CMR in Central vascular Imaging

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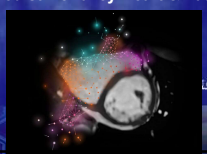

1

Contrast Enhanced MRA

- Gadolinium based contrast administered – first pass
- Imaging of entire 3D dataset can be done in 15-25 seconds (single breath hold)
- Advantages
  - Large FOV
  - High spatial resolution
  - High SNR

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High resolution 3D angio

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K-space Filling

- Ordering schemes
  - Linear
  - Centric
- Center : Image intensity
- Periphery : Fine detail

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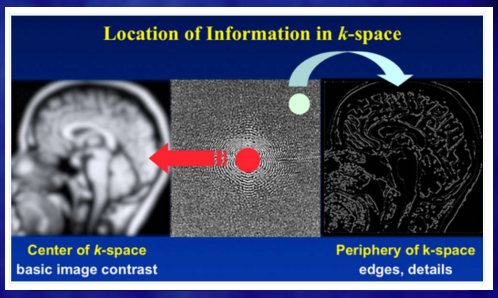

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MRIquestions.com

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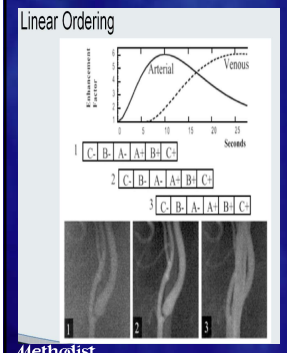

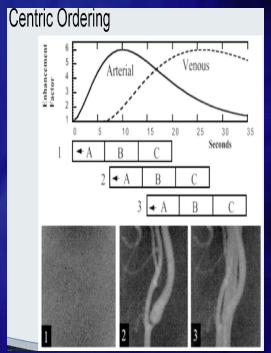

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Gadolinium contrast timing

- Timing bolus
- Fluoroscopic triggering
  - Automated
  - Manual
- Time resolved

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Timing Bolus

- Test dose with 1-2 cc of contrast and 20-30 cc of saline flush
- Measure transit time
- Time full bolus such that middle part of infusion coincide with center of K space

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Fluoroscopic Triggering

- Begin contrast infusion
- When contrast arrives to the vessel of interest, trigger 3D sequence

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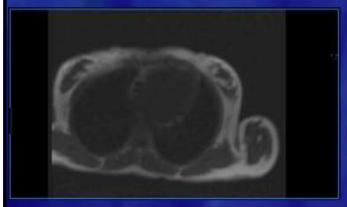
Care Bolus



- Center of the k-space is measured as quickly as possible when the contrast agent reaches the region to be examined

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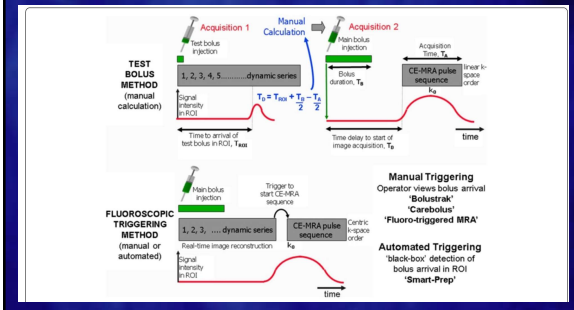

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Time Resolved MRA

- Dynamic information about flow
- Lower spatial resolution
- Acquires multiple 3D data set every few seconds (5-8)
- Outer part of K-space is sparsely sampled

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VIBE - MRA

- Volume inter-polated breath holding examination

VIBE

MRI measurement technique: FLASH 3D imaging technique with reduced data acquisition time by using data interpola-tion, or partial Fourier tech-niques, or both, primarily for dynamic contrast-enhanced examinations of the abdomen.

