ECOCARDIOCHIRURGIA

Milano 28 febbraio – 1 marzo 2013

CORSO AVANZATO DI ECOCARDIOGRAFIA DI "ECOCARDIOCHIRURGIA"
con uno sguardo all'imaging integrato

PARTE PROPEDEUTICA: ANATOMIA "VISTA" CON LE METODICHE DISPONIBILI

Arturo Raisaro, *Pavia.*

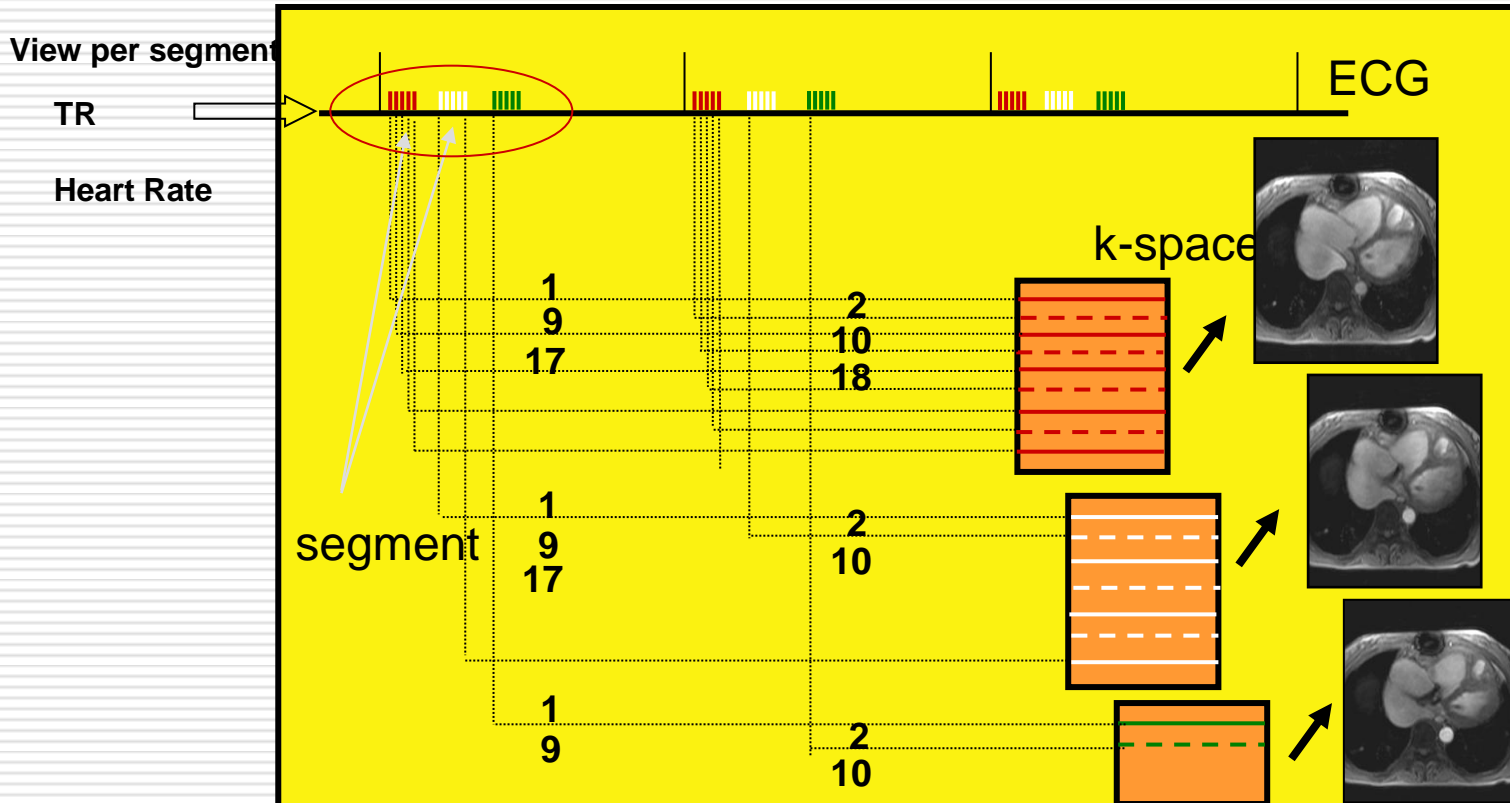Anatomia del cuore e dei grandi vasi con i campi magnetici.

Come ricostruire l'anatomia del cuore (la RM).

Cine Magnetic Resonance Imaging
Principle and sequence

Fast cardiac cine MRI

Segmented K-Space / Mutiphase single slice acquisition

(Atkinson and Edelman Radiology 1991)

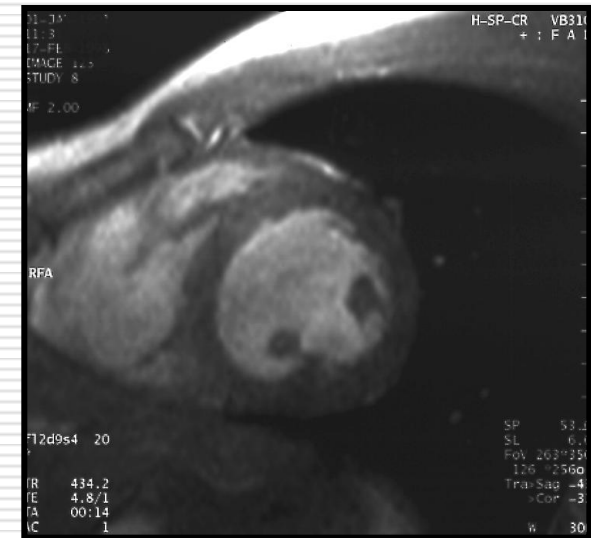# Cine Magnetic Resonance Imaging
Principle and sequence

Improving imaging time and quality

Breath-hold Cine MRI

Conventional Cine MRI

Segmented Cine MRI

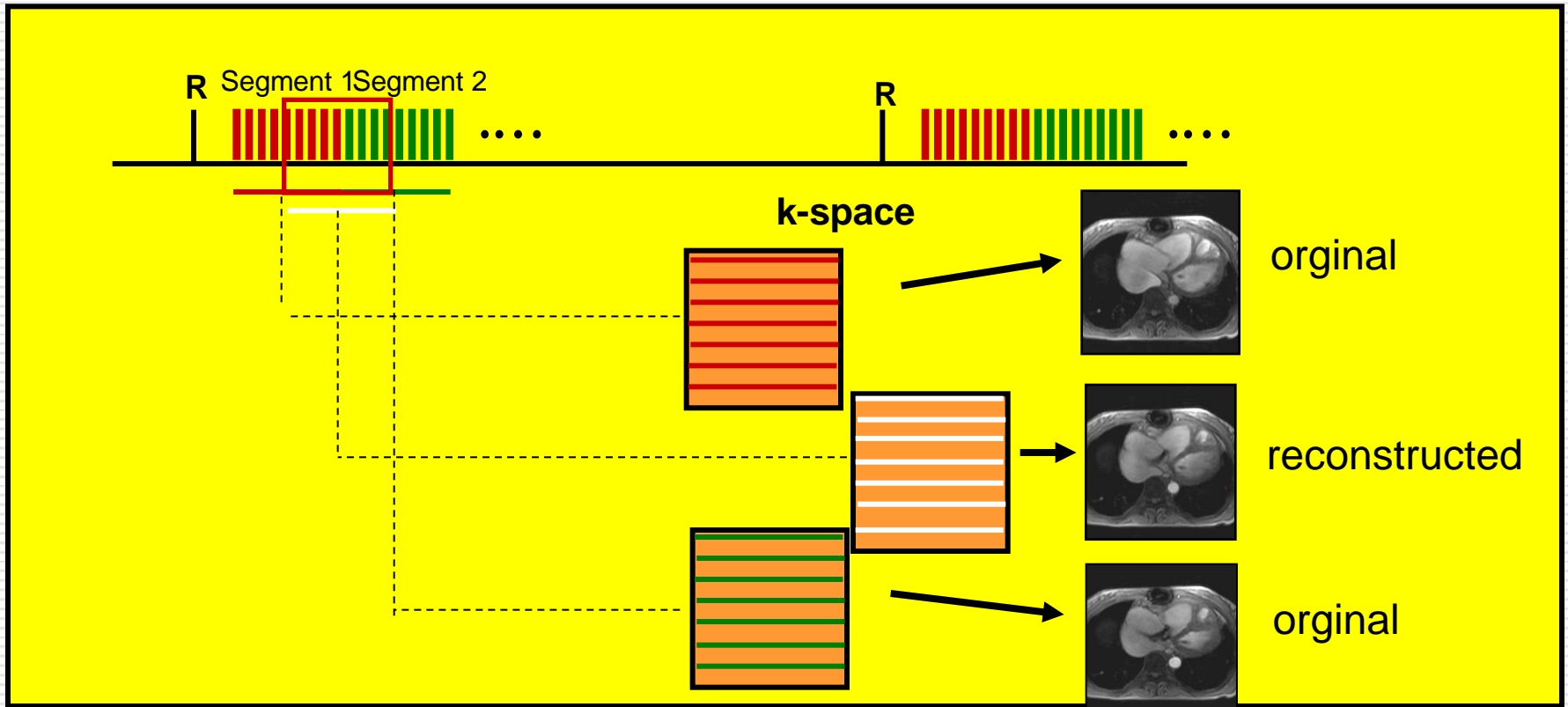1 view per segment / 3 NEX / 5 min 21 sec   9 view per segment / 1 NEX / 14 sec

Cine Magnetic Resonance Imaging
Principle and sequence

Improving Temporal Resolution

Echo Sharing / View Sharing
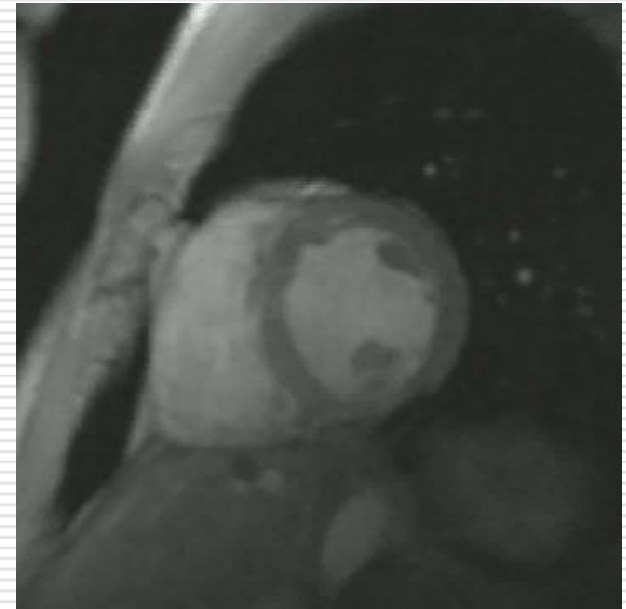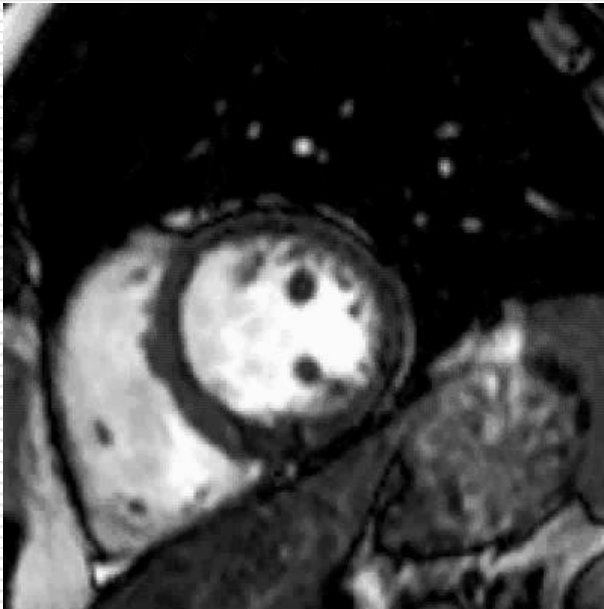
(Foo T et al Radiology 1995)

Cine Magnetic Resonance Imaging
Principle and sequence

Steady State Free Precession vs Spoiled Fast Gradient Echo

PRO:
a) Higher CNR blood/myocardium, less dependent on flow-related enhancement
b) Faster (TR=3msec vs 8 msec), higher temporal and spatial resolution
c) Better definition of endocardium, epicardium and pericardium (accurate anotomic depiction)
CONS:
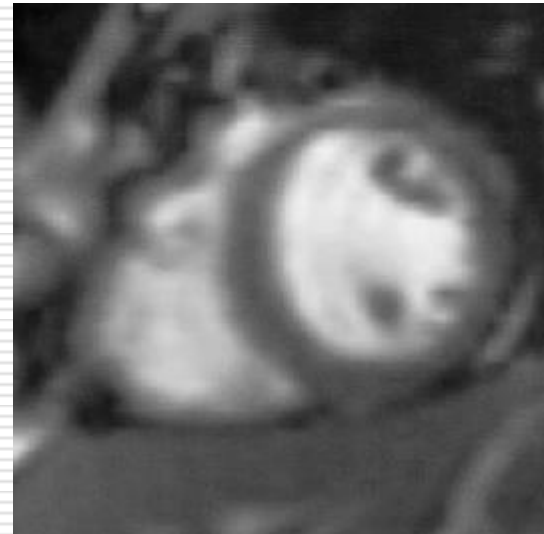More sensitive to pulsatile flow artefacts, magnetic field inhomogeneities (dark stripes)

(Carr JC et al Radiology 2001)

Cine Magnetic Resonance Imaging
Principle and sequence
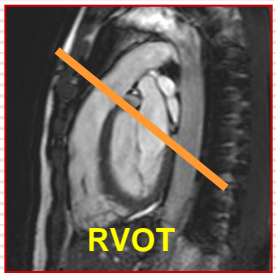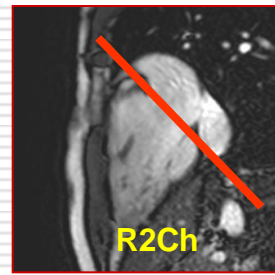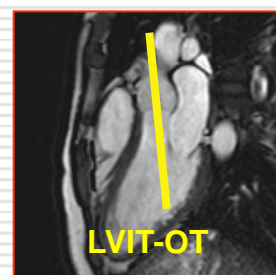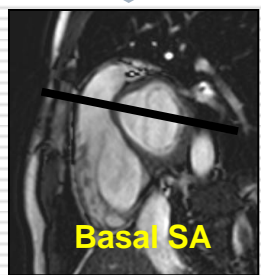
Single slice SSFP vs Multislice real time SSFP

Imaging Parameters for cine MRI	Single slice SSFP	real time SSFP
Repetition time (msec)	3.6	2.6
Echo time (msec)	1.8	1.3
Flip angle	60°	50°
In plane resolution	2.2 X 1.4	4.2 X 2.7
Voxel size (mm3)	24.6	90.7
Time resolution (msec)	54	90.7

