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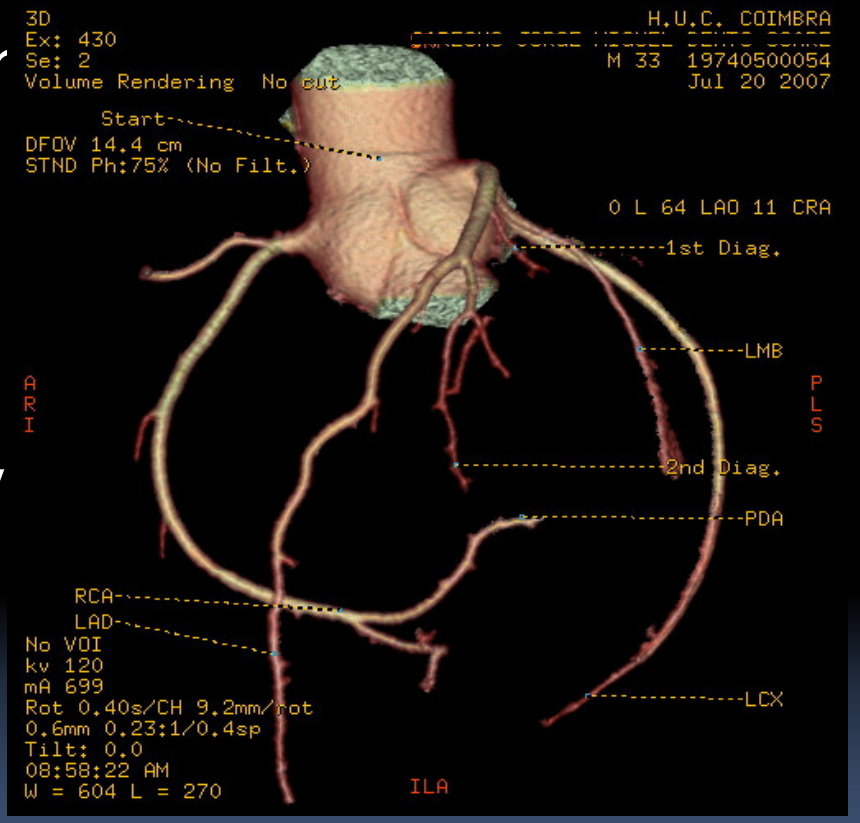
# ADENOSINE-STRESS MR IMAGING

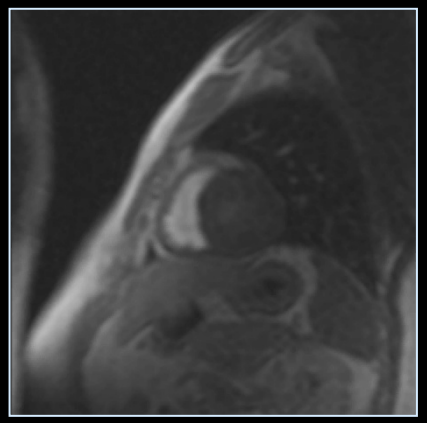
# Imaging evaluation CAD

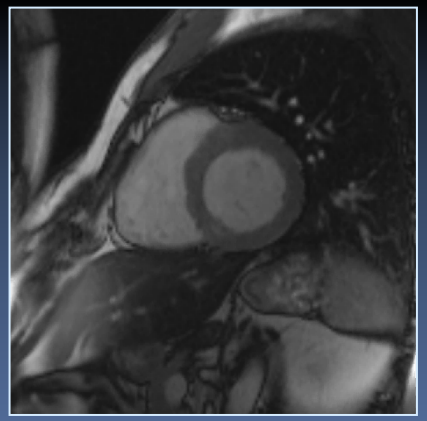
- Anatomic demonstration of the coronaries
- Functional imaging
  - SPECT
  - Stress echocardiography
  - Stress MRI
    - Myocardium perfusion (adenosine)
    - Wall motion abnormalities (dobutamine)



# Stress induced MRI in diagnosis of CAD

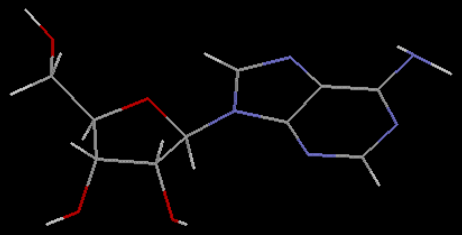
- dynamic first-pass perfusion imaging
  - perfusion defects induced by a vasodilator (adenosine)
  - gadolinium injection
- stress induced wall motion abnormalities imaging
  - induced by dobutamine





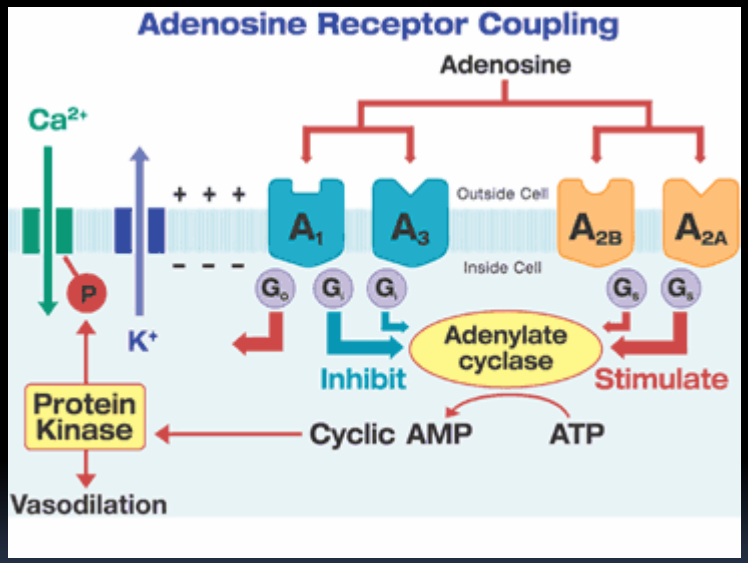
# Adenosine-stress MR imaging

- Adenosine
  - small, ubiquitous heterocyclic compound
  - produced endogenously in vascular smooth muscle and endothelium, or derived via the extracellular dephosphorylation of adenosine triphosphate (ATP) and adenosine diphosphate (ADP)



