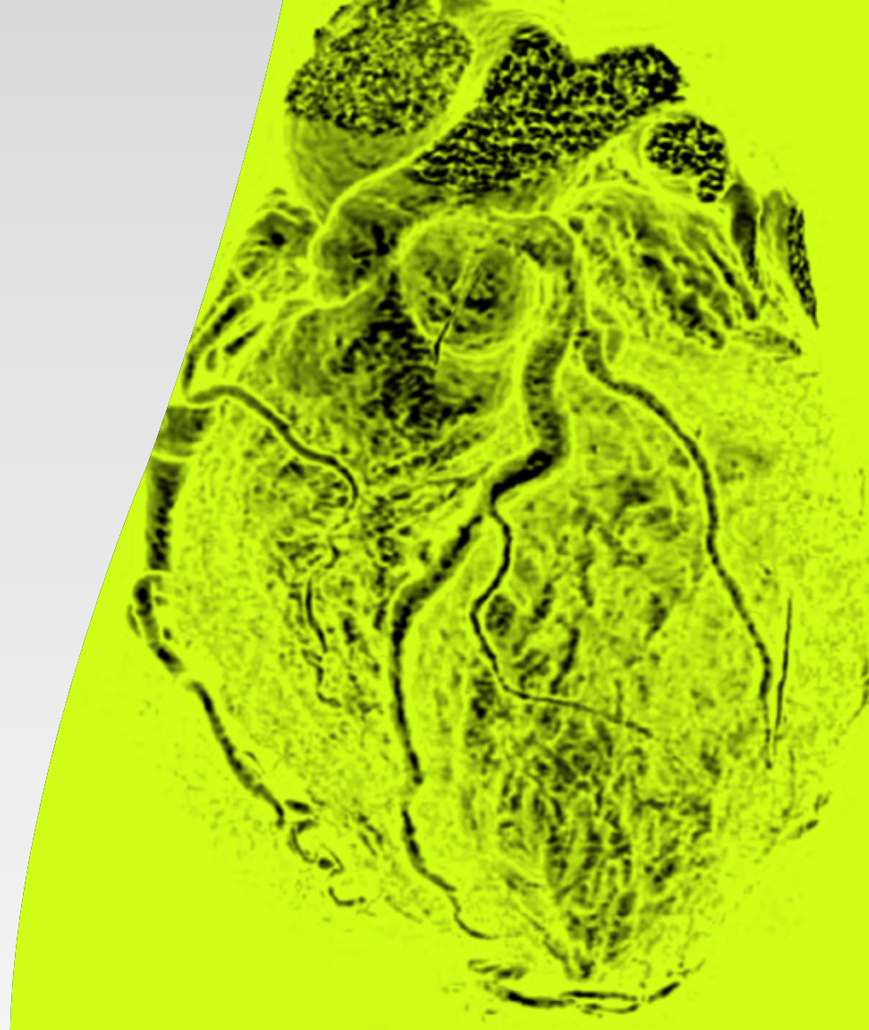
MODERN RADIOLOGY eBook

Cardiac Imaging

心脏影像学



EUROPEAN SOCIETY OF RADIOLOGY

Preface

Modern Radiology is a free educational resource for radiology published online by the European Society of Radiology (ESR). The title of this second, rebranded version reflects the novel didactic concept of the ***ESR eBook*** with its unique blend of text, images, and schematics in the form of succinct pages, supplemented by clinical imaging cases, Q&A sections and hyperlinks allowing to switch quickly between the different sections of organ-based and more technical chapters, summaries and references.

Its chapters are based on the contributions of over 100 recognised European experts, referring to both general technical and organ-based clinical imaging topics. The new graphical look showing Asklepios with fashionable glasses, symbolises the combination of classical medical teaching with contemporary style education.

Although the initial version of the ***ESR eBook*** was created to provide basic knowledge for medical students and teachers of undergraduate courses, it has gradually expanded its scope to include more advanced knowledge for readers who wish to 'dig deeper'. As a result, *Modern Radiology* covers also topics of the postgraduate levels of the *European Training Curriculum for Radiology*, thus addressing postgraduate educational needs of residents. In addition, it reflects feedback from medical professionals worldwide who wish to update their knowledge in specific areas of medical imaging and who have already appreciated the depth and clarity of the ***ESR eBook*** across the basic and more advanced educational levels.

I would like to express my heartfelt thanks to all authors who contributed their time and expertise to this voluntary, non-profit endeavour as well as Carlo Catalano, Andrea Laghi and András Palkó, who had the initial idea to create an ***ESR eBook***, and - finally - to the ESR Office for their technical and administrative support.

Modern Radiology embodies a collaborative spirit and unwavering commitment to this fascinating medical discipline which is indispensable for modern patient care. I hope that this ***educational*** tool may encourage curiosity and critical thinking, contributing to the appreciation of the art and science of radiology across Europe and beyond.

Minerva Becker, Editor
Professor of Radiology, University of Geneva, Switzerland

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章节大纲：

前言

*《现代放射学》*是由欧洲放射学协会 (European Society of Radiology, ESR) 在线发布的免费放射学教育资源。第二版（更名版）标题反映了 ***ESR 电子书***新颖的教学概念，它以简洁页面的形式巧妙地融合文本、图像和示意图，并辅以临床影像学案例、问答部分和内容超链接，使读者能够在各基于器官的部分、更具技术性的章节、摘要以及参考文献之间快速切换浏览。

其章节以 100 多名公认欧洲专家的优秀稿件为根基，涉及各类一般技术和基于器官的临床影像学主题。同时采用了全新的图形外观，展示了佩戴时尚眼镜的 Asklepios，象征着传统医学教学与现代风格教育的结合。

虽然初版 ***ESR 电子书***旨在为医学生和本科生教师提供医学基础知识，但现已逐渐扩充其知识领域，为希望“深入挖掘”的读者提供了更多高阶技术知识。因此，*《现代放射学》*还涵盖了***欧洲放射学培训课程***研究生水平的各类主题，旨在解决住院医师的研究生教育需求。此外，书中还囊括了全球医疗专业人士的反馈，他们希望更新自己在医学影像特定领域的知识，并对 ***ESR 电子书***在基础和高等教育水平上的深度和清晰度表示高度赞赏。

我要衷心感谢所有为这项非营利活动自愿贡献时间和专业知识的作者，以及最初提出创作 ***ESR 电子书***的 Carlo Catalano、Andrea Laghi 和 András Palkó，最后还要感谢 ESR 办公室所提供的技术和行政支持。

*《现代放射学》*充分体现了医者的协作精神和对这门热门医学学科坚定不移的承诺，这是现代患者护理必须具备的优秀精神品质。我希望这款***教育***工具能够激励各位始终保持好奇心和批判性思维，从而促进整个欧洲乃至欧洲以外地区对放射学艺术和科学的认识。

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This is a translation of the Chapter of the **Modern Radiology eBook.**

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NOTE FROM THE COORDINATORS:
Thank you to Chinese radiology experts for bridging languages and open the world-class English resource by ESR to every Mandarin-speaking student, fueling global radiology talent with a single click

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Cardiac Imaging

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章节大纲：

翻译致谢

本章节为《现代放射学电子书》的部分译文。

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心脏影像学

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译者寄语：
感谢中国放射学专家们的倾力奉献！你们跨越了语言的鸿沟，将欧洲放射学会 (ESR) 的世界级学术宝库呈献给广大中文学子。如今，前沿智慧一键即达，为全球放射学人才的蓬勃发展注入了强劲动力。

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>▪< FURTHER KNOWLEDGE

>|< COMPARE

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/ Cardiac Imaging

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/ 导示

章节大纲：

<▪> 核心知识

<!> 注意

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>▪< 进阶知识

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<∞> 参考文献

<?> 问题

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

Cardiac Imaging

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章节大纲：

基于 ESR 课程的放射学教育

心脏影像学

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Chapter Outline

- Anatomy
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  - Cardiac Valves
  - Pericardium
  - Innervation
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- Strengths, Weaknesses and Role of Imaging Modalities
  - Chest X-Ray
  - Echocardiography
  - Coronary Angiography
  - Cardiac Computed Tomography
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  - Ischaemic Heart Disease (Suspected CAD, Known CAD, Myocardial Infarction)
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  - Coronary Artery Disease (CAD)
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  - Cardiomyopathies
- Pericardial Disease
- Congenital Heart Disease
- Cardiac Masses
- Test Your Knowledge

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章节大纲

章节大纲：

- 解剖结构
  - 心腔
  - 心脏瓣膜
  - 心包
  - 神经支配
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- 影像学检查方法的优势、劣势和作用
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  - 冠状动脉造影
  - 心脏计算机断层扫描
  - 心脏磁共振成像
    - 心脏平面
  - 心肌灌注闪烁显像
- 按病理分类的心脏影像检查主要适应证
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  - 非缺血性心脏病（心肌炎、心肌病、心包疾病、先天性心脏病、心脏肿块）
- 缺血性心脏病 (IHD)
  - 冠状动脉疾病，冠心病 (CAD)
  - CAD 与非 CAD 的主要影像学检查方法
  - 冠状动脉 CT 血管成像在 CAD 评估中的应用
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  - 心肌梗死
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  - 心肌病
- 心包疾病
- 先天性心脏病
- 心脏肿块
- 知识测试

Anatomy

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章节大纲：

解剖结构

/ Anatomy

The heart is located in the centre of the thoracic cavity, in the middle mediastinum

- / Behind the sternum and the costal cartilages, which protect it like a shield
- / In front of the vertebral column, from which it is separated by the oesophagus and aorta
- / On top of the diaphragm, which separates it from the underlying viscera
- / Between the two lungs

Its shape can be approximated to that of a truncated cone, that is orientated in the thorax with its apex projecting forward, to the left and downward, and the base faces in a posterior direction.

The weight is about 250-300 g in the adult, measuring 12 cm in length, 9-10 cm in width and about 6 cm in thickness.

FIGURE 1

Different coronal views of the heart on a conventional X-ray (**A**: PA projection), CT (**B**) and MRI (**C**) images.

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/ 心脏影像学

/ 解剖结构

章节大纲：

心脏位于胸腔中部，中纵隔内

- / 前邻胸骨与肋软骨（呈盾牌样保护）
- / 后邻脊柱，两者间有食管和主动脉相隔
- / 下方贴附膈肌（与腹腔脏器分隔）
- / 两侧为肺组织

心脏形态近似截顶圆锥体，在胸腔内的方位为：心尖朝向左前下方，心底朝向后方。

成人心脏重约 250-300 g，长径 12 cm，横径 9-10 cm，厚度约 6 cm。

图 1

心脏在不同成像方法中的冠状切面：常规 X 线（**A**：后前位投照）、CT (**B**) 和 MRI (**C**)。

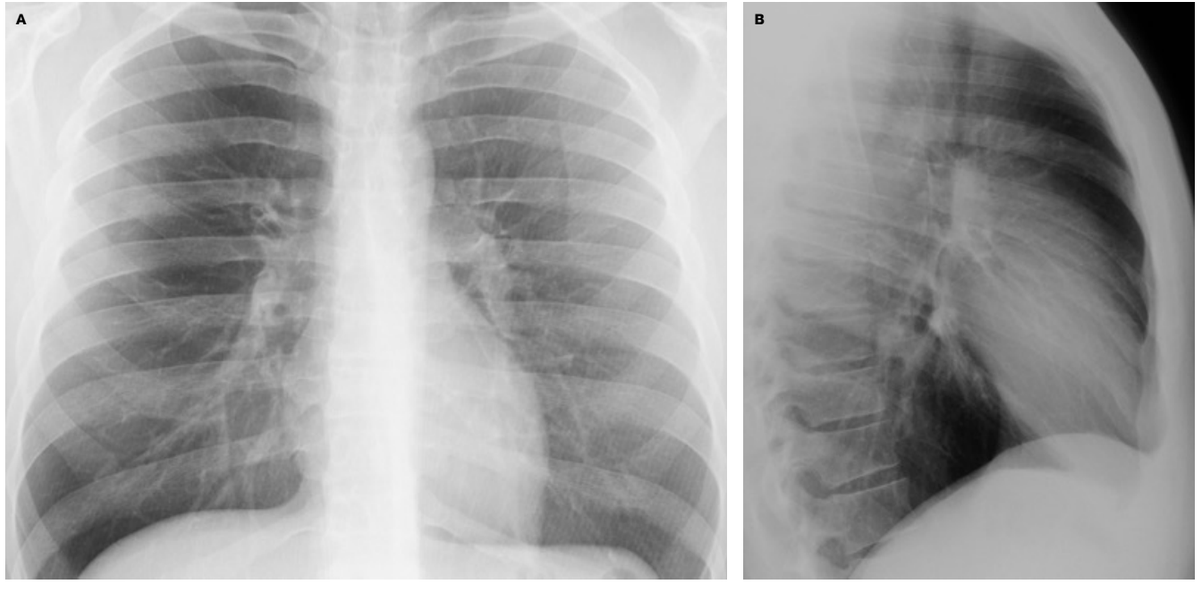

FIGURE 2

Chest X-ray; the cardiac silhouette can be appreciated on the PA (**A**) and left lateral (LL, **B**) projections.

