors.[198] Moreover, coronary vasodilator dysfunction quantified by PET is an independent correlate of cardiac mortality among both diabetics and non-diabetics.[199]

6.4.3.4 Stress cardiac magnetic resonance

There is an independent association between adverse cardiac outcomes in multivariate analysis for patients with an abnormal dobutamine stress CMR and $>99\%$ event-free survival in patients with no evidence of ischaemia over a 36-month follow-up.[200] Similar data exist for perfusion CMR using adenosine stress.[201] Assuming that the biological principles are the same for stress echocardiography and stress SPECT as they are for CMR, new wall motion abnormalities (≥ 3 segments in the 17 segment model) induced by stress or stress-induced reversible perfusion deficits $>10\%$ (≥ 2 segments) of the LV myocardium should be regarded as indicating a high event risk situation.[194] However, there are as yet no data providing proof that this distinction can be made by CMR in the same way as with SPECT. In fact CMR estimates of the extent of perfusion deficit as a percentage of the entire LV are imprecise, as compared with SPECT, as only three slices of the LV are currently examined by standard CMR machines.

Risonanza Magnetica

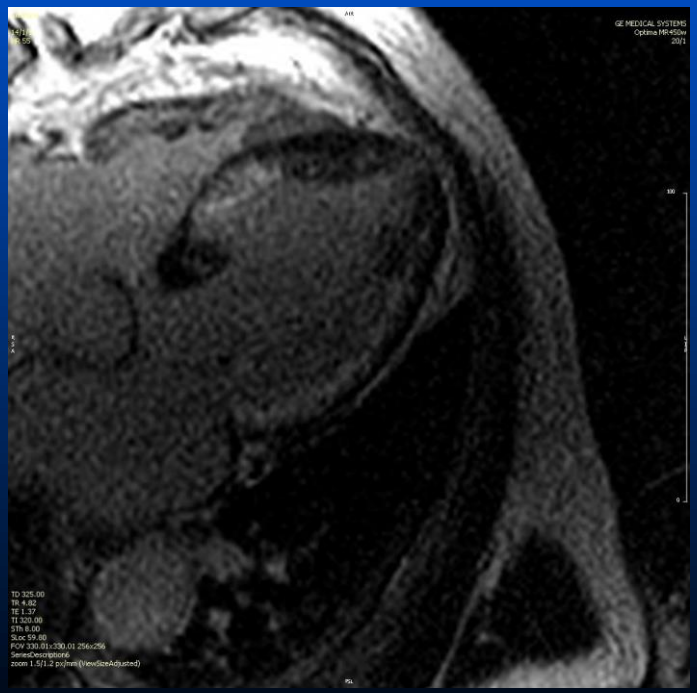
Risonanza magnetica

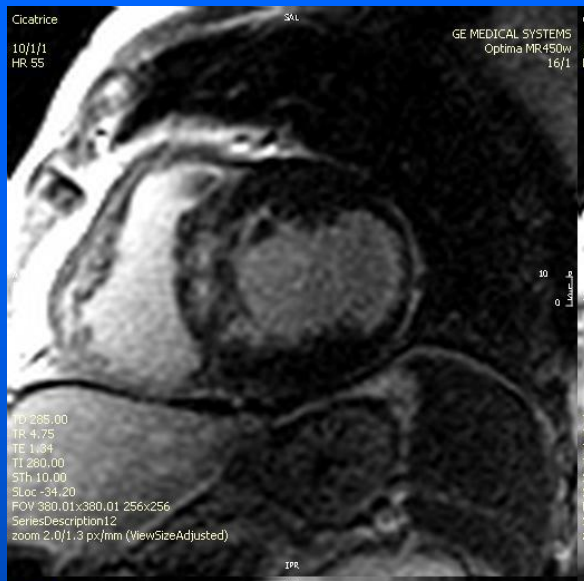
- **Apparecchiature ad alto campo**
- **Non invasiva, multiparametricità, multiplanarietà**
- **Composizione tissutale, valutazione funzionale**
- **Gating cardiaco: sincronizzazione con tracciato ECG**
- **Immagini statiche del cuore**
- **Piani: asse corto, asse lungo verticale, asse lungo orizzontale**
- **Sequenze veloci, cine-RM (immagini in movimento), tagging miocardico (individua la stessa zona di miocardio nelle diverse fasi del ciclo)**
- **Analisi anatomica e funzionale (gold standard per la FE)**

Delayed enhancement

La ricerca di vitalità con tecnica fast GRE IR dopo 5-10’ dall’iniezione del MDC permette di evidenziare le zone infartuate (e fibrotiche) non vitali come iperintense (bright is dead) per accumulo extracellulare e ritardato wash-out.

Visualizza direttamente la fibrosi miocardica e permette la determinazione della sua estensione (transmurale, subepicardica o subendocardica) e quantificazione. Se l’estensione del DE supera il 75% il miocardio è considerato non vitale.

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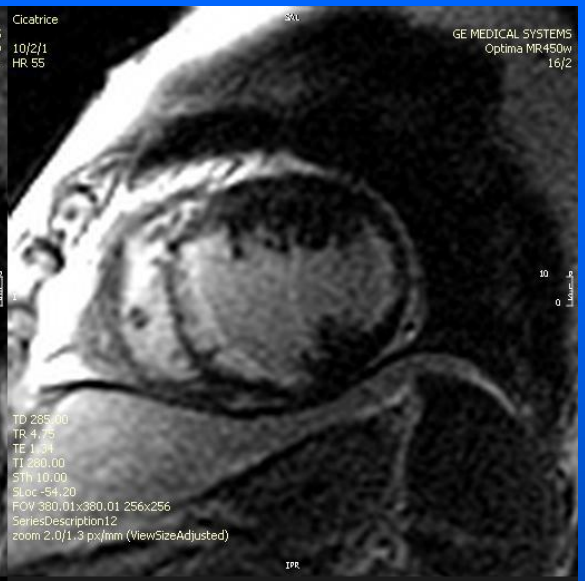
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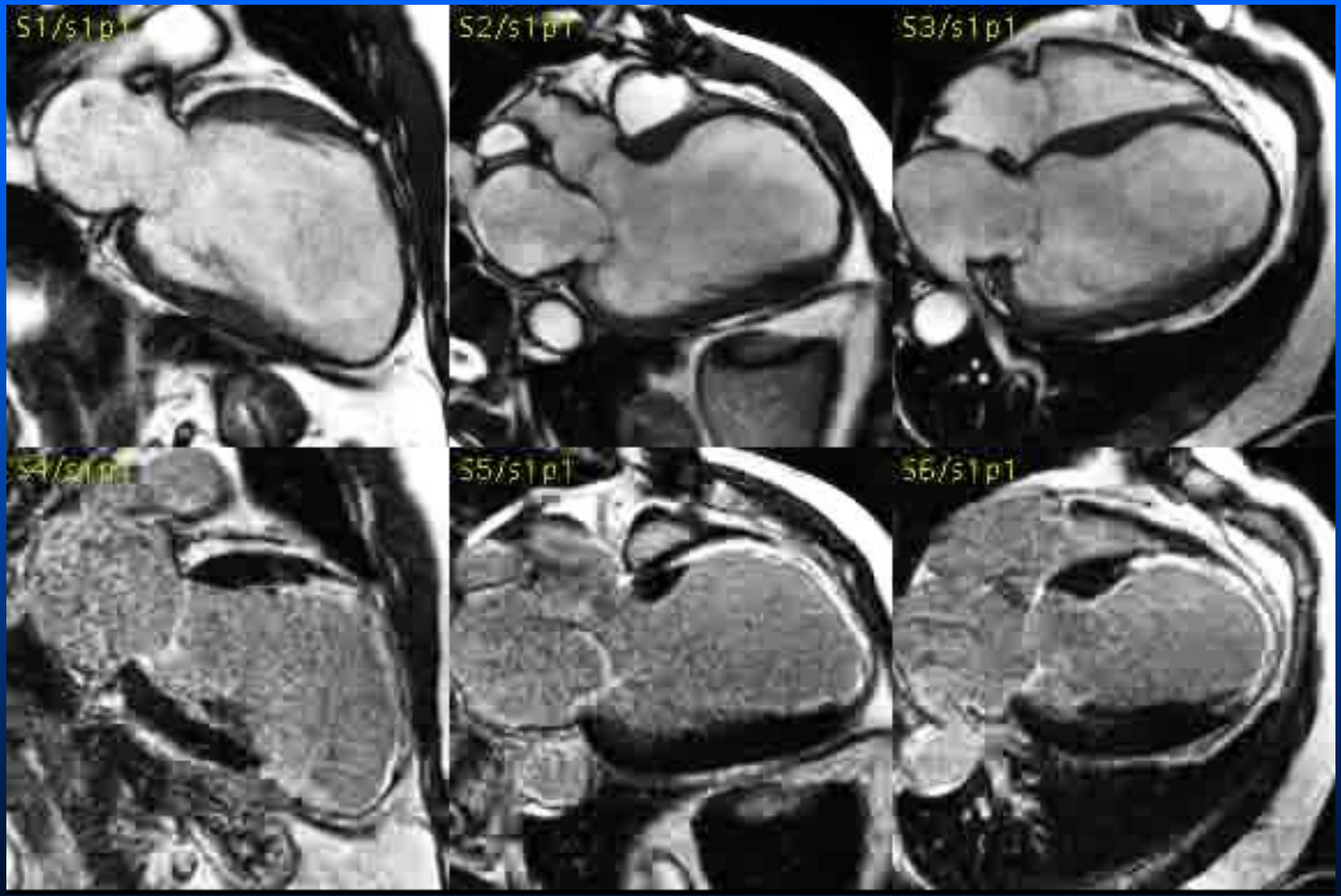
Aneurisma + cicatrice medio apicale



