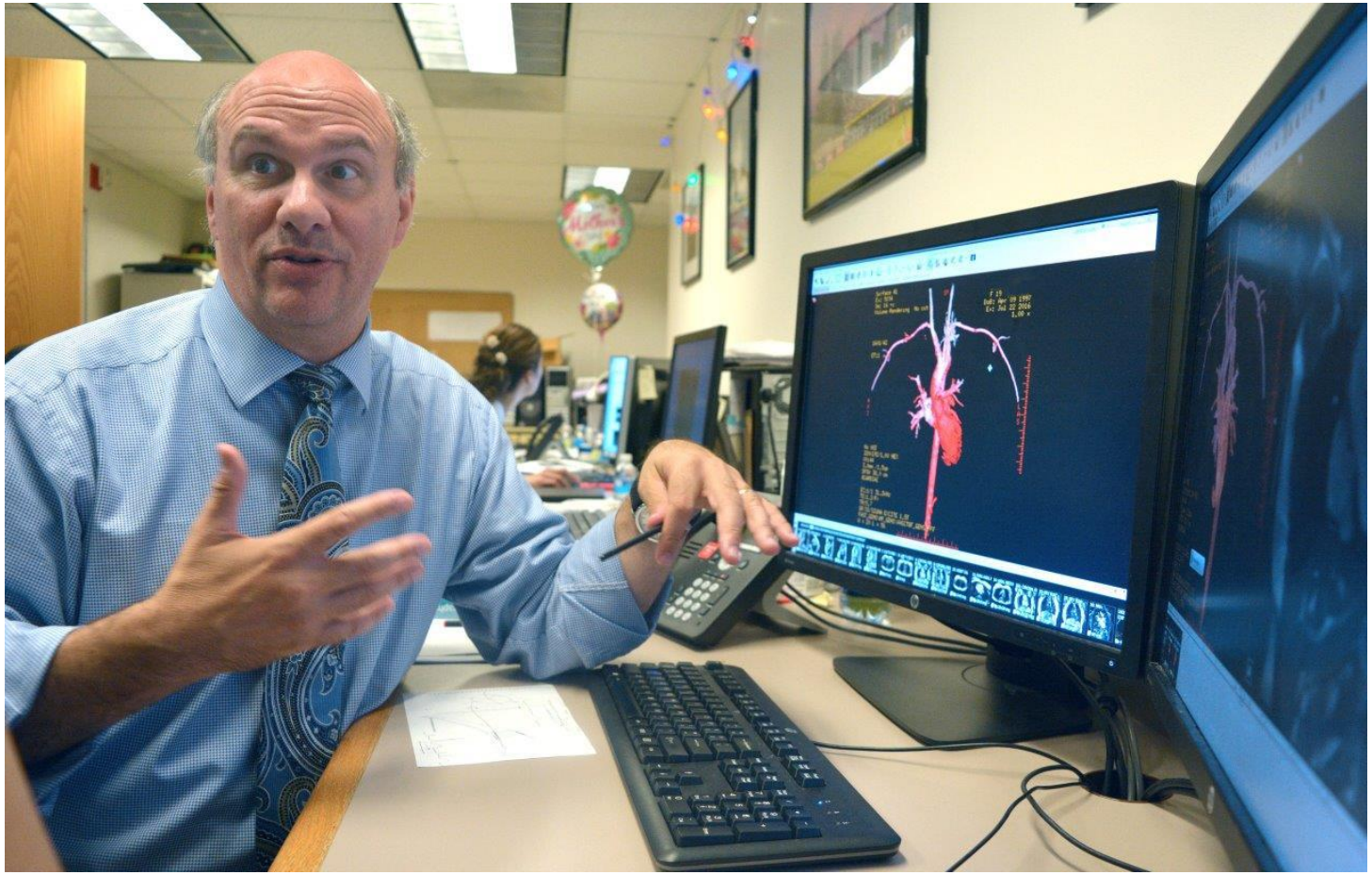
Advanced Cardiac MRI

SAED ALNAIMAT, MD

CENTER FOR CARDIAC MRI, ALLEGHENY GENERAL HOSPITAL

PITTSBURGH

ACKNOWLEDGEMENT



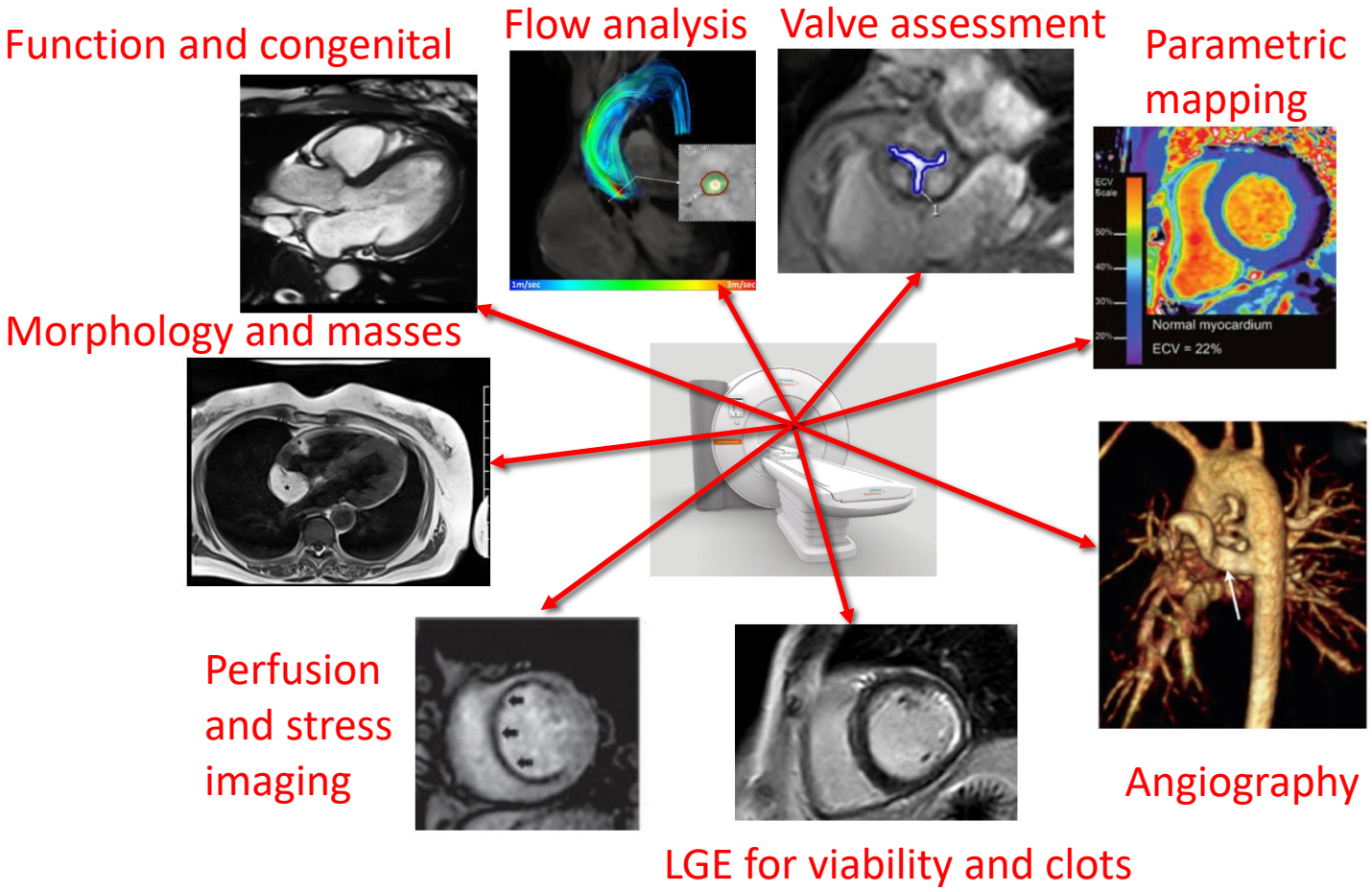
Dr. Robert Biederman

BACKGROUND

Dr. Raymond Damadian (1977)

WHEN TO OBTAIN A CARDIAC MR?