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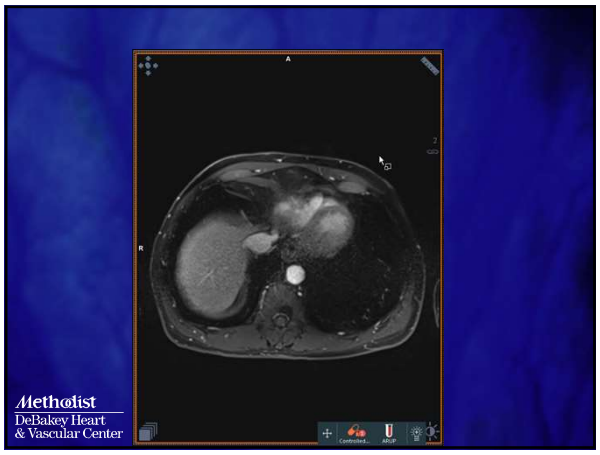

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EKG gating

- Motion is worst at the aortic root and along a mobile dissection flap , typically 250-300 msec

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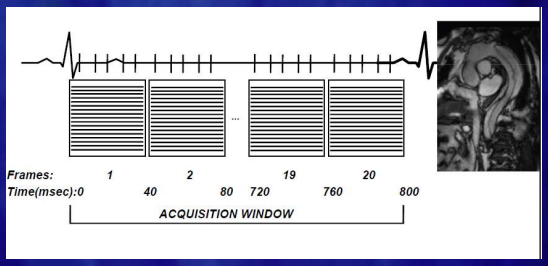
Retrospective gating



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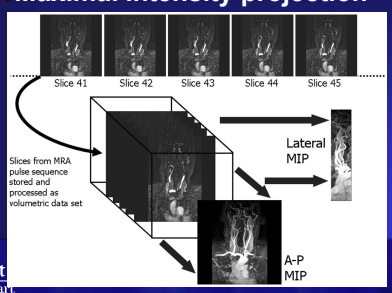
Visualization techniques

- Maximal intensity projection



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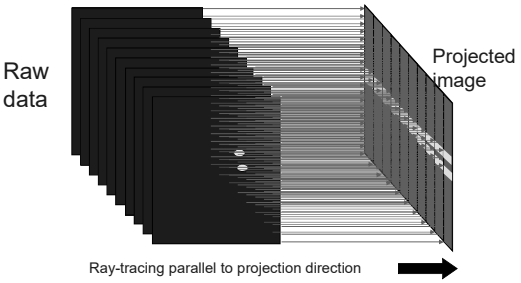
Maximum Intensity Projection

Ray-tracing algorithm



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Comparison of Methods for Aorta Imaging

Lesion	TTE	TOE	CT	MRI
Ascending aortic dissection	++	+++	+++	+++
Aortic arch dissection	+	+	+++	+++
Descending aortic dissection	+	+++	+++	+++
Size	++	+++	+++	+++
Mural thrombus	+	+++	+++	+++
Intramural haematoma	+	+++	++	+++
Penetrating aortic ulcer	++	++	+++	+++
Involvement of aortic branches	+*	(+)	+++	+++

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Erbel. European Heart Journal (2014) 35, 2873–2926

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Choice of Imaging Modalities

Advantages of CT

- Universal availability
- Short scan times
- Higher spatial resolution
- Less cost
- Compatibility with ferromagnetic metals
- Coronary evaluation
- 2D/3D reconstructions
- Better for calcification

Advantages of CMR

- Tissue characterization, aortic wall imaging
- Dynamic imaging (dissection)
- Venous imaging
- AV pathology
- Pts with iodine allergy
- 4D flow
- Radiation free / young/pregnant/ACHD serial imaging

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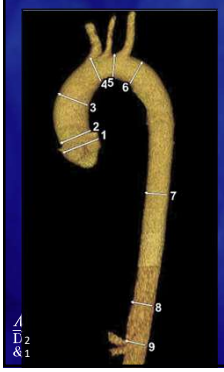
Standard Anatomic Landmarks of the Thoracoabdominal Aorta



Anatomic Location	
1.	Aortic sinuses of Valsalva
2.	Sinotubular junction
3.	Mid ascending aorta (midpoint in length between Nos. 2 and 4)
4.	Proximal aortic arch (aorta at the origin of the innominate artery)
5.	Mid aortic arch (between left common carotid and subclavian arteries)
6.	Proximal descending thoracic aorta (begins at the isthmus, approximately 2 cm distal to left subclavian artery)
7.	Mid descending aorta (midpoint in length between Nos. 6 and 8)
8.	Aorta at diaphragm (2 cm above the celiac axis origin)
9.	Abdominal aorta at the celiac axis origin

Hiratzka. J Am Coll Cardiol. 2010;55(14):1509-1544

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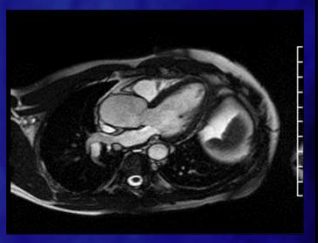
Effaced STJ Trileaflet AV