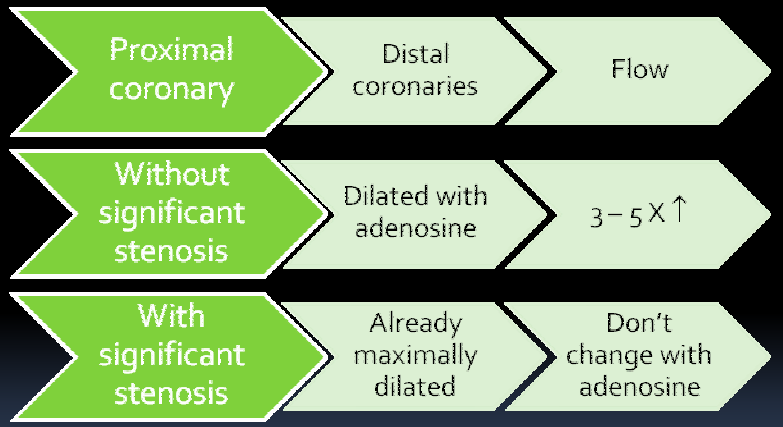
# Adenosine-stress MR imaging

- Adenosine action
  - 4 known receptors subtypes (A1, A2A, A2B and A3)
  - A2A receptors (cardiac-specific) - triggers several reactions leading to coronary vasodilatation



# Adenosine-stress MR imaging

- Coronary vasodilatation induced by adenosine
  - patients without CAD
    - the resistance vessel blood flow is increased 3 - 5 x above the baseline
  - patients with CAD
    - the resistance vessels distal to a hemodynamic significant stenosis are usually maximally dilated in order to maintain normal resting flow, and consequently not affected by adenosine



# Adenosine-stress MR imaging

| Proximal coronary | Distal coronaries | Flow |
|---|---|---|
| Without significant stenosis | Dilated with adenosine | 3–5 X ↑ |
| With significant stenosis | Already maximally dilated | Don't change with adenosine |

# Adenosine-stress MR imaging

- Indications
- American College of Cardiology (2006)
  - symptomatic patients with an intermediate pretest probability
    - with uninterpretable electrocardiograms
    - or unable to exercise

# Adenosine-stress MR imaging

- Contraindications to the administration of adenosine
  - history of bronchospasm or asthma
  - persistent hypotension (systolic blood pressure < 90 mmHg)
  - unstable angina
  - recent acute myocardial infarct (< 2 days)
  - high-grade AV block
  - uncontrolled arrhythmias
  - critical aortic stenosis

# Adenosine-stress MR imaging

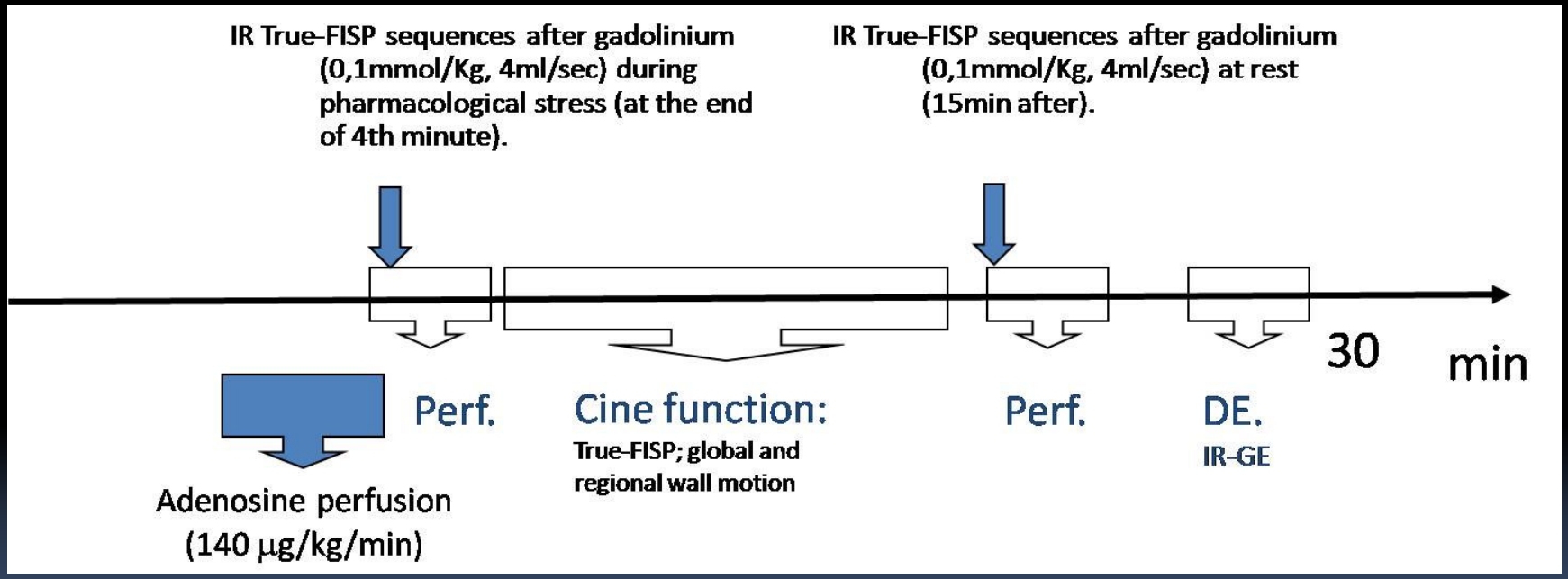
- Adenosine side effects
  - Bernhardt et. al (2005)
    - adenosine stress MRI
    - 3.174 patients
    - 35% patients reported minor complications
    - mild chest pain or dyspnea (30%), temporarily and asymptomatic AV block (3%) and nausea (2%).
  - resolve rapidly upon termination of the infusion, as the half life of adenosine is very short (seconds)
  - Aminophylline may be used as an antidote, but is rarely necessary
  - Adenosine is an extremely safe pharmacologic stress agent

# Adenosine-stress MR imaging

- Preprocedure routine
  - not eating or drinking for more than 4 hours before testing
  - not taking xanthine derivatives (aminophylline)
  - not having caffeine-containing products for 24 hours prior to testing
- Devices required
  - MR-compatible infusion system
  - transfer
  - advance support table including an external cardio defibrillator