(Lee et al Radiology 2002)
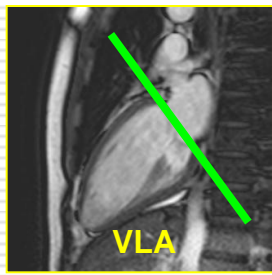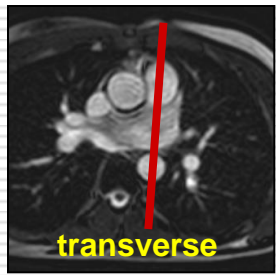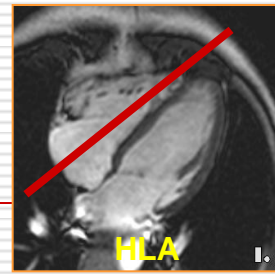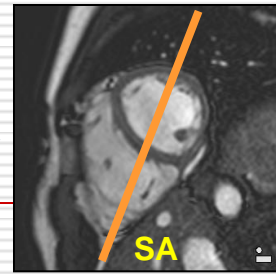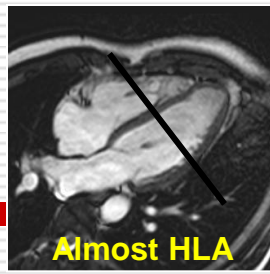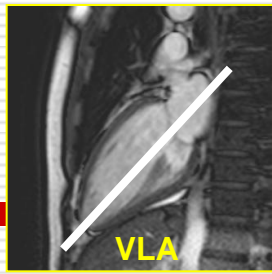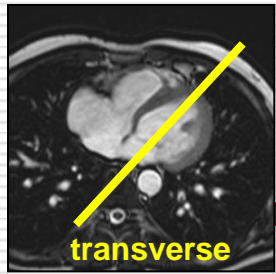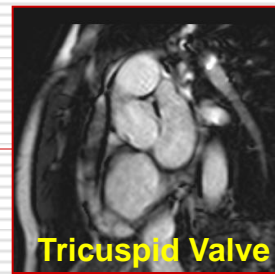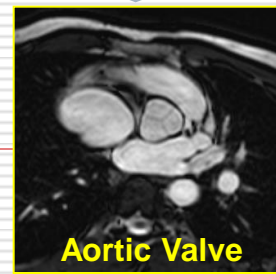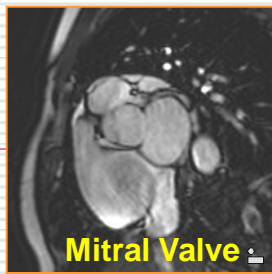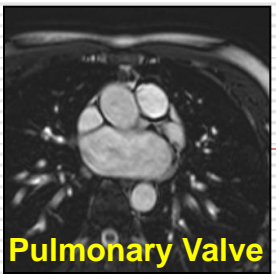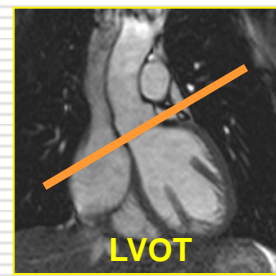
transverse → VLA → Almost HLA → SA → HLA

transverse → VLA → Basal SA → LVIT-OT → R2Ch

RVOT

Determination of Cardiac Axis

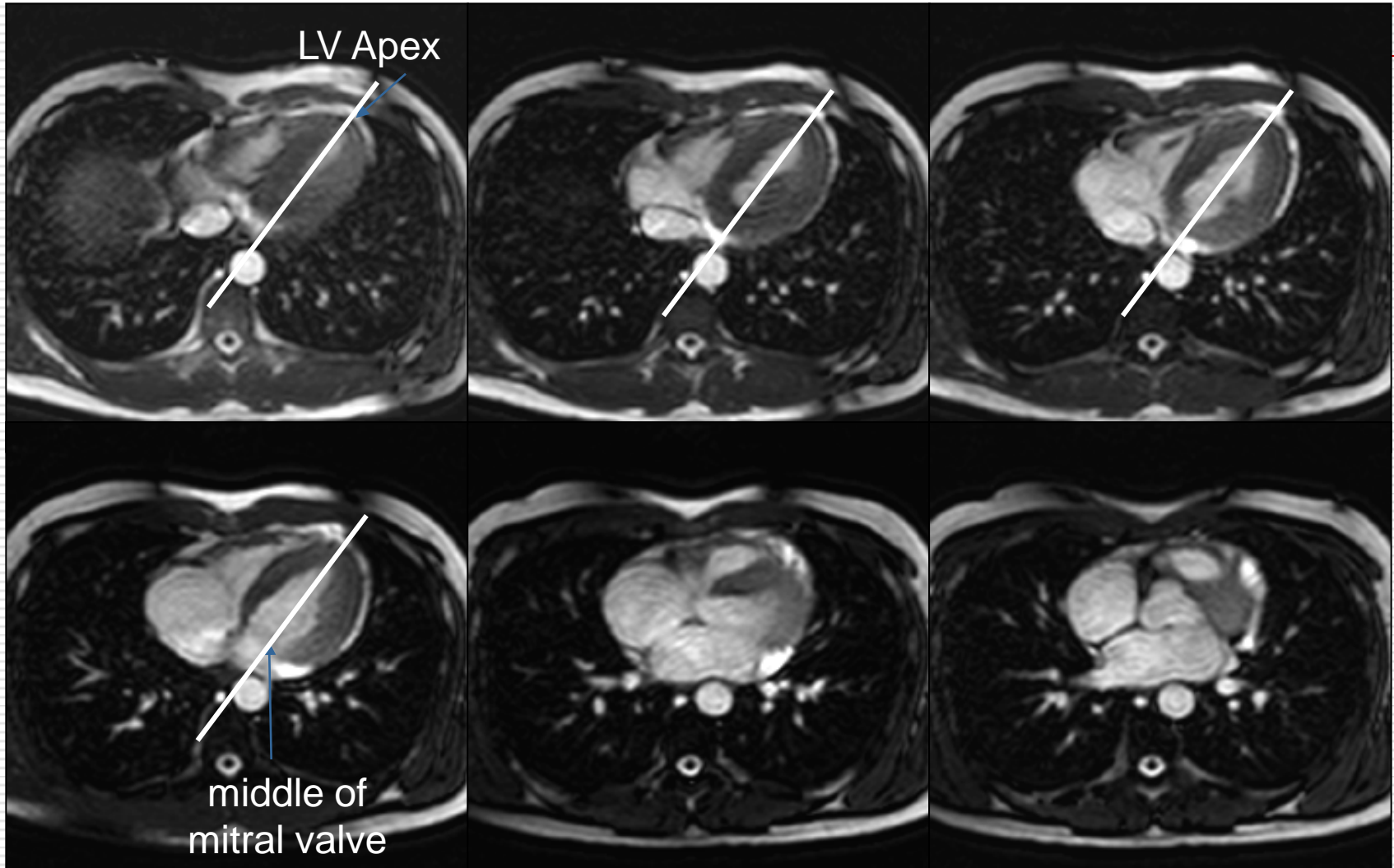LVOT

Pulmonary Valve   Mitral Valve   Aortic Valve   Tricuspid Valve

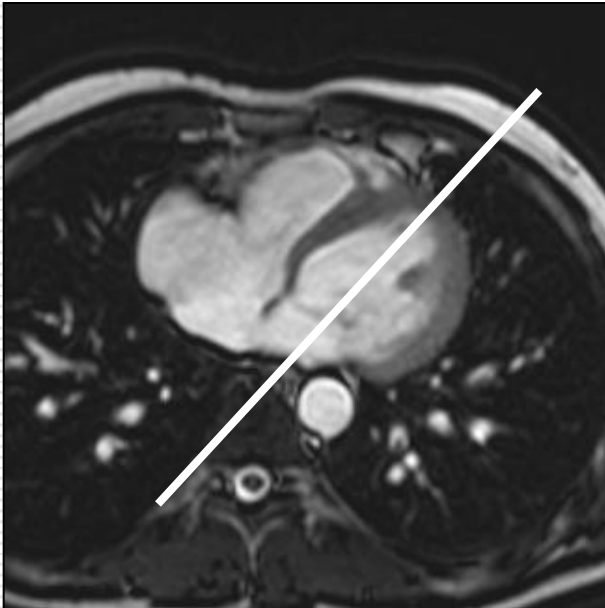# Cine Magnetic Resonance Imaging
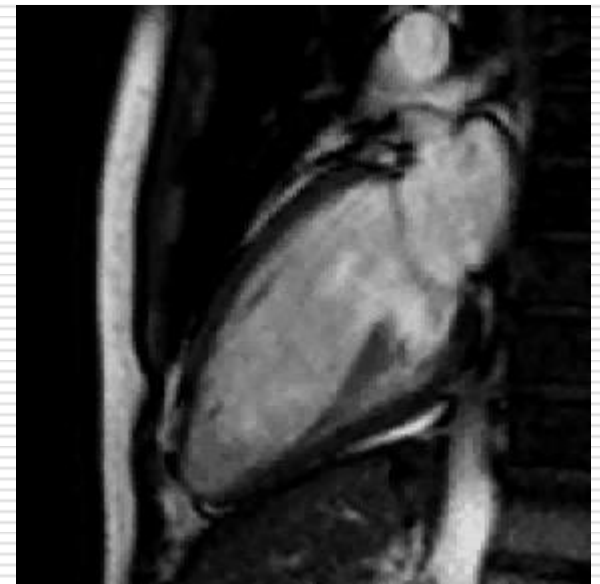## Determination of cardiac planes

Cine Magnetic Resonance Imaging
Determination of cardiac planes
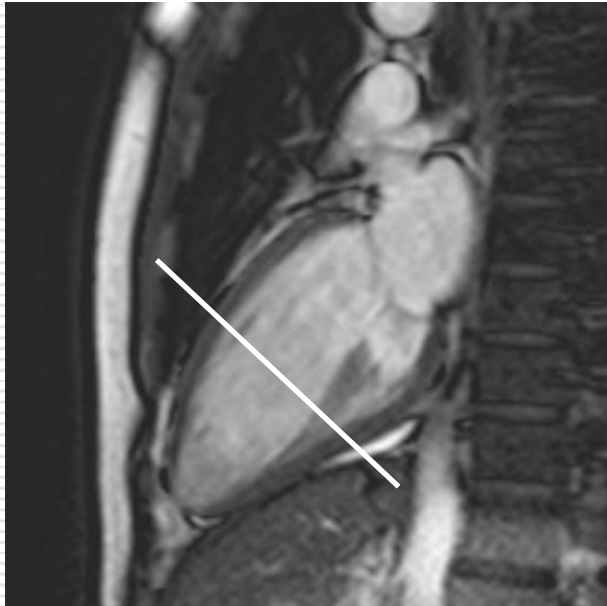
Axial Scout

**Vertical long axis
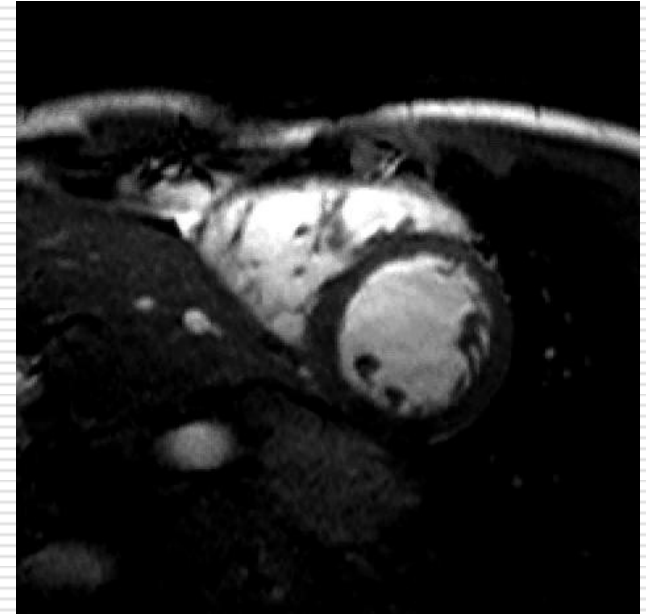2 chambers view**

Cine Magnetic Resonance Imaging
Determination of cardiac planes

VLA / 2-chamber view

Short-axis

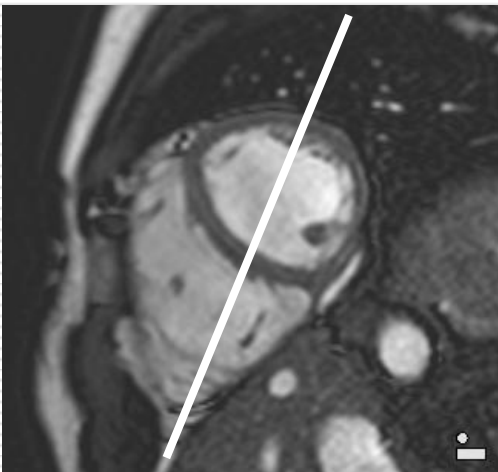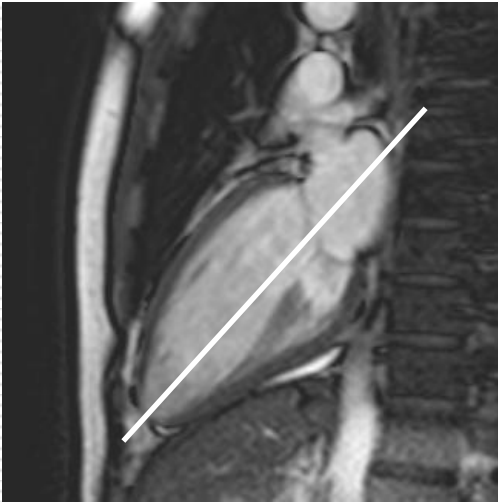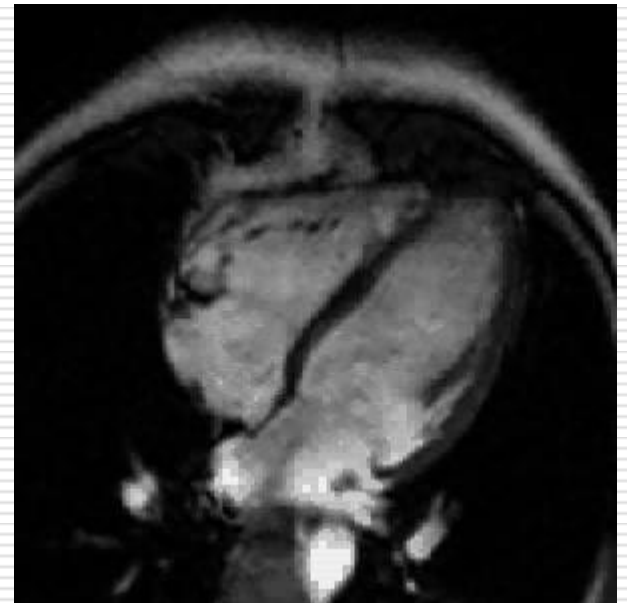# Cine Magnetic Resonance Imaging
Determination of cardiac planes