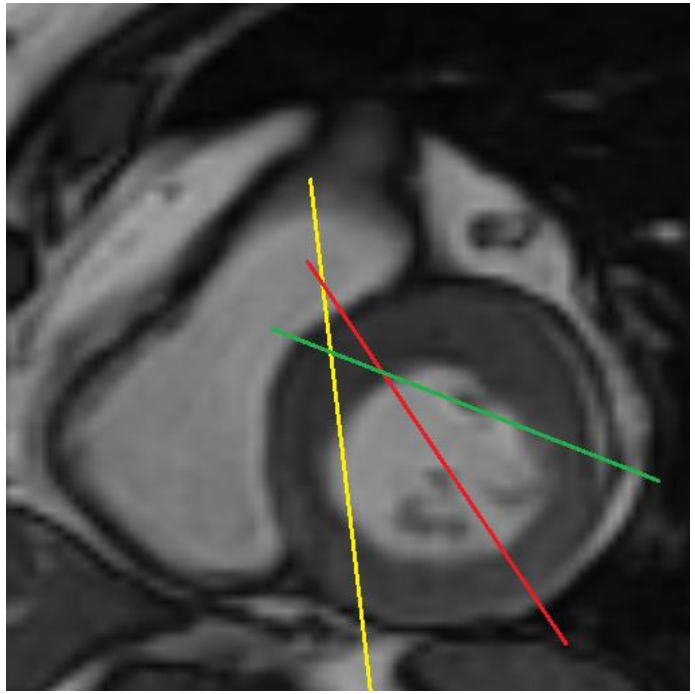
SCOPE OF CMR

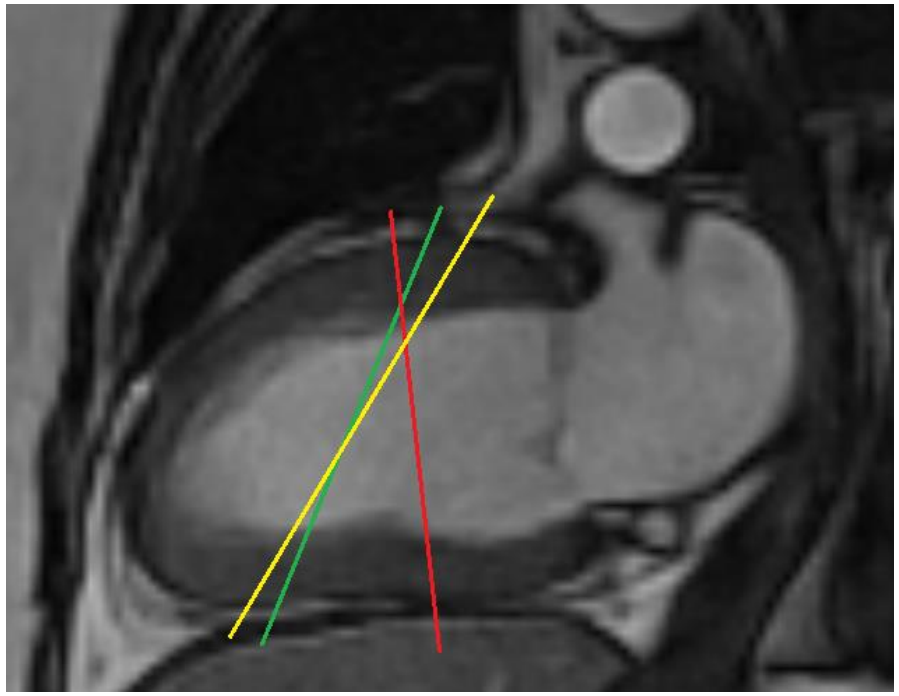

Function and congenital
Flow analysis
Valve assessment
Parametric mapping
Morphology and masses
Normal myocardium
ECV = 22%
Perfusion and stress imaging
Angiography
LGE for viability and clots

ANATOMIC ASSESSMENT

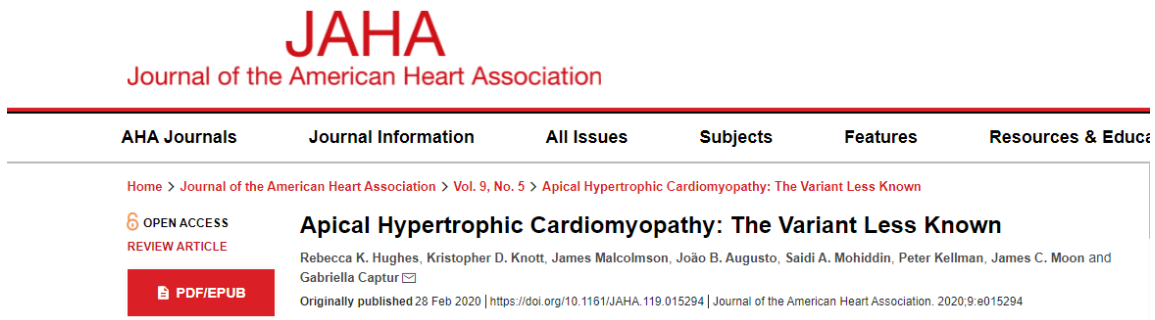
- CMR provides unparalleled assessment of cardiac chamber size, function, wall thickness, and tissue characterization.
- Examples of cardiac disorders that are best (if not exclusively) assessed by CMR include:
  - Hypertrophic cardiomyopathy
  - Cardiac amyloidosis
  - Cardiac sarcoidosis
  - Hemochromatosis
  - Mitral annular disjunction
  - Non-compaction
  - ARVD
  - Pericarditis
  - Cardiac masses

ANATOMIC ASSESSMENT





HYPERTROPHIC CARDIOMYOPATHY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OPEN ACCESS
REVIEW ARTICLE

PDF/EPUB

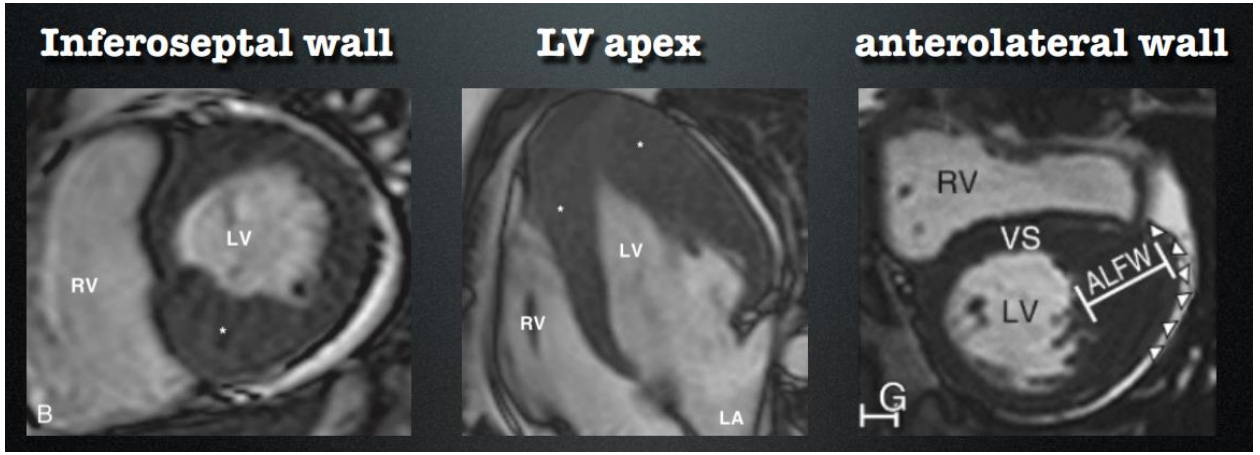
Apical Hypertrophic Cardiomyopathy: The Variant Less Known

Rebecca K. Hughes, Kristopher D. Knott, James Malcolmson, João B. Augusto, Saidi A. Mohiddin, Peter Kellman, James C. Moon and Gabriella Captur