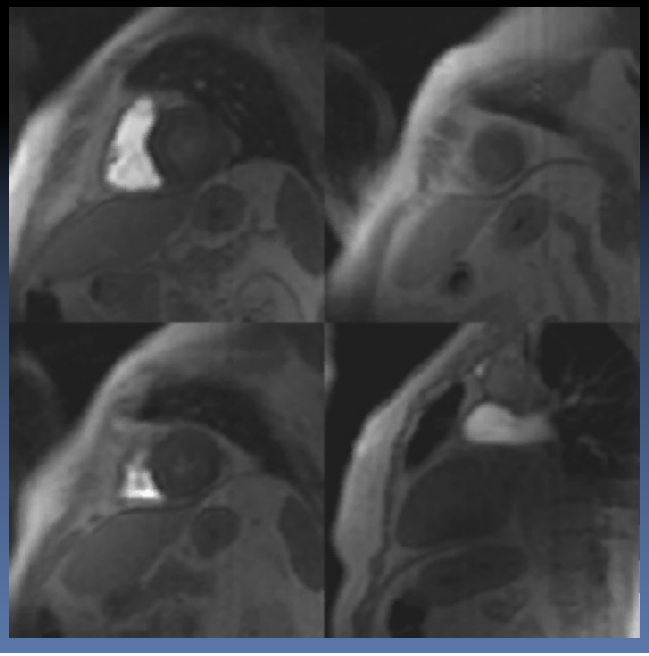
# Adenosine-stress MR imaging

- Imaging protocol



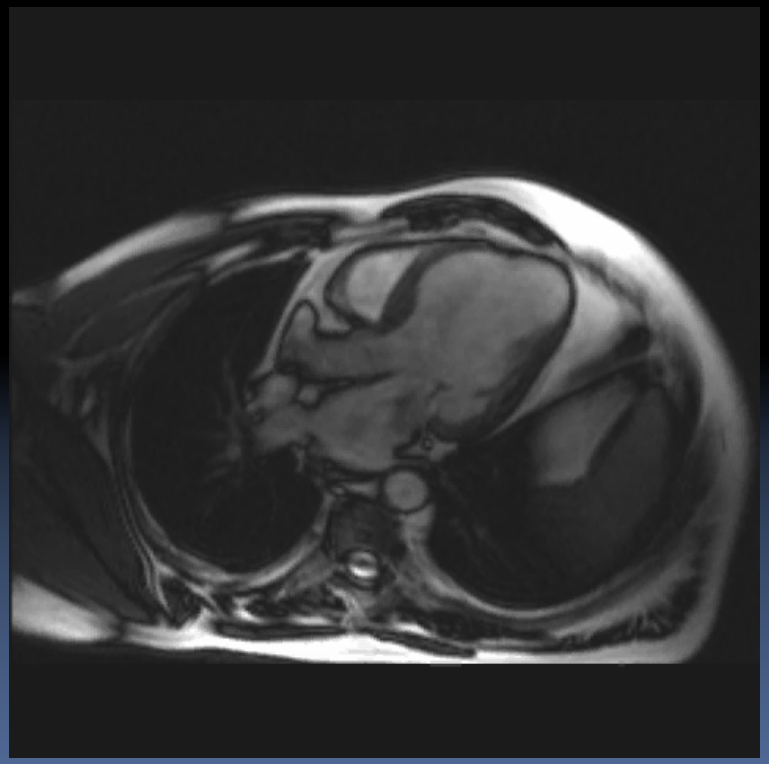
# Adenosine-stress MR imaging

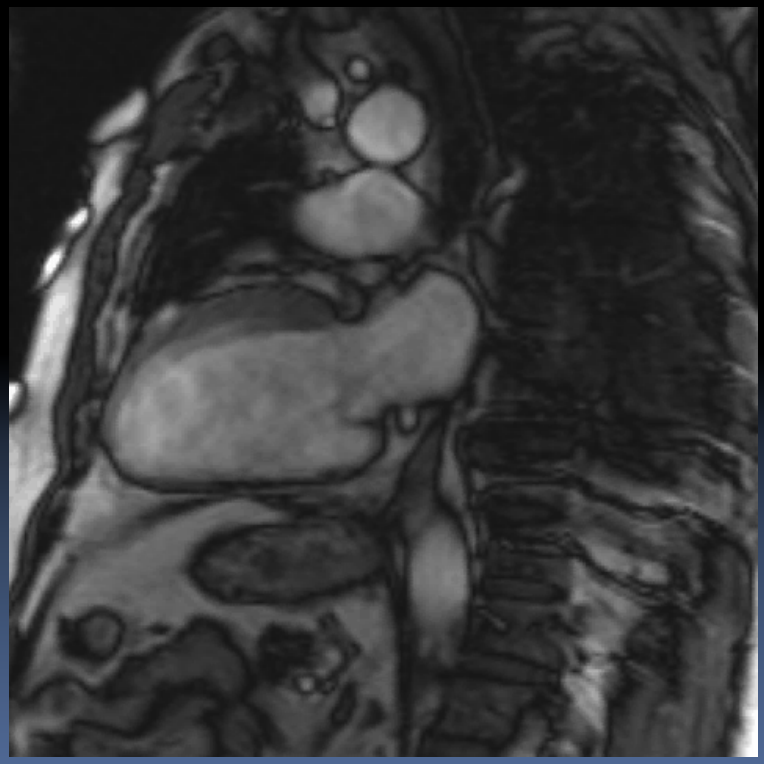
- Perfusion imaging: Inversion Recovery Steady State Free Precession
  - 4 sections in the short-axis LV
  - 3 sections in the short-axis LV + long-axis 2 chamber-view LV
  - RT:182 ms; ET: 1,1ms
  - ETL: 1; Flip angle: 15º
  - Matrix 128x75; FOV: 320x81
  - Thickness: 8mm
  - Saturation pulse: 90º
  - IT: 100ms



# Adenosine-stress MR imaging

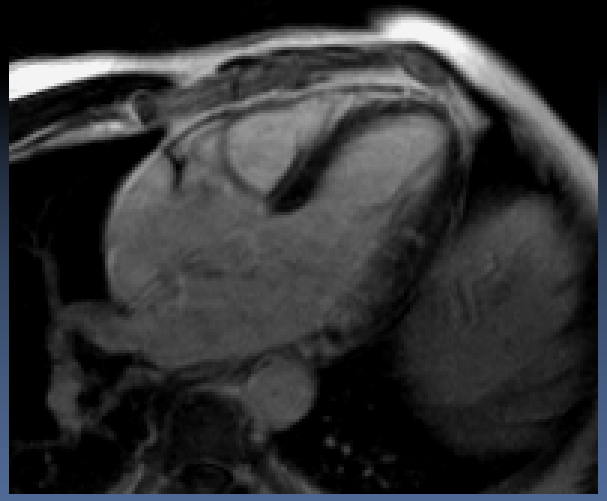
- Cine function: Steady State Free Precession
  - Cine images in the long-axis LV and in the short axis (25 phases /cycle)
  - RT: 55,6ms; ET: 1,3ms; Flip angle: 80º; Thickness: 6 - 8mm