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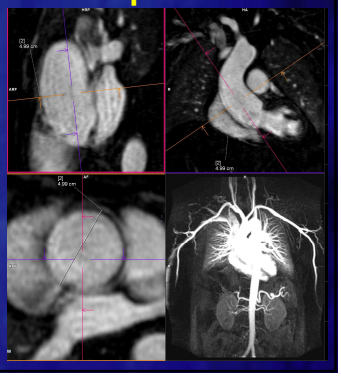
True short axis plane

- Diameter Is Measured Perpendicular to Axis of Blood Flow
- Double oblique method
- Outer to outer



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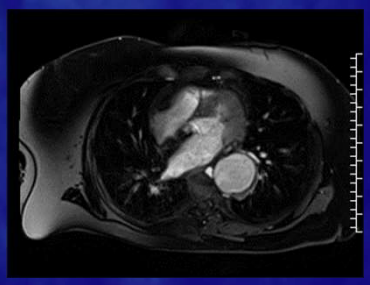
MRA Descending aortic aneurysm Severe atherothrombosis



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Aortic Size Index Nomogram

BSA	Aortic size (cm)									
	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	8.0
1.30	2.69	3.08	3.46	3.85	4.23	4.62	5.00	5.38	5.77	6.15
1.40	2.50	2.86	3.21	3.57	3.93	4.29	4.64	5.00	5.36	5.71
1.50	2.33	2.67	3.00	3.33	3.67	4.00	4.33	4.67	5.00	5.33
1.60	2.19	2.50	2.80	3.13	3.44	3.75	4.06	4.38	4.69	5.00
1.70	2.05	2.35	2.65	2.94	3.24	3.53	3.82	4.12	4.41	4.71
1.80	1.94	2.22	2.50	2.78	3.06	3.33	3.61	3.89	4.17	4.44
1.90	1.84	2.11	2.37	2.63	2.89	3.16	3.42	3.68	3.95	4.22
2.00	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
2.10	1.67	1.90	2.14	2.38	2.62	2.86	3.10	3.33	3.57	3.80
2.20	1.59	1.82	2.05	2.27	2.50	2.72	2.95	3.18	3.41	2.64
2.30	1.52	1.74	1.96	2.17	2.39	2.61	2.83	3.04	3.26	3.48
2.40	1.46	1.67	1.88	2.08	2.29	2.50	2.71	2.92	3.13	3.33
2.50	1.40	1.60	1.80	2.00	2.20	2.40	2.60	2.80	3.00	3.20

= low risk (~4% per yr)
= moderate risk (~8% per yr) 2.75 cm/BSA
= severe risk (~20% per yr) 4 cm/BSA

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Davies RR. Ann Thorac Surg 2006;81:169–77

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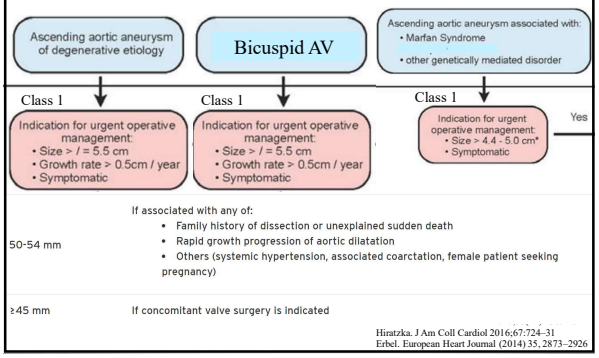
Class 1 Recommendations with Asymptomatic Patients With Ascending Aortic Aneurysm



Hiratzka. J Am Coll Cardiol 2016;67:724–31
Erbel. European Heart Journal (2014) 35, 2873–2926

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Coarctation
Cine- CMR, non-contrast

- Discrete narrowing at the juxtaductal segment of the descending aorta
- Associations
  - HTN
  - Claudication
  - Turner's syndrome
  - ICH
  - BAV, Shon'es complex