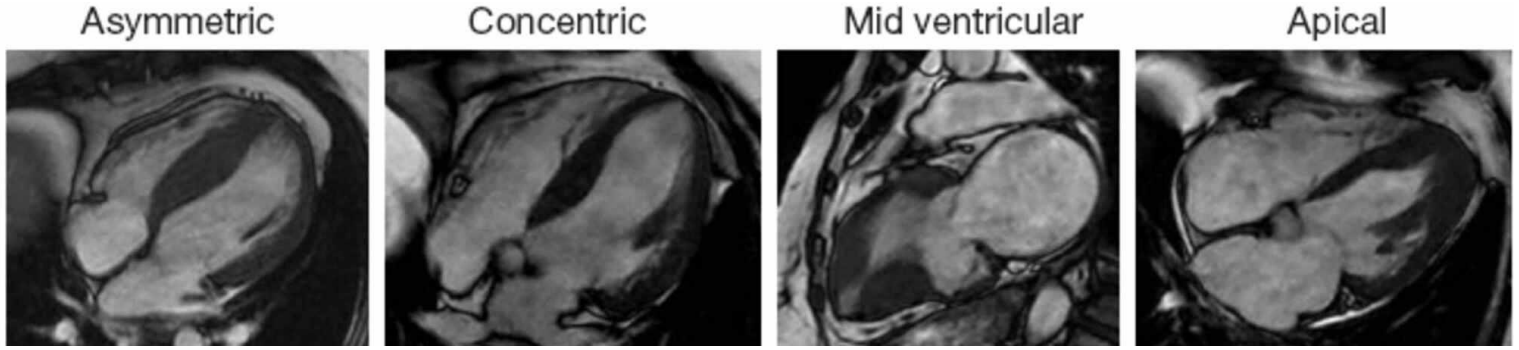
Originally published 28 Feb 2020 | https://doi.org/10.1161/JAHA.119.015294 | Journal of the American Heart Association. 2020;9:e015294

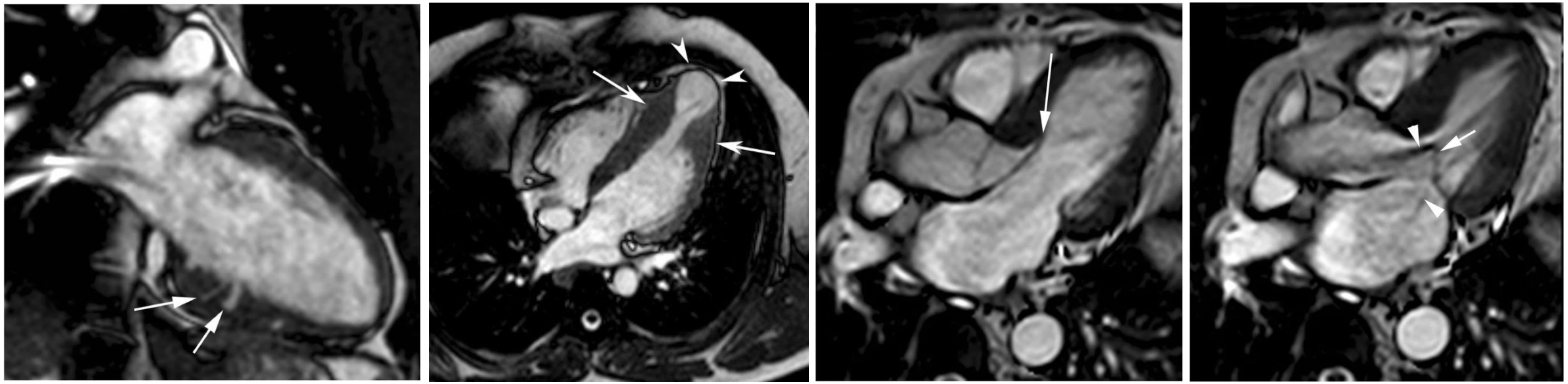
- Apical hypertrophy was missed by echocardiography in 40% of cases, later detected by CMR

Echo "blind" areas

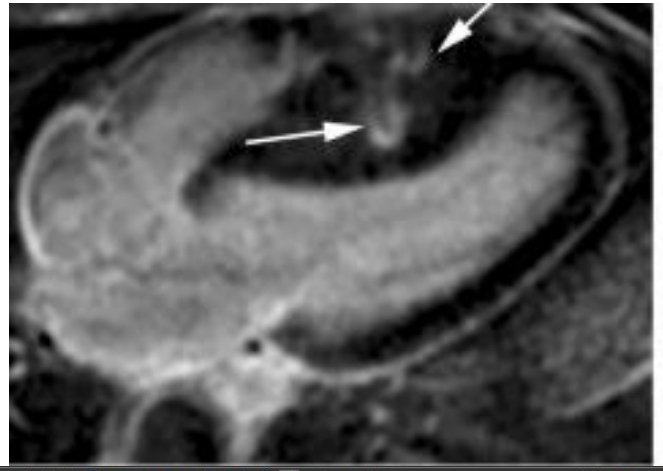


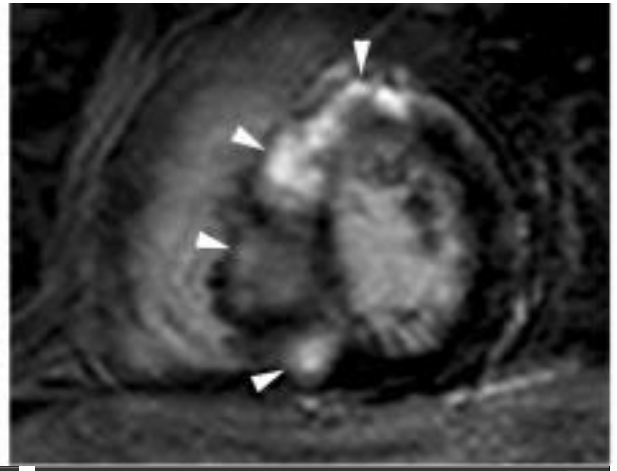
HYPERTROPHIC CARDIOMYOPATHY

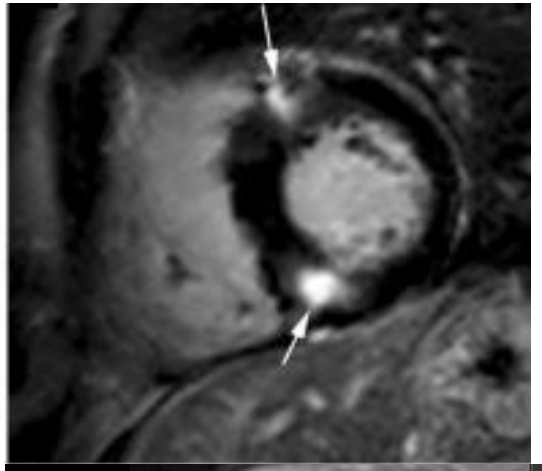


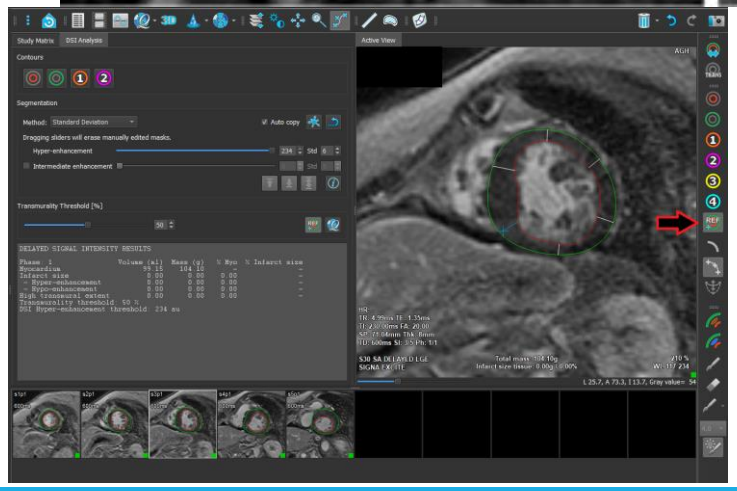


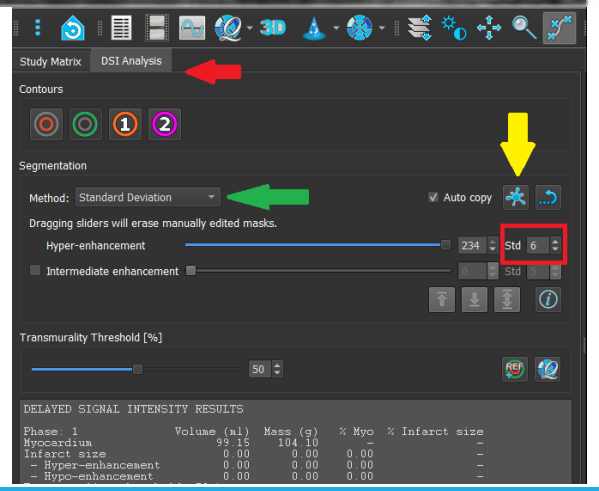
LGE QUANTIFICATION

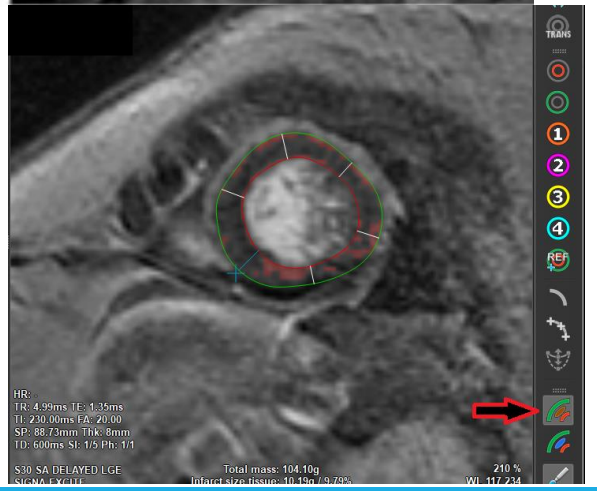












AHA/ACC CLINICAL PRACTICE GUIDELINE

Circulation. 2020;142:e558–e631.