# Adenosine-stress MR imaging

- Delayed enhancement imaging
  - 4 sections in the short-axis and 3 sections in the long-axis LV ( 2D )
  - IR Gradient echo
  - Phase-sensitive inversion recovery (PSIR)
  - For optimal nulling of viable myocardium, use the TI-Scout **sequence** in conjunction with the **PSIR** image reconstruction



# Adenosine-stress MR imaging

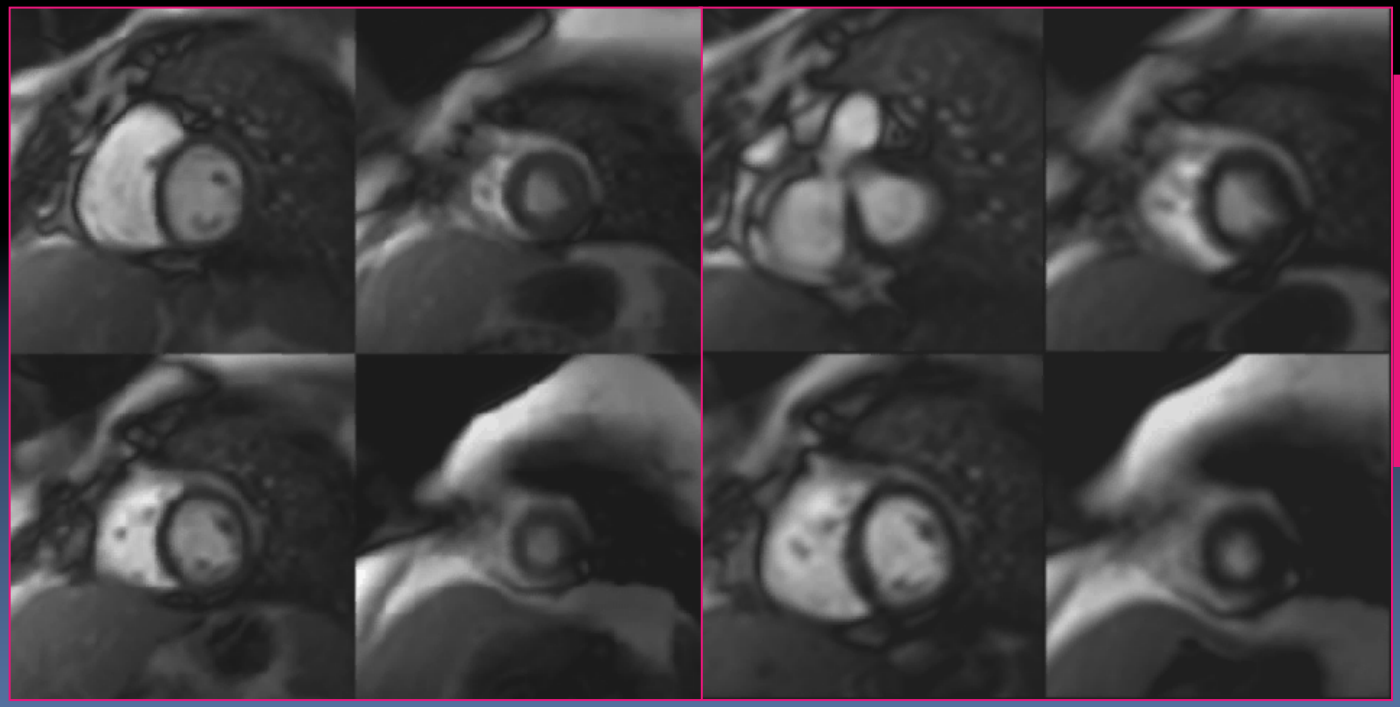
- Image interpretation

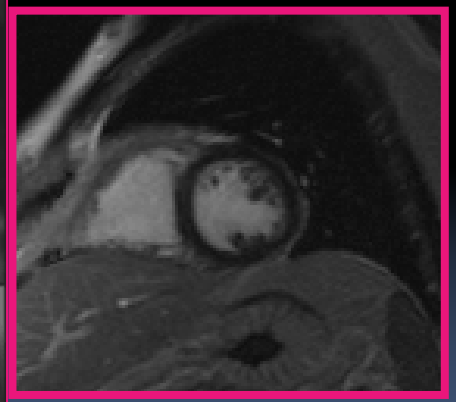
| CORONARY ARTERY CONDITION | DISTAL FLOW | PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|---|---|
| **Normal** | Normal | Without defects | Without defects | "All black" |
| **Stenosis (Ischemia)** | Normal at rest (maximally dilated) | Without defects | **With defects** | "All black" |
| **Stenosis (infarct)** | Absent | **With defects** | **With defects** | **Brigth Signal** |

# Adenosine-stress MR imaging

- Normal

| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| Without defects | Without defects | “All black” |