Ricerca ischemia inducibile e vitalità

La RM con mezzo di contrasto permette di valutare la presenza di ischemia con studio perfusionale, sia in basale che dopo stimolo farmacologico

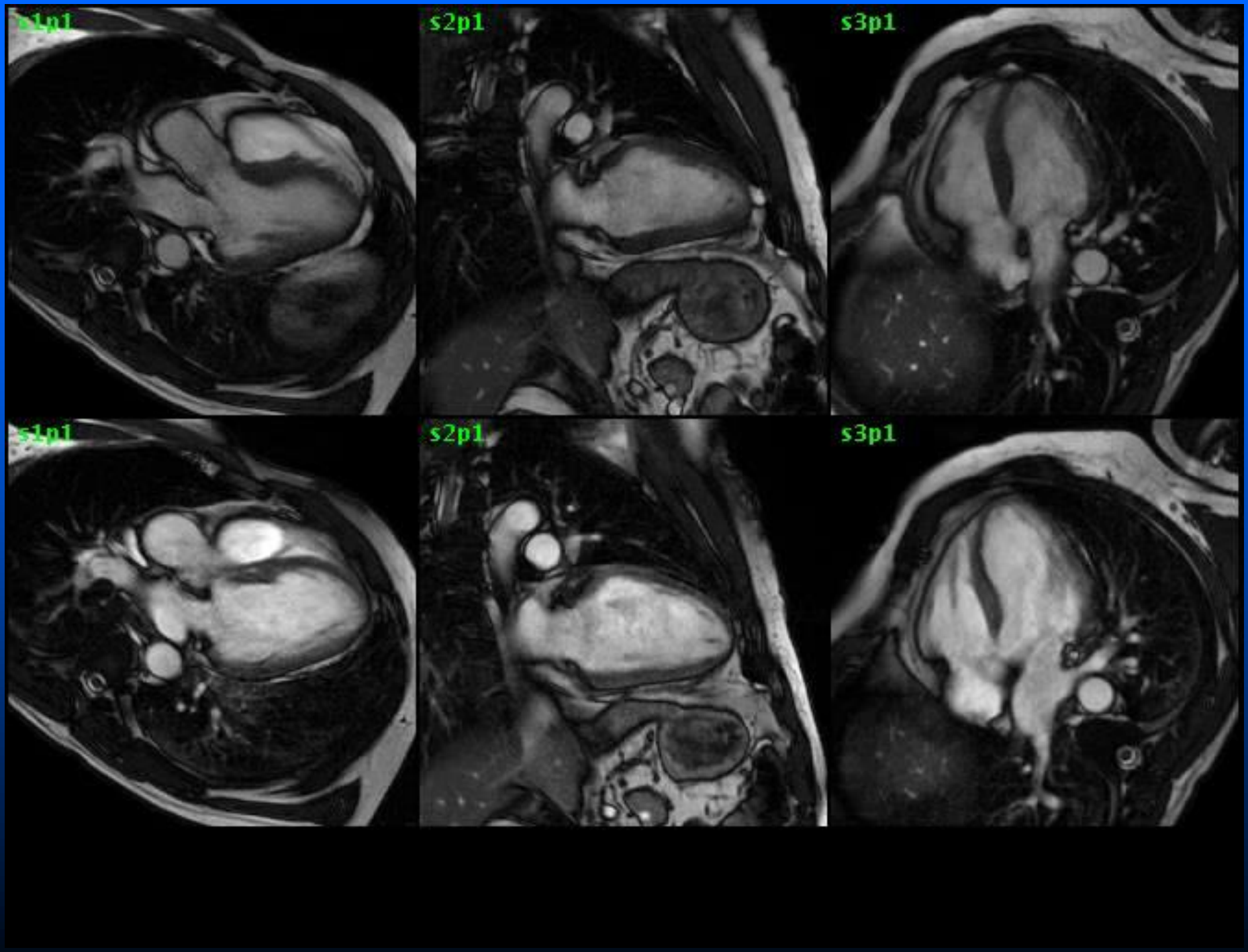
La metodica Delayed Enhancement (DE) permette la valutazione della vitalità dei segmenti miocardici.

Le sequenze per lo studio perfusionale vengono generalmente attuate con l'utilizzo di mezzo di contrasto a base di gadolinio (contrasto paramagnetico intravascolare/extracellulare)

Perfusione

Lo stress farmacologico sfrutta la tecnica del primo passaggio dopo iniezione di MDC. Le aree non perfuse si evidenzano con tecnica FIESTA come più scure (segnale ipointenso).

La RM con stress farmacologico ricalca come protocolli gli stessi usati in ecocardiografia. In particolare sono diffusamente utilizzati lo stress con adenosina e dipiridamolo che agiscono mediante “furto da vasodilatazione”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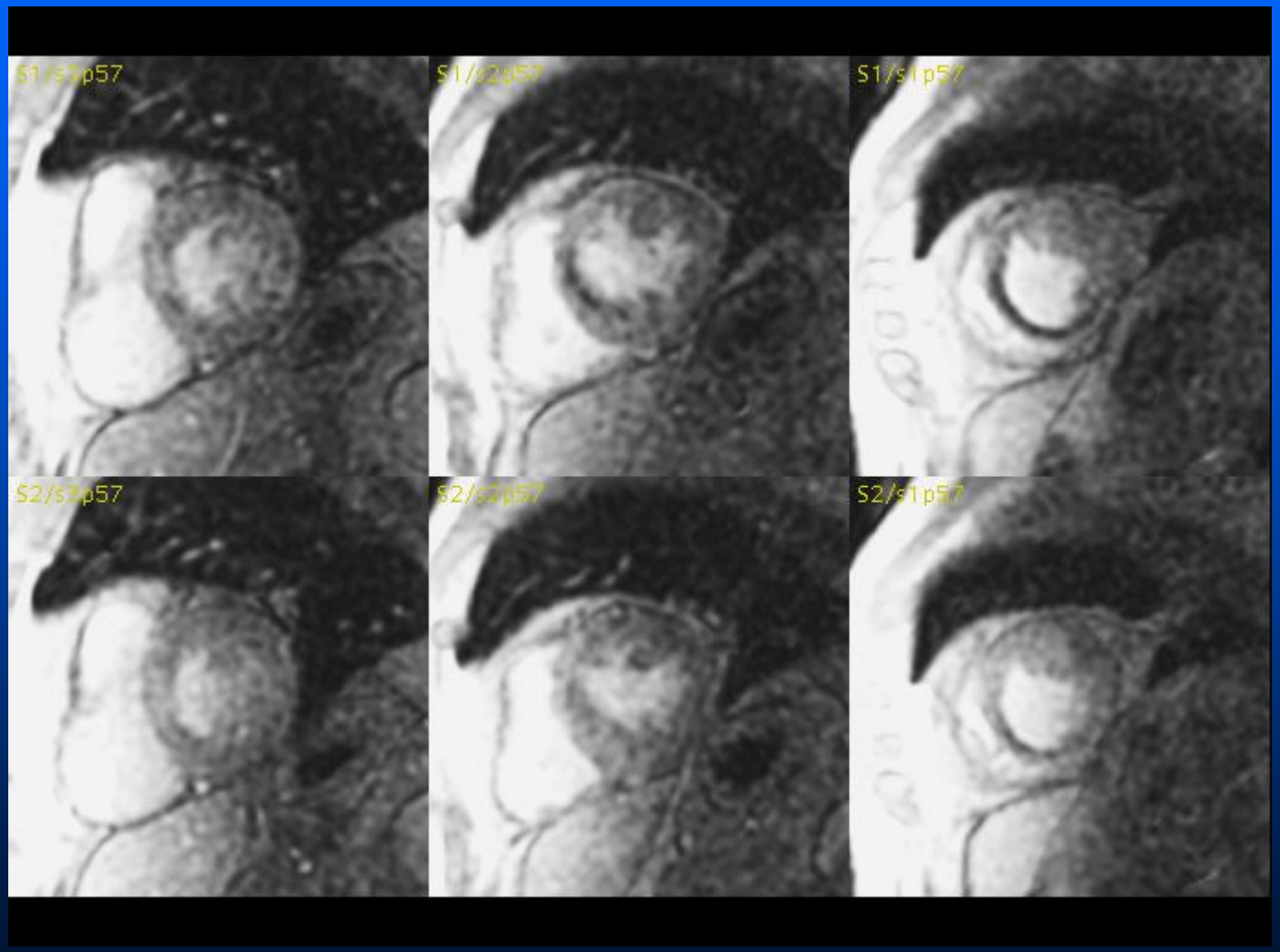
Analisi di perfusione



Dipiridamolo

Riposo

Controindicazioni:

PaceMaker e ICD

Tutto ciò che ha una componente metallica deve essere verificato se compatibile o meno (http://www.mrisafety.com)