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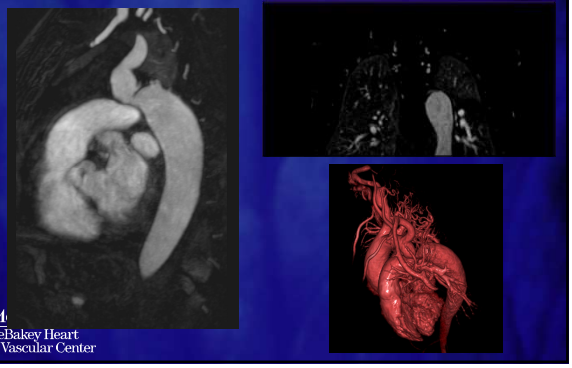
3D-MR angiography



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Markers of significant Coarac

- Reversal of intercostal flow
- Flow differential between proximal and distal end of the aorta

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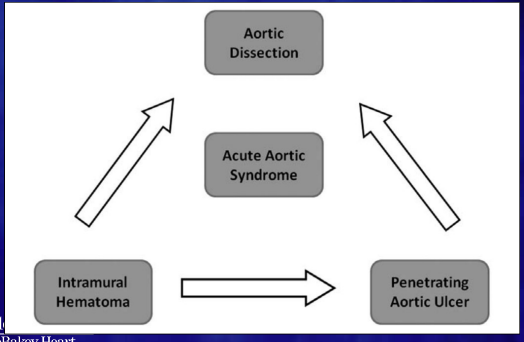
Acute Aortic Syndrome (AAS):
Spectrum of Related Entities Characterized by Disruption of the Aortic Wall



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Sheikh. Circulation. 2013;128:1122-1127

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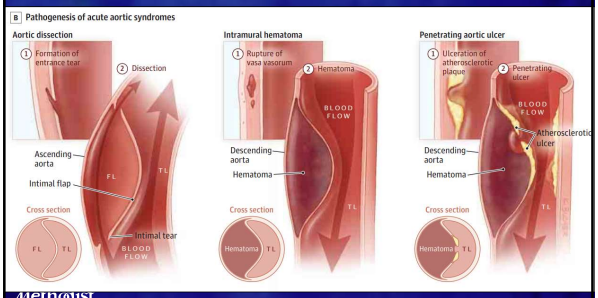
Acute aortic syndrome



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Mussa. JAMA. 2016;316(7):754-763

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Role of Imaging in Aortic Dissection

- Determine extent of dissection
- Dimensions of aorta, branch vessels
- Viability of solid organs.

- Life-threatening complications of dissection:
  - Pericardial hemorrhage and tamponade
  - Mediastinal hemorrhage
  - Acute aortic valve insufficiency
  - Coronary artery & carotid artery dissection
  - End-organ malperfusion syndromes

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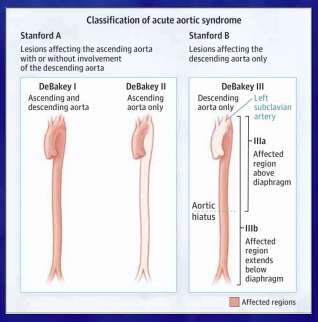
Aortic Dissection Classification: 2 Systems



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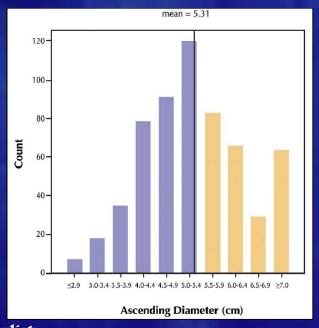
Type A Dissections Do Occur at Small Sizes



Pts with certain genetic syndromes & abnormal tissue morphology

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Pape LA. Circulation 2007;116:1120 –7.

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CT/CMR Gold Standard for Diagnosis

Table 2. Reported Sensitivity and Specificity of Diagnostic Tools for Acute Aortic Syndrome[a]

Diagnostic Tool[b]	Studies, No.[c]	Patients, No.	Threshold	All AASs[d,e] Sensitivity	Specificity
CT[27]	1	49		100 (86.3-100)	100
MRI[29-31]	3	116		95.0-100	94.0-98.0
TEE[17,27,29,30,32,33]	6	520		86.0-100	90.0-100
TTE[34,35]	2	228		73.7-100	71.2-91.0
Intravascular ultrasound[36]	1	28			
D-dimer[37-42]	6	876	>0.5-0.7 μg/mL	51.7-100	32.8-89.2
Elastin degradation products[43]	1	609	>3 SD above mean of healthy patients	99.8 (99.1-100)	
MMP 8/9[44]	1	126	>3.6 ng/mL	100 (93.2-100)	9.5 (3.9-18.5)
Smooth muscle myosin heavy chain[45]	1	27	>10 ng/mL	90.0 (78.7-100)	97.0
Soluble lectin-like oxidized LDLR 1[46]	1	19	>150 pg/mL	89.5	94.3