2020 AHA/ACC Guideline for the Diagnosis and Treatment of Patients With Hypertrophic Cardiomyopathy

A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Recommendations for CMR Imaging

Referenced studies that support the recommendations are summarized in Online Data Supplement 4.

COR	LOE	Recommendations
1	B-NR	1. For patients suspected to have HCM in whom echocardiography is inconclusive, CMR imaging is indicated for diagnostic clarification.[1–7]
1	B-NR	2. For patients with LVH in whom there is a suspicion of alternative diagnoses, including infiltrative or storage disease as well as athlete's heart, CMR imaging is useful[1–7] (Figure 1).
1	B-NR	3. For patients with HCM who are not otherwise identified as high risk for SCD, or in whom a decision to proceed with ICD remains uncertain after clinical assessment that includes personal/family history, echocardiography, and ambulatory electrocardiographic monitoring, CMR imaging is beneficial to assess for maximum LV wall thickness, ejection fraction (EF), LV apical aneurysm, and extent of myocardial fibrosis with LGE.[1–15]
1	B-NR	4. For patients with obstructive HCM in whom the anatomic mechanism of obstruction is inconclusive on echocardiography, CMR imaging is indicated to inform the selection and planning of SRT.[16–20]
2b	C-EO	5. For patients with HCM, repeat contrast-enhanced CMR imaging on a periodic basis (every 3 to 5 years) for the purpose of SCD risk stratification may be considered to evaluate changes in LGE and other morphologic changes, including EF, development of apical aneurysm, or LV wall thickness (Figure 1, Table 7).

Table 7. Established Clinical Risk Factors for HCM Sudden Death Risk Stratification

Family history of sudden death from HCM	Sudden death judged definitively or likely attributable to HCM in ≥1 first-degree or close relatives who are ≤50 y of age. Close relatives would generally be second-degree relatives; however, multiple SCDs in tertiary relatives should also be considered relevant.
Massive LVH	Wall thickness ≥30 mm in any segment within the chamber by echocardiography or CMR imaging; consideration for this morphologic marker is also given to borderline values of ≥28 mm in individual patients at the discretion of the treating cardiologist. For pediatric patients with HCM, an absolute or z-score threshold for wall thickness has not been established; however, a maximal wall that corresponds to a z-score ≥20 (and >10 in conjunction with other risk factors) appears reasonable.
Unexplained syncope	≥1 Unexplained episodes involving acute transient loss of consciousness, judged by history unlikely to be of neurocardiogenic (vasovagal) etiology, nor attributable to LVOTO, and especially when occurring within 6 mo of evaluation (events beyond 5 y in the past do not appear to have relevance).
HCM with LV systolic dysfunction	Systolic dysfunction with EF <50% by echocardiography or CMR imaging.
LV apical aneurysm	Apical aneurysm defined as a discrete thin-walled dyskinetic or akinetic segment of the most distal portion of the LV chamber; independent of size.
Extensive LGE on CMR imaging	Diffuse and extensive LGE, representing fibrosis, either quantified or estimated by visual inspection, comprising ≥15% of LV mass (extent of LGE conferring risk has not been established in children).
NSVT on ambulatory monitor	It would seem most appropriate to place greater weight on NSVT as a risk marker when runs are frequent (≥3), longer (≥10 beats), and faster (≥200 bpm) occurring usually over 24 to 48 h of monitoring. For pediatric patients, a VT rate that exceeds the baseline sinus rate by >20% is considered significant.

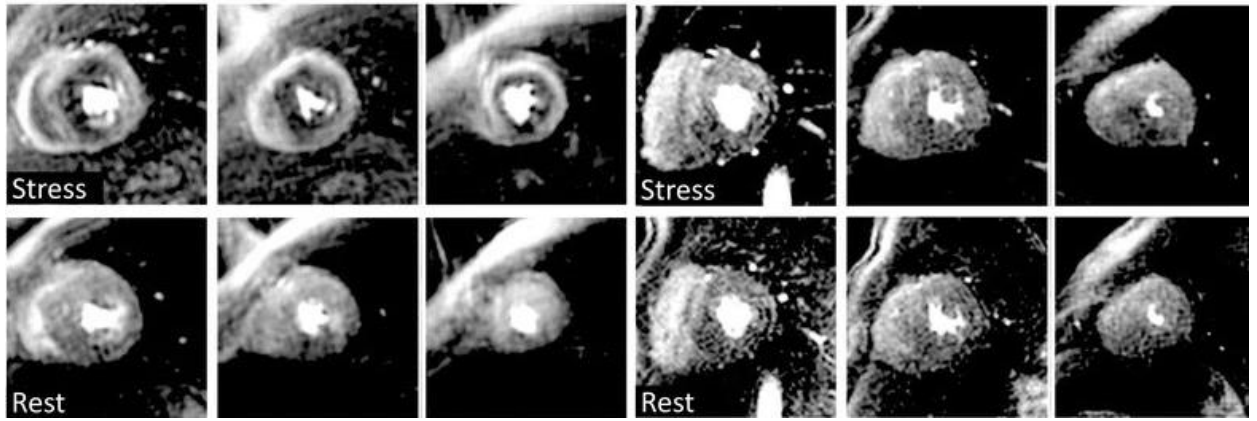
CORONARY MICROVASCULAR ISCHEMIA

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Coronary Microvascular Dysfunction and Prognosis in Hypertrophic Cardiomyopathy

Franco Cecchi, M.D., Iacopo Olivotto, M.D., Roberto Gistri, M.D.,
Roberto Lorenzoni, M.D., Giampaolo Chiriatti, M.D., and Paolo G. Camici, M.D.