Horizontal long-axis
4 chambers view

Cine Magnetic Resonance Imaging
Determination of cardiac planes

Cine Magnetic Resonance Imaging
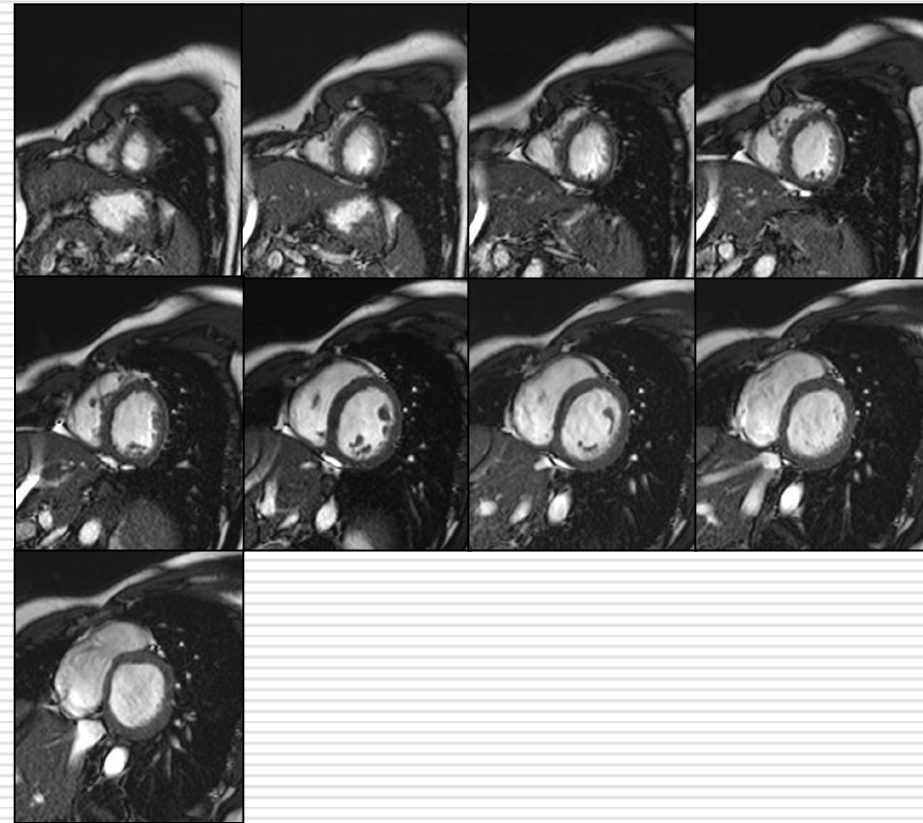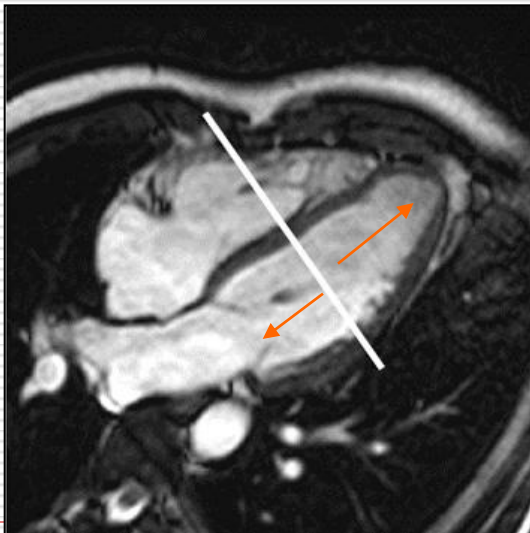## Ventricular volumes, mass and function

end diastole

end systole

RV

LV

RV

LV

1 / 0 ms
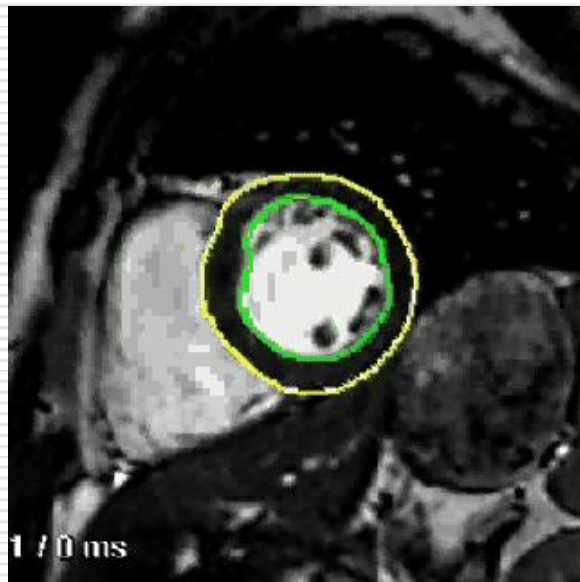
Cine Magnetic Resonance Imaging
Ventricular volumes, mass and function

A) estimation of ventricular volumes

Modified Simpson Rule

$(Am + (Am + Ap)/2 + Ap/3) \times L/3$
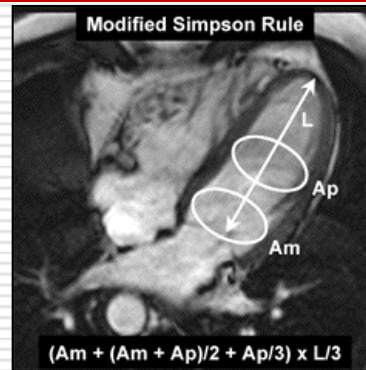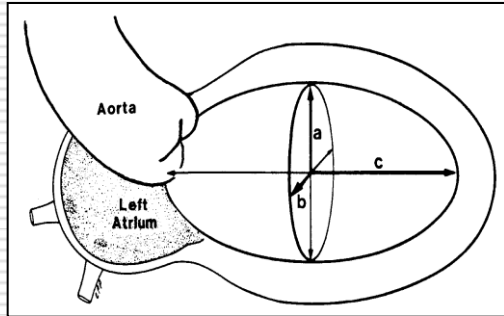
+ fast data acquisition and data analysis
- **well-suited** for projection techniques (e.g. ventriculography) but not for tomographic techniques
- less accurate than volumetric quantification (e.g. diseased ventricles)

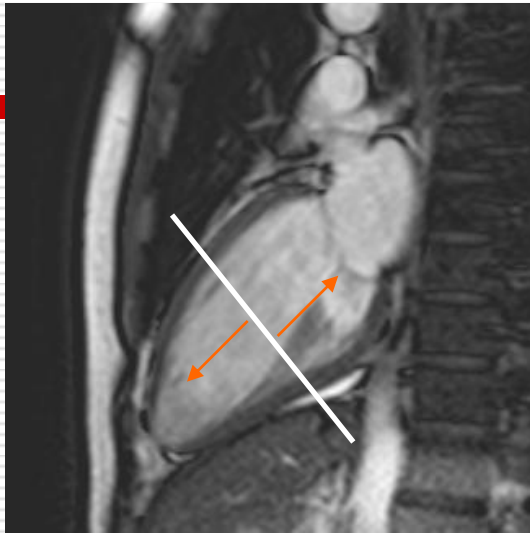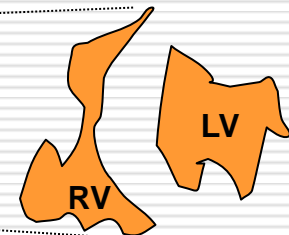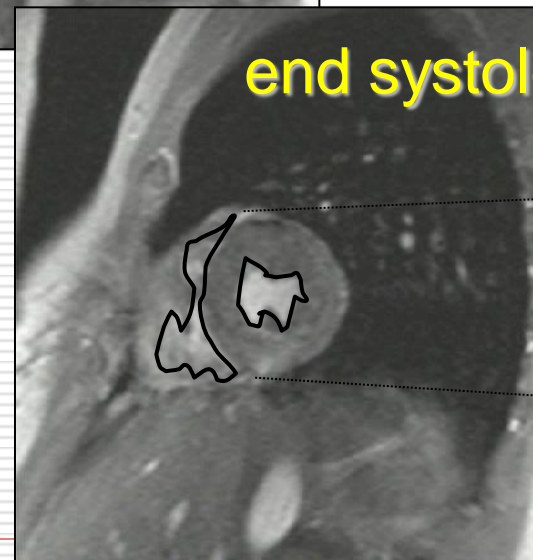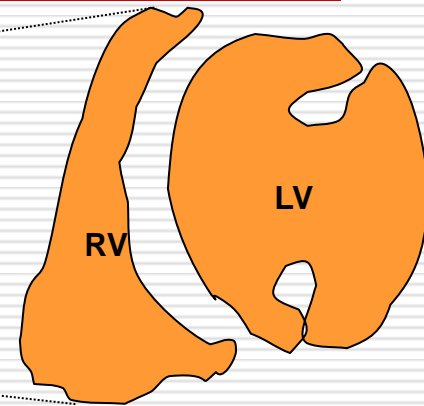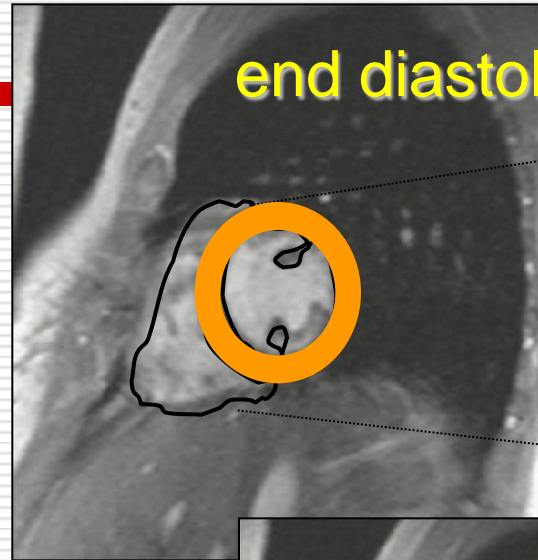## B) volume quantification using slice summation
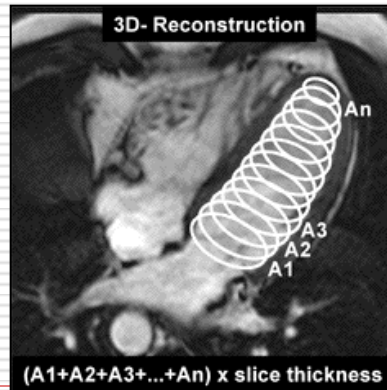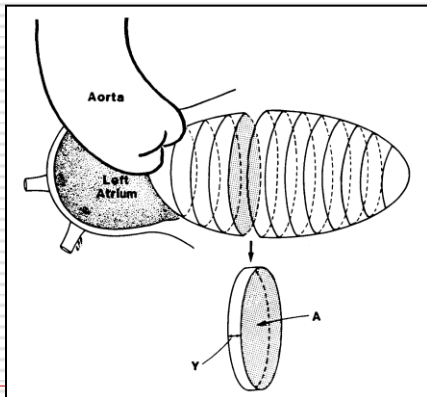
3D- Reconstruction

$(A1+A2+A3+...+An) \times$ slice thickness

+
+
-

Cine Magnetic Resonance Imaging
Ventricular volumes, mass and function

Limitation

1) No correction for longitudinal shortening (Through-plane motion)

2) Endocardial contouring (trabeculae and papillary muscle)

3) LV base slice ?
large volume change in submitral region

4) Partial volume effect at LV apex

5) Dependance on MRI sequence
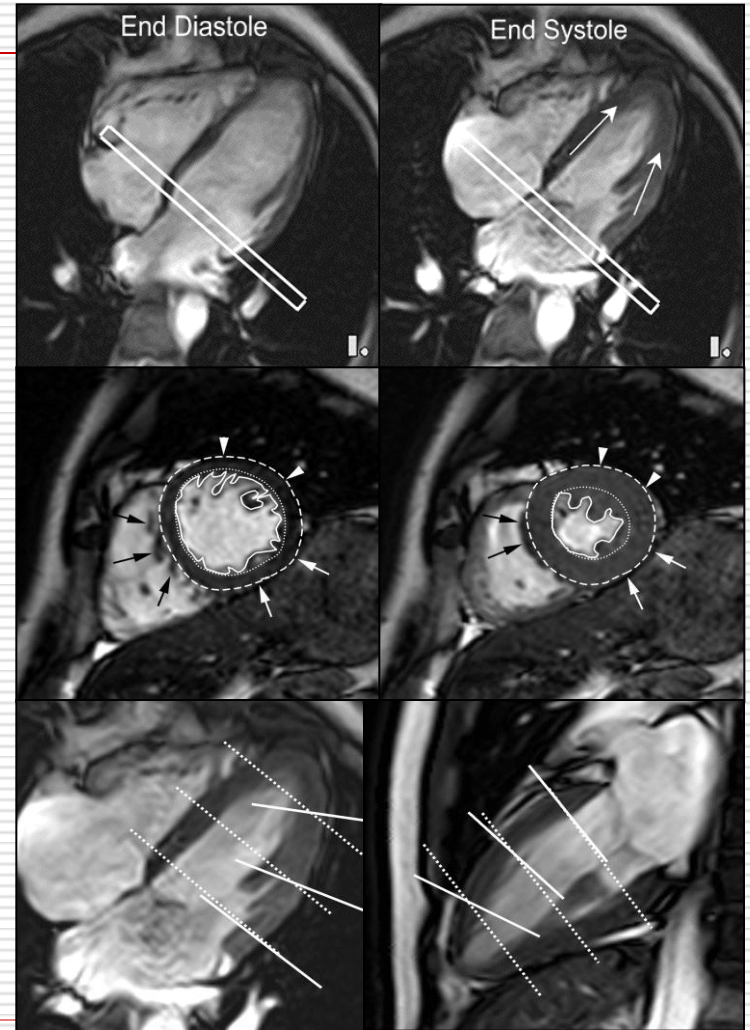
Cine Magnetic Resonance Imaging
Comparison with other Tecniques

Clinical Change	Cardiac US		MRI		% reduction in
	SD	N°	SD	N°	sample size
LV-EDV, 10 mL	23.8	121	7.4	12	90
LV-ESV, 10 mL	15.8	53	6.5	10	81
LV-EF, 3% (abs)	6.6	102	2.5	15	85
LV-Mass, 10 g	36.4	273	6.4	9	97

$$N = f(\alpha,P)\sigma^2\, 2/\delta^2$$

f = 10.5
σ = 0.05
P = 0.90

power 90 %, p < 0.05

Adapted from Bellinger et al., J cardiovasc Magn Reson. 2000; 2(4):271-8

Cine Magnetic Resonance Imaging
Comparison with other Tecniques

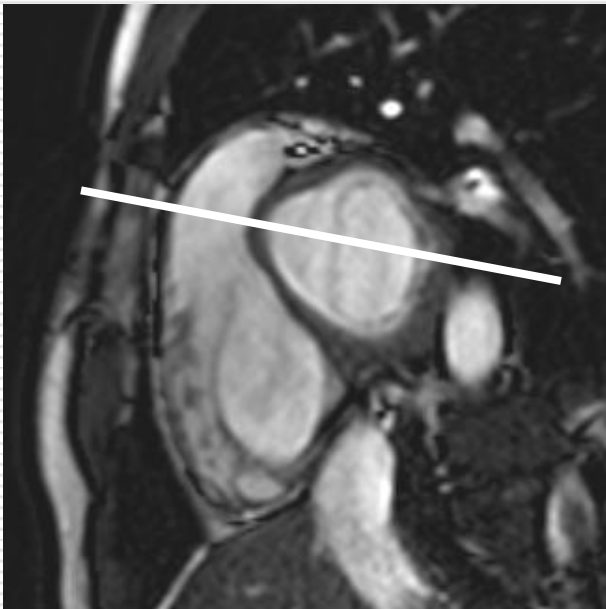|	Interobserver Variability (%)	Intraobserver Variability(%)
EDV		
CCT	2.6±2.0	2.0±1.3
CMR	6.3±5.7	2.4±2.3
RT3DE	11.2±8.6	3.9±2.0
ESV		
CCT	5.7±5.2	2.2±3.1
CMR	7.7±6.6	6.3±4.6
RT3DE	14.2±11.8	5.6±3.9
EF		
CCT	6.5±4.9	2.1±3.4
CMR	8.5±9.7	6.2±6.2
RT3DE	10.5±8.3	5.6±3.4

Data are expressed as means±SD.