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electrocardiographic gating is crucial for reducing motion artifact, particularly in the aortic root, ascending aorta, and proximal arch

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Treatment Recommendations

Table 4. Treatment Recommendations for Acute Aortic Syndrome

Stanford Type	ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM 2010[65a]	Level (Grade)[b]	ESC 2014[69c]	Level (Grade)[b]	This Review	Level (Grade)[b]
Aortic Dissection						
A	Open surgical procedure	I (B)	Open surgical procedure	I (B)	Open surgical procedure	I (B)
B						
Complicated[d]	Surgical procedure[e]	I (B)	TEVAR	I (C)	TEVAR	I (C)
Uncomplicated[d]	Medical therapy	I (B)	Medical therapy or TEVAR	I (C) or IIA (B)	Medical therapy or TEVAR	I (C) or IIA (C)
Intramural Hematoma						
A						
Complicated[d]	Open surgical procedure	IIA (C)	Open surgical procedure	I (C)	Open surgical procedure	IIA (C)
Uncomplicated[d]	Not mentioned		Not mentioned		Medical therapy	IIA (C)
B						
Complicated[d]	Surgical procedure[e]	IIA (C)	TEVAR	IIA (C)	TEVAR	IIA (C)
Uncomplicated[d]	Medical therapy	I (B)	Medical therapy	I (C)	Medical therapy	IIA (C)

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Mussa. JAMA. 2016;316(7):754-763

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Table 8. Suggested Follow-up of Aortic Pathologies After Repair or Treatment

Pathology	Interval	Study
Acute dissection	Before discharge, 1 mo, 6 mo, yearly	CT or MR, chest plus abdomen TTE
Chronic dissection	Before discharge, 1 y, 2 to 3 y	CT or MR, chest plus abdomen TTE
Aortic root repair	Before discharge, yearly	TTE
AVR plus ascending	Before discharge, yearly	TTE
Aortic arch	Before discharge, 1 y, 2 to 3 y	CT or MR, chest plus abdomen
Thoracic aortic stent	Before discharge, 1 mo, 2 mo, 6 mo, yearly Or 30 days*	CXR, CT, chest plus abdomen
Acute IMH/PAU	Before discharge, 1 mo, 3 mo, 6 mo, yearly	CT or MR, chest plus abdomen

Hiratzka. J Am Coll Cardiol. 2010;55(14):1509-154

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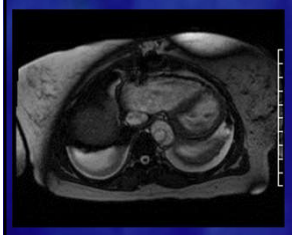
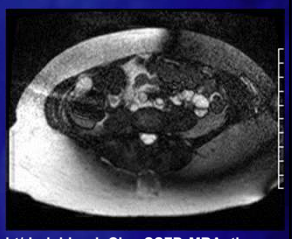
CMR in Aortic Dissection

Chest



Abdomen



CMR Sequences: Bright/dark blood, Cine SSFP, MRA, time resolved, VIBE

Noncontrast and contrast sequences are recommended by the SCMR as part of a standard thoracic MRA protocol

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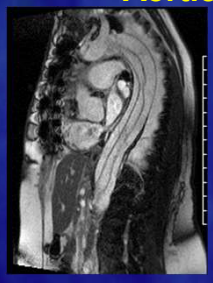
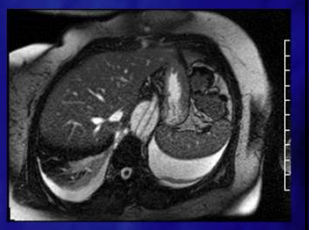
Dynamic CMR Imaging Aortic Dissection





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True lumen

- Smaller
- Oval in configuration
- Hugs inner curve of the aorta
- Rarely thrombosed
- Faster flow
- Antegrade flow

False Lumen

- Larger
- Crescent shaped
- Extends along the outer curve of aorta
- Often thrombosed
- Slower flow
- Retrograde flow