Claustrofobia

Scintigrafia miocardica

Scintigrafia miocardica

- **Scintigrafia (planari e SPECT) con Tallio - 201 e tecneziati (Tc-99-MIBI, tetrafosmina): studi di perfusione miocardica in condizioni basali, stress fisico e farmacologico**

- **PET: studi di perfusione (13N- NH_3) e metabolismo 18F-FDG (miocardio vitale)**

Scintigrafia miocardica

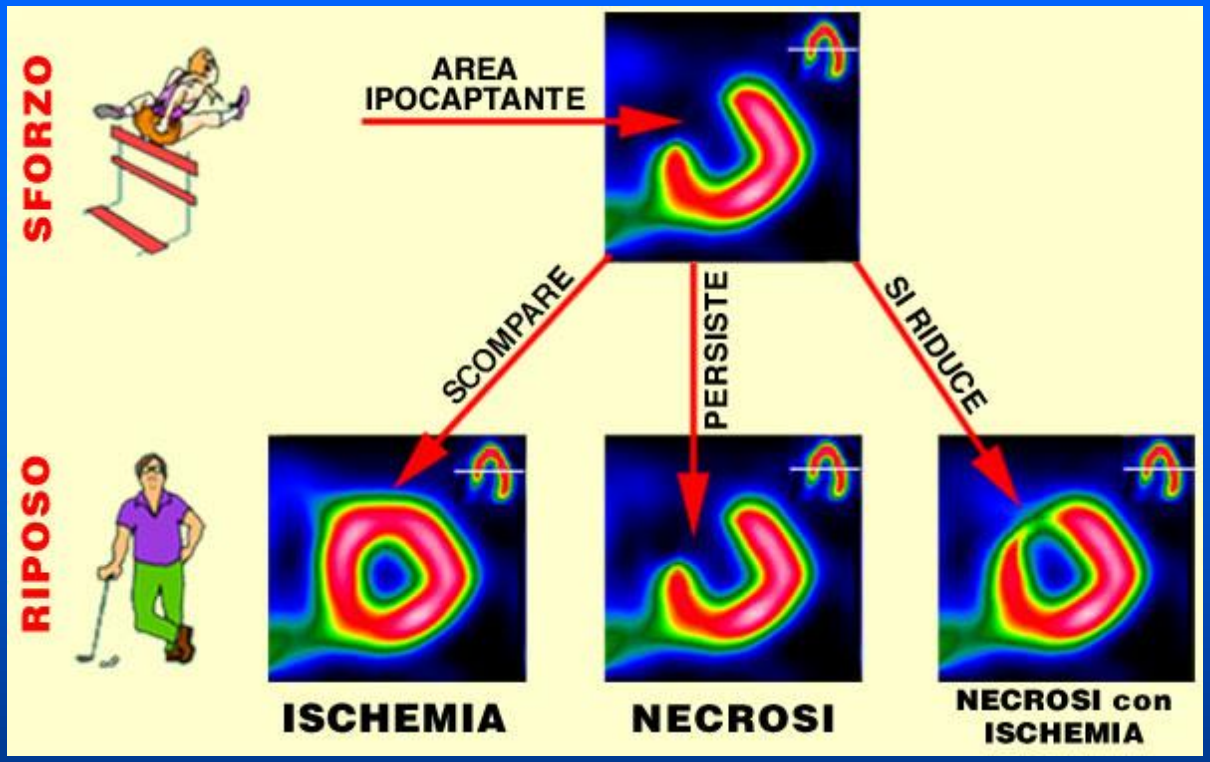
- Uso di traccianti radioattivi a bassissimo dosaggio che hanno la capacità di legarsi alle cellule cardiache in modo direttamente proporzionale al flusso coronarico.

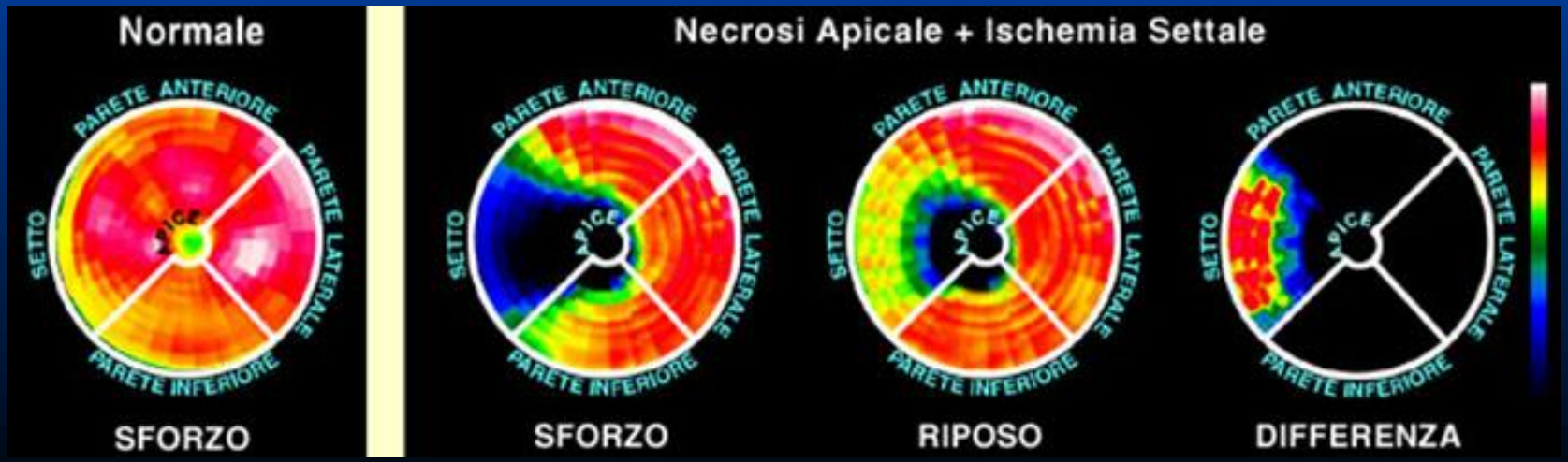
- Informazioni anche sulla contrattilità globale e segmentaria del muscolo cardiaco (valutazione semiquantitativa), sulle sue dimensioni e sulla presenza di cellule vitali all'interno di aree infartuate

Scintigrafia miocardica

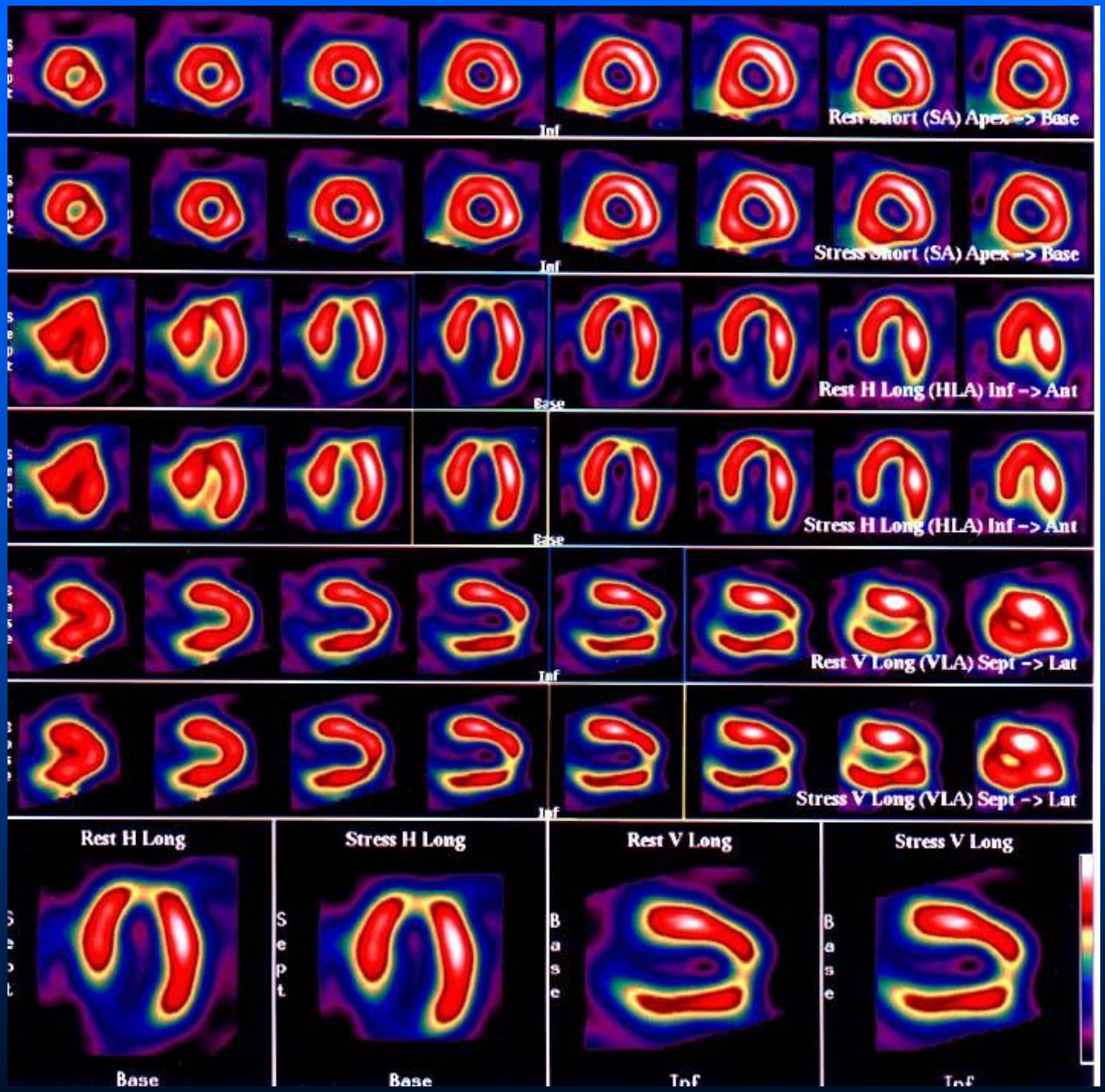
- L'esame può essere eseguito utilizzando protocolli diversi; nella maggioranza dei casi il primo step consiste in una prova da sforzo (o stress farmacologico con Dipiridamolo), alla fine della quale viene iniettato in vena il tracciante radioattivo e fatta una prima acquisizione d'immagine.
- Dopo circa 4 ore (e in alcuni casi 24 ore, a seconda del farmaco utilizzato) viene eseguita una seconda acquisizione d'immagine a riposo, quindi una ricostruzione con il confronto delle immagini.