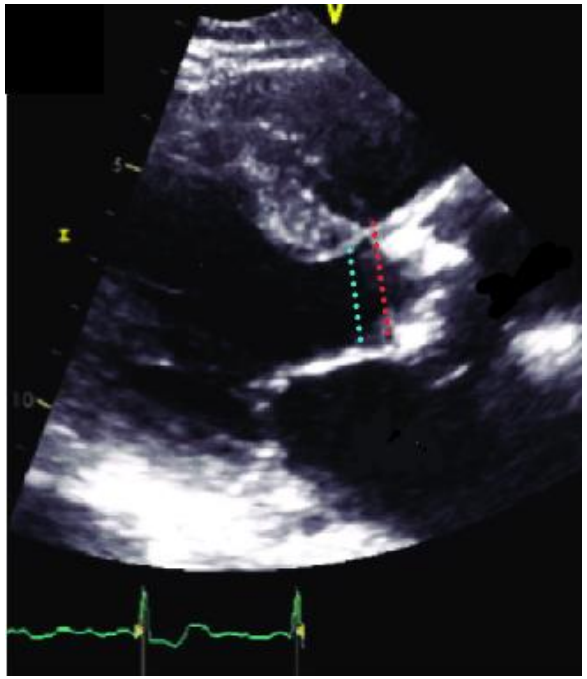


VALVE ASSESSMENT

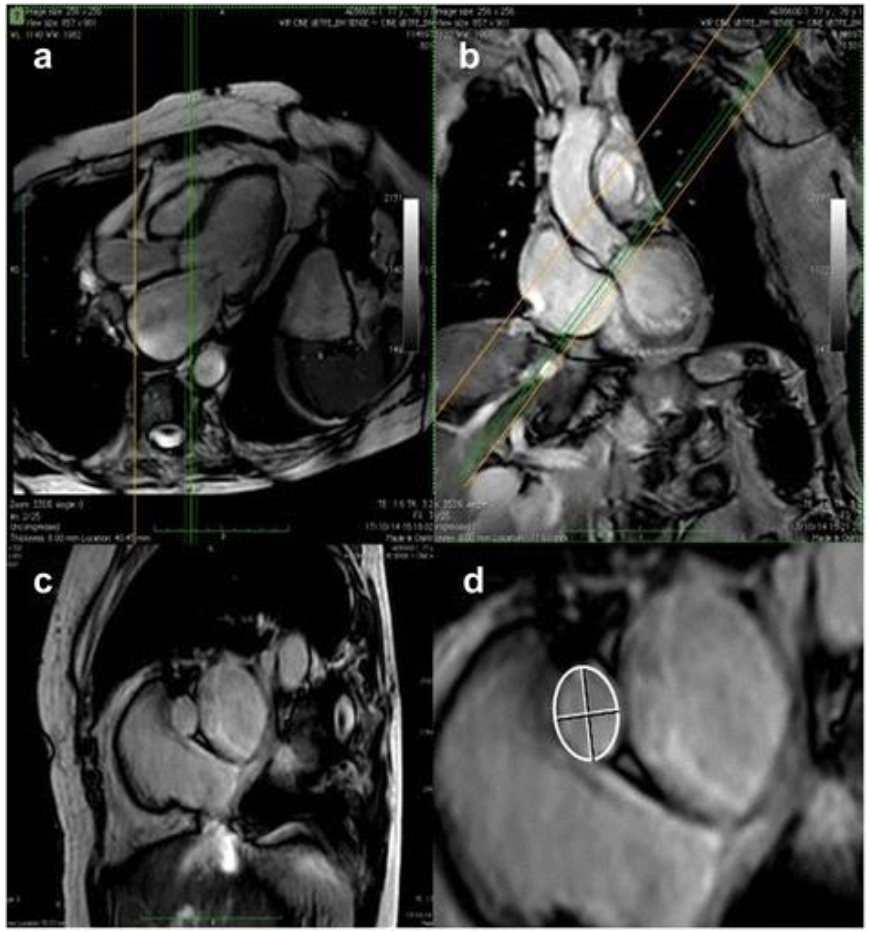
- CMR provides excellent assessment for all valvular pathologies
- No assumptions
- Direct planimetry for valve area measurement at the correct orthogonal plane
- Flow assessment by CMR works very well under continuous, laminar flow conditions without friction or turbulence

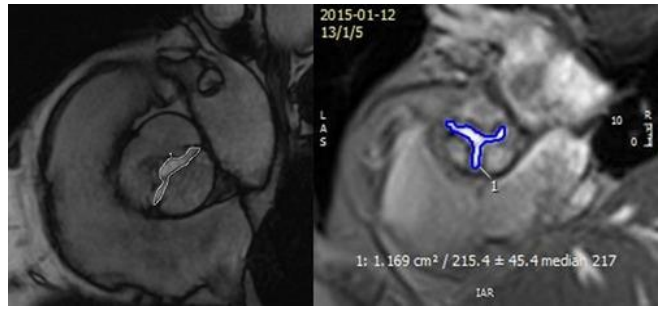
AORTIC STENOSIS

Echo



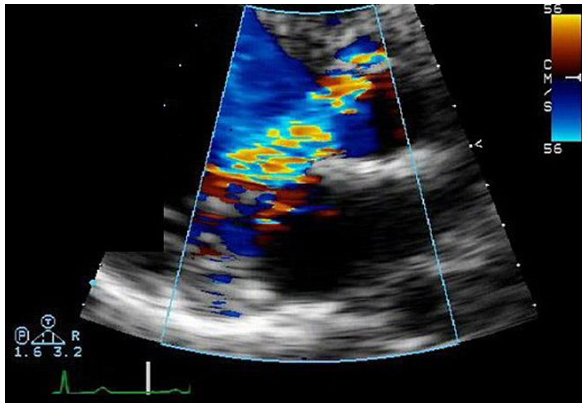
CMR





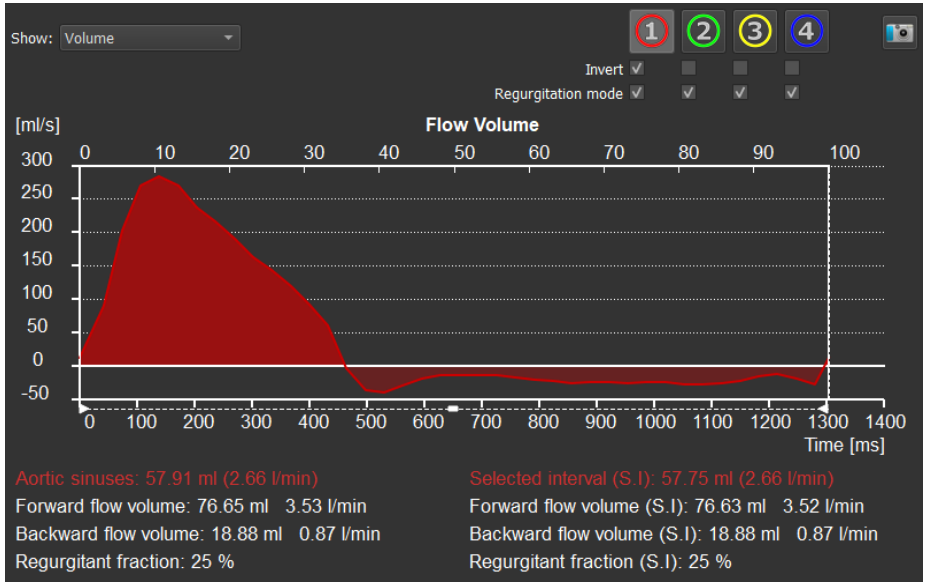
AORTIC REGURGITATION

Echo



- Jet width?
- Vena contracta width?
- ERO?
- Pressure half-time?

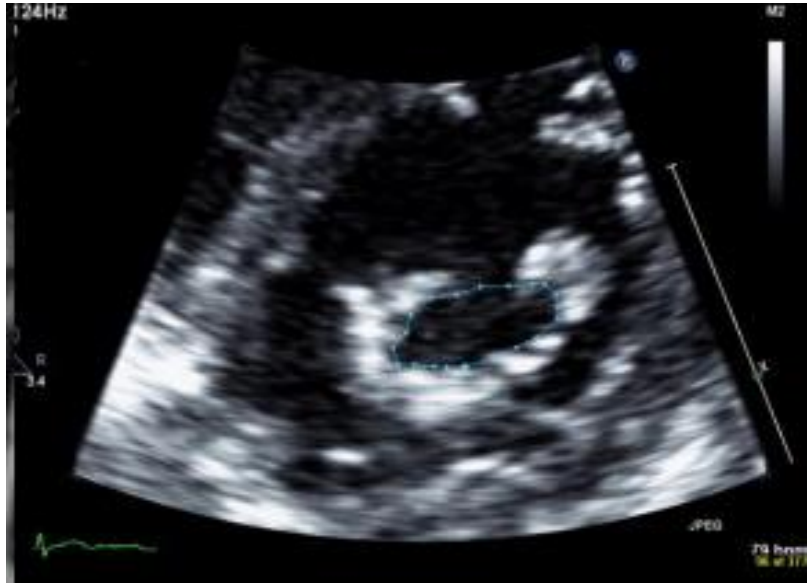
CMR (PVM)



- Direct measurement of regurgitant volume and regurgitant fraction
- Ability to directly measure regurgitant orifice