Sugeng et al. Circulation 2006; 114:654-661

Cine Magnetic Resonance Imaging
Determination of cardiac planes
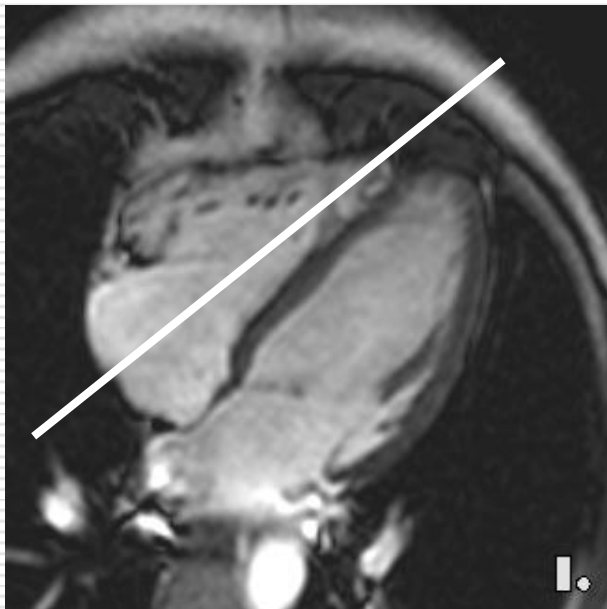
Basal short-axis

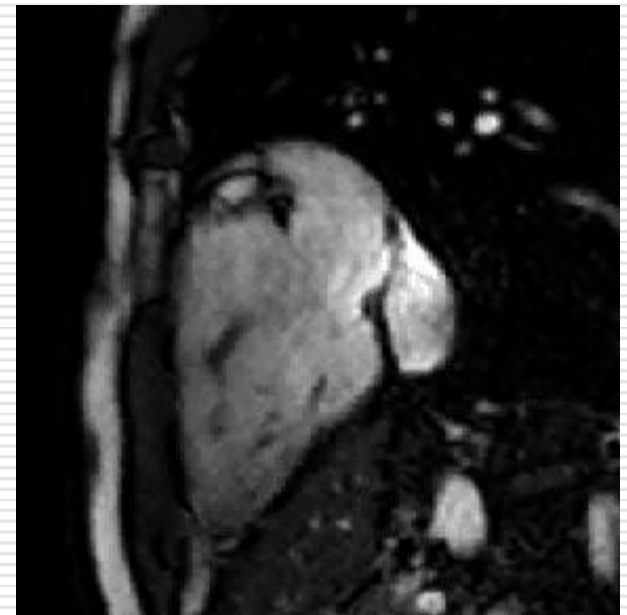In-outflow view / 3-chamber view

Cine Magnetic Resonance Imaging
Determination of cardiac planes
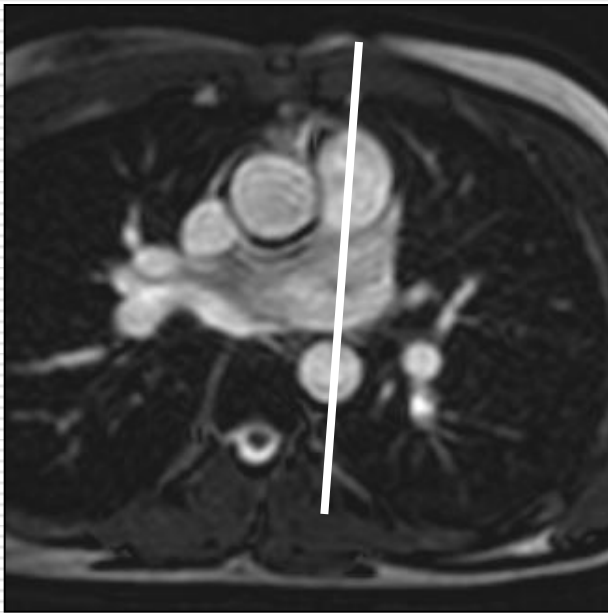
HLA / 4-chamber view

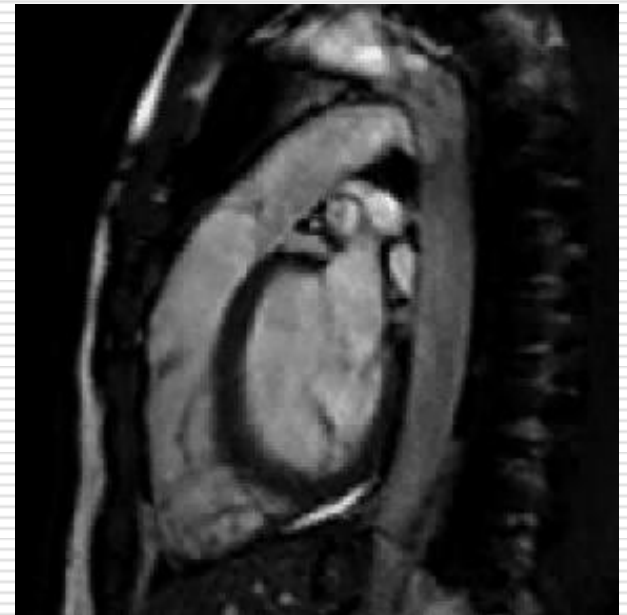RV VLA / RV 2-chamber view

Cine Magnetic Resonance Imaging
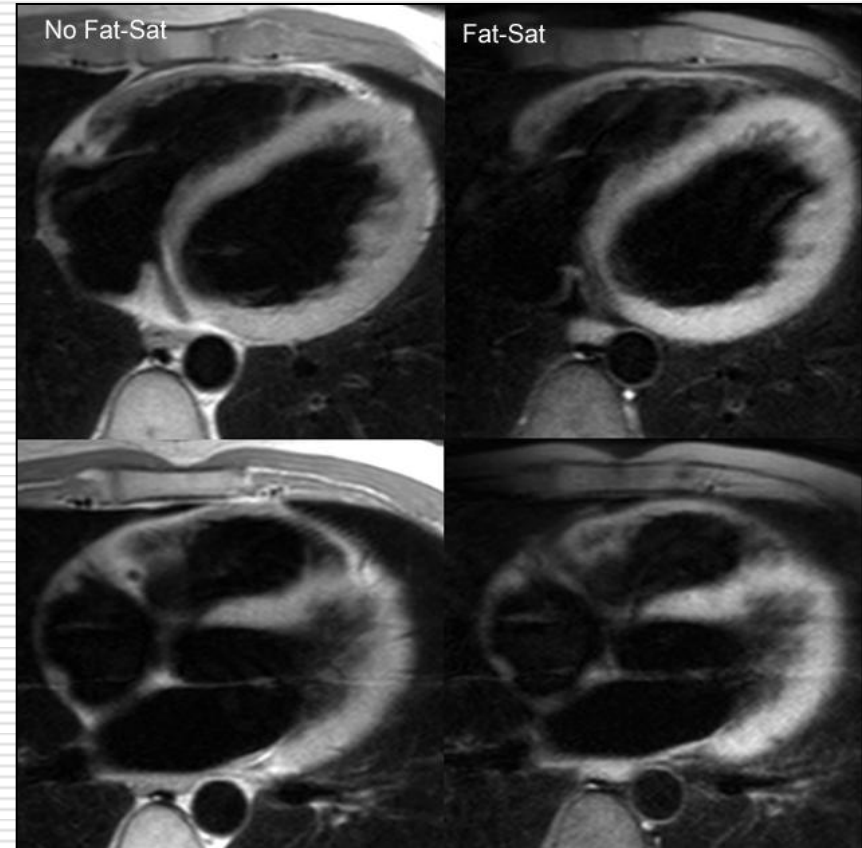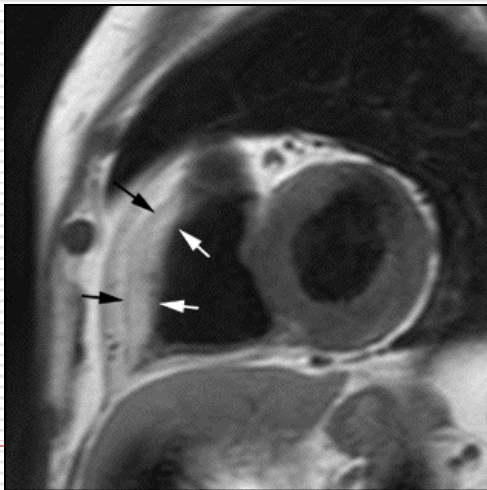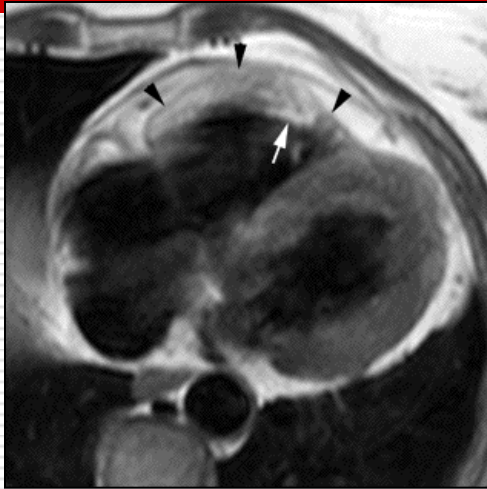**Determination of cardiac planes**

Axial plane
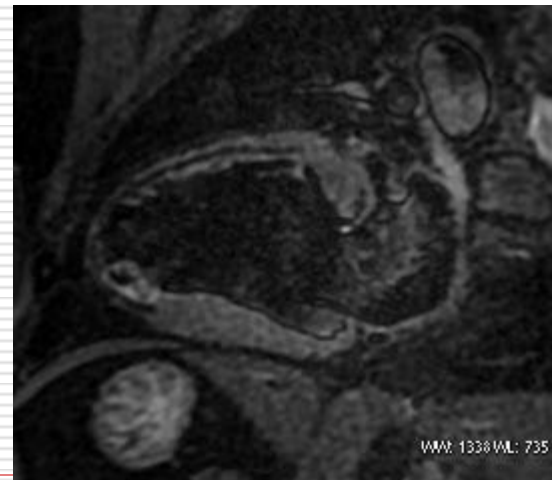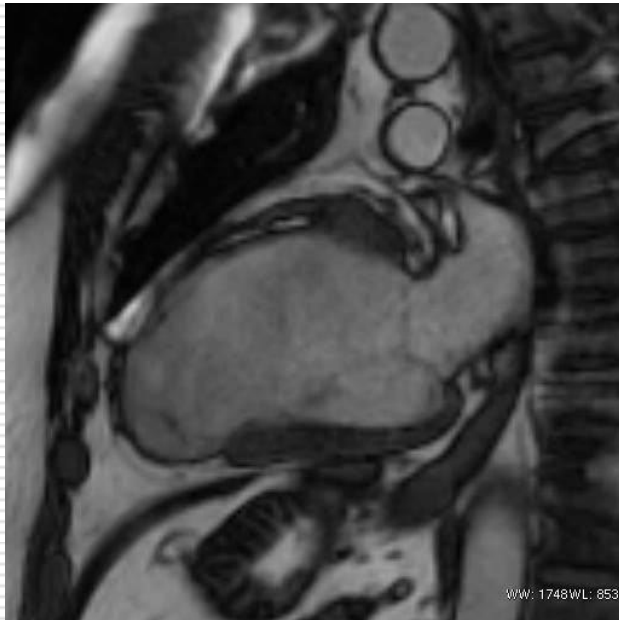
RVOT