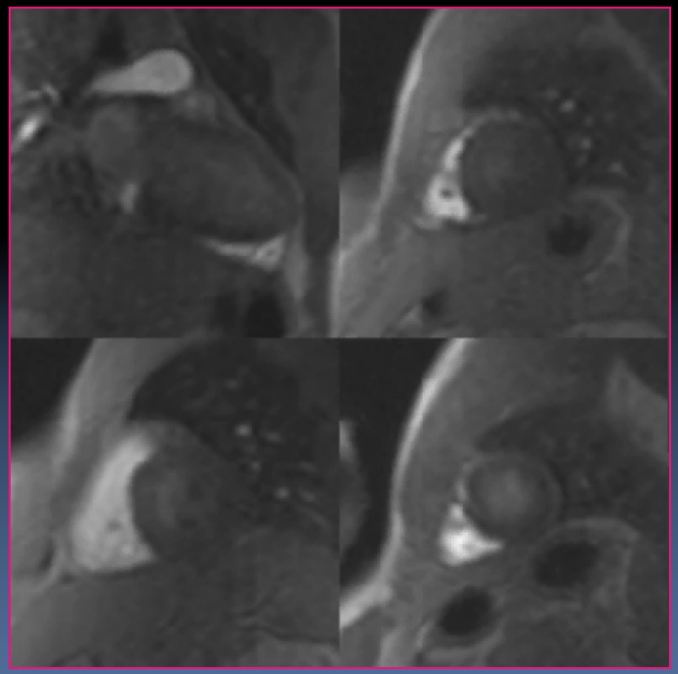


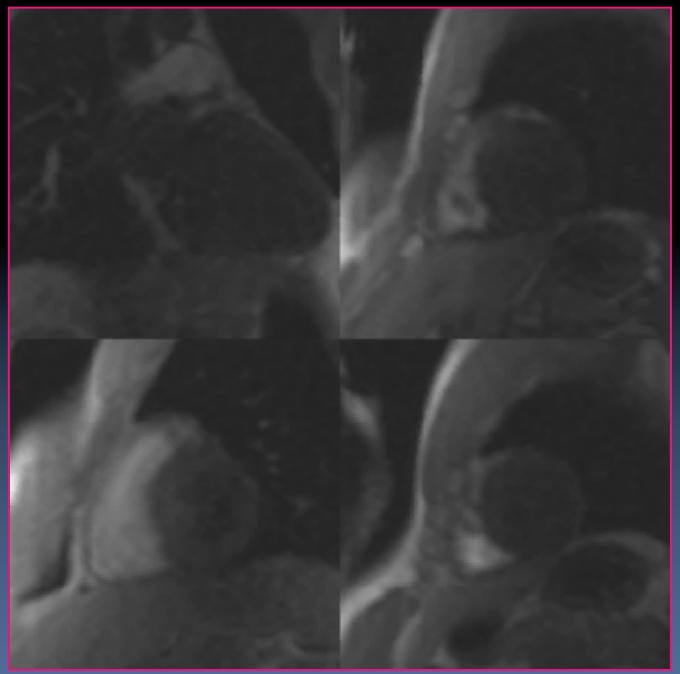


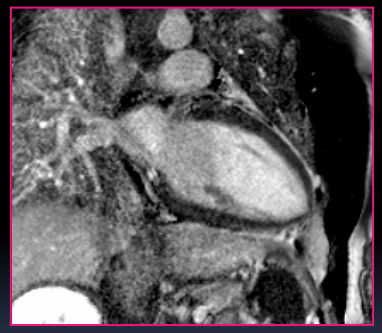
# Adenosine-stress MR imaging

Normal (hypertension)

| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| Without defects | Without defects | “All black” |

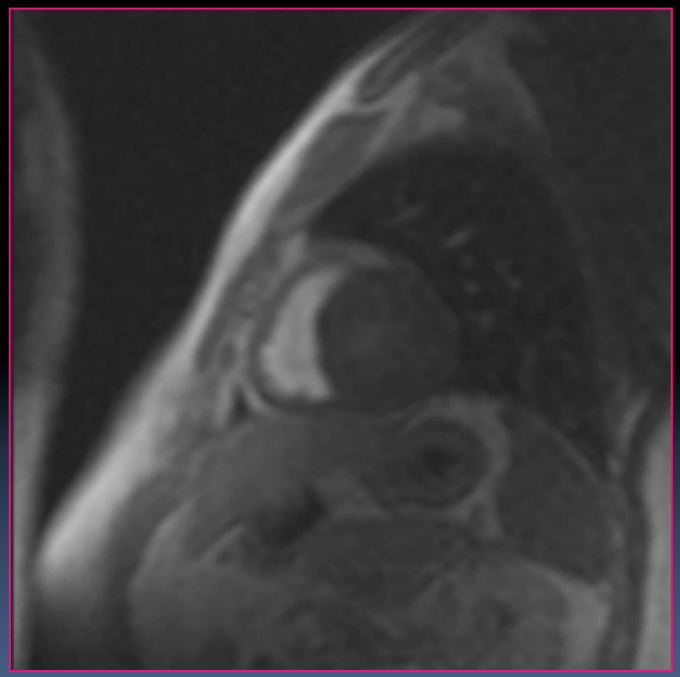




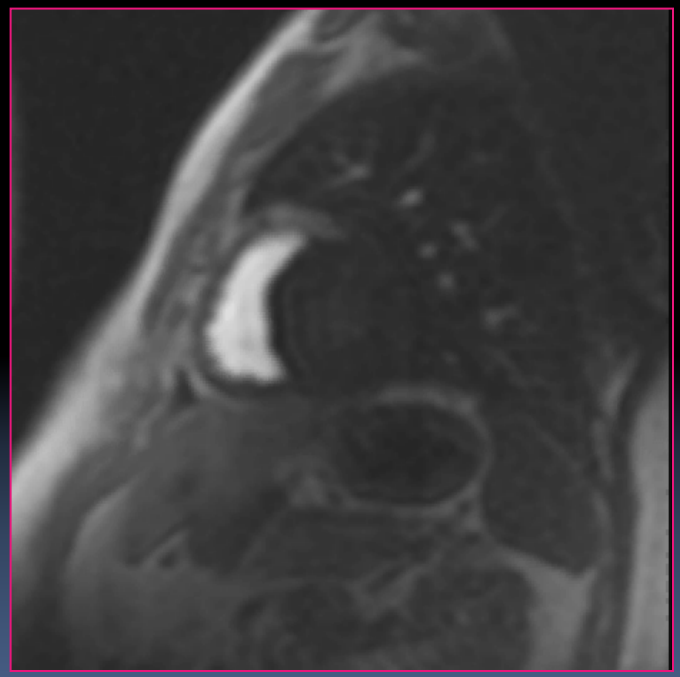


# Adenosine-stress MR imaging

- Normal (hypertension)