Scintigrafia miocardica





Scintigrafia miocardica



Raccomandazioni:

- Pur essendo la dose di sostanza radioattiva minima è consigliabile evitare per 48 ore contatti prolungati con bambini e donne in gravidanza.

- Le donne in età fertile devono accertarsi di non essere in stato interessante prima di intraprendere l'esame.

- Nel caso il test sia eseguito con l'iniezione di dipiridamolo è anche opportuno che il paziente non assuma teofillina (contenuta nel thè) o sostanze simili come la caffeina contenuta nel caffè / coca cola così come nel cioccolato.

Accuratezza diagnostica

STRESS TEST	SENSITIVITY	SPECIFICITY
Exercise ECG	68%	77%
Exercise SPECT	87%	73%
Pharm SPECT	89%	75%
Exercise Echo	84%	86%
Dobut Echo	81%	85%
CMR Stress*	83%	86%

ACC/AHA 1997-2001

RM perfusionale: accuratezza diagnostica

Table 5. Sensitivity and Specificity of Recent CMR Perfusion Studies on a Per-Patient Basis for Detecting Coronary Arterial Luminal Narrowings ≥50%

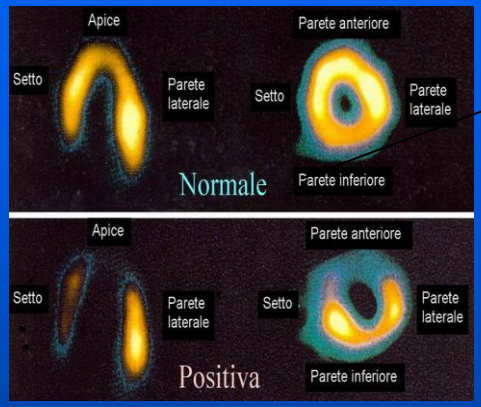
Investigators	n	Stress Agent	Sensitivity (%)	Specificity (%)
Cury et al.[137]	46	Dipyridamole	97	75
Doyle et al.[138]	184	Dipyridamole	57	78

Table 6. Sensitivity and Specificity of Recent CMR Wall Imaging Studies on a Per-Patient Basis in Detecting Coronary Arterial Luminal Narrowings ≥50%

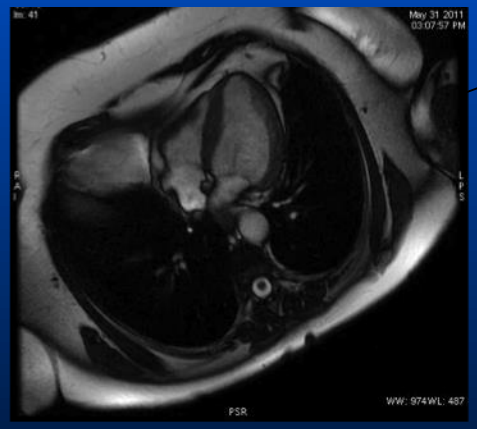
Investigators	n	Stress Agent	Sensitivity (%)	Specificity (%)
Baer et al.[150]	23	Dipyridamole	78	NA
Baer et al.[151]*	32	Dobutamine	84	NA
Hundley et al.[149]	41	Dobutamine and atropine	83	83
Jahnke et al.[152]	40	Dobutamine	89	75
Nagel et al.[148]	172	Dobutamine	86	86
Paetsch et al.[153]	79	Adenosine	91	62
Paetsch et al.[153]	79	Dobutamine and atropine	89	81
Paetsch et al.[154]	150	Dobutamine	78	88
Pennell et al.[155]	40	Dipyridamole	62	100
Pennell et al.[156]	25	Dobutamine	91	100
Rerkpattanapipat et al.[157]	27	Exercise	79	85
Schalla et al.[158]	22	Dobutamine	81	83
van Rugge et al.[159]	45	Dobutamine	81	100
van Rugge et al.[160]	39	Dobutamine	91	0.83

CMR indicates cardiovascular magnetic resonance; and NA, not available.
*Utilized 2 perfusion territories (left anterior descending coronary artery and combined left circumflex artery/right coronary artery).
Modified from Nandalur et al.[146]

Accuratezza diagnostica



- Stress fisico o farmacologico
- Monitoraggio ECG
- Valutazione semiquantitativa della Cinesi
- BLS nella stanza nucleare
- Alta esposizione a radiazioni



- Solo stress farmacologico
- Tratto ST non valutabile
- Monitoraggio della cinesi in Real Time
- BLS fuori dalla stanza con RM
- Nessuna esposizione a radiazioni

RM perfusionale: accuratezza diagnostica

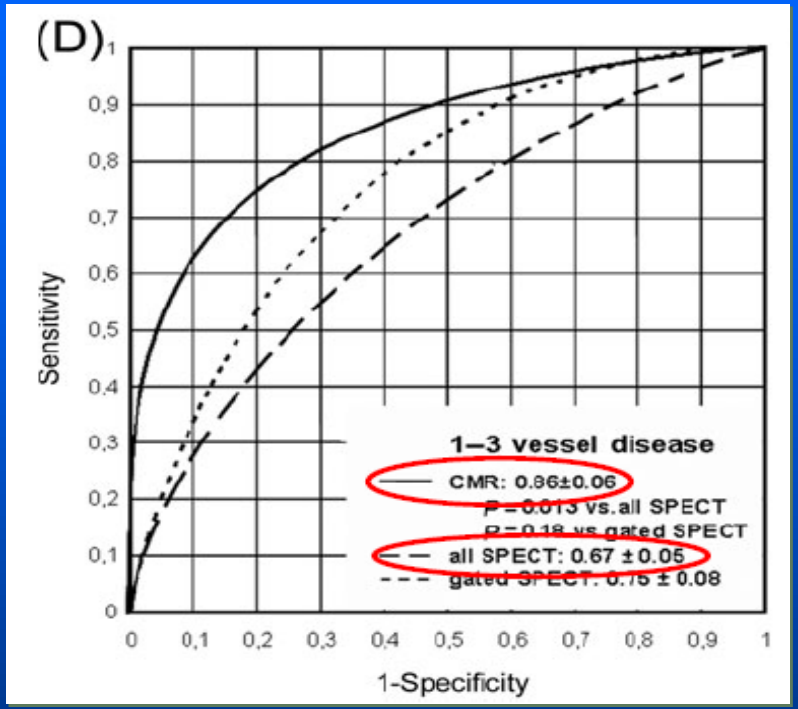
European Heart Journal (2008) 29, 480–489
doi:10.1093/eurheartj/ehm617

CLINICAL RESEARCH
Imaging

MR-IMPACT: comparison of perfusion-cardiac magnetic resonance with single-photon emission computed tomography for the detection of coronary artery disease in a multicentre, multivendor, randomized trial

Juerg Schwitter[1]*, Christian M. Wacker[2], Albert C. van Rossum[3], Massimo Lombardi[4], Nidal Al-Saadi[5], Hakan Ahlstrom[6], Thorsten Dill[7], Henrik B.W. Larsson[8], Scott D. Flamm[9], Moritz Marquardt[10], and Lars Johansson[6]

La sensibilità della RM perfusionale è stata superiore alla SPECT perfusionale, mentre la specificità è stata inferiore se comparata alla SPECT. In pazienti selezionati (senza aritmie severe), la RM è un approccio sicuro e un'alternativa alla SPECT per identificare alterazioni della perfusione nella cardiopatia ischemica



European Heart Journal (2013) 34, 775–781
doi:10.1093/eurheartj/ehs022

CLINICAL RESEARCH
Imaging

MR-IMPACT II: Magnetic Resonance Imaging for Myocardial Perfusion Assessment in Coronary artery disease Trial: perfusion-cardiac magnetic resonance vs. single-photon emission computed tomography for the detection of coronary artery disease: a comparative multicentre, multivendor trial

Juerg Schwitter[1]*, Christian M. Wacker[2], Norbert Wilke[3], Nidal Al-Saadi[4], Ekkehart Sauer[5], Kalman Huettle[6], Stefan O. Schönberg[7], Andreas Luchner[8], Oliver Strohm[9], Hakan Ahlstrom[10], Thorsten Dill[11], Nadja Hoebel[12], and Tamas Simor[13], for the MR-IMPACT Investigators