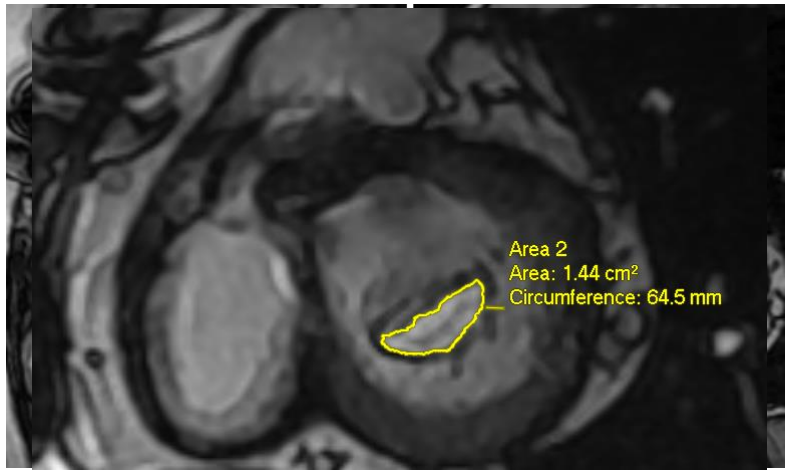
MITRAL STENOSIS

Echo

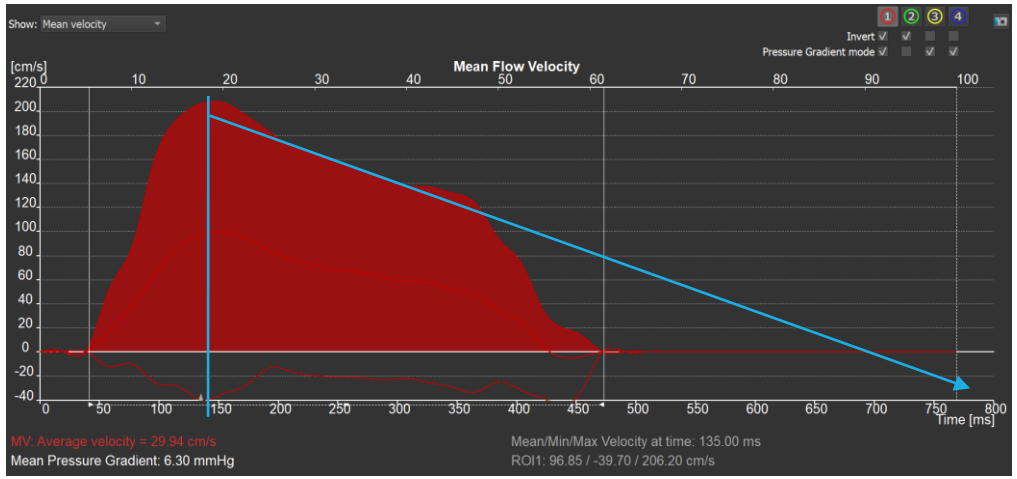


- Level?
- Angle?

CMR



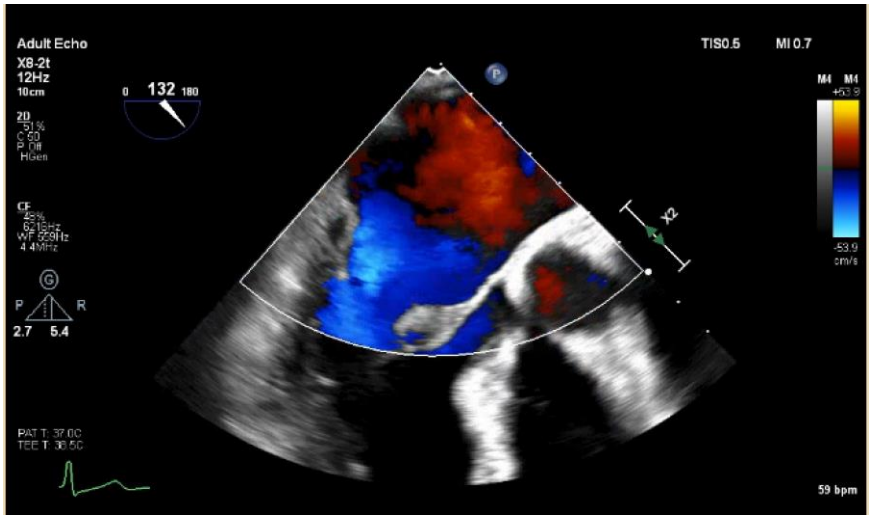
- No assumptions



PHT = 29% of total deceleration time (DT). MVA = 220 / Pressure half time. MVA = 220/(680-140)*0.29 = 1.4 cm2

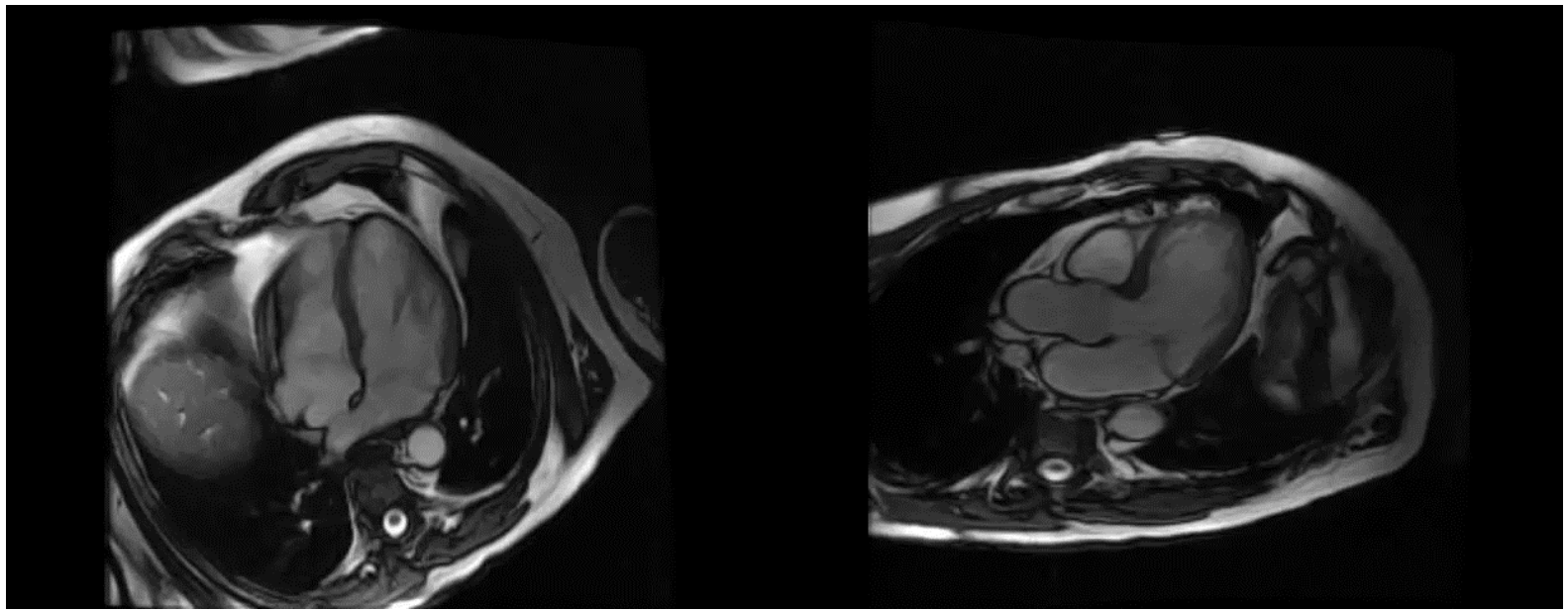
MITRAL REGURGITATION

Echo



- Moderate-to-severe mitral regurgitation
- PISA ERO 0.29 cm2, regurgitant volume 32 cc, vena contracta 0.64 cm ?
- Volumetric analysis likely underestimated due to eccentricity of regurgitant jet.

CMR



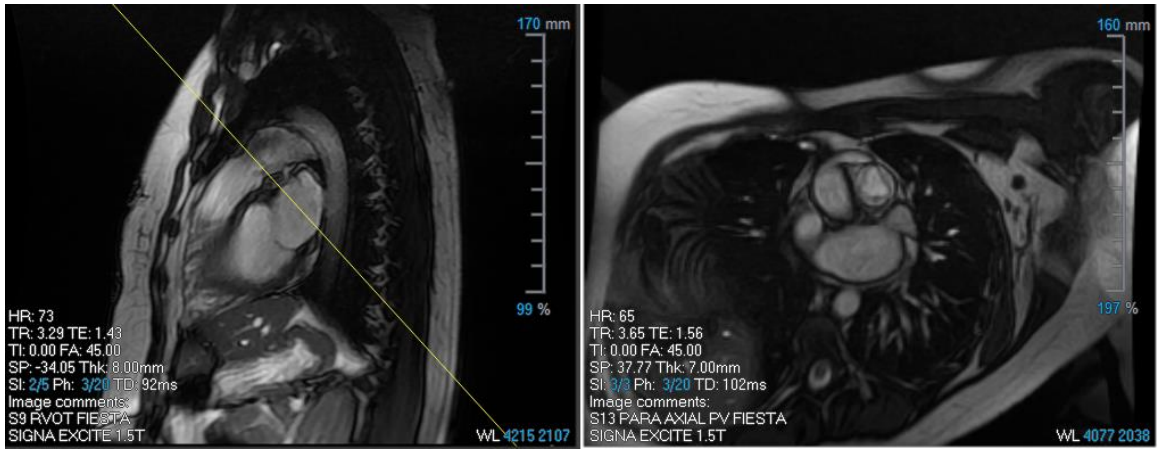
- **MR = LV stroke volume (EDV-ESV) – Aortic forward flow (PVM)**
- Eccentric mitral regurgitation noted (posteriorly directed). Severe mitral regurgitation. Regurgitant volume is 47 cc. Regurgitant fraction is 42% by phase velocity mapping
- Mitral valve disjunction noted (11mm).