Fast Spin Echo MRI
Clinical Application

Cardiac Morphology and Characterization

Fast Spin Echo MRI
Clinical Application

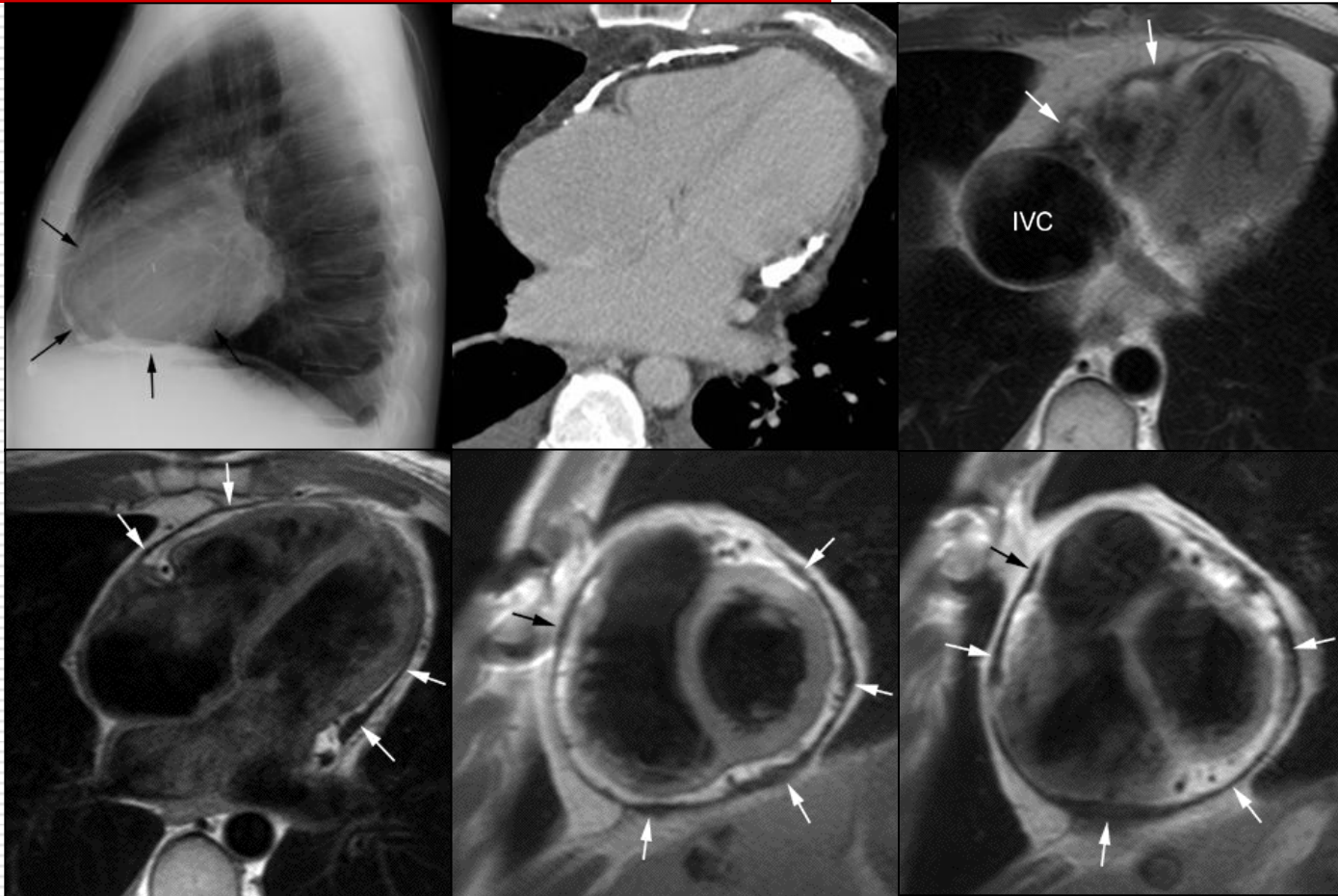## Cardiac Morphology and Characterization
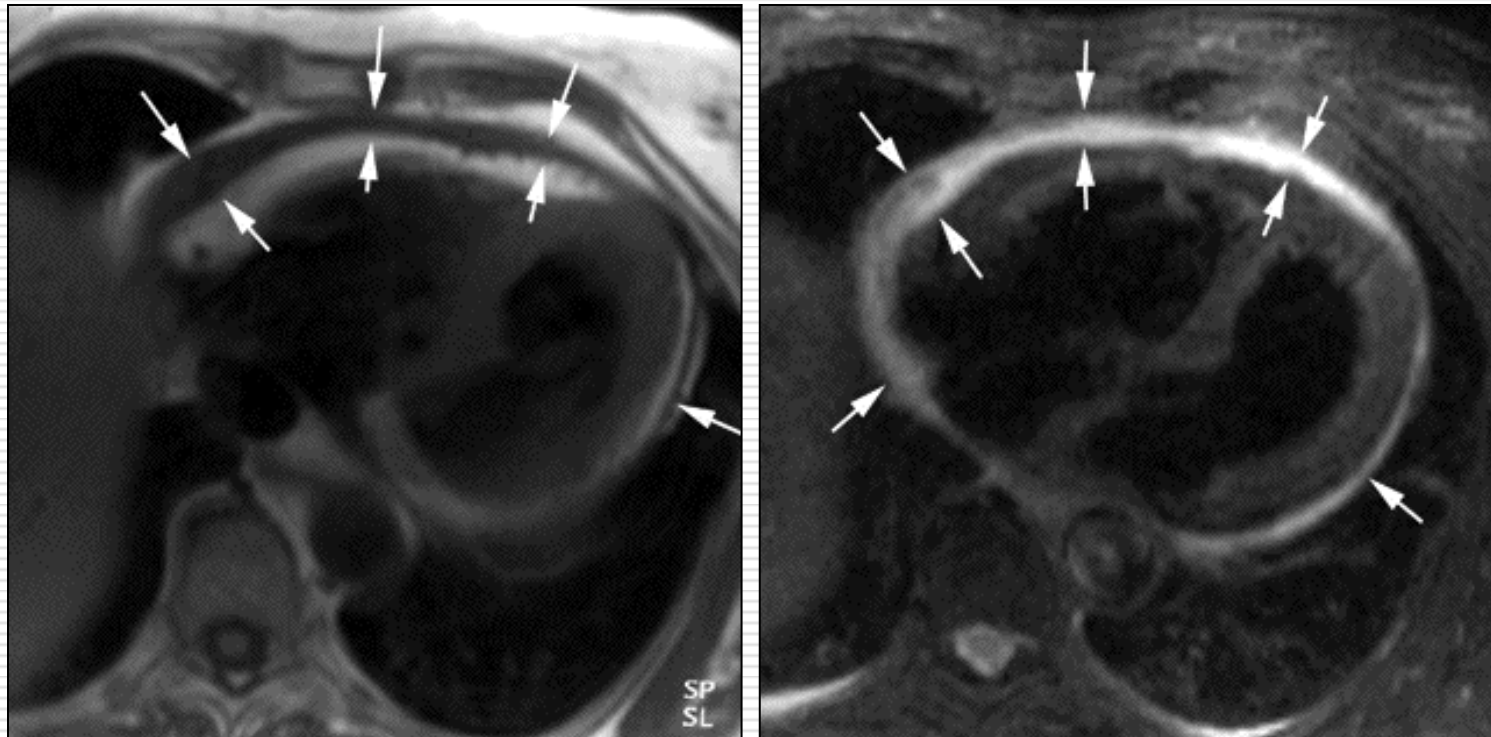
Pericardial Morphology and Characterization

Fast Spin Echo MRI
Clinical Application

Pericardial Characterization

Fast Spin Echo MRI
Clinical Application

T2 Weighted STIR Magnetic Resonance Imaging of the Heart

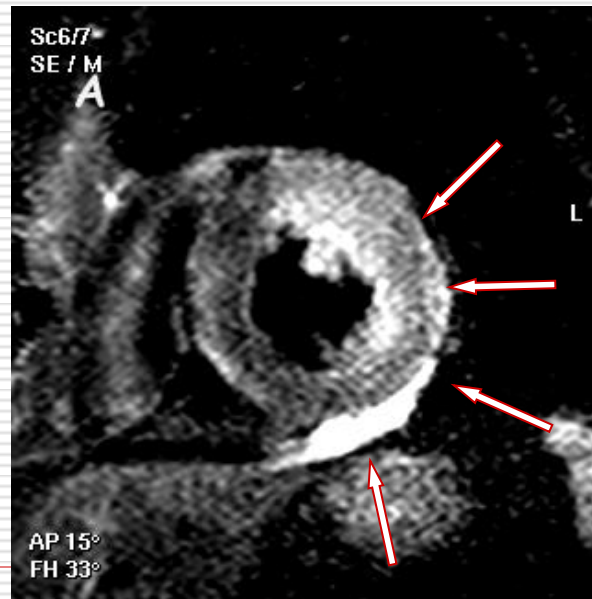**T2 depends on several factors**

cell membrane components (~ 20 μsec)

Highly mobile H of fatty acids (140 msec)

**mobile tissue water (40 msec) contributes 75% of T2-weighted signal (TE=60-65 msec)**

Abdel-Aty et al J Magn Reson Imaging 2007

Fast Spin Echo MRI
Clinical Application
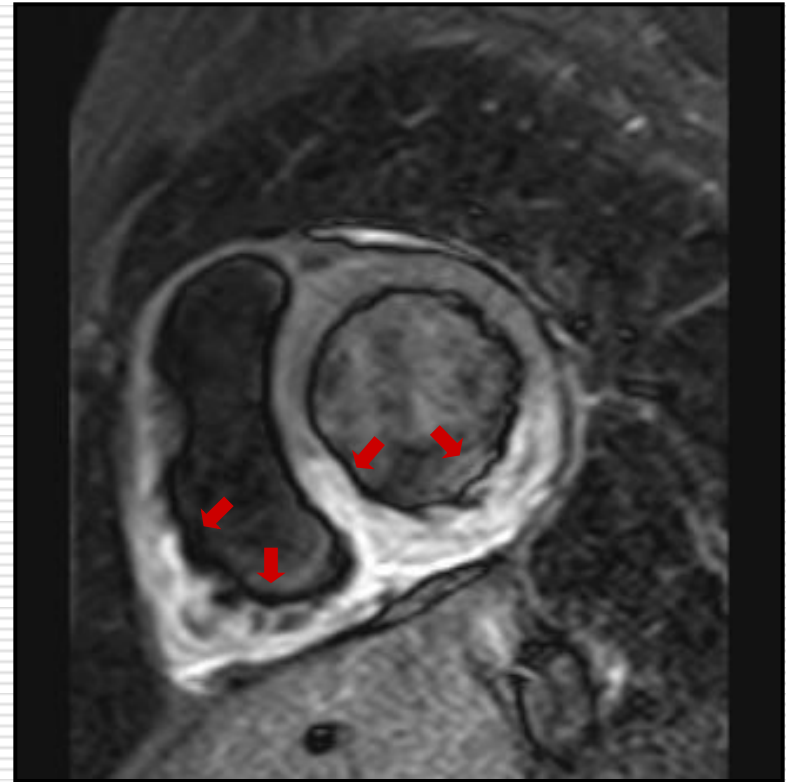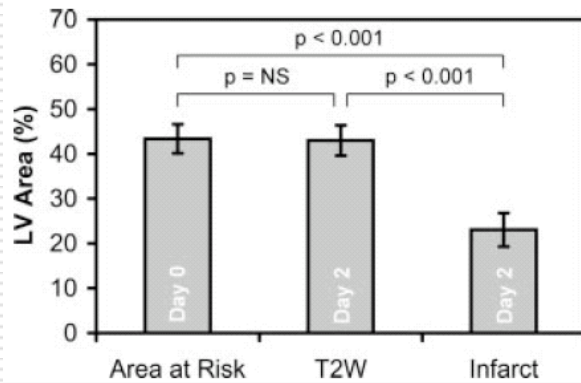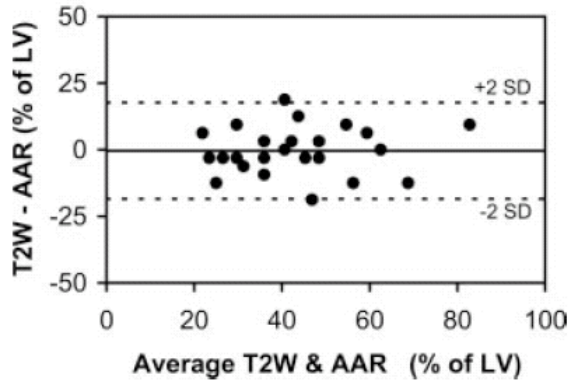
Clinical Application of cardiac T2–w STIR MRI

a)   infarct-related edema (acute vs chronic ischemic event)

b)   Myocarditis

c)   Non ischemic cardiomyopathy (e.g. acute phase of sarcoidosis, stress cardiomyopthy)

d)   Heart Transplant (acute rejection)
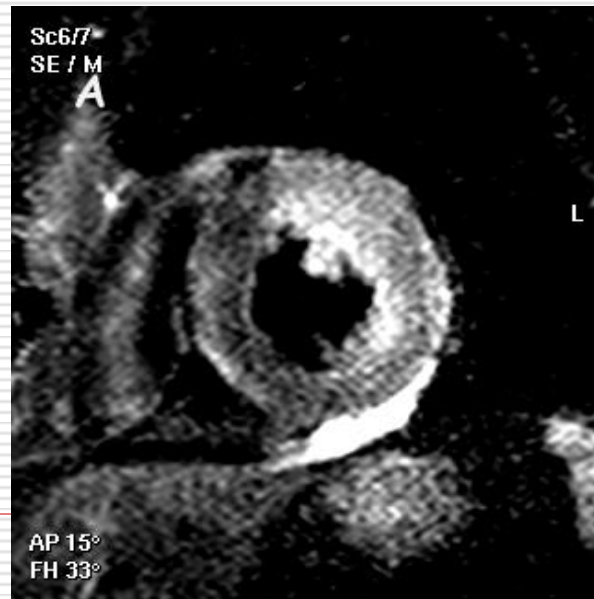
Fast Spin Echo MRI
Clinical Application
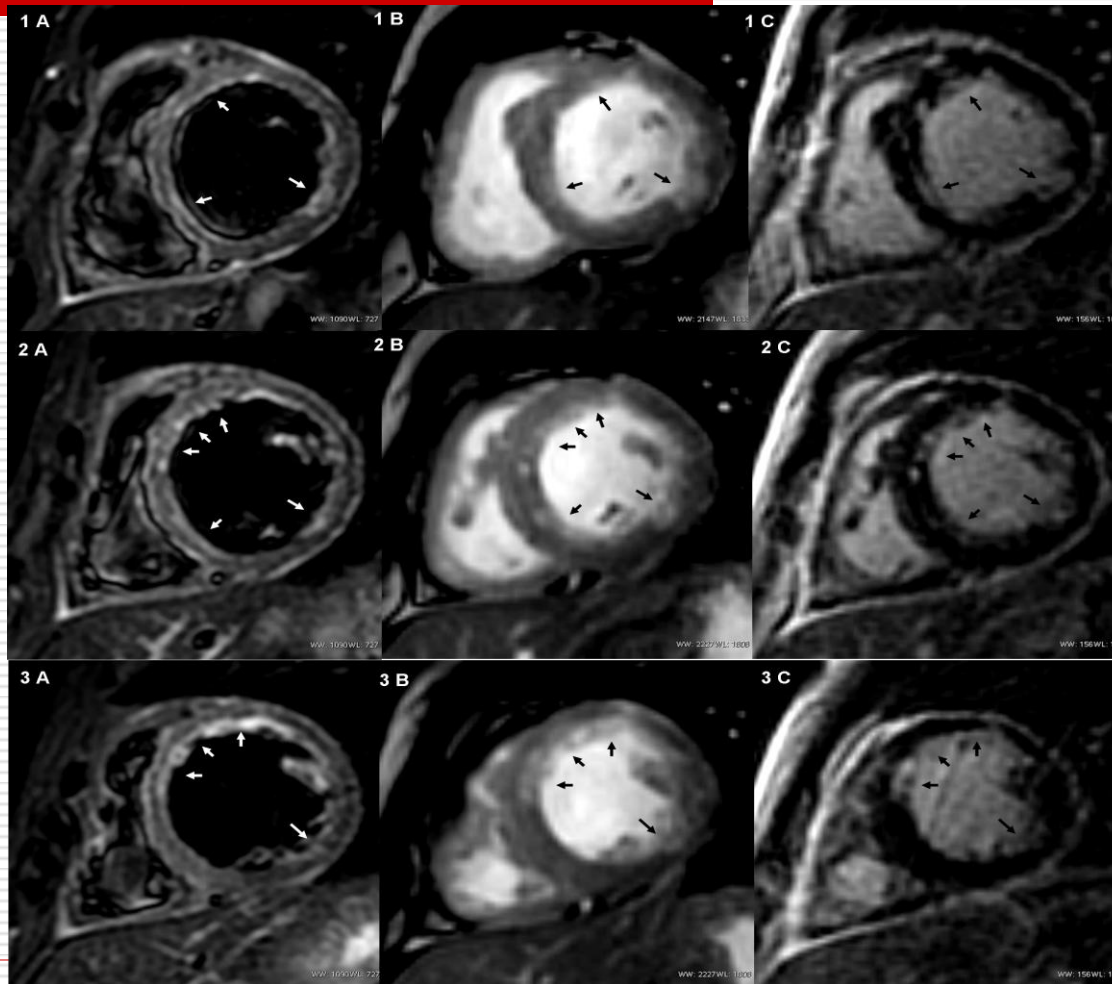
T2 Weighted STIR MRI and Infarct-related Edema