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章节大纲：

图 2

胸部 X 线；心影可在后前位 (**A**) 和左侧位 (LL, **B**) 观察。

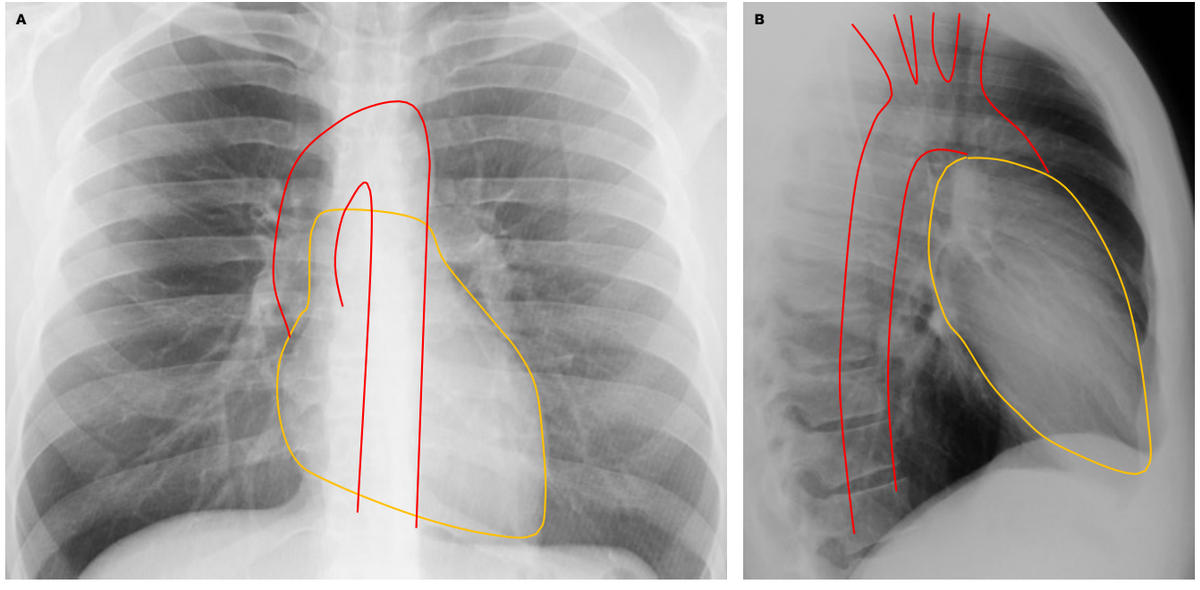

FIGURE 3

Chest X-ray (CXR): **A**: postero-anterior (PA) view; **B**: left lateral (LL) view; the **yellow line** encircles the cardiac silhouette, that projects for 1/3rd on the right side and 2/3rds on the left side of the midline. The **red line** encircles the thoracic aorta: ascending aorta arises from the left ventricle and continues in the aortic arch and then in the descending aorta, whose outline is easier to appreciate in the LL projection rather than in the PA projection.

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图 3

胸部 X 线 (CXR)：**A**：后前位 (PA) 视图；**B**：左侧位 (LL) 视图；**黄色**轮廓线示心影，1/3 位于中线右侧，2/3 位于中线左侧。**红色**轮廓线示胸主动脉：升主动脉起自左心室，延续为主动脉弓及降主动脉，其轮廓在 LL 投照较 PA 投照更易观察。

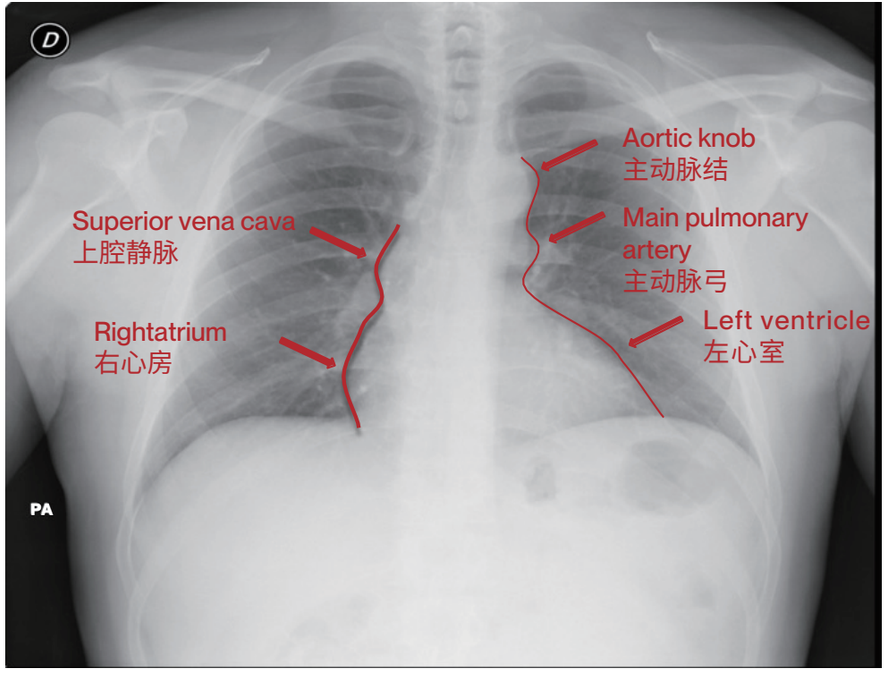

FIGURE 4

Cardiac contours on chest X-ray PA projection

On the right side, two contours can be identified, the superior one is a low-density line close to the vertebral column, it is caused by the superior vena cava. This contour meets inferiorly with the second one, formed by the right atrium.

On the left, we can identify three contours: the most cranial one is known as the aortic knob, it is formed by the overlapping of the aortic arch and the the first portion of the descending aorta. Just below this first contour is the second one, the main pulmonary artery. The third and most caudal of the left contours is formed by the left ventricle.

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图 5

胸部 X 线 PA 位的心脏轮廓

在右侧，可识别两条轮廓，上方为靠近脊柱的低密度线影，由上腔静脉形成。该轮廓向下与第二条轮廓相交，后者由右心房形成。

在左侧，可以识别三条轮廓：最靠头侧的称为主动脉结，由主动脉弓与降主动脉起始段重叠形成。紧接其下方的第二条轮廓为主肺动脉段。左侧最靠尾侧的第三条轮廓由左心室形成。

FIGURE 5

Computed Tomography (CT) series of coronal slices showing the heart (**yellow line**) located in the mediastinum between the two lungs, and the thoracic aorta (**red line**). The aorta can be clearly seen originating from the left ventricle at the aortic valve.

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章节大纲：

图 5

计算机断层扫描 (CT) 冠状位连续图像显示位于两肺之间纵隔内的心脏（**黄线**）以及胸主动脉（**红线**）。可清晰观察到主动脉自左心室经主动脉瓣发出。

/ Cardiac Chambers

The heart has four chambers: two right chambers and two left chambers separated by interatrial and interventricular septa.

Right atrium and right ventricle receive blood from the superior and inferior vena cava and eject it into the pulmonary trunk.

Left atrium and left ventricle receive blood from the pulmonary veins and eject it into the aorta.

The atria have thin walls and a reservoir function, they receive blood from the veins and convey it into the corresponding ventricles through the atrioventricular valves (mitral and tricuspid).The ventricles have a pump function, they push the blood into the large arteries through the semilunar valves (aortic and pulmonary).

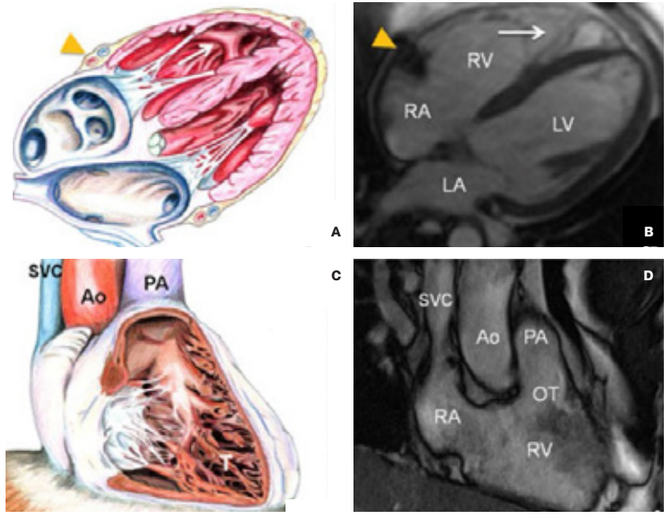

FIGURE 6

Freehand drawings (**A**, **C**) and corresponding MRI images on four chamber (**B**) and three chamber view (**D**) demonstrating right ventricular anatomy. We can appreciate the moderator band (**white arrow**), and the right atrio- ventricular groove (**yellow arrowheads**), containing the right coronary artery and small cardiac vein.

In (**D**) the RA and RV are depicted along with the OT, the PA and the inflow tract (SVC).

RA = right atrium, RV = right ventricle, LA = left atrium, LV = left ventricle, SCV = superior vena cava, Ao = aorta, PA = pulmonary artery, OT = right ventricular outflow tract. T = trabeculations.

Figure reproduced from: Galea, N., Carbone, I., Cannata, D. et al. Right ventricular cardiovascular magnetic resonance imaging: normal anatomy and spectrum of pathological findings. Insights Imaging 4, 213–223 (2013). https://doi.org/10.1007/s13244-013-0222-3

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章节大纲：

/ 心腔

心脏有四个腔：右侧两个左侧两个，由房间隔和室间隔分隔。

右心房和右心室接收来自上、下腔静脉的血液，并将其射入肺动脉干。

左心房和左心室接收来自肺静脉的血液并将其射入主动脉。

心房壁薄，具有储血功能，接收静脉血液并通过房室瓣（二尖瓣和三尖瓣）将其输送至相应心室。心室具有泵血功能，通过半月瓣（主动脉瓣和肺动脉瓣）将血液推入大动脉。

图 6

手绘示意图 (**A**, **C**) 及对应的 MRI 四腔 (**B**) 和三腔心视图 (**D**) 显示右心室解剖结构。我们可以看见调节束（**白色箭头**）和右房室沟（**黄色箭头**），沟内走行右冠状动脉及心小静脉。

图 (**D**) 显示 RA 和 RV 以及 OT、PA 和流入道 (SVC)。

RA=右心房，RV=右心室，LA=左心房，LV=左心室，SCV=上腔静脉，Ao=主动脉，PA=肺动脉，OT=右心室流出道。T=肌小梁。

图片来源： Galea, N., Carbone, I., Cannata, D. et al. Right ventricular cardiovascular magnetic resonance imaging: normal anatomy and spectrum of pathological findings. Insights Imaging 4, 213–223 (2013). https://doi.org/10.1007/s13244-013-0222-3

/ Cardiac Valves

Atrioventricular valves: open during diastole and close during systole

- / Tricuspid valve, on the right side, made of three leaflets
- / Mitral valve, on the left side, made of two leaflets

Semilunar valves: so named for the crescent shape of their cusps, open during systole and close during diastole

- / Aortic valve, on the left side, typically tricuspid
- / Pulmonary valve, on the right side

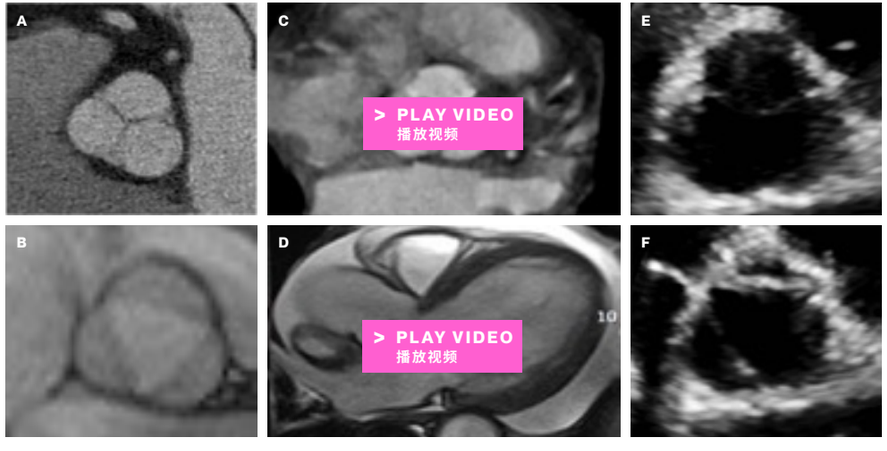

FIGURE 7

Aortic valve morphology on CT (**A**) and MR scans (**B**). Aortic valve function on cine CT (**C**) showing cusps movement and cine MR (**D**) showing transvalvular flow, which appears as a «black jet». Echocardiographic images of a closed (**E**) and open (**F**) aortic valve.