rest

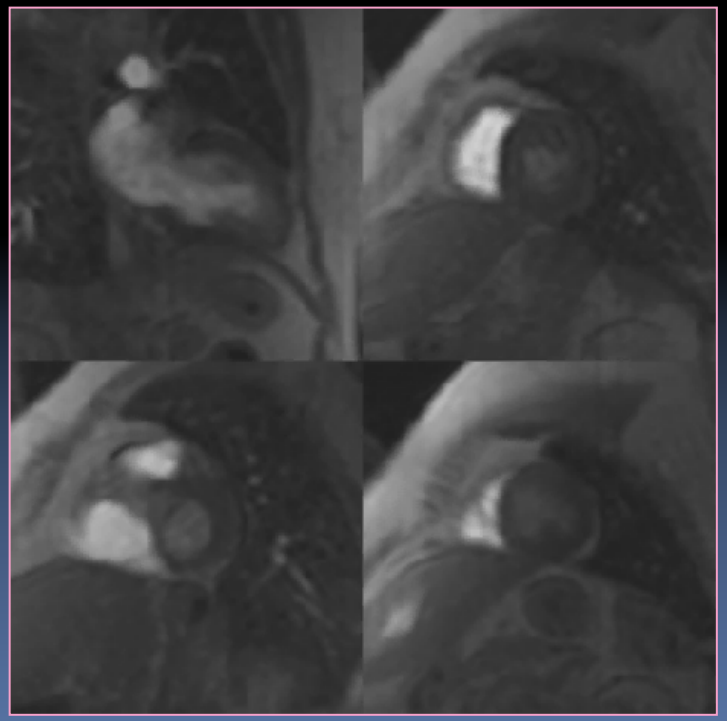


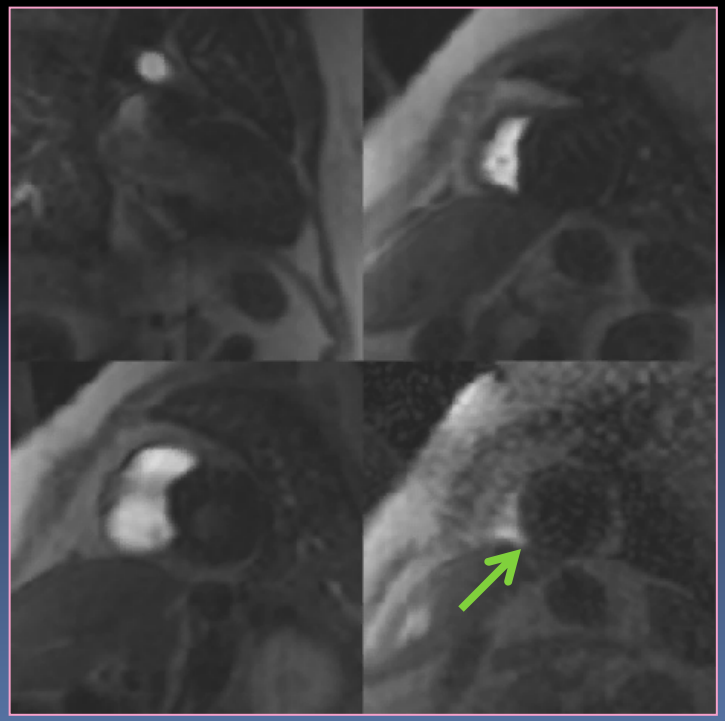
stress

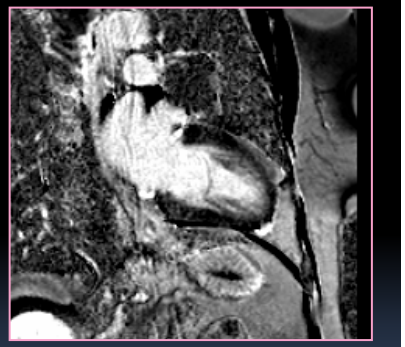
# Adenosine-stress MR

- Ischemia

| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| Without defects | With defects | “All black” |