PULMONIC VALVE

Echo (VTI)

- This section is intentionally left blank

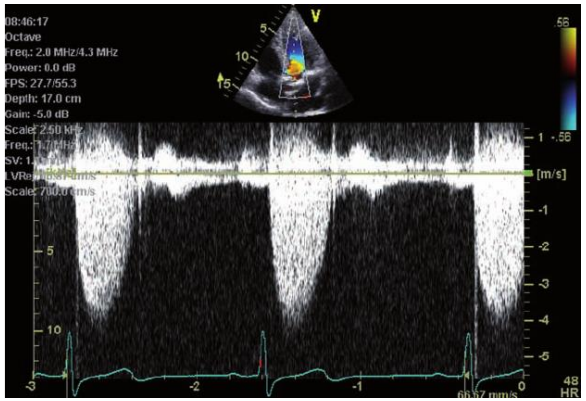
CMR (PVM)



- Direct measurement of pulmonic valve area of the orthogonal view
- Direct measurement of regurgitant flow

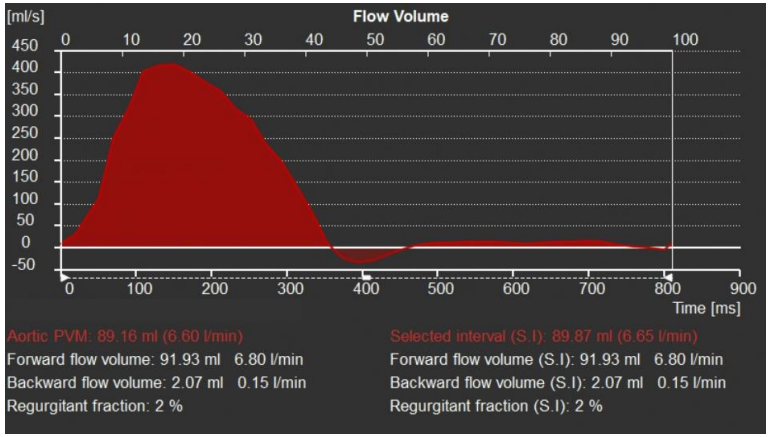
Flow quantification

Echo (VTI)



- Represent one line of cross-sectional area of flow
- May not be aligned with the flow
- Acquired over one cardiac cycle
- Subject to variability (position, orientation, operator, window)

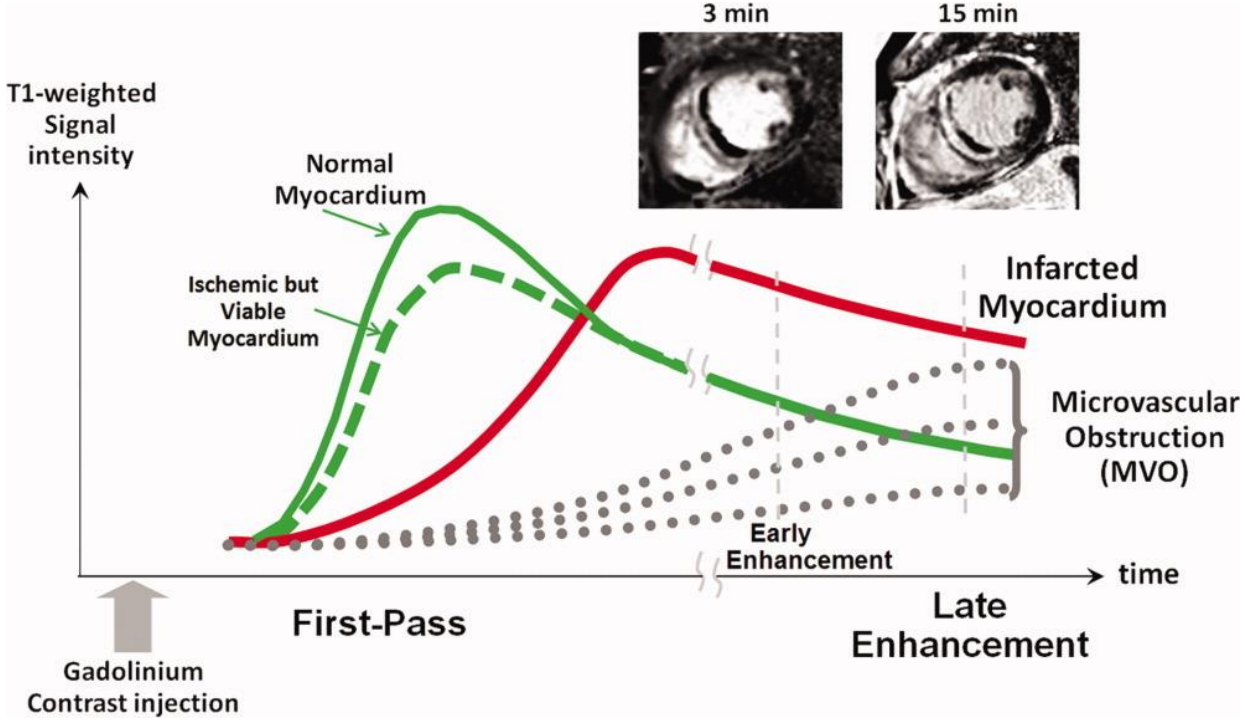
CMR (PVM)

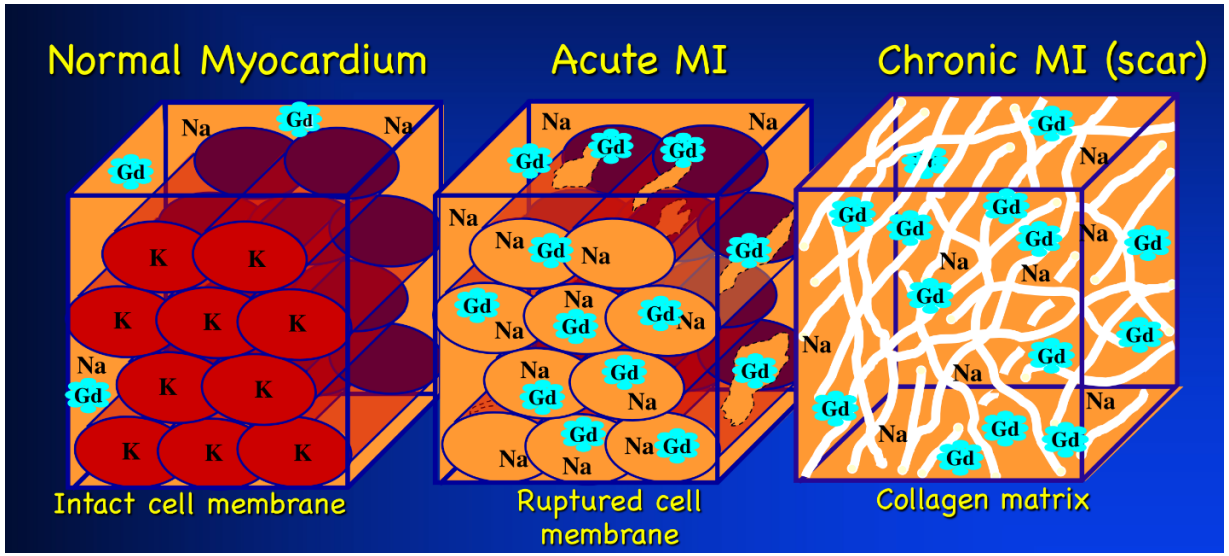


- Represent the whole cross-sectional flow
- Obtained exactly perpendicular to the flow even if eccentric flow
- Averaged from several cardiac cycles ~ 2 minutes
- Highly reproducible

VIABILITY

What is LGE?