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章节大纲：

/ 心脏瓣膜

房室瓣： 舒张期开放，收缩期关闭

- / 三尖瓣，位于右侧，由三个瓣叶组成
- / 二尖瓣，位于左侧，由两个瓣叶组成

半月瓣：因瓣膜呈新月形而得名，收缩期开放，舒张期关闭

- / 主动脉瓣，位于左侧，通常为三叶式结构
- / 肺动脉瓣，位于右侧

图 7

CT (**A**) 与 MR 扫描 (**B**) 显示的主动脉瓣形态。电影 CT (**C**) 显示瓣尖运动评估主动脉瓣功能，电影 MR (**D**) 显示的跨瓣血流（表现为“黑色射流”）。超声心动图显示主动脉瓣关闭 (**E**) 和开放 (**F**) 状态。

/ Pericardium

A thin flask-shaped fibroserous membrane, that contains the heart and the roots of the great vessels and is composed of two layers, the inner serosa (also referred as the visceral pericardium) and the outer serosa (parietal pericardium). It forms a complete sac filled with up to 50 mL of plasmatic ultrafiltrate.

/ Innervation

The heart has extrinsic and intrinsic innervation, which stimulate the heartbeat independently and coordinately. The cardiac conduction system consists of a pacemaker centre at the level of the sinus node and conduction pathways that transmit the pulse up to the ventricular myocardium.

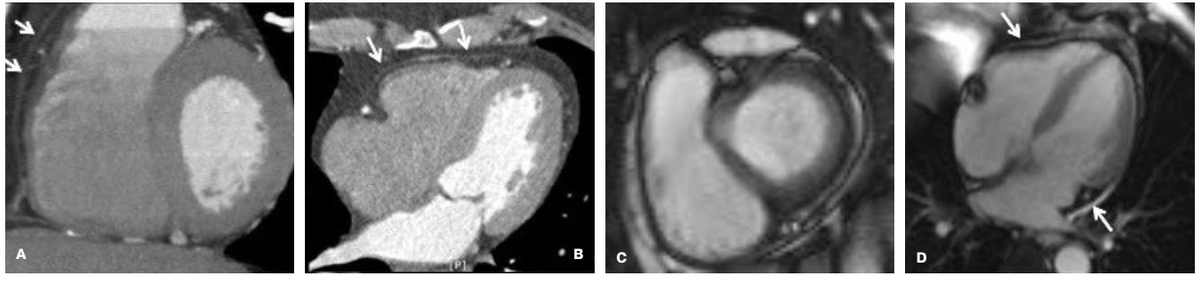

FIGURE 8

CT scan (**A**, **B**) showing normal appearance of pericardium. Normal pericardium is also shown as it appears on "white-blood" MRI sequences (**C**, **D**).

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章节大纲：

/ 心包

菲薄的烧瓶状纤维浆膜结构，包裹心脏及大血管根部，由两层组成：内层浆膜层（也称为脏层心包）与外层浆膜层（壁层心包）。其形成封闭囊腔，内含不超过 50 mL 的血浆超滤液。

/ 神经支配

心脏具有外在和内在双重神经支配，可独立且协调地激发心跳。心脏传导系统由窦房结水平的起搏中心及传导通路组成，能将电脉冲传递至心室心肌。

图 8

CT 扫描 (**A**, **B**) 显示的正常心包形态。"亮血" MRI 序列 (**C**, **D**) 显示的正常心包形态。

/ Blood Supply

Coronary Anatomy

Two coronary arteries arise from the sinuses of the aortic root: the right coronary artery (RCA) from the right sinus, the left main coronary artery (LM) from the left sinus.

- RCA descends in the coronary sulcus between right atrium and ventricle, turns posteriorly onto the diaphragmatic surface of the heart still following the sulcus. It gives off atrial and acute marginal branches.
- LM passes between pulmonary trunk and left auricle before entering the coronary sulcus, here it divides into the left anterior descending artery (LAD) and Left circumflex artery (LCX).
  - LAD descends obliquely towards the apex in the anterior interventricular septum while giving off diagonal and septal branches.
  - LCX runs in the coronary sulcus up to the diaphragmatic surface of the heart giving off obtuse marginal branches.

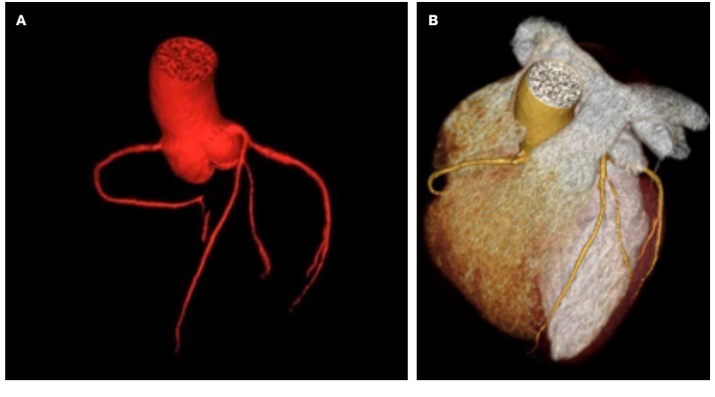


FIGURE 9

(**A**) CT 3D Volume Rendering of the aortic root and coronary tree. (**B**) CT 3D Volume Rendering of heart and coronary tree.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 血供

冠状动脉解剖

两条冠状动脉起自主动脉根部的主动脉窦：右冠状动脉 (right coronary artery, RCA) 起自右冠窦，左主干 (left main coronary artery, LM) 起自左冠窦。

- RCA 在右心房与右心室之间的冠状沟内下行，随后沿冠状沟向后延伸至心脏膈面。其分支包括心房支和锐缘支。
- LM 穿过肺动脉干与左心耳之间，进入冠状沟后分为两支：左前降支 (LAD) 和左回旋支 (LCX)。
  - LAD 沿前室间沟斜行向心尖方向走行，发出对角支和室间隔支。
  - LCX 沿冠状沟走行至心脏膈面，发出钝缘支。

图 9

(**A**) 主动脉根部及冠状动脉树的 CT 三维容积重建图像。
(**B**) 心脏及冠状动脉树的 CT 三维容积重建图像。

- RCA supplies the right atrium and ventricle, the sinoatrial and atrioventricular nodes and the posterior one third of the interventricular septum (in cases of right dominance, see below).
- LAD supplies the anterior two thirds of the interventricular septum and the anterior wall of the left ventricle.
- LCX supplies the lateral wall of the left ventricle and the left atrium.

Venous Drainage

The coronary veins return deoxygenated blood from the myocardium back to the right atrium. Most venous blood returns via the coronary sinus.

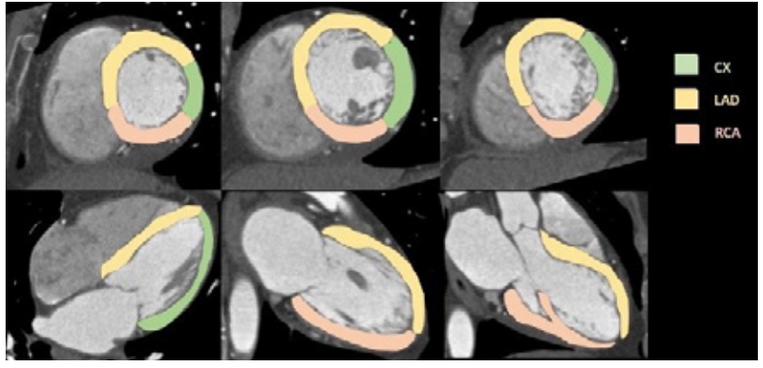


FIGURE 10

Graphic representation of the coronary artery territories.

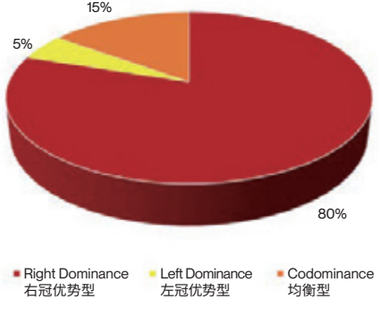


FIGURE 11

Coronary dominance refers to the coronary artery giving off the posterior interventricular artery. Right dominance occurs in 80% of the population, left dominance (from the LCX) in 5% and codominance in 15%.

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

- RCA 供应右心房、右心室、窦房结和房室结，以及室间隔后三分之一（右冠优势型时，见下文）。
- LAD 供应室间隔前 2/3 和左心室前壁。
- LCX 供应左心室侧壁和左心房。

静脉引流

冠状静脉将心肌的脱氧血引流入右心房。大部分静脉血通过冠状窦回流。

图 10

冠状动脉供血区域示意图。

图 11

冠状动脉优势型是指发出后室间支的冠状动脉。人群中右冠优势型占 80%，左冠优势型（来自 LCX）占 5%，均衡型占 15%。

Strengths, Weaknesses and Role of Imaging Modalities

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

影像学检查方法的优势、劣势和作用

/ Chest X-Ray

Chest X-ray can show abnormalities in the size and shape of the heart, which may indicate heart failure, pericardial effusion or heart valve disorders. Moreover, chest X-ray may reveal pulmonary changes as a consequence of heart disease (e.g. pulmonary oedema as result of congestive heart failure).

The main limitation of this modality in the study of the heart is the difficulty in distinguishing the various overlapping cardiac structures, as they share similar radiographic density.

Understanding what makes up the normal contours of heart and mediastinum on a PA chest X-ray is an important skill for most physicians, as it is required to correctly allocate any abnormality that is detected.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 胸部 X 线

胸部 X 线检查可显示心脏大小和形状异常，这些异常可能提示心力衰竭、心包积液或心脏瓣膜疾病。此外，胸部 X 线检查可发现由心脏病引起的肺部变化（如充血性心力衰竭引起的肺水肿）。

这种心脏检查方式的主要局限性在于难以区分重叠的不同心脏结构，因为 X 线下它们具有相似的密度。

了解后前位胸部 X 线片上心脏和纵隔的正常轮廓是放射医师的重要技能，因为这是准确发现影像异常的必要条件。

/ The Cardiothoracic Ratio

The cardiothoracic ratio is a simple yet effective tool to look for cardiomegaly. This ratio must be measured on a PA chest X-ray and is calculated dividing the widest horizontal diameter of the heart by the maximal horizontal diameter of the thoracic rib cage. A normal ratio should be < 0.5, values above this point to cardiomegaly or other pathologies (pericardial effusion).

<!> ATTENTION

Cardiothoracic ratio on CXR: You shouldn't measure the cardiothoracic ratio on an AP projection as the cardiac silhouette is typically magnified in these cases. Cardiothoracic ratio is useful to detect eccentric hypertrophy of the heart, concentric hypertrophy will generally go undetected.

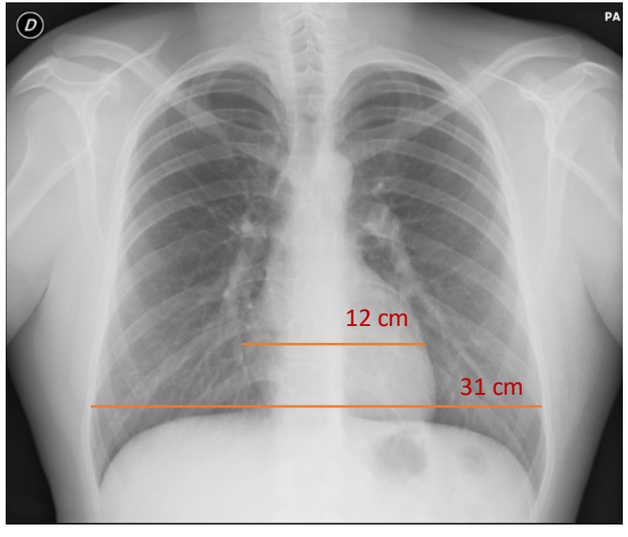


FIGURE 12

Chest X-ray (PA) showing a normal cardiothoracic ratio (< 0.5).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心胸比率

心胸比率是检测心脏肥大简单但有效的工具。该比率必须在后前位胸部 X 线片上测量，通过心脏最大水平径除以胸廓最大水平径计算得出。正常比率应 <0.5，高于此值提示心脏肥大或其他病变（如心包积液）。

<!> 注意

CXR 心胸比率测量：不应在前后位投照片上测量心胸比率，因为此时心影通常会被放大。心胸比率有助于检测心脏离心性肥大，而向心性肥大通常无法通过该方法发现。

图 12

胸部 X 线 (PA) 片显示正常心胸比率 (< 0.5)。

>|< COMPARE

In the Patient A the cardiothoracic ratio is 0.41 (< 0.5), while in the Patient B it is 0.55 (> 0.5), an evidence of cardiac enlargement.