Aletras et al Circulation 2006

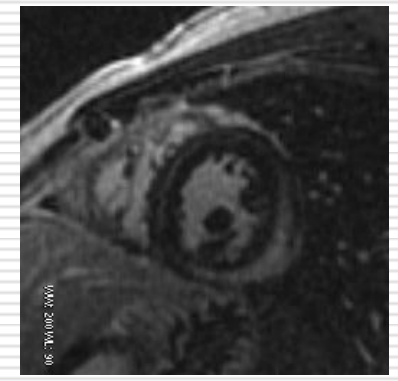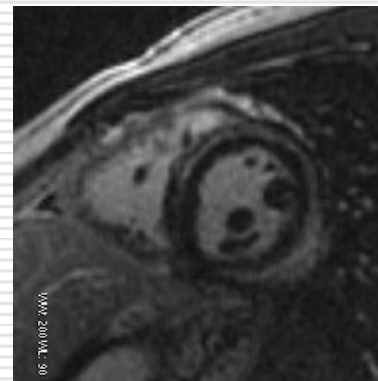# Fast Spin Echo MRI
Clinical Application
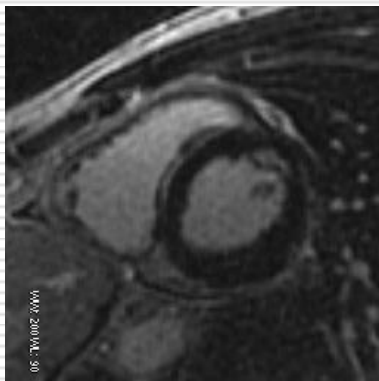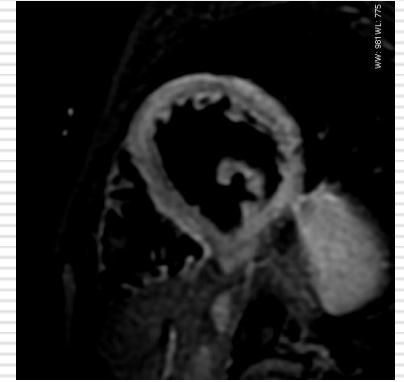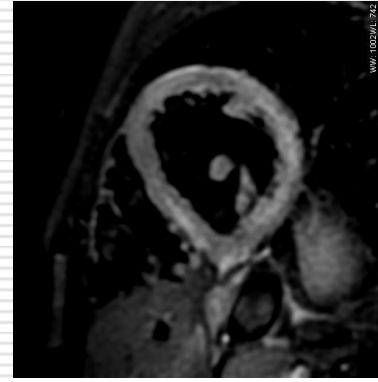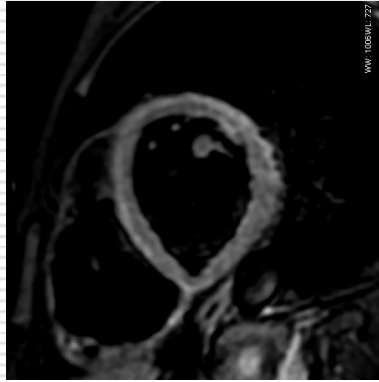
T2 Weighted STIR Magnetic Resonance Imaging and NICM

Fast Spin Echo MRI
Clinical Application

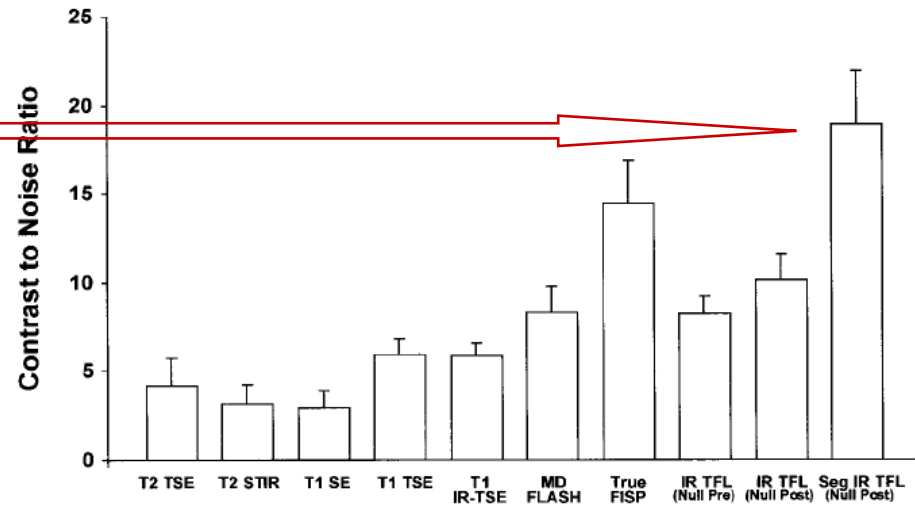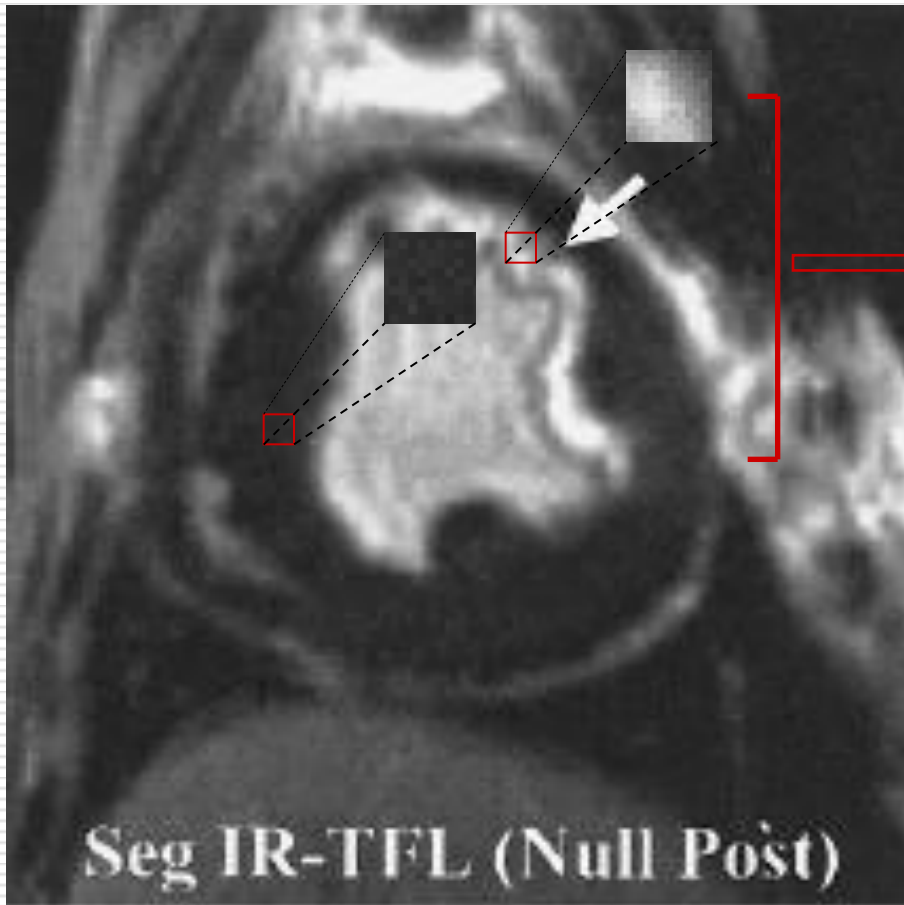### T2 Weighted STIR Magnetic Resonance Imaging and NICM
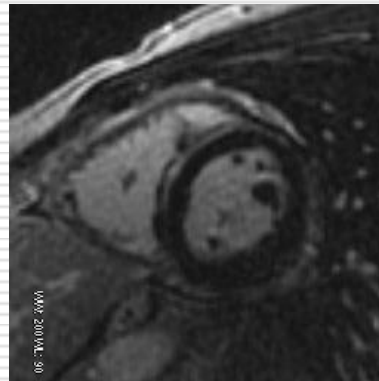
Post-Contrast Imaging
Principle and sequence

Myocardial Infarct MR Imaging
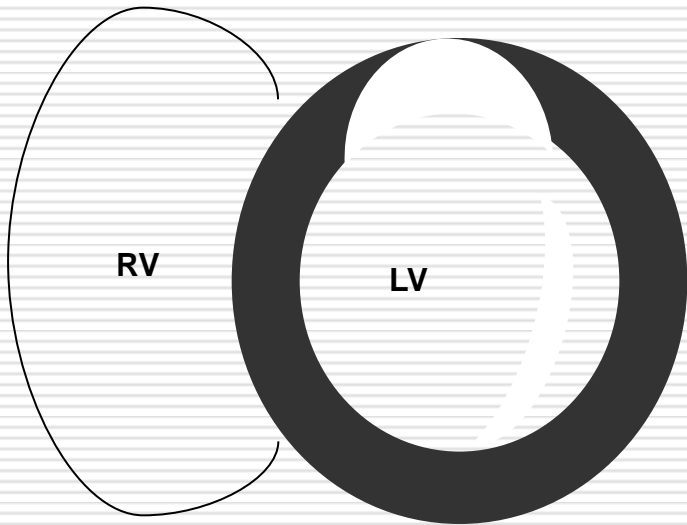## Segmented Inversion Recovery (IR) Fast Gradient Echo

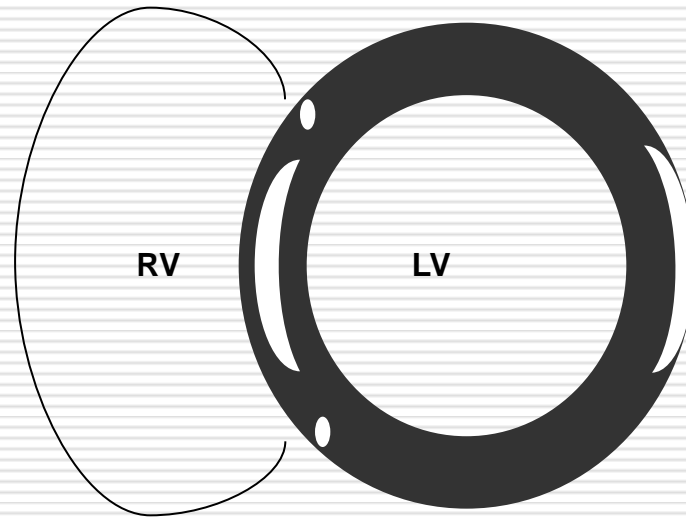*(Simonetti O et al Radiology 2001)*

Post-Contrast Imaging
Clinical Application

Pattern of delayed gadolinium enhancement

RV   LV

Ischemic Pattern

RV   LV

Non ischemic pattern

Post-Contrast Imaging
Clinical Application

Pattern of delayed gadolinium enhancement

Sarcoidosis

Myocarditis

Valvular Heart Disease
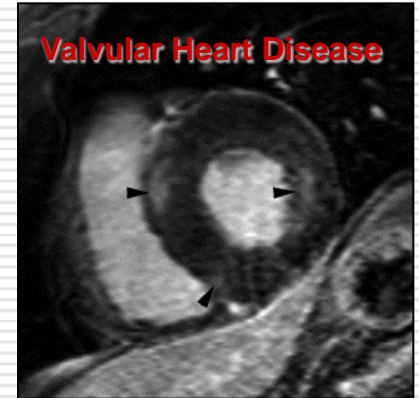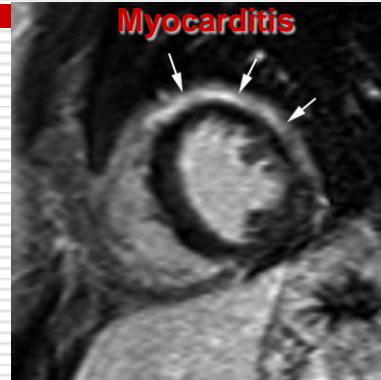
Non ischemic Pattern

HCM

Amyloydosis

Dilated Cardiomyopathy
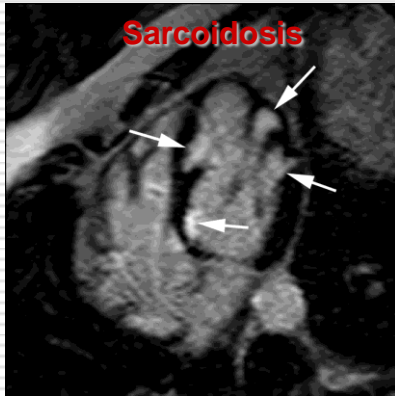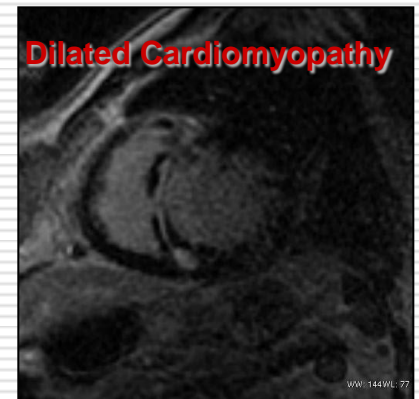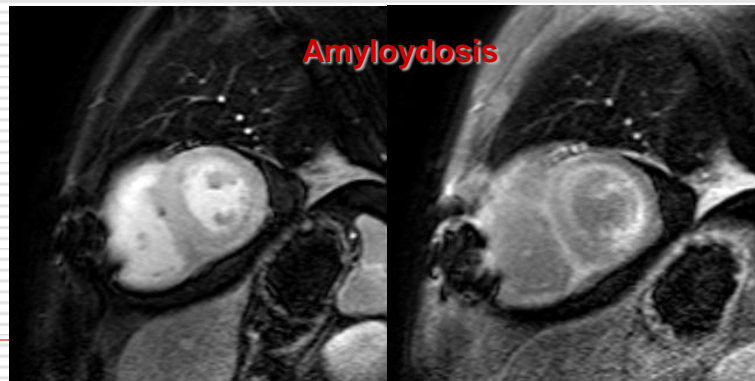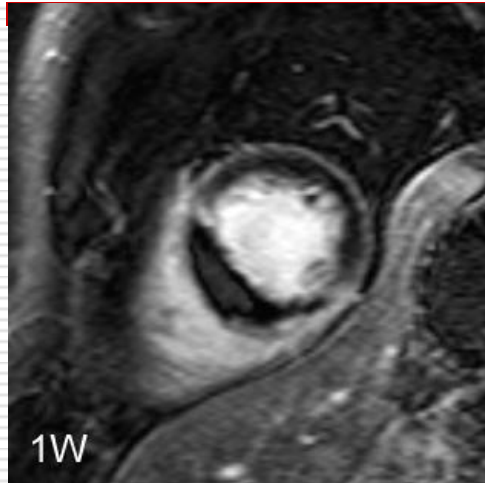
Post-Contrast Imaging
Clinical Application

Pattern of delayed gadolinium enhancement
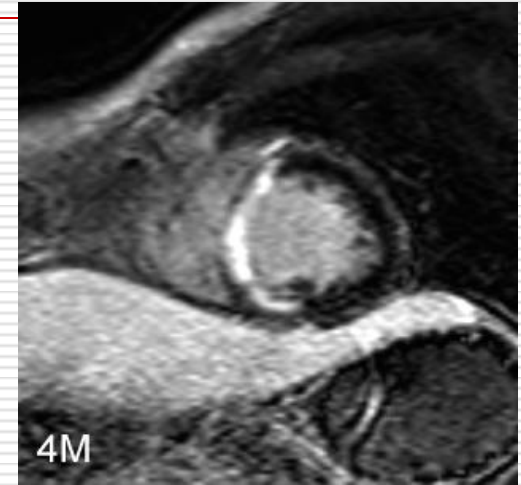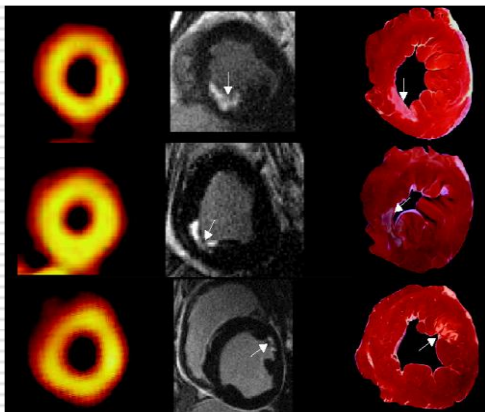
Ischemic Pattern