RM: stratificazione prognostica

Incremental Prognostic Significance of Combined Cardiac
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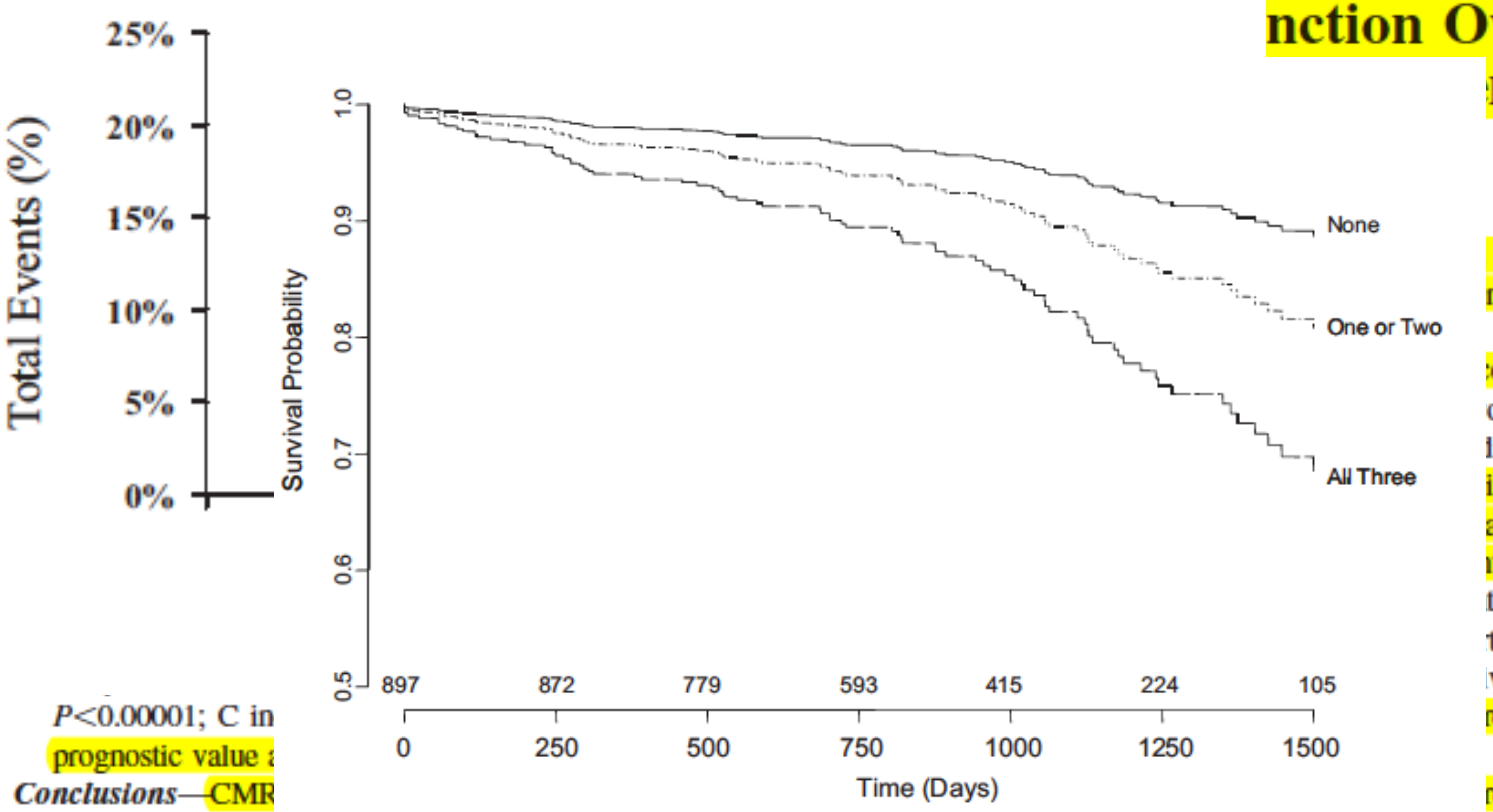

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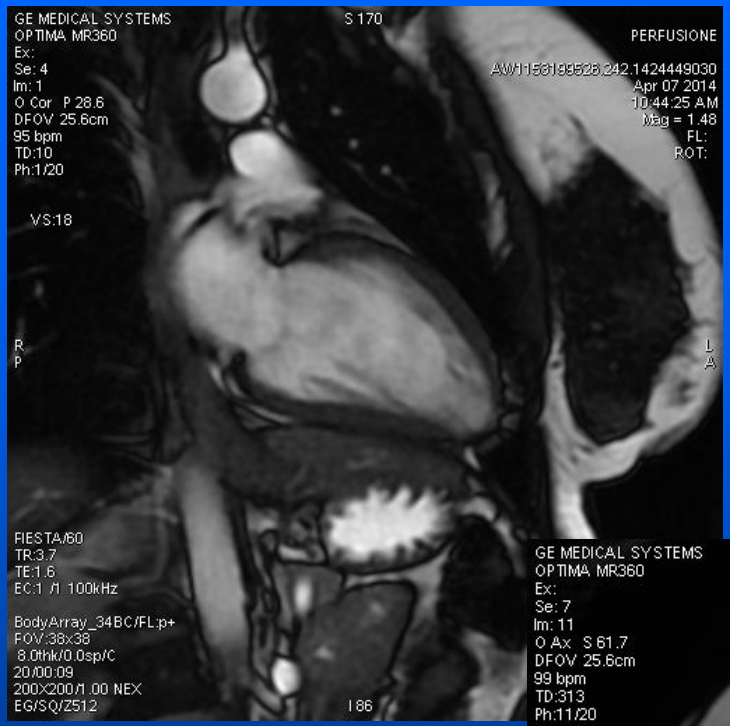
Conclusions—CMR remental
value for prediction of adverse events over pre-CMR data and can be combined to further enhance prognostication. Normal combined CMR confers a low risk of subsequent cardiac events. (***Circulation***. 2011;123:1509-1518.)

Risonanza magnetica

- Valvulopatie
- Miocarditi/versamento pericardico
- Cardiopatie congenite
- Malattie dei grandi vasi