FIGURE 13

Chest X-ray in a 27 years old healthy patient (**A**) and in a patient affected by post-ischaemic heart failure (**B**).

/ Cardiac Imaging

CHAPTER OUTLINE:

>|< 比较

患者 A 的心胸比率为 0.41 (< 0.5)，而患者 B 为 0.55 (> 0.5)，提示心脏扩大。

图 13

27 岁健康受试者胸部 X 线片 (A) 与缺血后心力衰竭患者胸部 X 线片 (B)。

/ 心脏影像学

章节大纲：

/ Echocardiography

Echocardiography (ultrasonography, US) is often used as a first step in the evaluation of cardiac pathologies, as it is a low cost, widely available and non-invasive technique.

Possible pitfalls of echocardiography are the acoustic impedance of the thorax, which can be overcome using a transoesophageal approach, and inter-operator variability.

The main goals of echocardiography are:

- To study cardiac anatomy: characterisation of Congenital Heart Disease (CHD), evaluation of pericardial effusion and detection of intracardiac masses or thrombi.
- To estimate cardiac function: assessment of cardiac motility and cardiac chamber 's performance (ejection fraction, EF; end-diastolic volume, EDV; end-systolic volume, ESV).
- To study cardiac valves: evaluation of valves morphology and thickness, estimation of transvalvular flow and detection of valvular stenosis or insufficiency, using Doppler-US.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 超声心动图

超声心动图（超声检查，US）常作为心脏疾病评估的首选方法，因其具有成本低、普及广且无创的特点。

超声心动图的潜在局限包括胸壁声阻抗干扰（可通过经食管途径克服）以及操作者间的差异性。

超声心动图的主要检查目标是：

- 研究心脏解剖结构：先天性心脏病 (CHD) 特征分析、心包积液评估及心内占位或血栓检测。
- 评价心脏功能：评估心脏运动及心腔功能（射血分数 EF、舒张末期容积 EDV、收缩末期容积 ESV）。
- 研究心脏瓣膜：评价瓣膜形态和厚度，通过多普勒超声估测跨瓣血流，检测瓣膜狭窄或关闭不全。

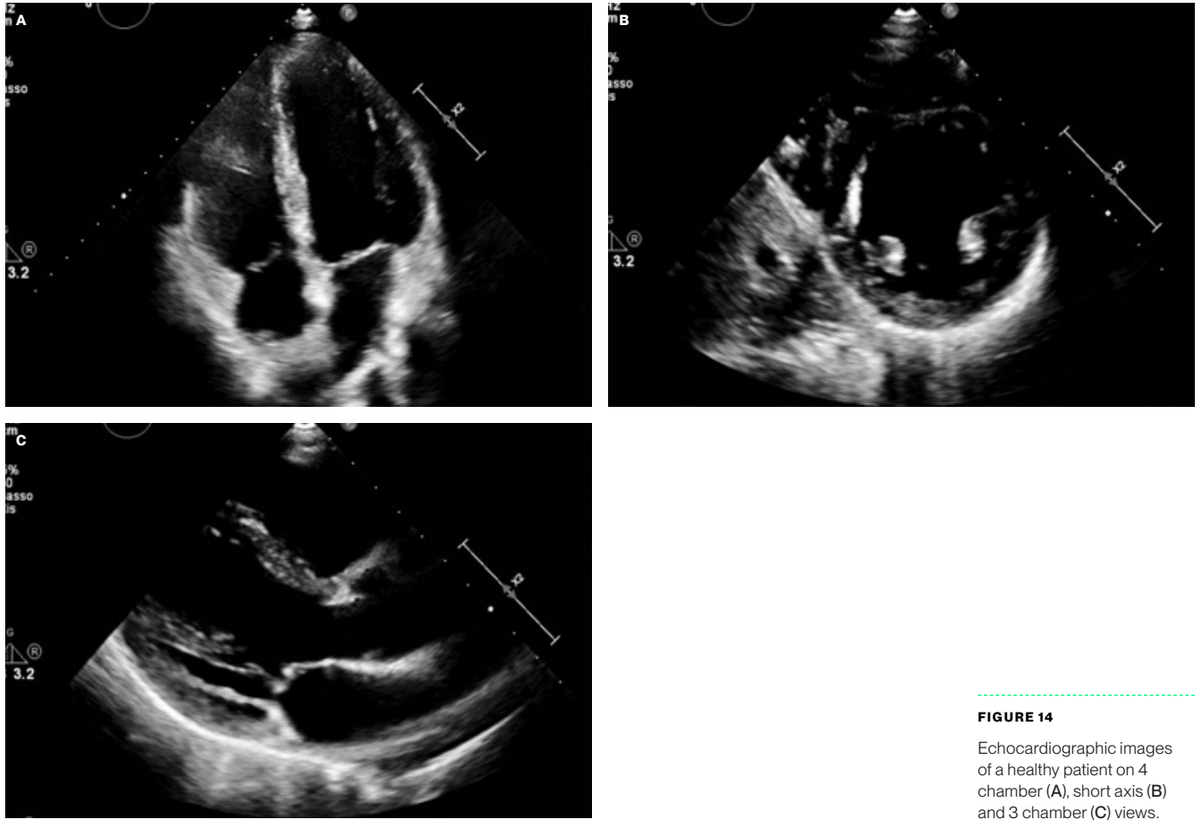


FIGURE 14

Echocardiographic images of a healthy patient on 4 chamber (A), short axis (B) and 3 chamber (C) views.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 14

健康受试者的超声心动图图像：四腔心切面 (A)、短轴切面 (B) 及三腔心切面 (C)。

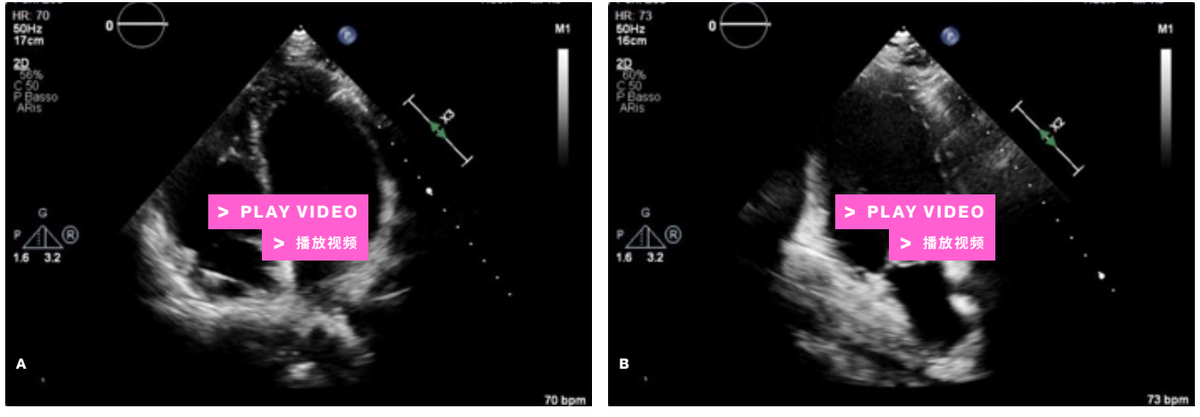


FIGURE 15

Echocardiographic videos of a healthy patient on 4 chamber view (**A**) and 2 chamber (**B**) views.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 15

健康受试者的超声心动图动态图像：四腔心切面 (**A**) 与二腔心切面 (**B**)。

/ Cardiac CT

CT scanning of the heart allows precise assessment of heart and coronary anatomy, made possible by the fast image acquisition and by the possibility to synchronise image capture and heart beat (ECG-gating).

Iodinated, intravenous contrast media are used for most cardiac protocols, in order to opacify the blood vessels and heart chambers; the formulations used are typically high-concentration.

Drawbacks of CT include radiation dose delivered, increased by ECG-gating, and potential toxicity of iodinated contrast media.

When coronary arteries are being investigated (Coronary CT Angiography) ECG-gating is fundamental to reduce the effects of heart motion. Heart rates that are excessively high (mostly above 70 bpm) lead to image quality that is hardly diagnostic even with the support of ECG-gating, making radiation dose unjustifiable. Such patients cannot undergo Coronary CT Angiography or need reduction of their heart rate through the use of B-blockers.

The accuracy of Coronary CT Angiography can be increased through the use of short – acting nitrates; these drugs cause vasodilation of the coronary arteries and allow better visualisation of the coronary lumen.

<∞> REFERENCE

European Heart Journal
(2008) 29, 531–556

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心脏 CT

心脏 CT 扫描能够精确评估心脏及冠状动脉解剖结构，这得益于快速图像采集以及图像捕捉与心跳同步（ECG 门控）技术。

大多数心脏检查方案使用静脉碘对比剂，以使血管和心腔显影；通常采用高浓度制剂。

CT 的缺点包括辐射剂量（ECG 门控会增加辐射剂量）以及碘对比剂的潜在毒性。

检查冠状动脉时（冠状动脉 CT 血管成像），ECG 门控对于减少心脏运动伪影至关重要。心率过高（多超过 70 次 / 分）时，即使借助 ECG 门控技术，仍会导致图像质量难以满足诊断需求，使得辐射剂量变得不合理。

这类患者不建议行冠状动脉 CT 血管成像，或需应用 β 受体阻滞剂降低心率。

冠状动脉 CT 血管成像的准确性可通过使用短效硝酸酯类药物提高；这些药物可引起冠状动脉扩张，从而更好地显示冠状动脉管腔。

<∞> 参考文献

European Heart Journal
(2008) 29, 531-556

ECG – gating consists in synchronisation of image acquisition and cardiac cycle to get an image of the heart as if it were still. Gating can be retrospective or prospective, in the first case images are acquired during most of the cycle and subsequently reconstructed in definite phases, whereas in the second case images are only acquired in a single phase of the cycle, usually in diastole. The latter modality allows radiation dose reduction but increases the risk of artifacts linked to heart rhythm. Because of the increased risk of artifacts, prospective gating is mostly used in patients with slow, regular heart beat. Furthermore valve function and wall motion can only be studied with retrospective gating, as it allows visualisation of these structures during the whole heart cycle.

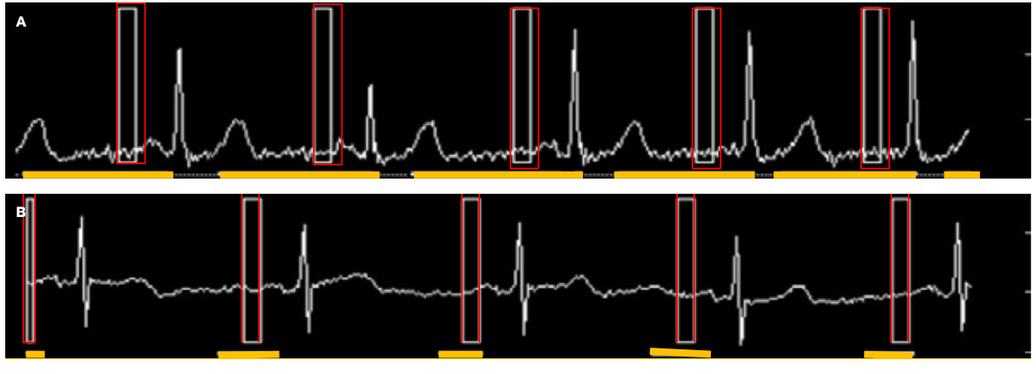


FIGURE 16

Graphs showing cardiac CT acquisition with retrospective (**A**) and prospective (**B**) ECG gating: the orange lines show the time interval of the cardiac cycle in which the image is acquired, while the red rectangles show the time interval of image reconstruction.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

ECG-门控通过同步图像采集与心动周期，获得心脏的类静态图像。门控可分为回顾性与前瞻性：前者在大部分心动周期内采集图像后重建特定时相，后者仅在一个时相（通常为舒张期）采集图像。前瞻性门控可降低辐射剂量，但会增加心律相关伪影风险。由于伪影风险增加，前瞻性门控主要用于心率缓慢且规律的患者。此外，瓣膜功能与室壁运动评估仅能通过回顾性门控实现，因其可显示整个心动周期中的结构变化。

图 16

采用回顾性 (A) 和前瞻性 (B) ECG 门控心脏 CT 采集模式示意图：橙色线条表示心动周期中采集图像的时间间隔，红色矩形表示图像重建的时间间隔。

/ Cardiac MRI

Cardiovascular Magnetic Resonance Imaging (CMR) can be used in the diagnostic and prognostic evaluation of multiple cardiovascular pathologies; it also provides the most accurate functional information regarding heart physiology (i.e., cardiac volumes and ejection fraction) and allows high resolution anatomical assessment without the drawback of ionising radiation.