CARDIOMIOPATIA IPERTROFICA: ANALISI DEGLI SPESSORI

- **Modello d'analisi a 17 segmenti, 6 basali, 6 medio-ventricolari, 4 distali e l'apice vero**

- **Gli spessori sono stati misurati sugli assi corti, tranne l'apice vero, misurato sugli assi lungi, in fase telediastolica**
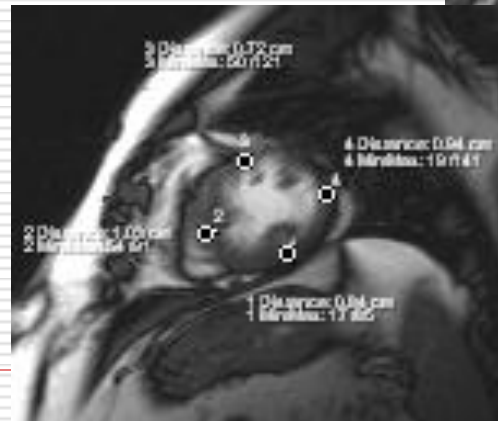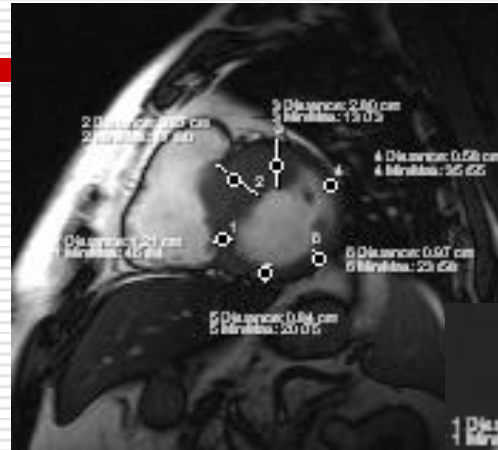
CARDIOMIOPATIA IPERTROFICA: FIBROSI SUBLIMINARE DIFFUSA
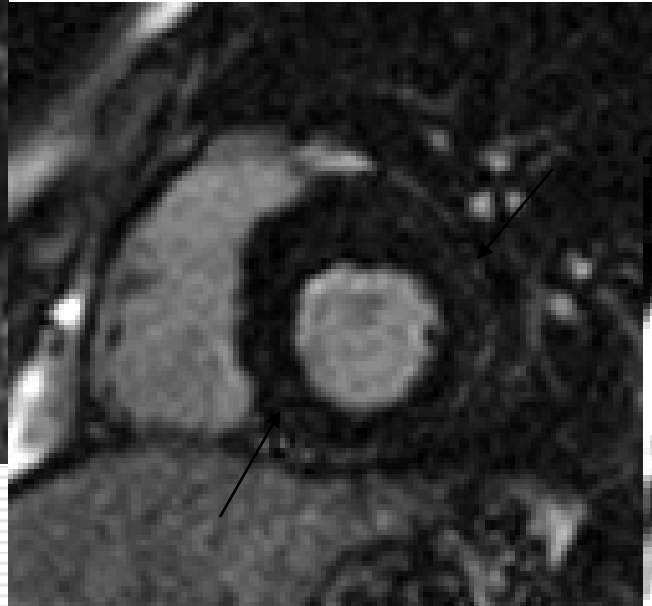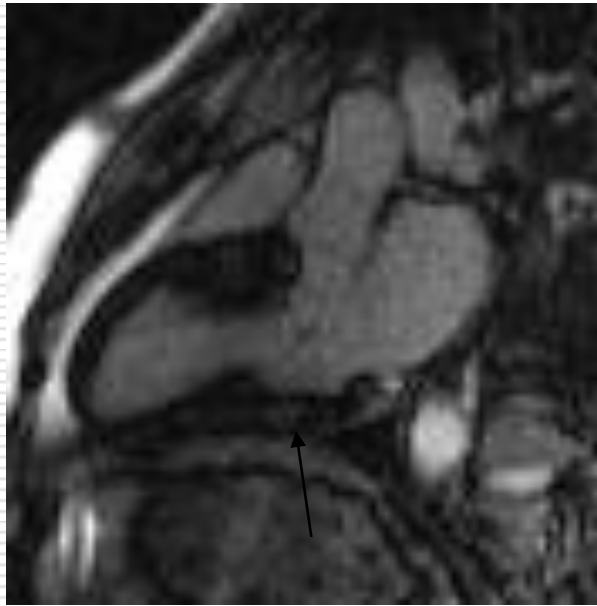
CARDIOMIOPATIA IPERTROFICA:
FIBROSI INTRAMIOCARDICA
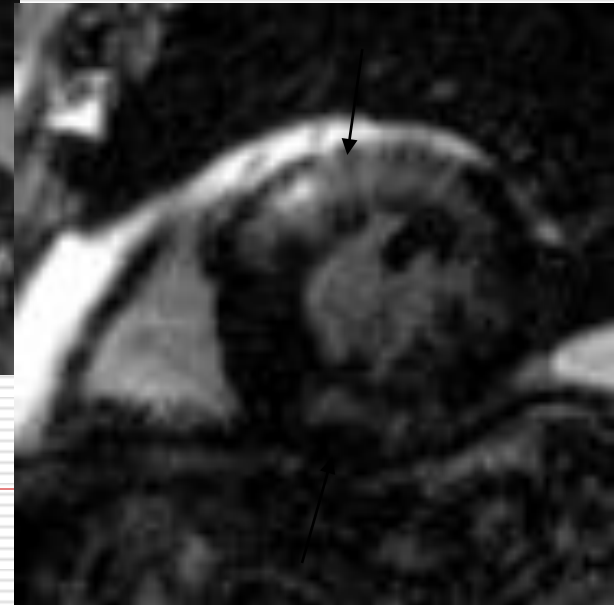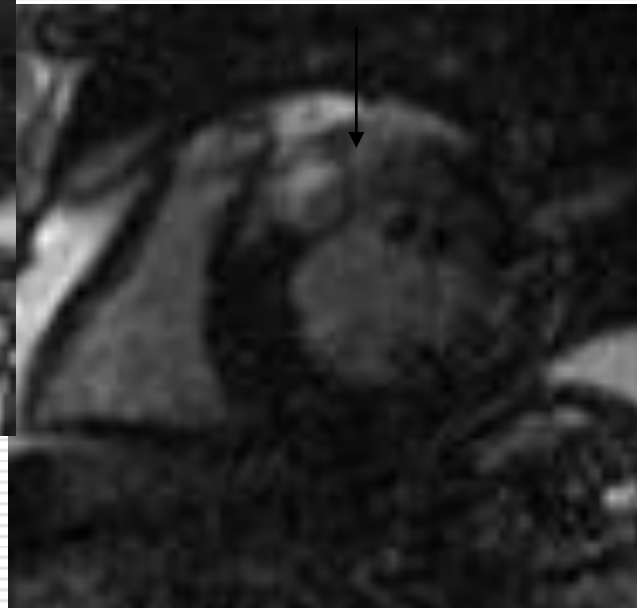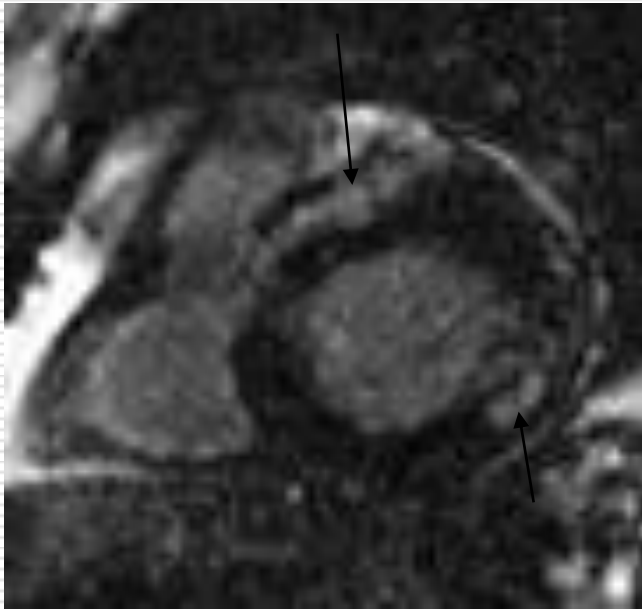
CARDIOMIOPATIA IPERTROFICA: FIBROSI SUBENDOCARDICA
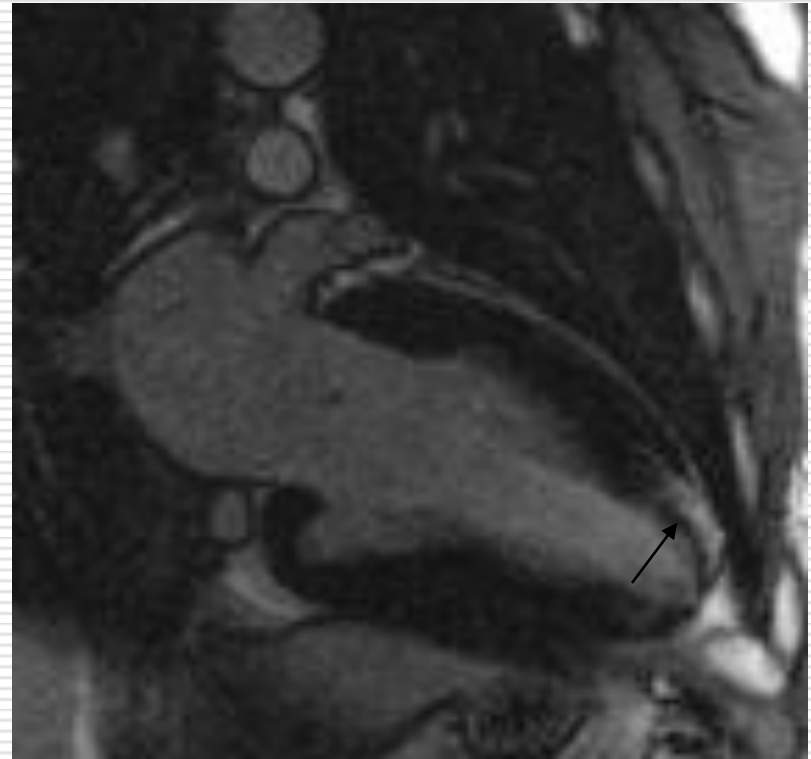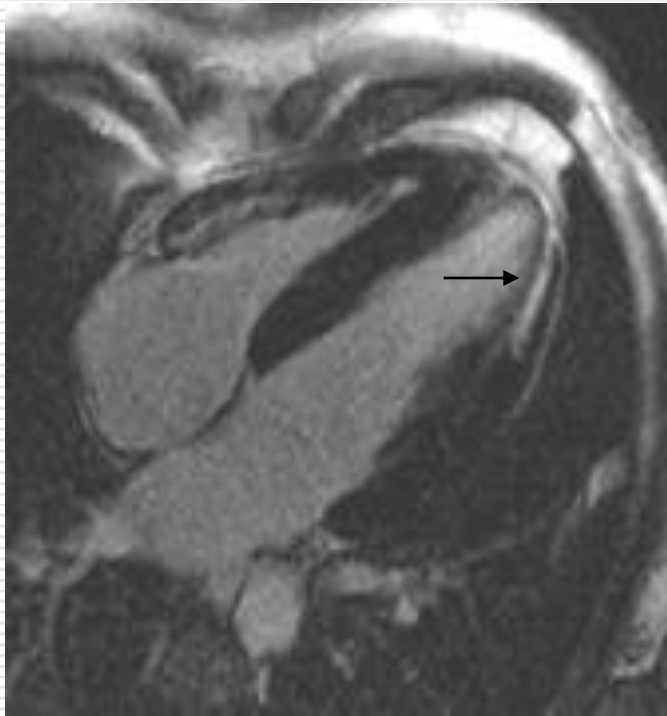
CARDIOMIOPATIA IPERTROFICA: FIBROSI GIUNZIONALE
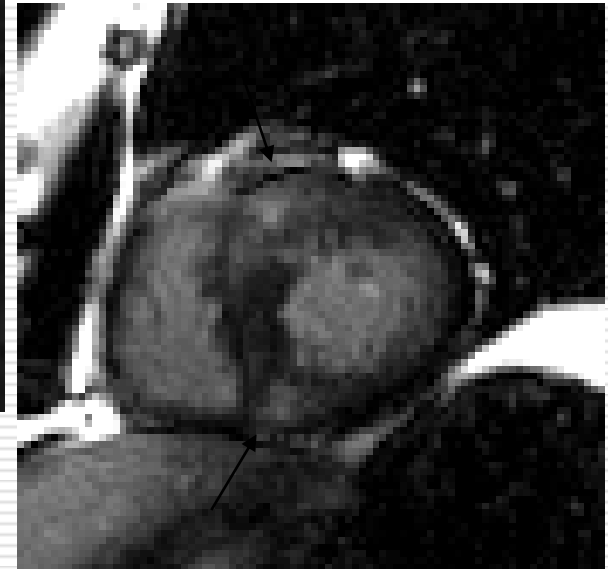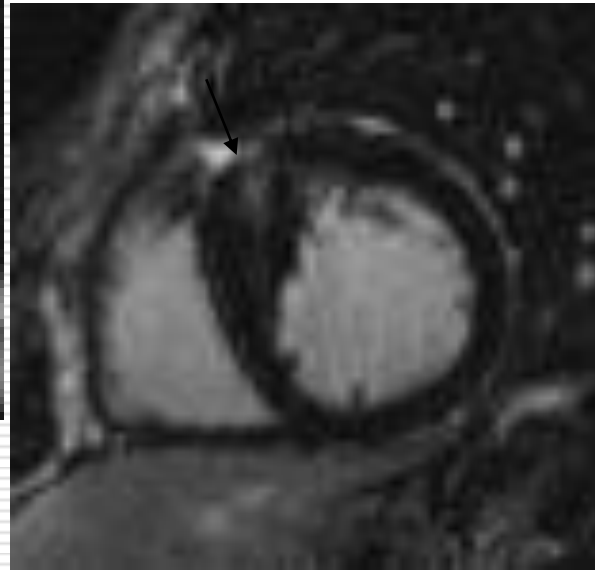
CARDIOMIOPATIA IPERTROFICA: FIBROSI EPICARDICA
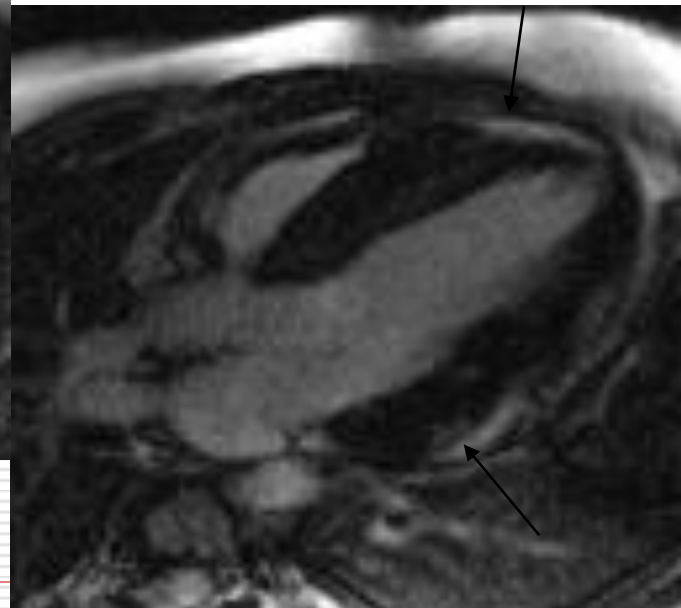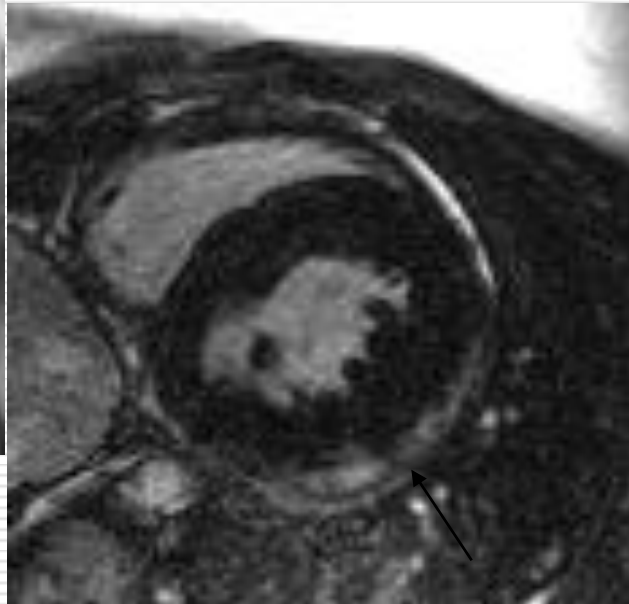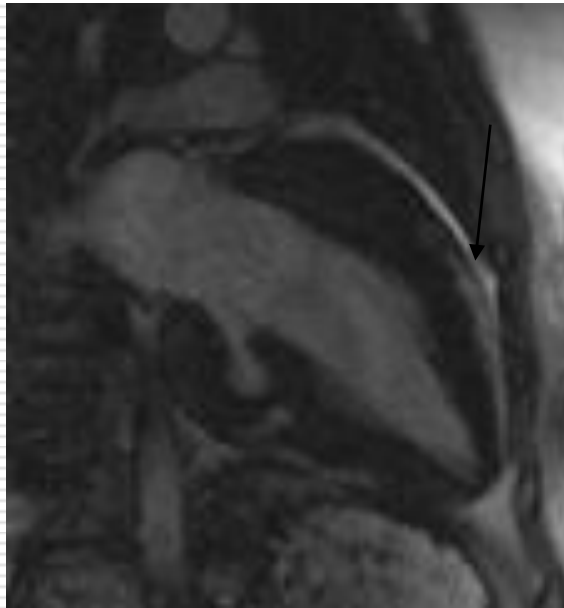
CINE-RMC