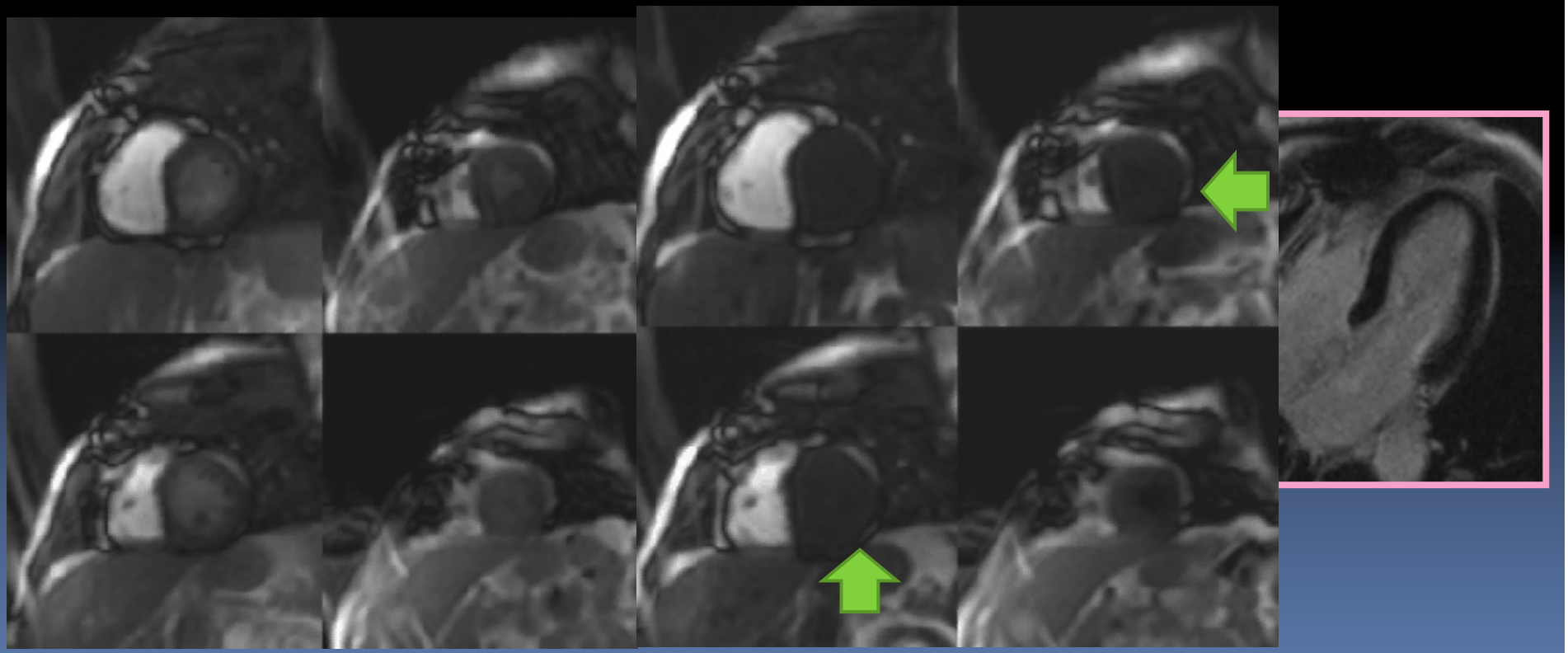


# Adenosine-stress MR

- Ischemia

Imaging

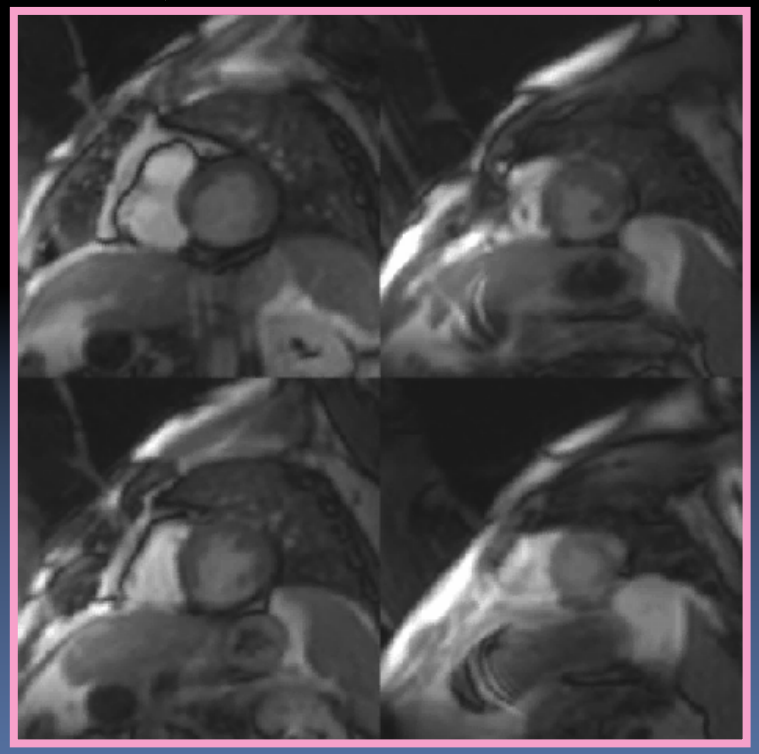
| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| Without defects | With defects | "All black" |

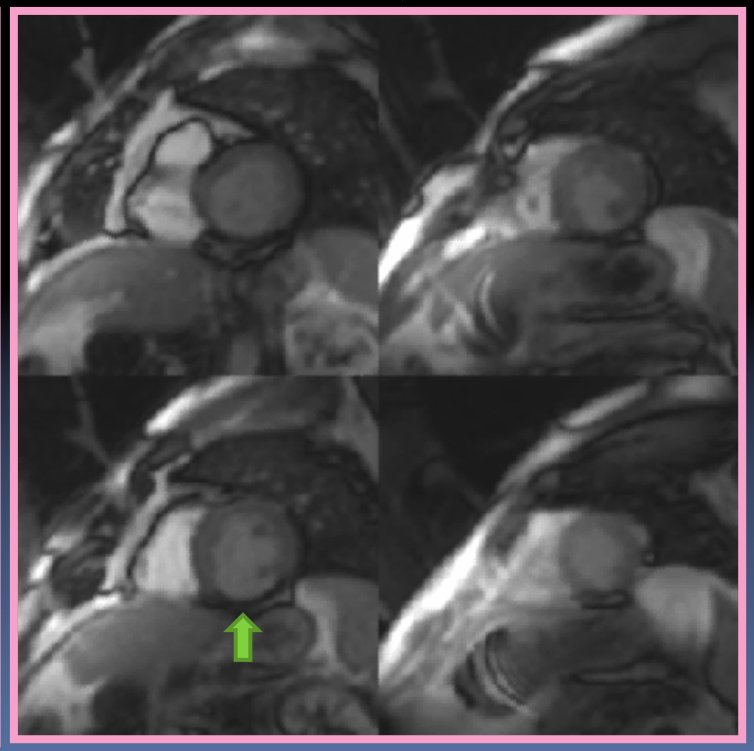


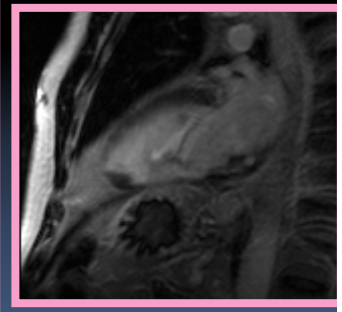
# Adenosine-stress MR Imaging

- Infarct

| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
| --- | --- | --- |
| With defects | With defects | Bright signal |