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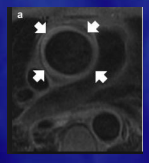
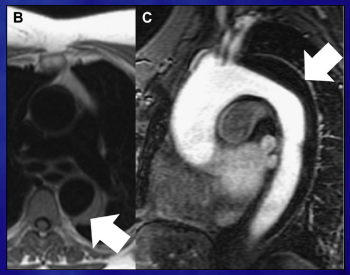
IMH: CMR Findings T2-weighted imaging – High signal





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Stein. Radiol Clin N Am 52 (2014) 195–217

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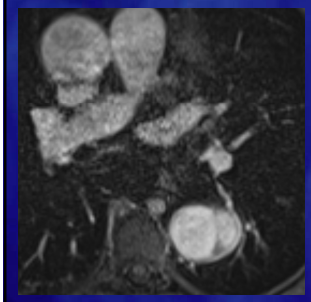
PAU – MRA Imaging



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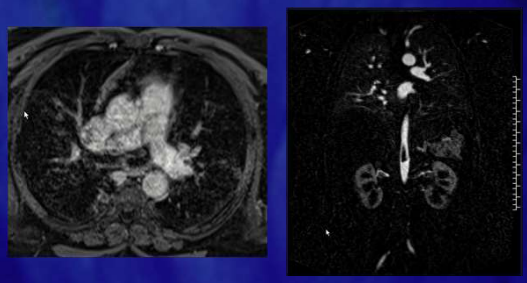
Aortic thrombus



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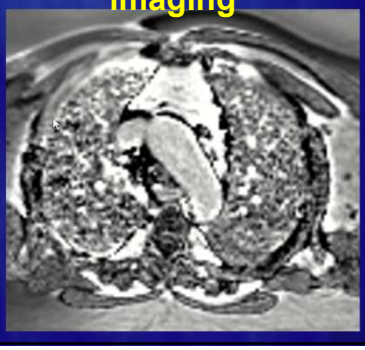
T1 600 msec, Thrombus imaging



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Non contrast 3D SSFP

- Allows visualization of background tissues
- Does not require intravenous contrast agents
- Not dependent of accurate timing
- Useful for coronary imaging, and aorta

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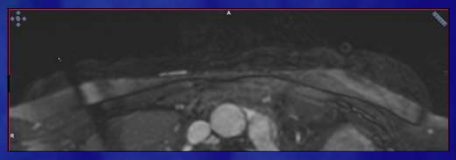
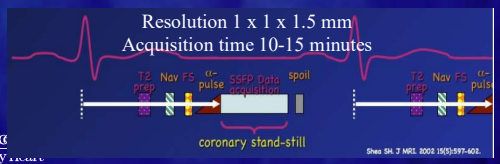
Coronary MRA





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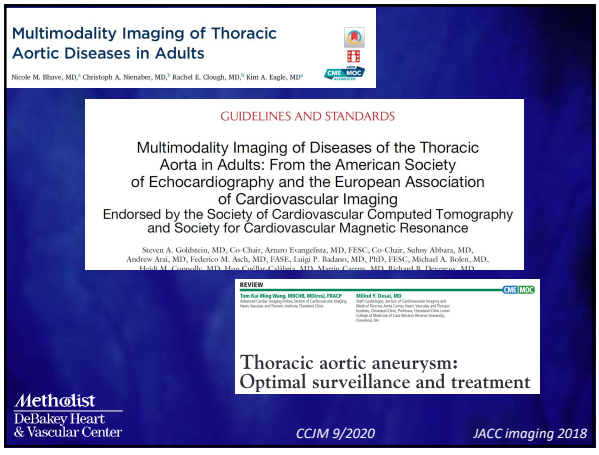

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QISS (Quiescent-Interval single shot) Knees to toes

- ECG-triggered, single-shot 2D acquisition of one slice per heartbeat
- In-plane saturation to suppress background tissue and a tracking saturation pulse to suppress venous signal prior to a quiescent inflow period.

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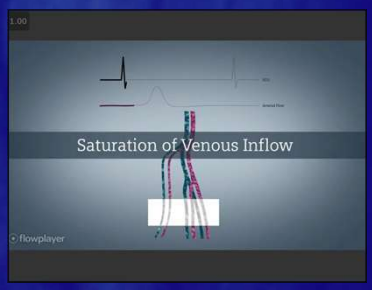
How it works



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