- Unenhanced CMR is useful for morphological and functional studies, but the injection of gadolinium-based contrast media allows tissue characterisation, the true strength of this technique, consisting in the detection of vital, suffering (oedematous) and necrotic/fibrotic myocardium.
- CMR is also able to study blood flow dynamics, looking for valvular stenosis and insufficiency, turbulence and shunts.
- ECG-gating can be applied to MRI as well, respiratory motion is reduced by acquiring images in breath holding.
- The main drawbacks of cardiac MRI are its costs, the exam duration (it can span from 30 to 60 minutes) and the limited availability of dedicated scans and operators.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏 MRI

/ 心脏影像学

章节大纲：

心血管磁共振成像 (CMR) 可用于多种心血管疾病的诊断和预后评估；它还能提供最准确的心脏生理功能信息（即心腔容积和射血分数），并实现无电离辐射的高分辨率解剖学评估。

- 非增强 CMR 适用于形态和功能研究，而注射钆对比剂可实现组织特征分析 - 这是该技术的真正优势，包括检测存活心肌、受损（水肿）心肌和坏死/纤维化心肌。
- CMR 还能研究血流动力学，探查瓣膜狭窄与关闭不全、湍流及分流。
- MRI 同样可应用 ECG 门控技术，通过屏气采集图像减少呼吸运动伪影。
- 心脏 MRI 的主要缺点是费用高、检查时间长（可达 30 至 60 分钟）以及检查需专用扫描设备和操作人员。

/ Cardiac Planes

An advantage of cardiac MRI is that images can be acquired in any plane. Traditional axial, coronal and sagittal planes have little use in the study of the heart, as this organ has a very specific orientation. Some specific planes are used in cardiac MRI to best visualise the heart:

- **Horizontal long axis** (four chamber view): this plane is perpendicular to the interventricular septum and passes through the cardiac apex and the atrioventricular valves . It allows complete view of the 4 heart chambers, the interventricular septum, the free walls and the atrioventricular valves.
- **Vertical long axis** (two chamber view): this plane passes through the apex and the mitral valve as well but is parallel to the interventricular septum, allowing visualisation of the left ventricle and atrium.
- **Short axis:** This plane is perpendicular to the interventricular septum and somewhat parallel to the atrioventricular plane. More of these planes are drawn at different levels along the interventricular septum, allowing visualisation of this important structure in between the left and right ventricles or the left and right atria. This view is particularly useful to perform volumetric measurements that allow calculation of stroke volume and ejection fraction.
- **Three chamber view:** This plane allows visualisation of aortic root and valve, LV outflow and inflow tracts and portions of left atrium and ventricle.

Different MRI sequences will have the blood depicted as hyperintense or hypointense when compare with the myocardium. Morphological sequences will generally be “black-blood”, functional sequences will be “bright blood”.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心脏平面

心脏 MRI 的优势在于可在任意平面采集图像。传统的轴位、冠状位和矢状位平面在心脏研究中用途有限，因该器官具有特定空间方位。心脏 MRI 采用以下特定平面以最佳显示心脏结构：

- **水平长轴**（四腔心切面）：此平面垂直于室间隔，穿过心尖和房室瓣。可完整显示 4 个心腔、室间隔、游离壁和房室瓣。
- **垂直长轴**（二腔心切面）：该平面同样穿过心尖和二尖瓣，但平行于室间隔，可显示左心室和左心房。
- **短轴：**该平面垂直于室间隔，且基本平行于房室平面。沿室间隔不同水平获取多幅图像，可观察左右心室或左右心房间的重要结构。此切面尤其适用于容积测量，以计算每搏输出量和射血分数。
- **三腔心切面：**该平面可显示主动脉根部和主动脉瓣、左室流出道和流入道以及部分左心房和左心室。

不同 MRI 序列中血液信号与心肌相比可呈高信号或低信号。形态学序列通常为“黑血”技术，功能学序列为“亮血”技术。

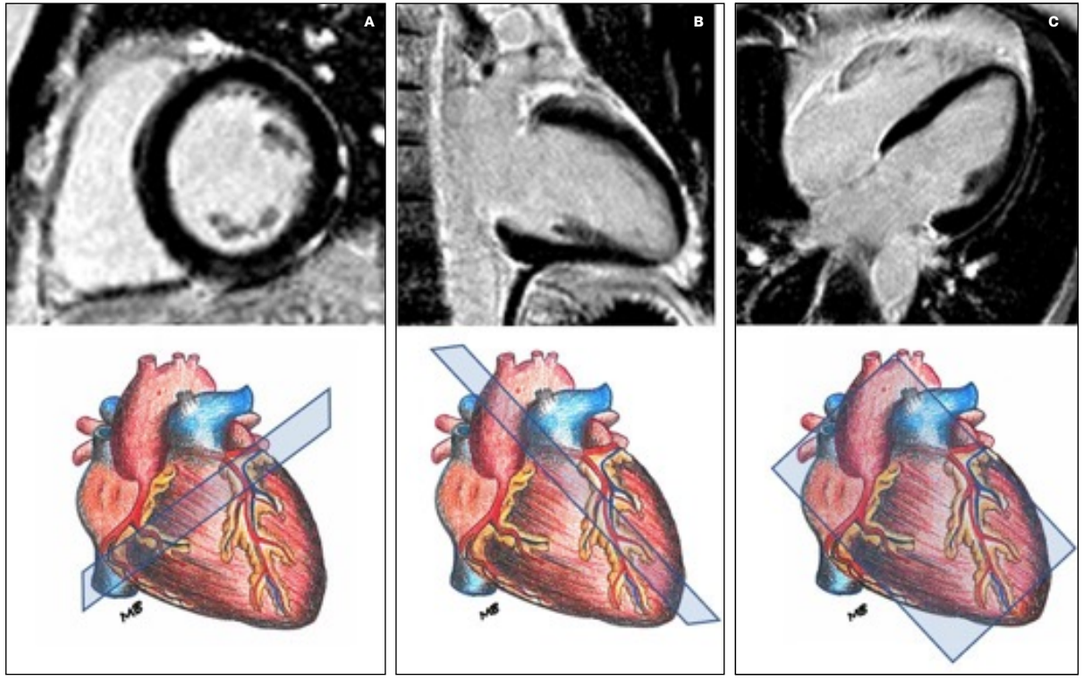


FIGURE 17

Late gadolinium enhancement (LGE) sequences and corresponding schematic drawings illustrating the short axis plane (**A**), 2 chamber plane (**B**) and 4 chamber plane (**C**) - There is no pathological parietal enhancement (upper rows).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 17

钆延迟强化 (LGE) 序列及相应的示意图显示短轴切面 (**A**)、二腔心切面 (**B**) 和四腔心切面 (**C**) - 未见病理性心壁强化（上行）。

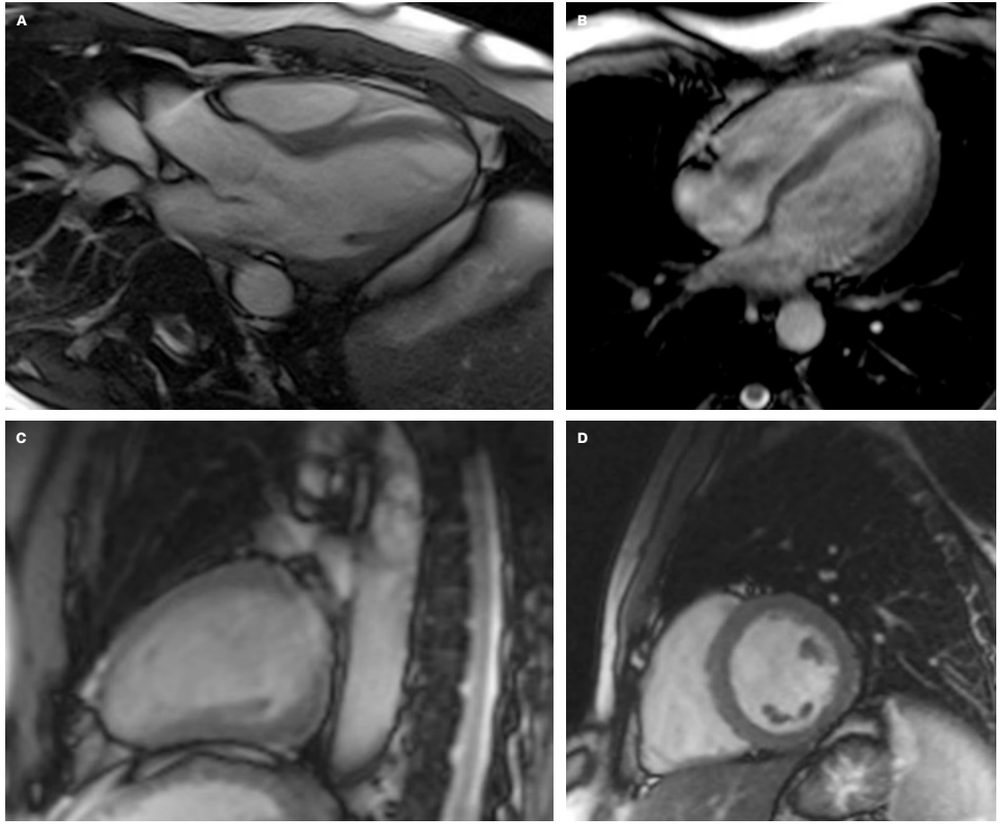


FIGURE 18

Three chamber view (**A**)

Four chamber view (**B**)

Two chamber view (**C**)

Short axis view (**D**)

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 18

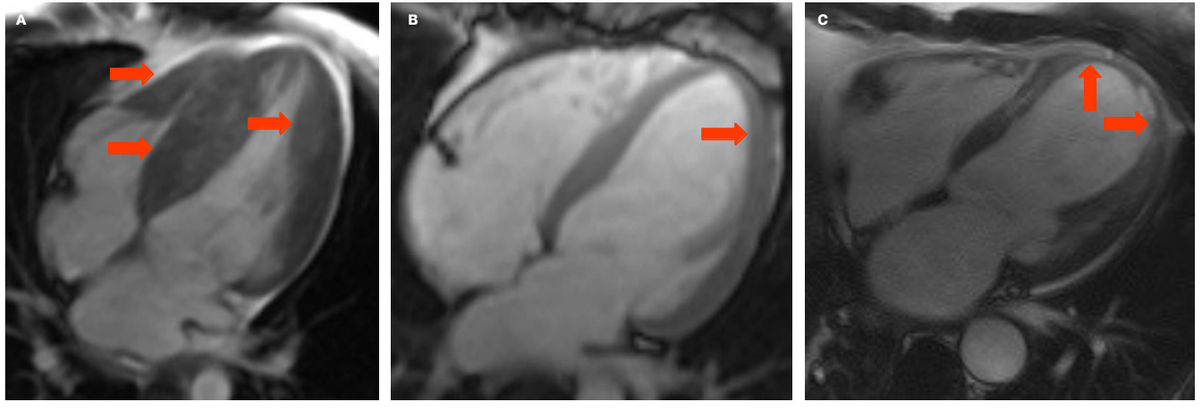
三腔心切面 (**A**)

四腔心切面 (**B**)

二腔心切面 (**C**)

短轴切面 (**D**)

>|< COMPARE



Hypertrophic (Thickened)
肥厚型 （增厚）

Normal
正常

Remodelled (Thinned)
重构型 （变薄）

FIGURE 19

Cine Steady-state-free-precession (SSFP) MR in four chamber view showing increased thickness of ventricular wall (**A**; **red arrows**), normal thickness (**B**; **red arrow**) and decreased thickness (**C**; **red arrows**).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