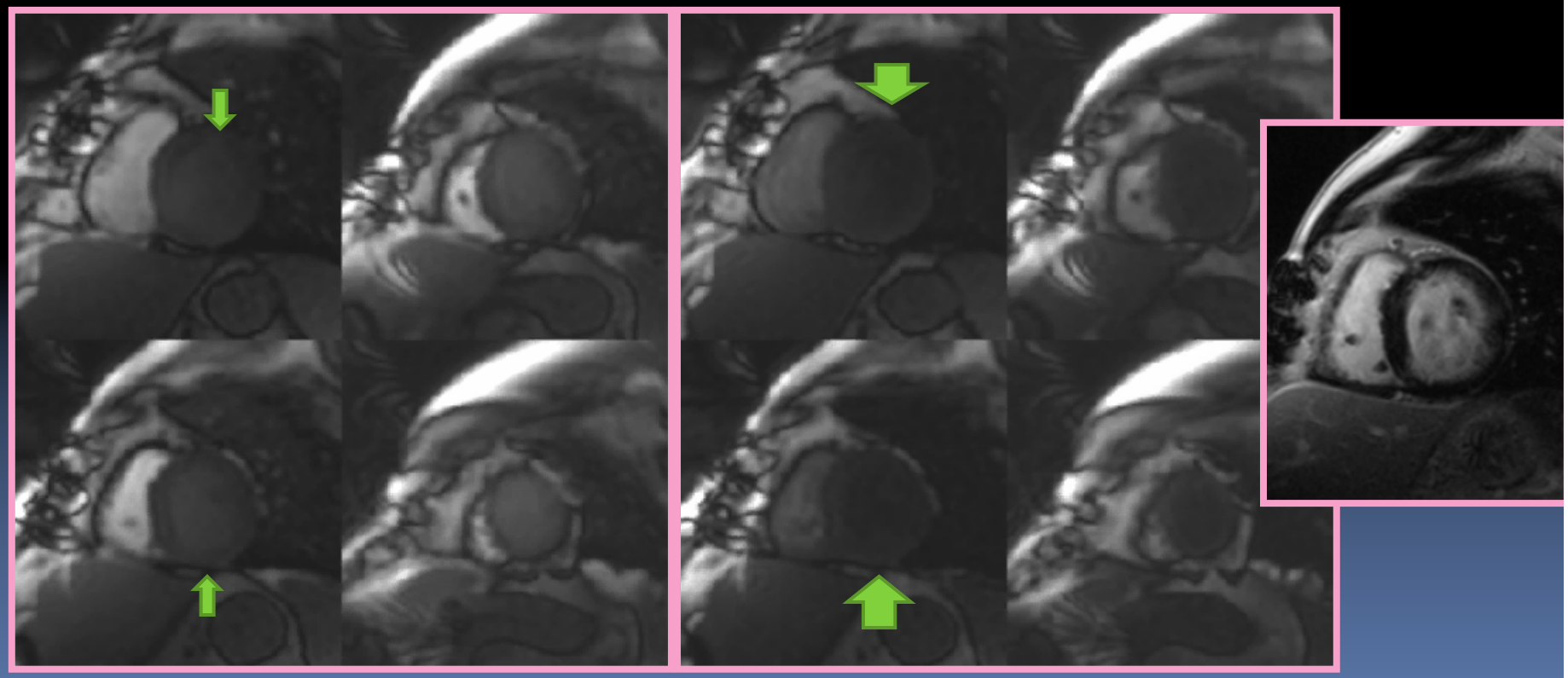




# Adenosine-stress MR imaging

- Infarct with residual ischemia

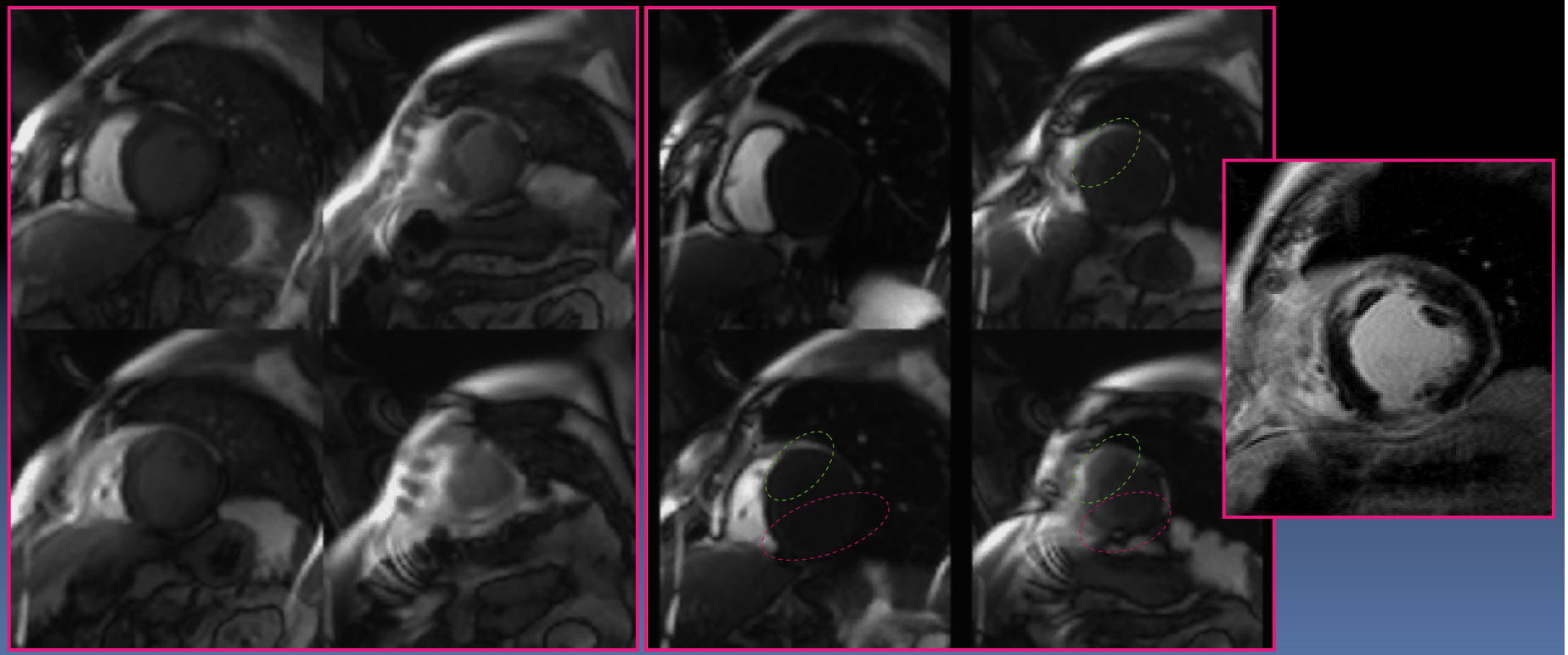
| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| With defects | With defects | Bright signal |



# Adenosine-stress MR imaging

infarct = Ischemia

| PERFUSION REST | PERFUSION STRESS | DELAYED ENHANCEM. |
|---|---|---|
| With defects | With defects ( ↑↑ ) | Bright signal |



# Adenosine-stress MR imaging

- Validation
  - Meta-analysis 2007 by Nandalur et al.
  - Diagnostic performance of stress cardiac MRI
  - 37 studies
    - 14 (754 patients) using stress-induced wall motion abnormalities
    - 24 (1.516 patients) using perfusion imaging
    - Specificities
      - 81% for perfusion imaging
      - 86% for stress-induced wall motion abnormalities imaging)
    - Sensitivities
      - 91% for perfusion imaging
      - 83% for stress-induced wall motion abnormities imaging

# Adenosine-stress MR imaging

- Validation

| Analysis and parameter | ≥ 50% stenosis in coronary angiography | | | |
|---|---|---|---|---|
| Per-segment/vessel | LAD | CX | RCA | LAD + CX + RCA |
| **Specificity** | **(9/12) 83 [42-94]** | **(9/12) 75 [42-94]** | **(9/10) 90 [55-99]** | **(27/34) 79 [62-91]** |

**Positive stress cardiac magnetic resonance (CMR):**
**Validation with coronary angiography**

Bruno Graça1 ;Paulo Donato1; Natália António2;Pedro Monteiro2 ; Henrique Rodrigues1 ;Lino Gonçalves2;Luís Providência2 ;Filipe Caseiro-Alves1
1Department of Radiology; 2Department of Cardiology; University Hospital of Coimbra; Portugal

- ESCR 2007
- 18 patients with positive stress perfusion MRI

# Adenosine-stress MR imaging

- Future perspectives
  - Adenosine selective A2 receptors
    - regadenoson (CVT3146), binodenoson (MRE0470 or WRC0470) and apadenoson (BMS068645 or ATL146e)
    - Administration in bolus
    - Without infusion
    - Less side effects
  - More comparative studies
    - Noninvasive evaluation of CAD
    - Considering the safety, cost - effectiveness, exposure radiation
    - Adapt the established guidelines for diagnostic workup
  - At which level of risk should an individual patient undergo diagnostic workup ?

# Adenosine-stress MR imaging

- Conclusions
  - Safe and practicable diagnostic tool in the diagnosis of CAD
    - higher spatial and temporal resolution (compared to SPECT)
    - provides functional and viability information
  - Repeatable / radiation free technique
  - Good diagnostic performance
    - already shown in patients with high prevalence of disease

# Coimbra