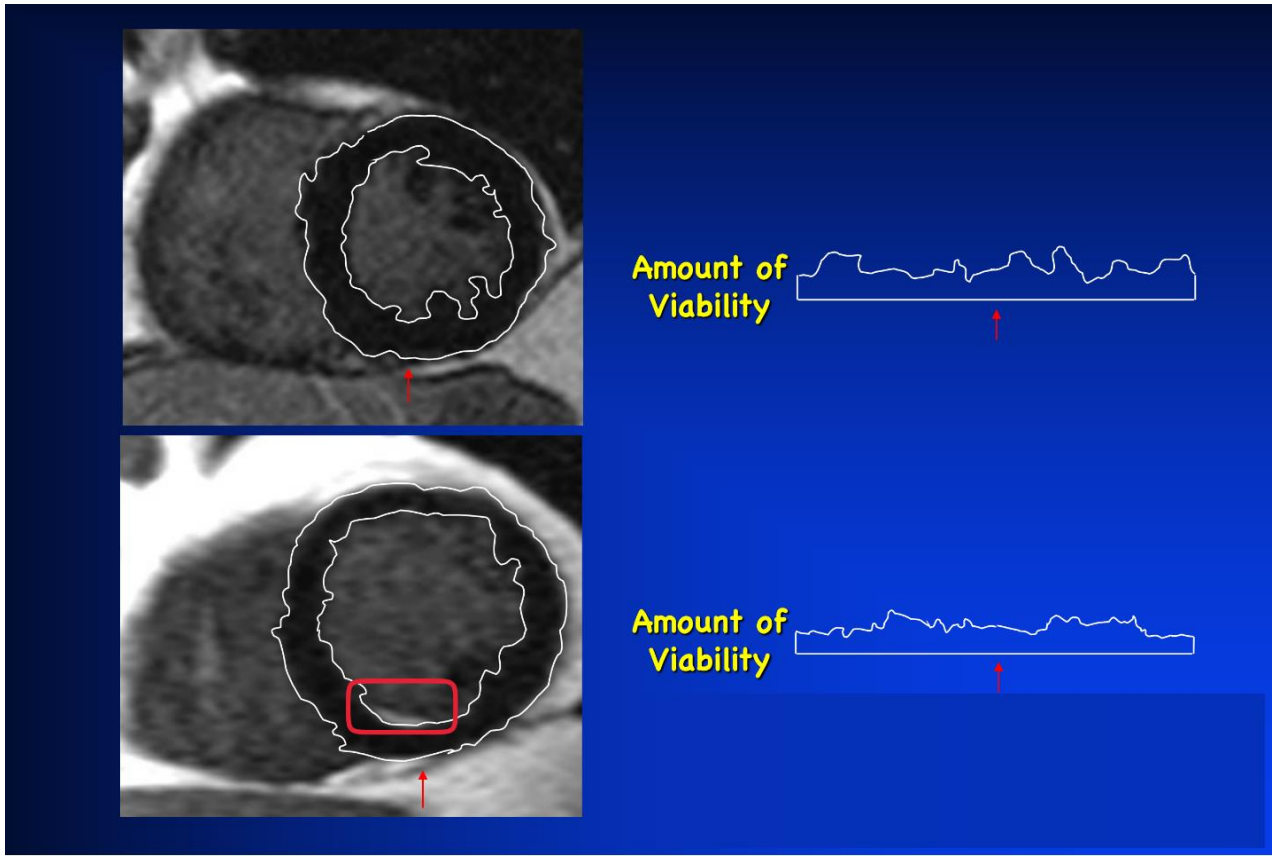




Kellman, P. and Arai, A.E. (2012), Cardiac imaging techniques for physicians: Late enhancement . J. Magn. Reson. Imaging, 36: 529 542

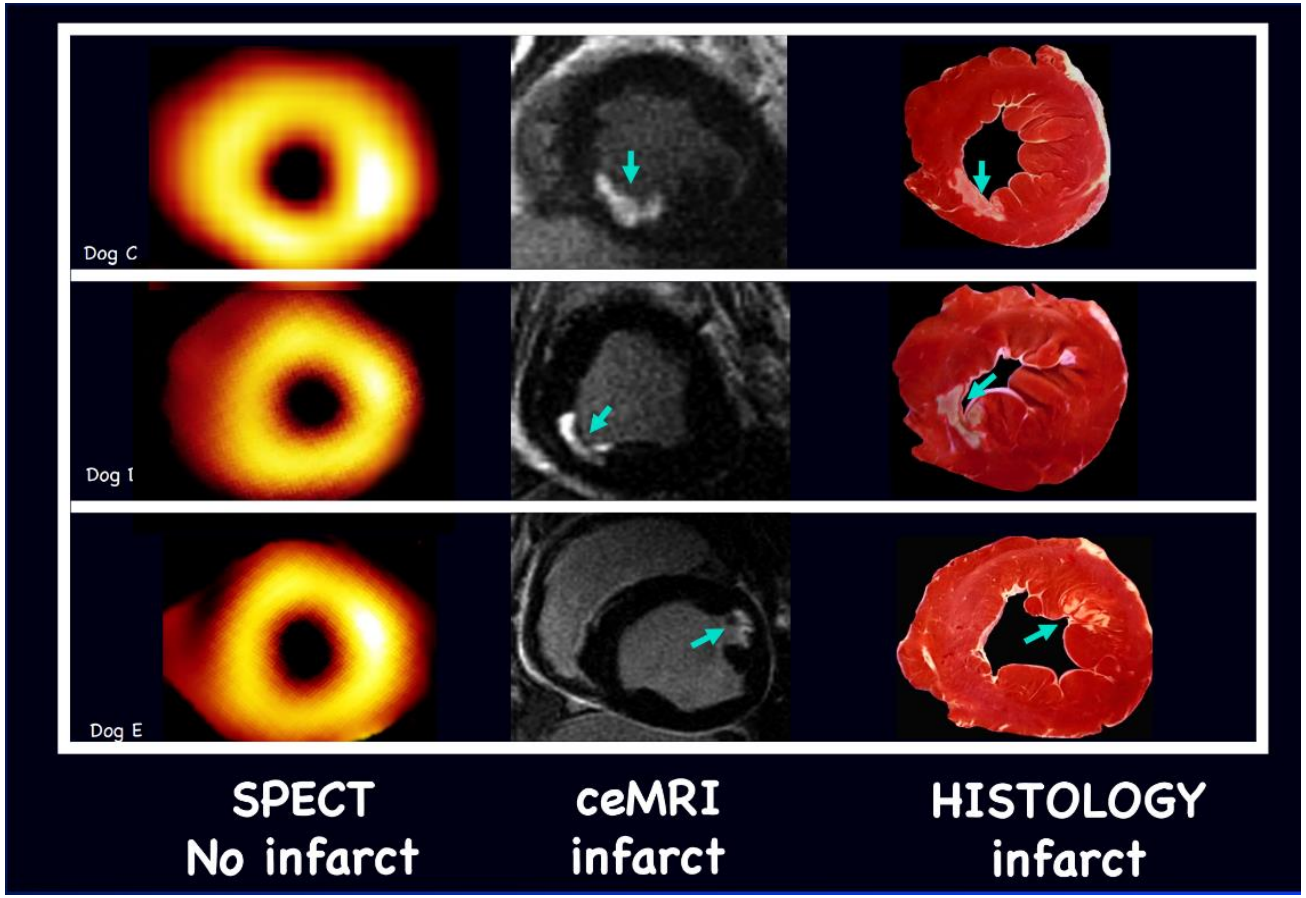
VIABILITY

What can CMR provide for viability assessment that other imaging modalities cannot?



Circulation 2005;112:135-44

VIABILITY



Lancet 2003;361:374-79

Take home points

- CMR is the gold standard for anatomic, functional, and tissue characterization of the heart
- CMR is evolving (parametric mapping, 4D flow, quantitative perfusion, compressed sensing etc.)
- CMR, if anything, is under-utilized. The more CMRs you order, the better fortune you will get.
- If you send us a patient, PLEASE PLEASE send along the history (we look at everything and do a free consultation for you!)