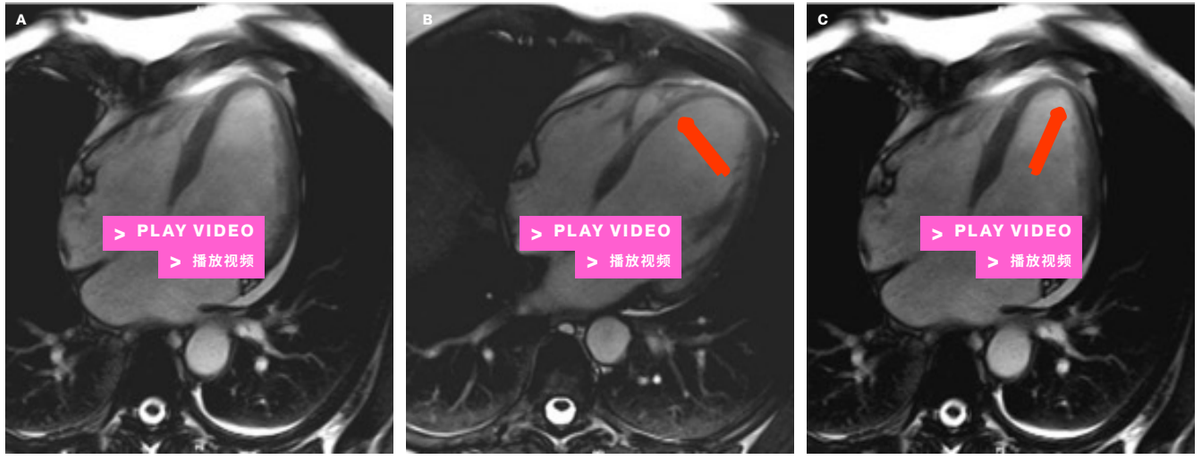
>|< 比较

章节大纲：

图 19

稳态自由进动电影 (SSFP) MR 四腔心切面，显示心室壁增厚（**A**；**红色箭头**）、正常（**B**；**红色箭头**）和变薄（**C**；**红色箭头**）。

>|< COMPARE



Normal
正常

A-/Hypokinetic
A-/运动减弱

FIGURE 20

Cine Steady-state-free-precession (SSFP) MR four chamber view showing normal wall contraction (**A**), septal a-/hypokinesia (**B**; **red arrow**) and apical dyskinesia (**C**; **red arrow**).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

>|< 比较

章节大纲：

图 20

稳态自由进动电影 (SSFP) MR 四腔心切面，显示室壁收缩正常 (**A**)、室间隔运动减弱/消失（**B**；**红色箭头**）和心尖部无运动（**C**；**红色箭头**）。

/ Nuclear Medicine

Nuclear medicine techniques have a leading role in cardiac pathologies, thanks to their ability to evaluate myocardial perfusion, metabolism and function.

The main techniques used in cardiac evaluation are Single Photon Emission Computerised Tomography (SPECT) and Positron Emission Tomography (PET).

/ SPECT imaging, performed at rest and stress state, is used to evaluate myocardial perfusion. The radiotracer (mostly thallium-201 and technetium-99m), administered intravenously, reaches viable cardiomyocytes, where it accumulates proportionally to myocardial perfusion. By using 3D reconstruction techniques, it is also possible to calculate functional parameters, such as End Diastolic Volume (EDV), End Systolic Volume (ESV) and Ejection Fraction (EF), which have an important prognostic role.

/ PET imaging is important in the evaluation of myocardial viability. The key concept is that hypoperfused but viable cardiomyocytes maintain glucose metabolism (hibernating myocardium): by administering 18-F-FDG, a glucose analogue, PET studies can highlight mismatch between myocardial perfusion and glucose intake, typical of hibernating myocardium.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 核医学

核医学技术在心脏疾病评估中具有主导地位，这得益于其评估心肌灌注、代谢和功能的能力。

心脏评估中使用的主要技术是单光子发射计算机断层扫描 (Single Photon Emission Computerised Tomography, SPECT) 和正电子发射断层扫描 (Positron Emission Tomography, PET)。

/ SPECT 成像在静息和负荷状态下进行，用于评估心肌灌注。静脉注射的放射性示踪剂（主要为铊-201 和锝-99m）到达存活心肌细胞，其积聚量与心肌灌注成正比。通过三维重建技术还可计算功能参数，如舒张末期容积 (EDV)、收缩末期容积 (ESV) 和射血分数 (EF)，这些参数具有重要的预后价值。

/ PET 成像对心肌活性评估至关重要。其核心概念是，低灌注但存活的心肌细胞仍维持葡萄糖代谢（冬眠心肌）：通过注射葡萄糖类似物 18-F-FDG，PET 可显示心肌灌注与葡萄糖摄取的不匹配现象——此为冬眠心肌的典型特征。

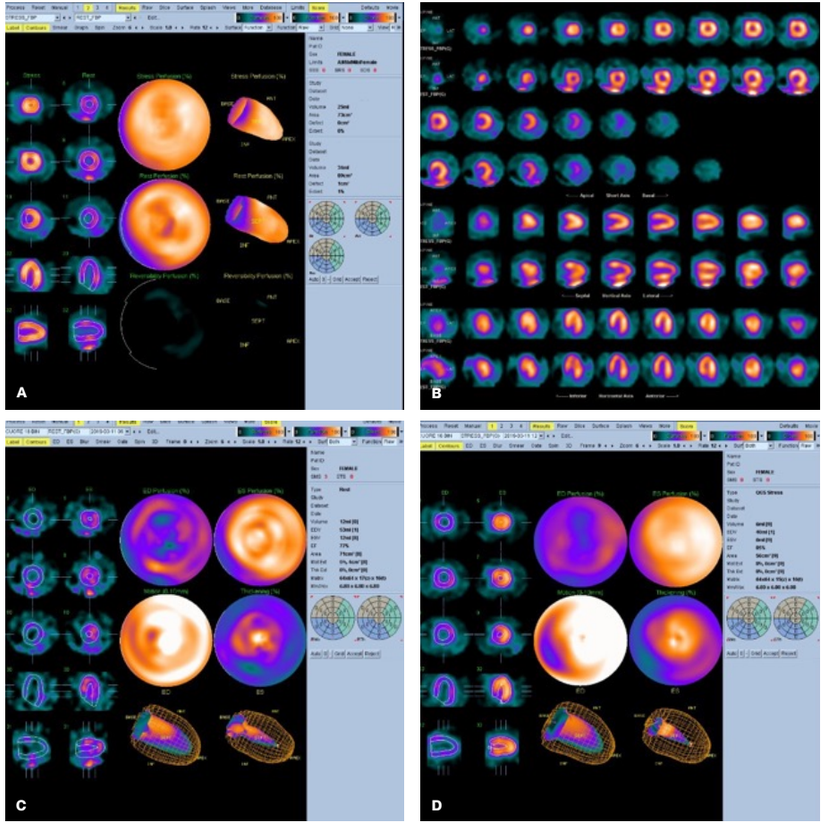


FIGURE 21

A) Myocardial perfusion SPECT study with 99mTc-sestaMIBI at rest and after stress showing images in three orthogonal planes. The radiotracer is evenly distributed in the left ventricle both at rest and after stress.

B) Three-dimensional tomographic reformatted images of left ventricular perfusion with polar maps to evaluate both qualitatively and quantitatively the presence of any perfusion defect, in terms of Summed Stress Score (SSS) and Summed Rest Score (SRS). In this study there is no significant perfusion defect, neither at rest nor under stress.

C and **D)** Tomographic reformatted images of gated – SPECT acquisitions for evaluation of left ventricular regional function and semiquantitative estimation of ventricular volumes and ejection fraction.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 21

A) 静息与负荷状态下 99m 锝-甲氧异腈 (99mTc-sestaMIBI) 心肌灌注 SPECT 研究，显示三个正交平面图像。放射性示踪剂在静息和负荷状态下均均匀分布于左心室。

B) 左心室灌注三维断层重建图像结合极坐标图，用于定性和定量评估灌注缺损，具体通过负荷总积分 (SSS) 和静息总积分 (SRS) 衡量。本研究中未见静息或负荷状态下的显著灌注缺损。

C 和 **D**）门控 SPECT 采集的断层重建图像，用于评估左心室局部功能以及半定量测算心室容积和射血分数。

Ischaemic Heart Disease (IHD)

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

缺血性心脏病 (IHD)

/ Coronary Artery Disease (CAD)

Suspected coronary artery disease (CAD):
the aim of imaging is to identify an obstructive coronary artery disease condition prior to infarct development. The strategies are the direct visualisation of the coronary tree or by functional tests that, by increasing the blood request from the myocardium, can induce a condition of transient ischaemia, documented as perfusion defect (Scintigraphy, Stress-MR) or anomalies of contractility (Echocardiography).

Stable setting:

- Echocardiography (contractility defects)
- Myocardial perfusion scintigraphy (perfusional defects)
- MRI (perfusional and contractility defects)

  All these tests can be performed as “stress - tests”, thus increasing their diagnostic abilities
- Cardiac CT
  - Cardiac Calcium Scoring (detection of coronary calcifications): as support to risk stratification
  - Coronary CT Angiography (anatomical search of stenosis) for early detection of obstructive CAD in symptomatic patients with negative functional tests or asymptomatic patients with unconclusive functional tests or patients unable to perform functional tests.

<∞> REFERENCES

Vasc Health Risk Manag. (2017) 13, 427–437
Curr Cardiol Rep. (2016) 18
Curr Cardiovasc Imaging Rep. (2017) 10
Cardiovasc Diagn Ther. (2017) 7, 189–195

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

/ 冠状动脉疾病，冠心病 (CAD)

章节大纲：

>疑诊冠心病 (CAD):
影像学目标是在心肌梗死发生前识别阻塞性冠状动脉病变。诊断策略包括直接显示冠状动脉树或通过功能检查——通过增加心肌需血量诱发短暂性缺血状态，记录为灌注缺损（闪烁显像、负荷-MR）或收缩异常（超声心动图）。

<∞> 参考文献

Vasc Health Risk Manag. (2017) 13, 427–437
Curr Cardiol Rep. (2016) 18
Curr Cardiovasc Imaging Rep. (2017) 10
Cardiovasc Diagn Ther. (2017) 7, 189–195

稳定状态：

- 超声心动图（收缩异常）
- 心肌灌注闪烁显像（灌注缺损）
- MRI（灌注和收缩异常）

  所有这些测试都可以作为“负荷试验”进行，以提高诊断效能
- 心脏 CT
  - 心脏钙化积分（检测冠状动脉钙化）：用于辅助风险分层
  - 冠状动脉 CT 血管成像（解剖学层面排查狭窄）可用于以下人群阻塞性 CAD 的早期检出：功能检查阴性但有症状的患者、功能检查结果不确定的无症状患者，或无法进行功能检查的患者。

Acute chest pain (emergency setting):

- Echocardiography (contractility defects and assessment of complications)
- Triple-rule-out CT (detection of coronary occlusion, rule out other cardiovascular causes of acute chest pain)
- Invasive coronary angiography (detection and treatment of an occlusive plaque)

Known CAD:

- CT (patency of coronary stents and coronary artery bypass grafts)
- MRI (assessment of cardiac viability mainly for prognostic purposes)

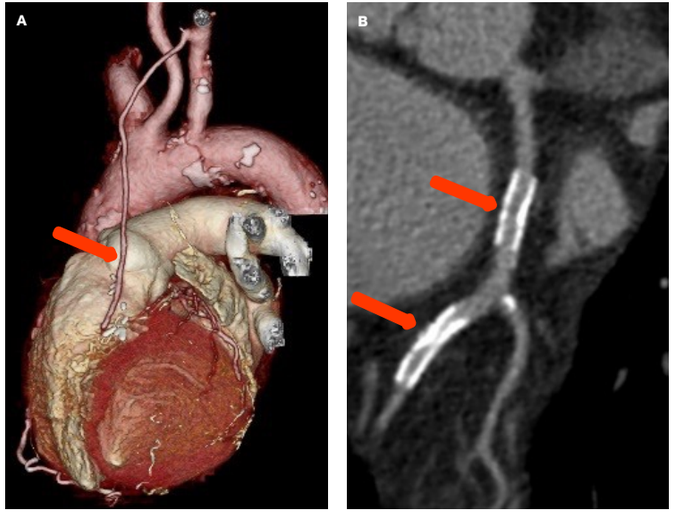


FIGURE 22

Coronary artery bypass graft of left internal mammary artery on left descending artery (**A**, **arrows**) and 2 stents on the circumflex artery (**B**, **arrows**).