Morfologia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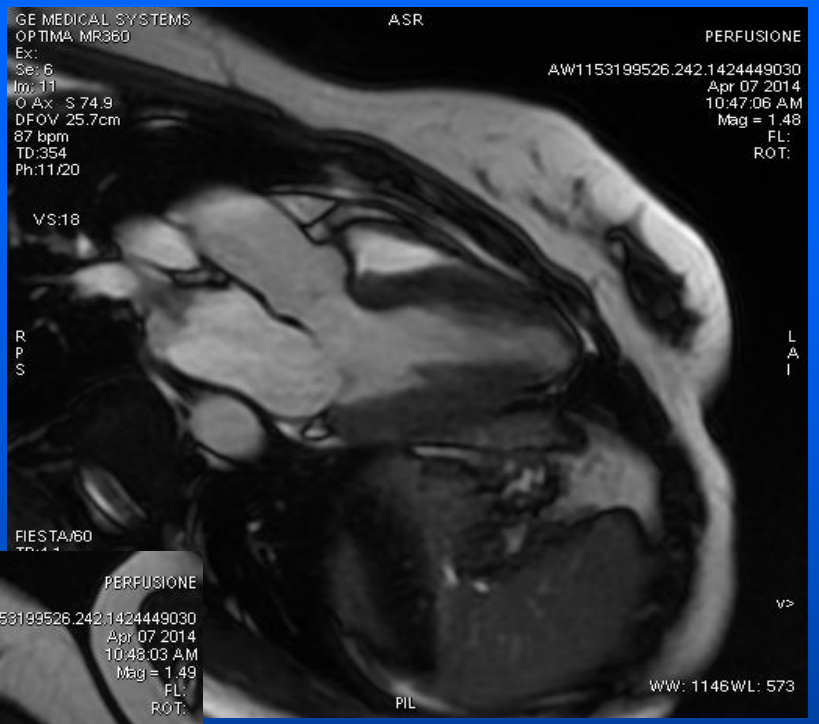
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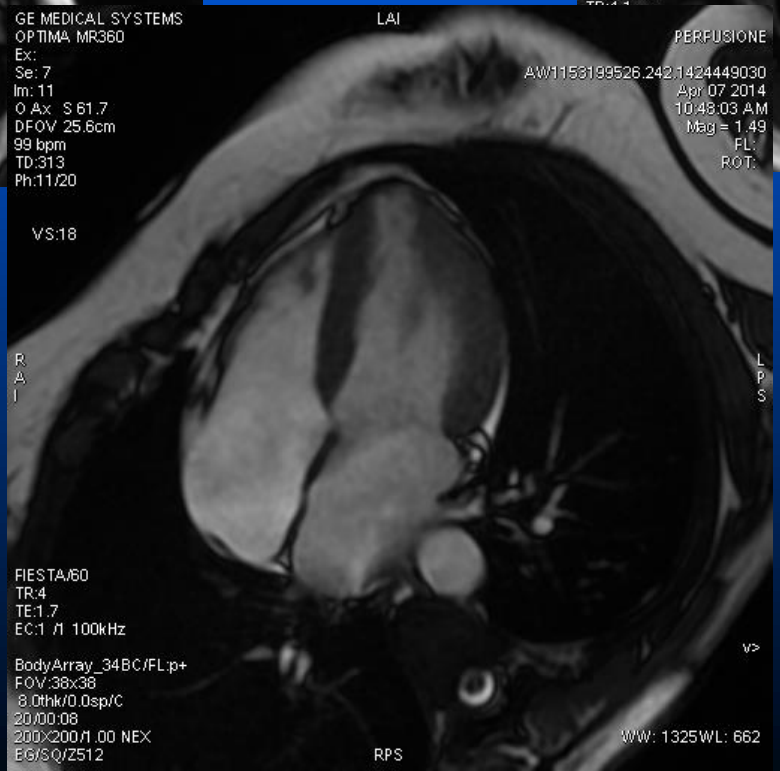
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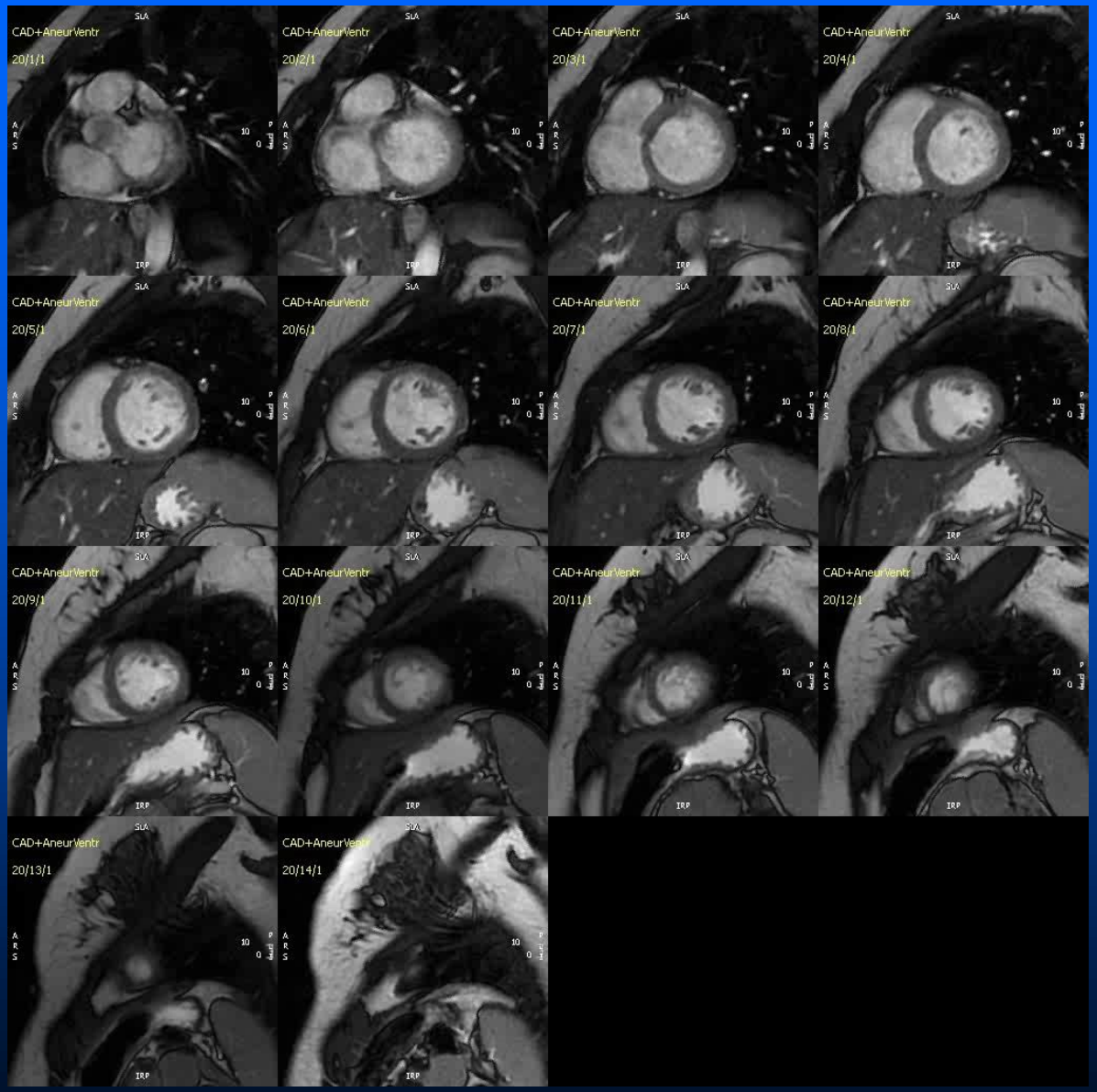
Morfologia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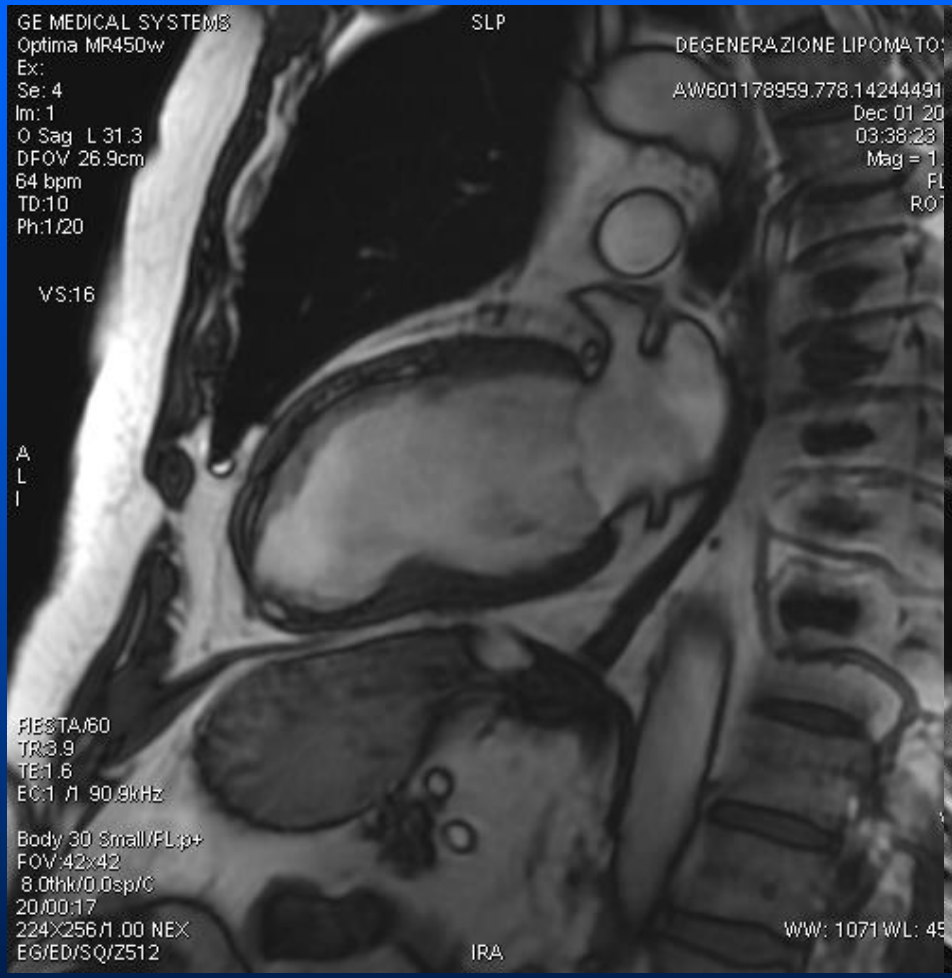
Morfologia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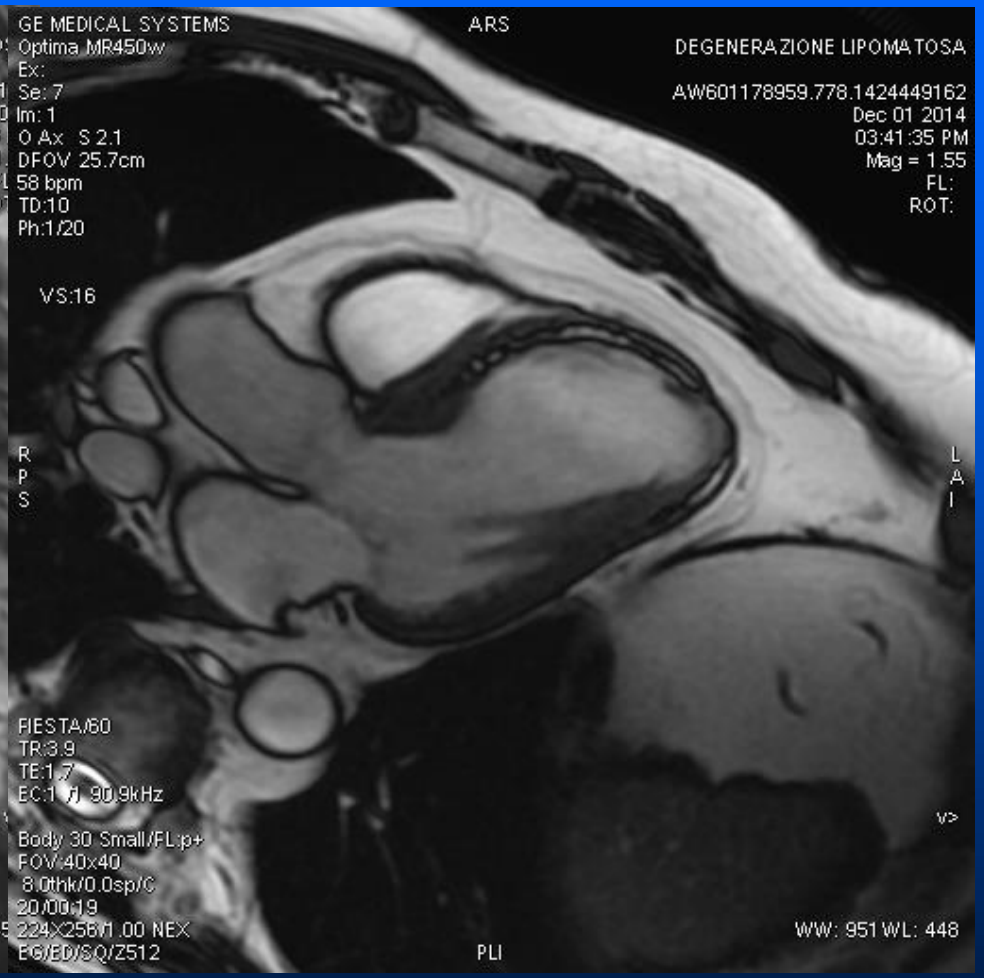