Studio della funzione

Ventricolo sinistro

- Non dilatato
- FE 55%
- Regolare spessore parietale
- Normale cinesi di parete

Ventricolo destro

- Lievemente dilatato
- FE 60%

CINE-RMC

ASSE LUNGO 4 CAMERE

ATRIO SINISTRO

⇩

Dimensioni aumentate

ATRIO DESTRO

⇩

**Dimensioni nei limiti
della norma**
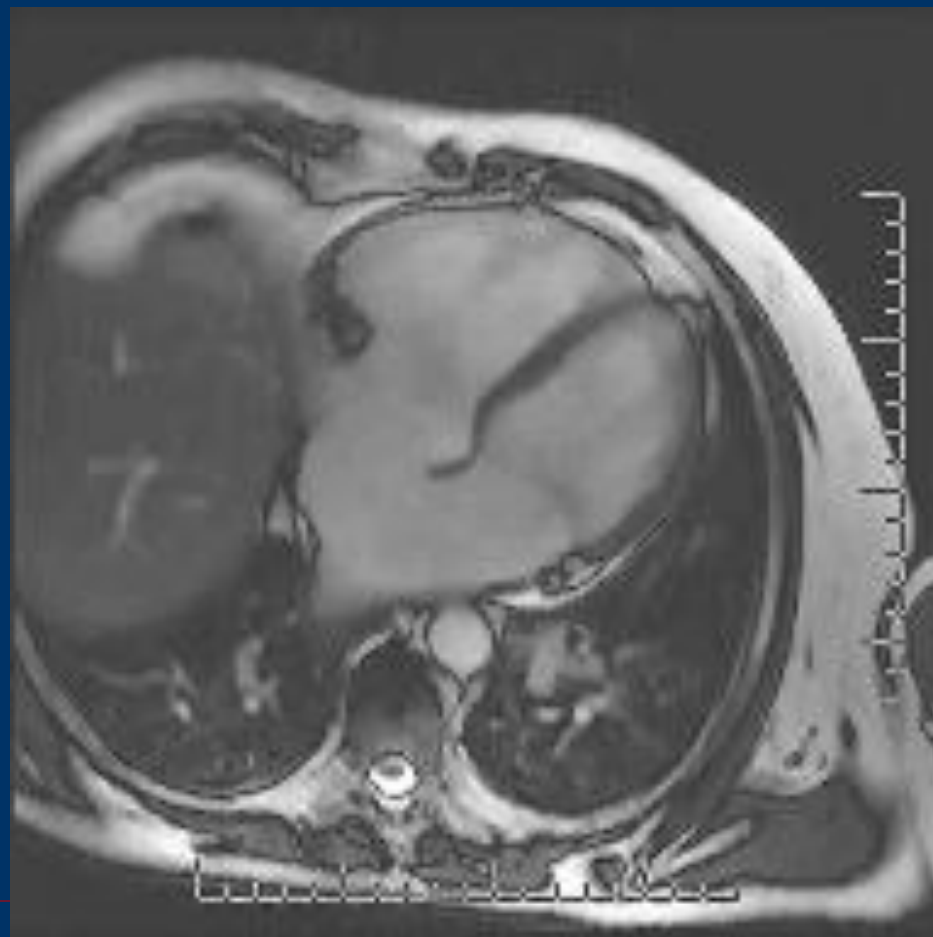
VALUTAZIONE DEL FLUSSO INTRACARDIACO

Per la valutazione del flusso sono state utilizzate due tecniche:

STUDIO DEL PRIMO PASSAGGIO DEL MEZZO DI CONTRASTO
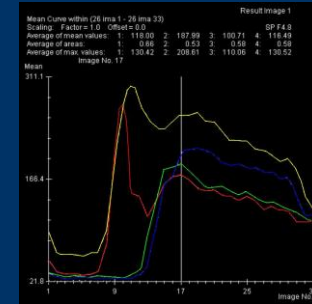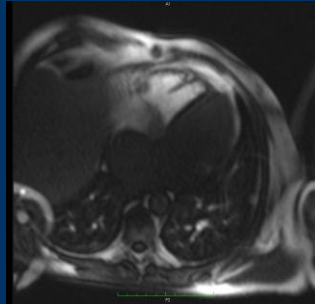
STUDIO CON PHASE CONTRAST
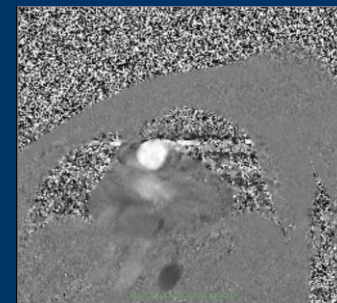
RMC FIRST-PASS

VALUTAZIONE QUANTITATIVA DELLA
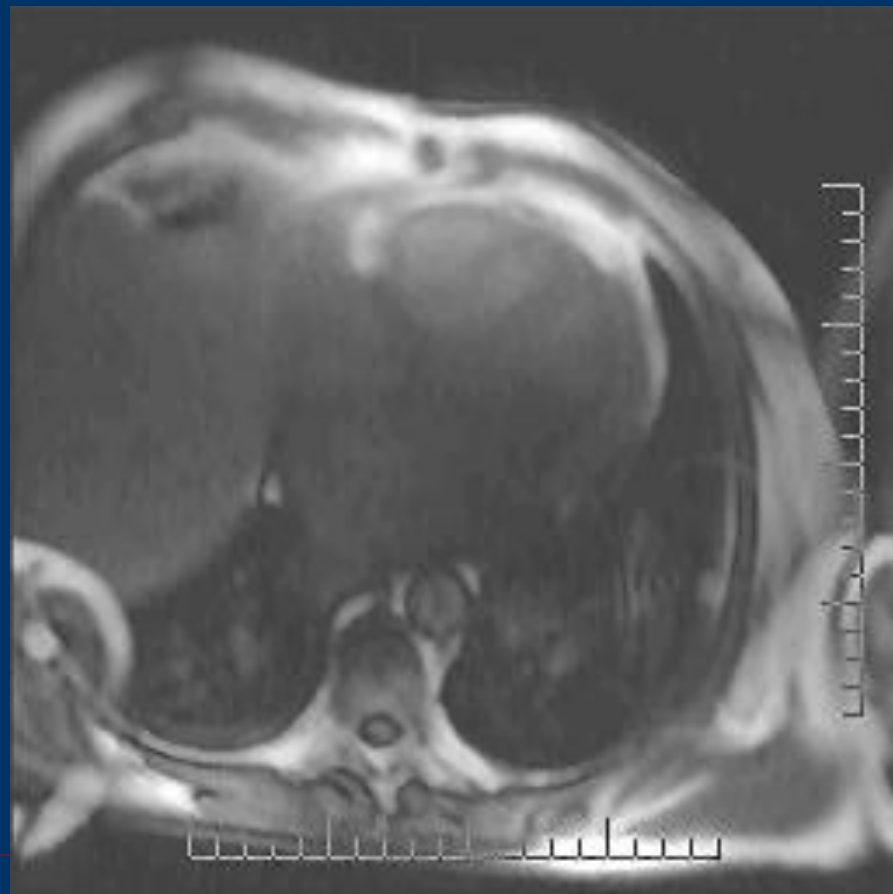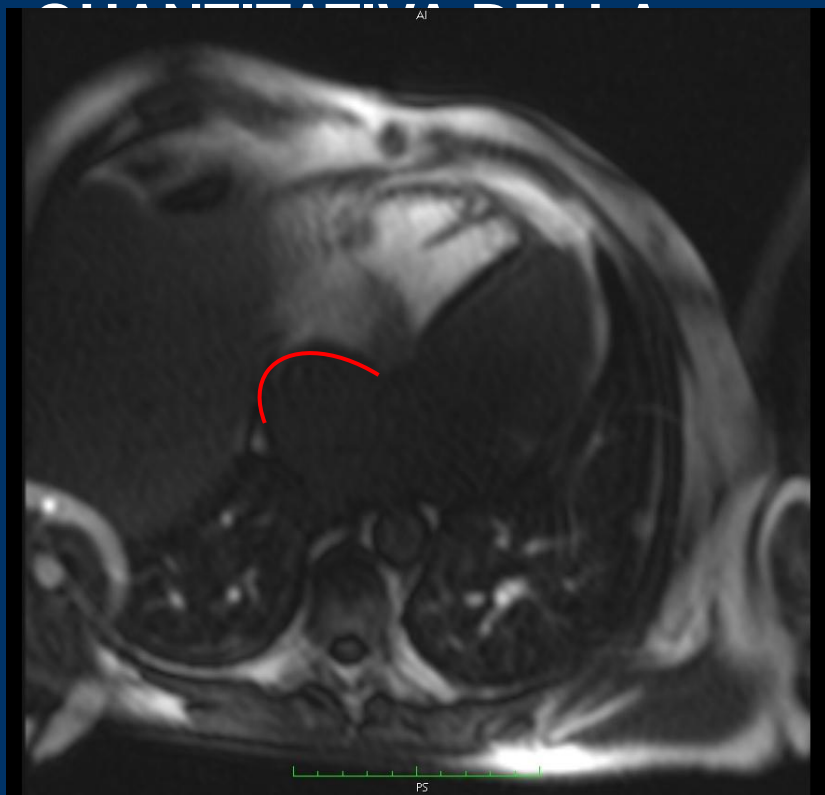
RMC FIRST-PASS

La variazione dell'intensità del segnale del mezzo di contrasto in ogni camera cardiaca è rappresentato da una singola curva:
ATRIO DESTRO – curva rossa
VENTRICOLO DESTRO – curva gialla
ATRIO SINISTRO – curva verde
VENTRICOLO SINISTRO – curva blu

DIFETTO INTERATRIALE

SHUNT CON DIREZIONE DEL FLUSSO DA SINISTRA VERSO DESTRA

Mean Curve within (26 ima 1 - 26 ima 33)
Result Image 1
Scaling: Factor = 1.0 Offset = 0.0
SP F4.8
Average of mean values: 1: 118.00 2: 187.99 3: 100.71 4: 116.49
Average of areas: 1:   0.66 2:   0.53 3:   0.58 4:   0.58
Average of max. values: 1: 130.42 2: 208.61 3: 110.06 4: 130.52

PHASE CONTRAST

PHASE CONTRAST

Qp/Qs = 2,2

VALUTAZIONE FUNZIONALE

Right Ventricle - Absolute

Cardiac Function			Normal Range (M) (MRI)	Units
Ejection Fraction	EF	59.5	47.00 ... 74.00	%
End Diastolic Volume	EDV	214.4	88.00 ... 227.00	ml
End Systolic Volume	ESV	86.9	23.00 ... 103.00	ml
Stroke Volume	SV	127.6	52.00 ... 138.00	ml
Cardiac Output	CO	9.18	2.82 ... 8.82	l/min
Myocardial Mass (at ED)		----	----	g
Myocardial Mass (Avg)		----	----	g

Filling and Ejection Data

Peak Ejection Rate	----	n.a.	ml/sec
Peak Ejection Time	----	n.a.	msec
Peak Filling Rate	----	n.a.	ml/sec
Peak Filling Time from ES	----	n.a.	msec

Patient ID: Examination Date: 15-Oct-08
Patient Height: 165.00 cm Patient Weight: 80.00 kg. Heart Rate: 72 Beats/min

Left Ventricle - Absolute

Cardiac Function			Normal Range (M) (MRI)	Units
Ejection Fraction	EF	52.6	56.00 ... 78.00	%
End Diastolic Volume	EDV	111.3	77.00 ... 195.00	ml
End Systolic Volume	ESV	52.7	19.00 ... 72.00	ml
Stroke Volume	SV	58.6	51.00 ... 133.00	ml
Cardiac Output	CO	4.22	2.82 ... 8.82	l/min
Myocardial Mass (at ED)		----	----	g
Myocardial Mass (Avg)		----	----	g

Filling and Ejection Data

Peak Ejection Rate	----	n.a.	ml/sec
Peak Ejection Time	----	n.a.	msec
Peak Filling Rate	----	n.a.	ml/sec
Peak Filling Time from ES	----	n.a.	msec

Patient ID: Examination Date: 15-Oct-08
Patient Height: 165.00 cm Patient Weight: 80.00 kg. Heart Rate: 72 Beats/min

Qp/Qs = 2,2

Conclusion