<∞> REFERENCE

Thorac Dis. (2017) 9 (Suppl 4), S283–S288

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

急性胸痛（急诊场景）：

- 超声心动图（收缩异常及并发症评估）
- 胸痛三联征 CT（检测冠状动脉闭塞，排除急性胸痛的其他心血管病因）
- 有创冠状动脉造影（检测并治疗阻塞性斑块）

已知 CAD：

- CT（冠状动脉支架及冠状动脉旁路移植血管的通畅性）
- MRI（评估心肌活性，主要用于预后判断）

图 22

左乳内动脉至左前降支的冠状动脉旁路移植血管（**A**，箭头）和回旋支上的 2 个支架（**B**，箭头）。

<∞> 参考文献

Thorac Dis. (2017) 9 (Suppl 4), S283–S288

/ Main Imaging Modalities in CAD versus Non-CAD: Strengths and Weaknesses

MODALITY	STRENGHTS	WEAKNESSES	CORONARY ARTERY DISEASE: SUSPECTED STABLE SETTING	 UNSTABLE SETTING	CORONARY ARTERY DISEASE: KNOWN
Echocardlography	1) Inexpensive 2) Fast 3) Real-time 4) Wide availability	1) Operator-dependent 2) Small acoustic window 3) Low sensitivity and specificity	Detection of contractility defects, at rest and stress state	Detection contractility defects and assessment of complications	
Myocardial Perfusion Scintigraphy	1) Relatively inexpensive 2) Functional information	1) Radioactivity 2) Low sensitivity 3) Use of radiopharmaceutical	Detection of perfusion defects		
Computed Thomography	1) Extremely high negative predictive value 2) Detection of collateral findings	1) Radioactivity 2) Use of contrast agent	1) Cardiac Calcium Scoring can detect coronary calcification and support risk stratification 2) Coronary CT angiography allows plaque detection and charaterisation	Triple-rule-out CT to detect coronary occlusion, rule out other cardiovascular causes of acute chest pain	Assessment of patency of coronary stents and coronary artery bypass grafts
Magnetic Resonance Imaging	1) High sensitivity and specificity	1) Expensive 2) Low availability 3) Radiation free 4) Use of Contrast agent	Can detect perfusional and contractility defects, at both rest and stress state		Assessment of cardiac viability and prognostic study
Invasive Coronary Angiography	1) High sensitivity and specificiy 2) Therapeutic	1) Invasivity 2) High radiation dose 3) Use of contrast agent 4) Expensive	Confirmation and treatment of a signiftcative stenosis detected in other modalities. It Is still the gold standard In CAD.	Detection and treatment of an occlusive plaque	

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ CAD 与非 CAD 的主要影像学检查方法：优势和劣势

检查设备	优势	劣势	冠状动脉疾病：疑诊 稳定期情况	 不稳定期情况	冠状动脉疾病：已知
超声心动图	1) 便宜 2) 快速 3) 实时 4) 普及率高	1) 操作者依赖性 2) 声窗小 3) 灵敏度和特异性低	静息及负荷状态下的收缩异常检测	收缩异常检测及并发症评估	
心肌灌注闪烁显像	1) 价格相对便宜 2) 提供功能信息	1) 放射性 2) 灵敏度低 3) 需使用放射性药物	灌注缺损检测		
计算机断层扫描	1) 极高阴性预测值 2) 可发现侧枝病变	1) 放射性 2) 需使用对比剂	1) 心脏钙化积分检测冠状动脉钙化，辅助风险分层 2) 冠状动脉 CT 血管成像可进行斑块检测和特征分析	胸痛三联征 CT 检测冠状动脉闭塞，排除急性胸痛的其他心血管病因	冠状动脉支架和冠状动脉旁路移植血管的通畅性评估
磁共振成像	1) 高灵敏度和高特异性	1) 昂贵 2) 普及率低 3) 无辐射 4) 需使用对比剂	能够检测静息及负荷状态的灌注与收缩异常		心肌活性评估及预后研究
侵入性冠状动脉造影	1) 高灵敏度和高特异性 2) 治疗性	1) 有创性 2) 高辐射剂量 3) 需使用对比剂 4) 昂贵	其他检查设备发现的显著狭窄后的确诊与治疗。它仍然是 CAD 诊断金标准。	阻塞性斑块的检测与治疗	

/ Main Imaging Modalities in CAD versus Non-CAD: Strengths and Weaknesses

MODALITY	MYOCARDITIS	CARDIO-MYOPATHIES	VALVULOPHATIES	PERICARDIAL DISEASE	CONGENITAL HEART DISEASE	CARDIAC MASSES
Echocardlography		Allows first diagnostic and functional evaluation	Diagnostic role and quantification of flow defects	Detection of effusion	Morphological and functional evaluation	Detection of the abnormality
Myocardial Perfusion Scintigraphy						
Computed Thomography			Morphological study, detection of calcifications, important preoperative role	Detection of effusion and calcifications	Best anatomical characterisation	Best anatomical characterisation
Magnetic Resonance Imaging	Provides diagnostic and prognostic information	Comprehensive diagnostic, functional and prognostic evaluation	Thorough flow rate and functional study	Differential diagnosis of pericardial thickening	Thorough anatomical and functional assessment	Follow-up

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ CAD 与非 CAD 的主要影像学检查方法：优势和劣势

检查设备	心肌炎	心肌病	瓣膜病	心包疾病	先天性心脏病	心脏肿块
超声心动图		实现初步诊断与功能评估	诊断价值及血流异常定量分析	积液检测	形态与功能评估	异常病变检测
心肌灌注闪烁显像						
计算机断层扫描			形态学研究、钙化检测（重要术前评估作用）	积液与钙化检测	最佳解剖学特征	最佳解剖学特征
磁共振成像	提供诊断和预后信息	全面的诊断、功能及预后评估	完整血流动力学与功能研究	心包增厚的鉴别诊断	全面的解剖与功能评估	随访

/ Coronary CT Angiography in CAD

There are a variety of techniques to image coronary artery disease. Coronary angiography has been the main exam for many years, and it is still the gold standard in the evaluation of coronary artery stenosis, but in certain patient groups it may be replaced by coronary CT angiography (cCTA).

Coronary CT angiography can easily evaluate coronary atherosclerosis and classificate it on the basis of:

- Composition of the plaques: calcified, mixed, soft;
- Distribution of the plaques: isolated and diffuse;
- Severity of the stenosis: 0% = no visible stenosis; 1-24% = minimal stenosis; 25-49% = mild stenosis; 50-69% = moderate stenosis; 70-99% = severe stenosis; 100% = occlusion

<!> ATTENTION

Cardiac CT is especially important because of its very high negative predictive value, meaning that a negative exam excludes presence of CAD.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 冠状动脉 CT 血管成像在 CAD 评估中的应用

冠状动脉疾病的影像学检查技术很多。冠状动脉造影检查多年来一直是主要的检查方法，目前仍是评价冠状动脉狭窄的金标准，但在某些患者群体中可能被冠状动脉 CT 血管成像 (coronary CT angiography, cCTA) 取代。

冠状动脉 CT 很容易评估冠状动脉粥样硬化，并根据以下特征进行分类：

- 斑块成分：钙化斑块、混合斑块、软斑块；
- 斑块分布：孤立性分布与弥漫性分布；
- 狭窄严重程度：0% = 无可见狭窄；1-24% = 轻微狭窄；25-49% = 轻度狭窄；50-69% = 中度狭窄；70-99% = 重度狭窄；100% = 完全闭塞

<!> 注意

心脏 CT 尤其重要，因为其阴性预测值非常高，意味着检查结果阴性即可排除 CAD。

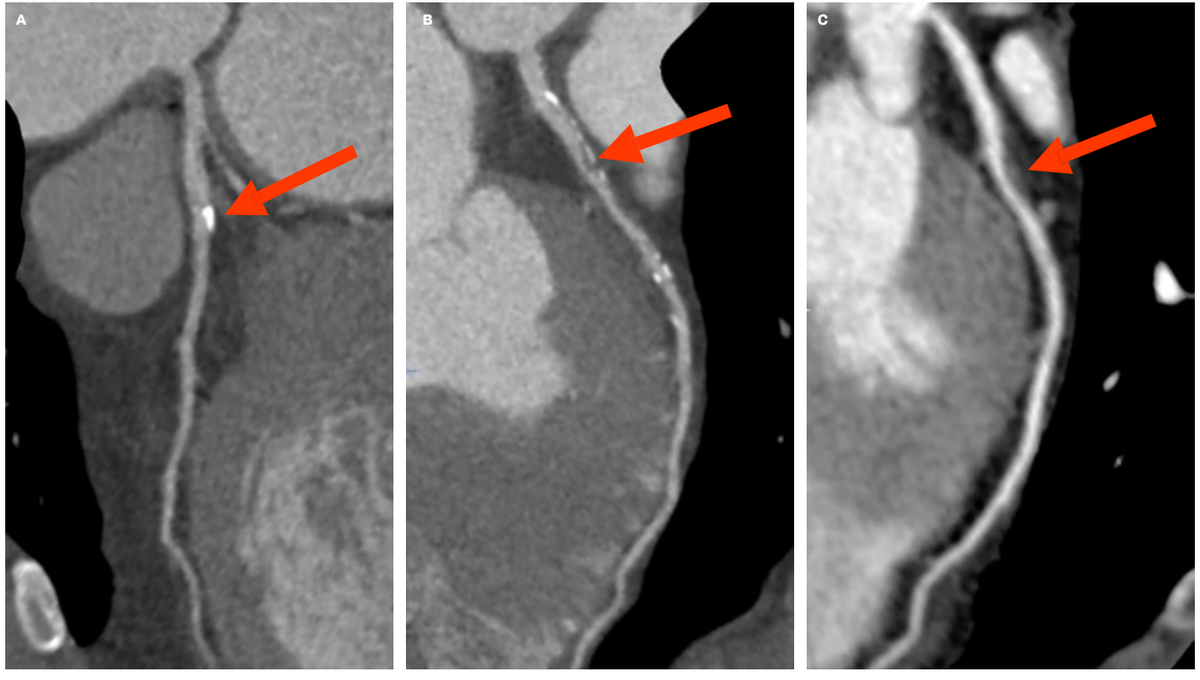


FIGURE 23

Classification of coronary plaques (**arrows**) on the basis of their composition: Calcific (**A**), mixed (**B**) and soft (**C**) plaques.

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 23

根据冠状动脉斑块的组成对其进行分类（箭头）：钙化 (**A**)、混合 (**B**) 和软 (**C**) 斑块。

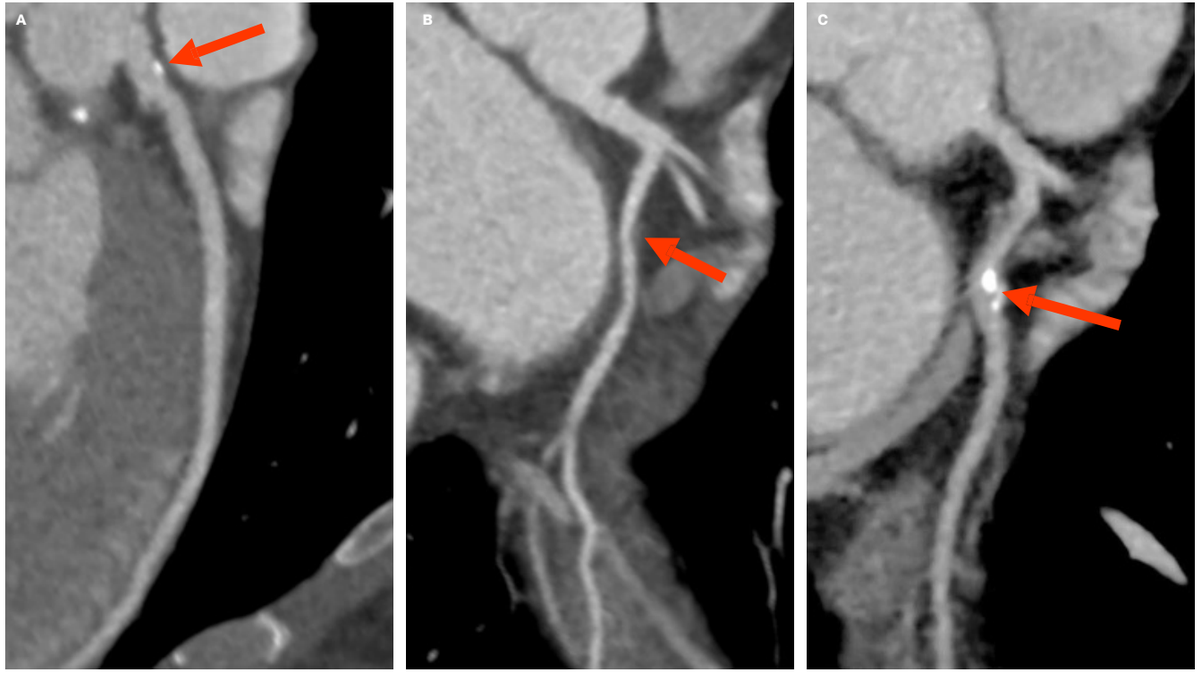


FIGURE 24

Classification of coronary plaques on the basis of severity of the stenosis: minimal (**A**), mild (**B**) and moderate (**C**) stenosis.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 24