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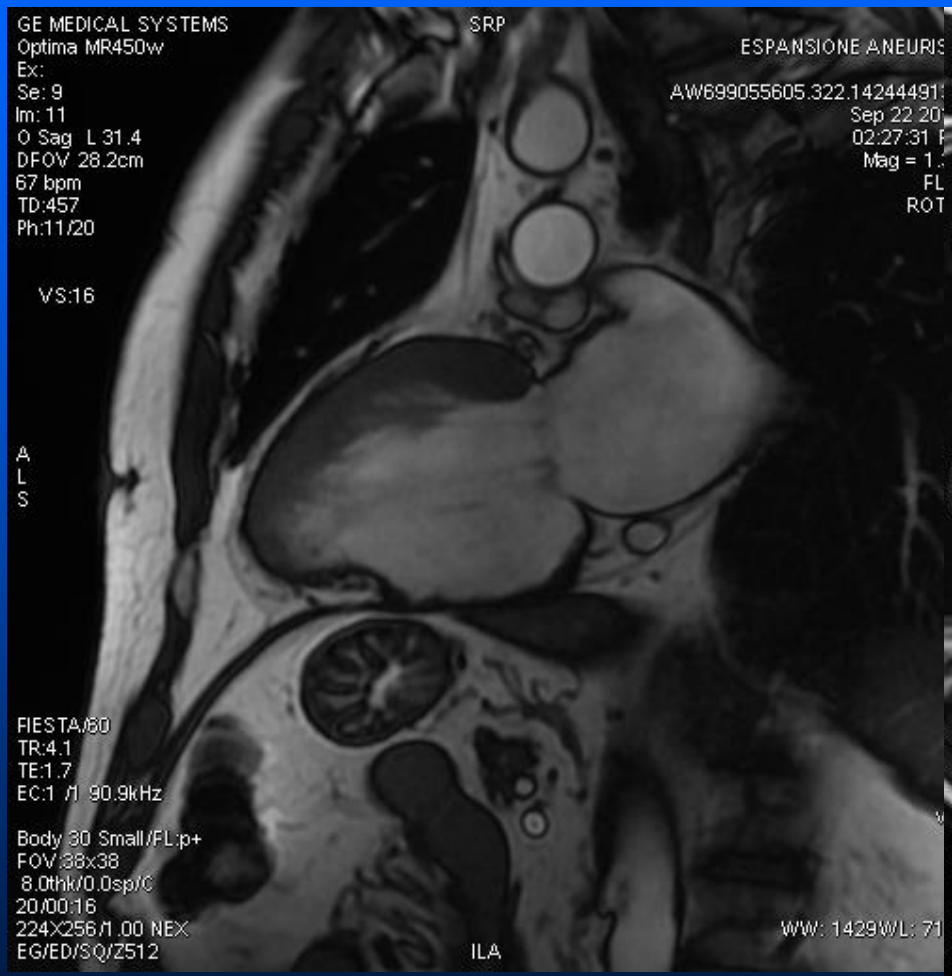
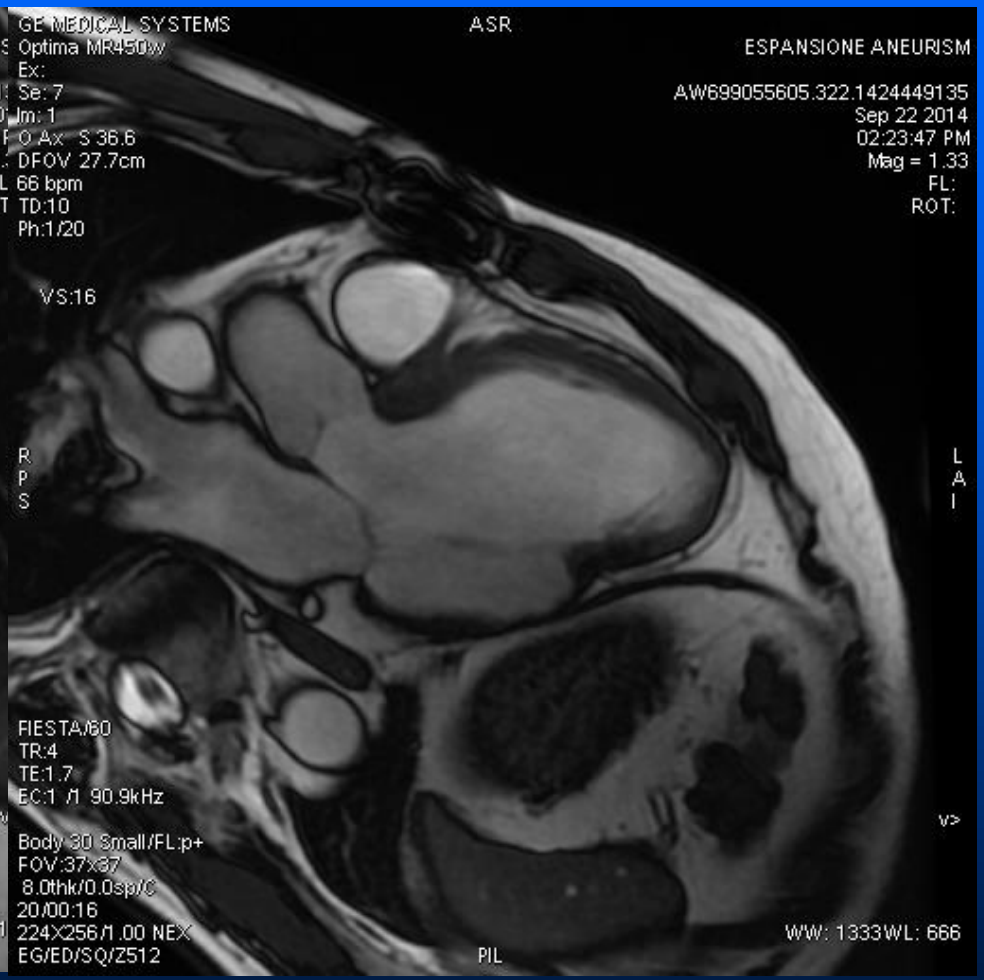
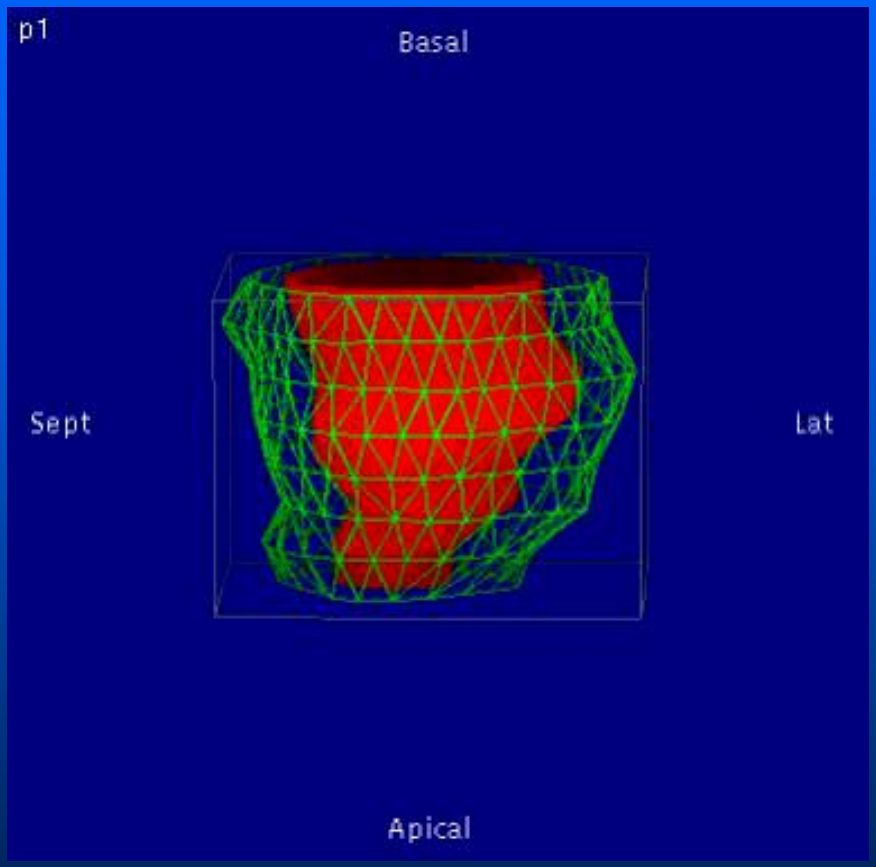
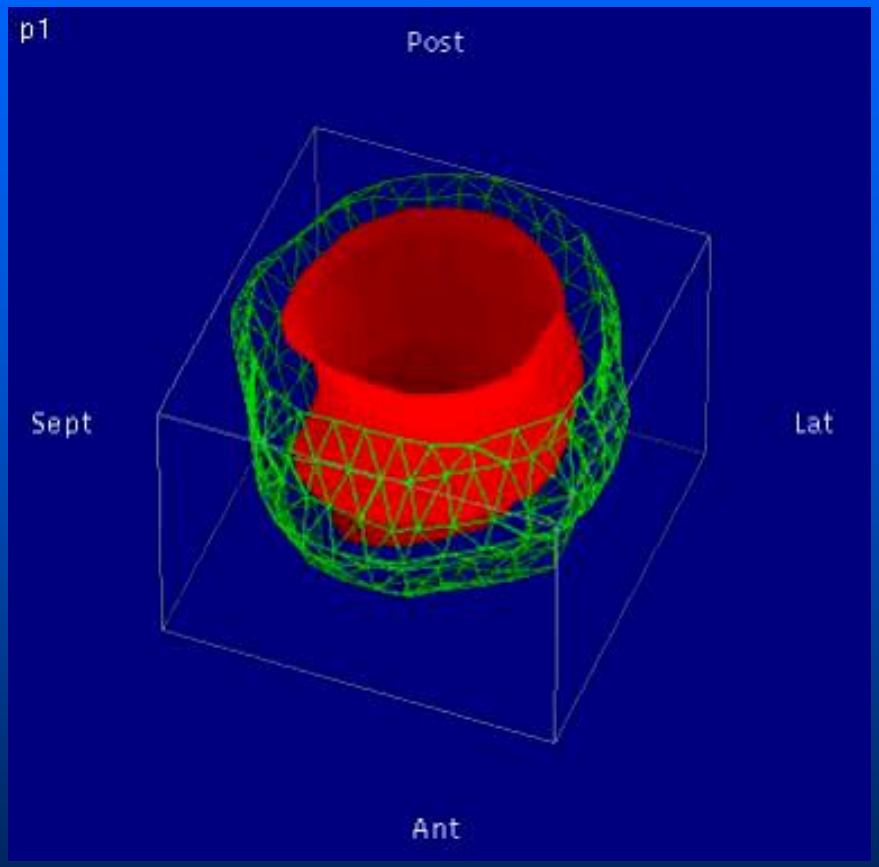
Se: 7
Im: 1
O Ax S 2.1
DFOV 25.7cm
58 bpm
TD:10
Ph:1/20
VS:16
ARS
DEGENERAZIONE LIPOMATOSA
AW601178959.778.1424449162
Dec 01 2014
03:41:35 PM
Mag = 1.55
FL:
ROT:
R
P
S
L
A
I
FIESTA/60
TR:3.9
TE:1.7
EC:1 /1 90.9kHz
Body 30 Small/FL:p+
FOV:40x40
8.0thk/0.0sp/C
20/00:19
224X256/1.00 NEX
EG/ED/SQ/Z512
WW: 951 WL: 448
PLI

Morfologia


GE MEDICAL SYSTEMS
Optima MR450w
Ex:
Se: 9
Im: 11
O Sag L 31.4
DFOV 28.2cm
67 bpm
TD:457
Ph:11/20
VS:16
SRP
ESPANSIONE ANEURIS
AW699055605.322.14244491
Sep 22 20
02:27:31
Mag = 1.
FL
ROT
A
L
S
FIESTA/60
TR:4.1
TE:1.7
EC:1 /1 90.9kHz
Body 30 Small/FL:p+
FOV:38x38
8.0thk/0.0sp/C
20/00:16
224X256/1.00 NEX
EG/ED/SQ/Z512
WW: 1429WL: 71
ILA


GE MEDICAL SYSTEMS
Optima MR450w
Ex:
Se: 7
Im: 1
O Ax S 36.6
DFOV 27.7cm
66 bpm
TD:10
Ph:1/20
VS:16
ASR
ESPANSIONE ANEURISM
AW699055605.322.1424449135
Sep 22 2014
02:23:47 PM
Mag = 1.33
FL:
ROT:
R
P
S
L
A
I
FIESTA/60
TR:4
TE:1.7
EC:1 /1 90.9kHz
Body 30 Small/FL:p+
FOV:37x37
8.0thk/0.0sp/C
20/00:16
224X256/1.00 NEX
EG/ED/SQ/Z512
WW: 1333WL: 666
PIL


p1
Basal
Sept
Lat
Apical


p1
Post
Sept
Lat
Ant

Costi!!

Test Ergometrico	55.78	euro
Ecostress	117.75	euro
Spect	188.51	euro
Cine RM	363.00	euro*
Pet	1189.40	euro

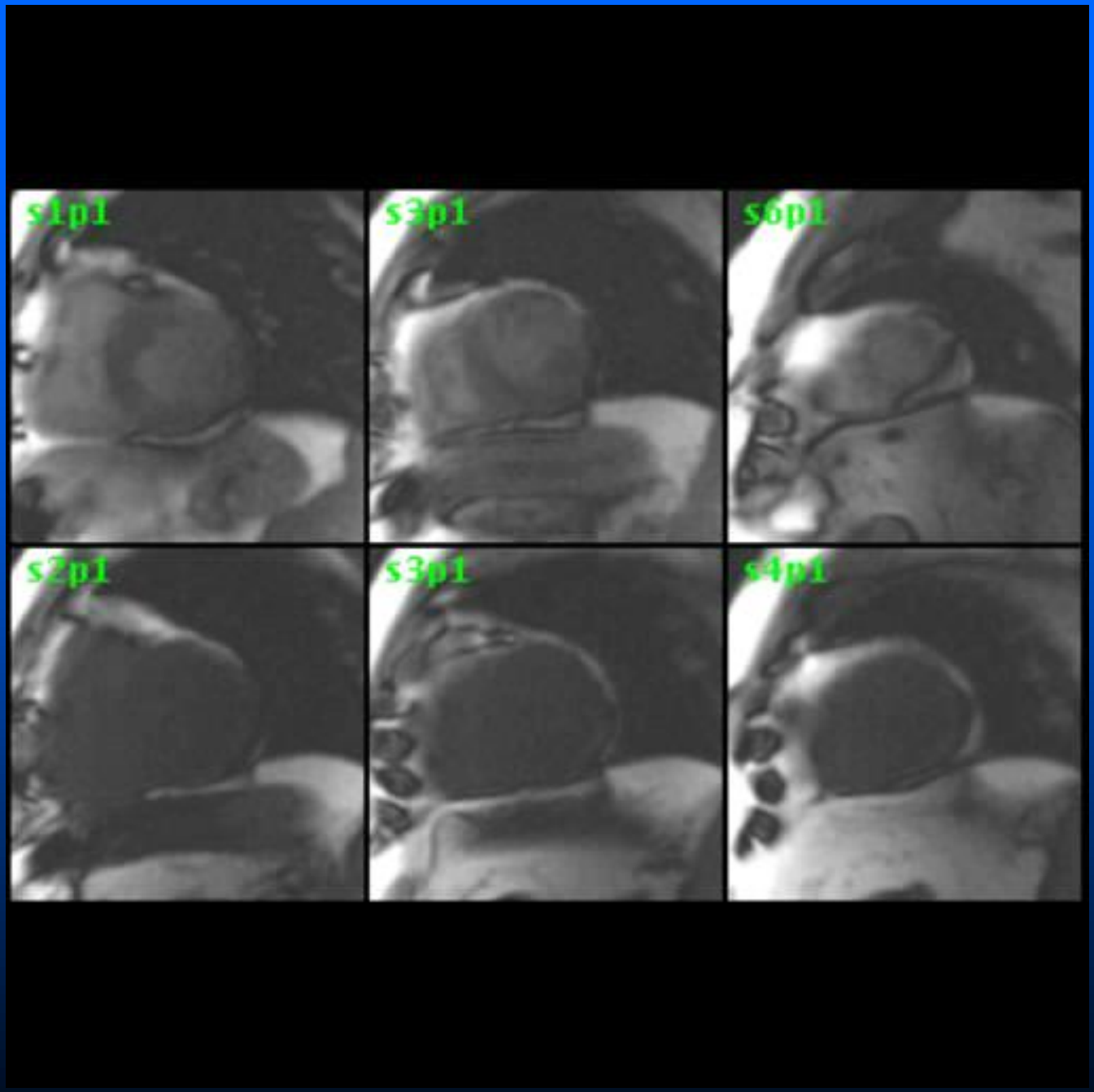
* 3 in 1

Take-home message

Collaboration is mandatory between cardiologist, radiologist and heart surgeon

«Be strong to be useful»

Georges Hébert


s1p1
s3p1
s6p1
s2p1
s3p1
s4p1