根据狭窄严重程度对冠状动脉斑块进行分类：轻微 (**A**)、轻度 (**B**) 和中度 (**C**) 狭窄。

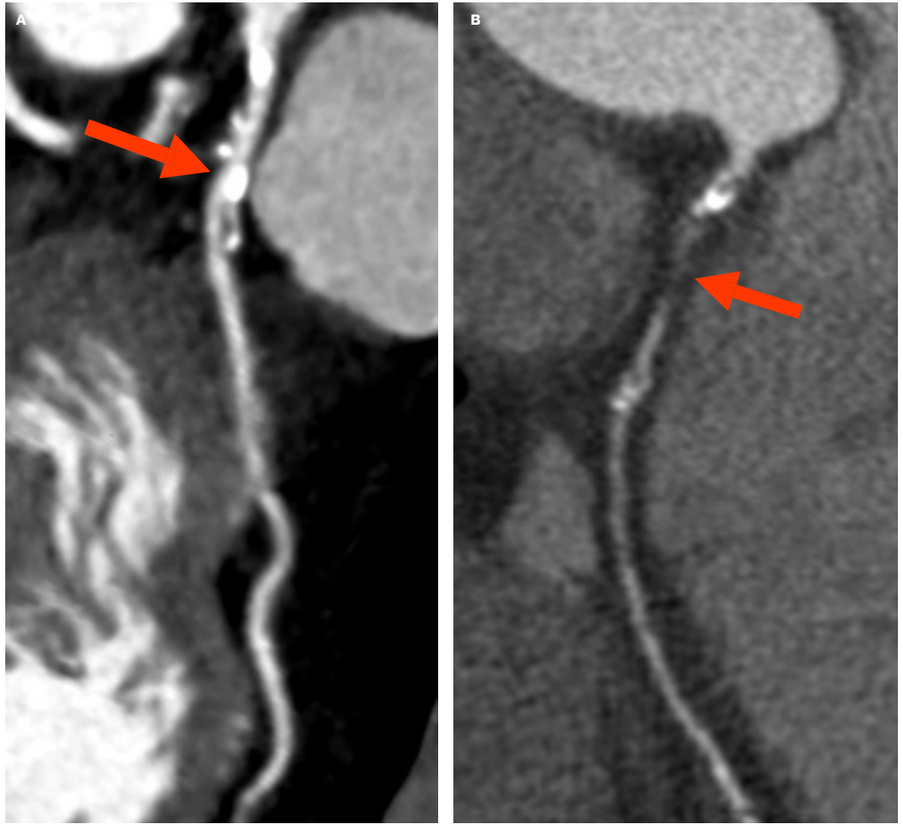


FIGURE 25

Classification of coronary plaques on the basis of severity of the stenosis: severe stenosis (A) and occlusion(B).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 25

根据狭窄严重程度对冠状动脉斑块进行分类：重度狭窄 (A) 和完全闭塞 (B)。

/ MRI, SPECT and Stress Imaging in CAD

MRI can also play a role in the evaluation of CAD, by performing a non-invasive assessment of myocardial perfusion, function and myocardial viability.

In the past decades, SPECT techniques were widely used to evaluate myocardial perfusion. This technique blends i.v. injection of a radioactive isotope with a 3D image acquisition, leading to localisation of the disease by comparing image at stress and rest state.

Nuclear perfusion studies are gradually being replaced by MRI stress test, which in conjunction with a dobutamine infusion, can be used to detect wall motion abnormalities induced by ischaemia. The technique has been shown to have a comparable safety profile to dobutamine stress echocardiography. Dobutamine stress cardiac MRI (CMR) may be useful in patients with sub-optimal acoustic windows, especially those in whom pharmacologic perfusion imaging using adenosine is contra-indicated.

Perfusion CMR is more widely used than dobutamine stress CMR. Recent studies have confirmed the good diagnostic accuracy of CMR perfusion imaging at 1.5 Tesla (T), as compared with nuclear perfusion imaging. Finally, quantitative CMR perfusion measurements demonstrate good correlations with FFR measurements.

<∞> REFERENCE

European Heart Journal
(2013) 34, 2949–3003

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ MRI、SPECT 和负荷显像在 CAD 评估中的应用

MRI 可通过无创方式评估心肌灌注、功能及心肌活性，在 CAD 的评估中同样具有重要价值。

在过去几十年，SPECT 技术被广泛用于评估心肌灌注。该技术通过静脉注射放射性同位素结合三维图像采集，对比负荷与静息状态图像实现病变定位。

目前核素灌注检查正逐步被 MRI 负荷试验取代，MRI 负荷试验联合多巴酚丁胺输注可用于检测缺血引起的室壁运动异常。该技术的安全性与多巴酚丁胺负荷超声心动图相当。多巴酚丁胺负荷心脏 MRI (CMR) 适用于超声声窗条件不佳的患者，尤其是腺苷药物负荷灌注显像禁忌的患者。

灌注 CMR 比多巴酚丁胺负荷 CMR 应用更广泛。近期研究证实，1.5T CMR 灌注显像的诊断准确度较核素灌注显像为好。最后，定量 CMR 灌注测量值与 FFR 测量值具有良好的相关性。

<∞> 参考文献

European Heart Journal
(2013) 34, 2949-3003

/ Myocardial Infarction

Myocardial infarction results from obstruction to blood flow in one district of the coronary tree, with resultant myocardial ischaemia. It is an acute event typically presenting with severe chest pain. Expedite diagnosis is crucial in this setting as these patient should undergo reperfusion as soon as possible. In this context, time saving modalities are especially useful.

- Chest X-rays are useful to exclude other causes of chest pain (e.g., pneumonia) but not to the direct diagnosis of acute myocardial infarction (AMI); sometimes they can demonstrate indirect and non specific signs of heart failure.
- Echocardiography, is a fast exam that allows a first confirmation of the diagnostic hypothesis of myocardial infarction. The typical finding in the acute setting is a regional wall motion abnormality of the affected walls (those perfused by the occluded coronary artery). Mitral regurgitation can also be seen when the ischaemia involves the papillary muscles.
- Coronary CT Angiography in the context of a Triple-rule-out protocol can assess patency of coronary arteries in the setting of acute chest pain, but only when the ECG alone is not enough to have diagnostic certainty.
- Invasive Coronary Angiography allows direct visualisation of the obstruction to blood flow. It is a pivotal modality as in the same context it is possible to proceed with primary percutaneous coronary intervention (primary PCI) with angioplasty and stenting to treat the stenosis.

Patients with high clinical suspicion of Acute Myocardial Infarction (AMI) should undergo prompt revascularisation with no need for further diagnostic evaluation.

<∞> REFERENCE

Academic Emergency Medicine (2013) 20, 861– 871

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European Radiology (2009), 19, 789-799

Circulation Journal (2009) 73, Issue 9, 1577-1588

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心肌梗死

心肌梗死是由于冠状动脉某支血流阻塞，导致心肌缺血。它是一种急性事件，表现为典型的严重的胸痛。在这种情况下，快速诊断至关重要，因患者需尽快接受再灌注治疗。此时，省时的检查方法尤为重要。

- 胸部 X 线检查可用于排除其他胸痛病因（如肺炎），但不能直接诊断急性心肌梗死 (AMI)；偶可显示心力衰竭的非特异性间接征象。
- 超声心动图作为快速检查手段，可初步确认心肌梗死的诊断假设。急性期的典型表现是受累室壁（由闭塞冠状动脉供血的室壁）出现节段性室壁运动异常。当缺血累及乳头肌时，也可见二尖瓣反流。
- 在胸痛三联方案中，冠状动脉 CT 血管成像可评估急性胸痛患者的冠状动脉通畅性，但仅适用于单纯 ECG 不足以明确诊断的情况。
- 侵入性冠状动脉造影可直接观察血流阻塞部位。该检查具有关键意义，因可同步进行直接经皮冠状动脉介入治疗（直接 PCI），通过血管成形术和支架置入治疗狭窄。临床高度怀疑急性心肌梗死 (AMI) 的患者应立即进行血运重建，无需进一步实施诊断性评估。

<∞> 参考文献

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- Myocardial scintigraphy can assess myocardial viability by detecting reversible perfusion defects through comparison of the images at rest and stress state.
- MRI in the acute setting can detect the presence of oedema in regions of the myocardium that are salvageable ("myocardium at risk"); on the basis of MRI findings it is possible to indicate the likelihood of success of revascularisation procedures.
- Perfusion MRI at rest and stress state using a "first-pass" techniques can detect a signal increase in normal myocardium and limited enhancement in the ischaemic one.
- MRI is also useful to identify the scar tissue using "delayed enhancement" techniques.
- MRI imaging can also provide information about cardiac function by estimating cardiac volumes (EDV, ESV, SV that can be increased) and contractility (that can be compromised), using cine-MRI sequences.
- In the chronic setting, delayed enhancement cardiac magnetic resonance is particularly useful in identifying patients with ischaemic cardiomyopathy and severe left ventricular dysfunction who would benefit from myocardial revascularisation.

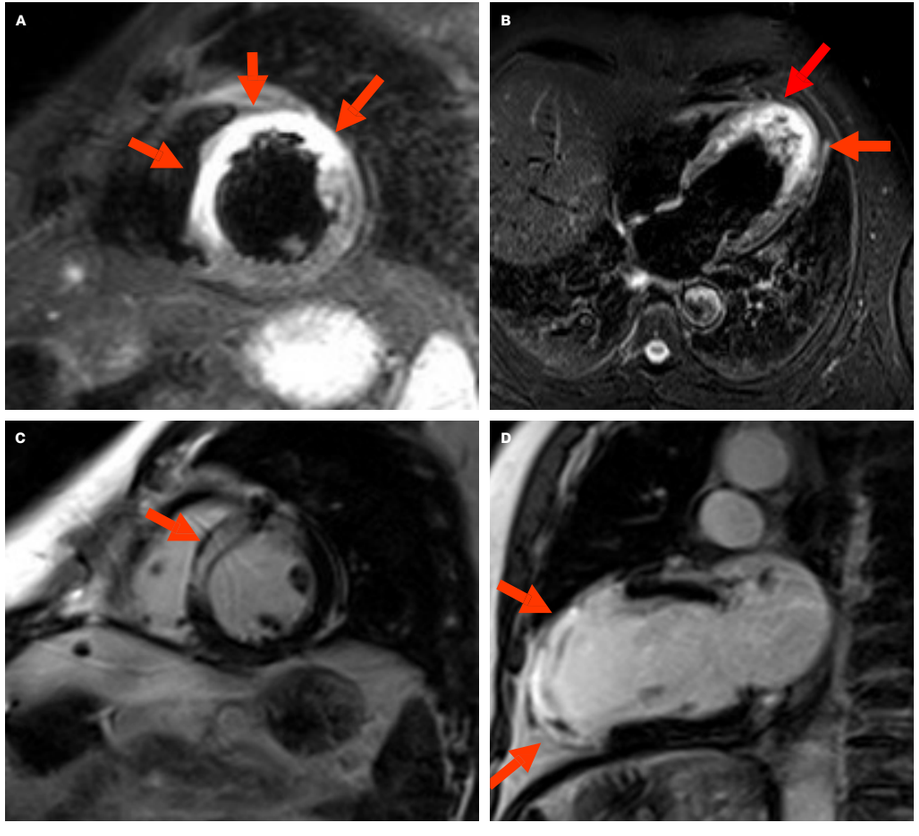
Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

- 心肌闪烁显像可通过比较静息和负荷状态下的图像来检测可逆性灌注缺损，从而评估心肌活性。
- 在急性期，MRI 可以检测可挽救的心肌区域是否存在水肿（"危险心肌"）；根据 MRI 结果，可预测血运重建手术的成功概率。
- 采用"首过"技术的静息与负荷灌注 MRI 可以检测到正常心肌的信号增强而缺血心肌强化受限。
- MRI 还可用于利用"延迟强化"技术来识别瘢痕组织。
- MRI 成像还可通过 cine-MRI 序列估计测算心腔容积（可能增大的 EDV、ESV、SV）和收缩功能（可能受损），从而提供有关心脏功能的信息。
- 在慢性期，心脏核磁共振延迟强化对识别可能从血运重建中获益的缺血性心肌病伴重度左室功能不全患者具有特殊价值。



<!> ATTENTION

Extremely interesting and useful is the accumulation of contrast medium in areas of necrosis 15-20 minutes after injection, a phenomenon referred to as delayed (or late) gadolinium enhancement (DE or LGE). Different patterns of delayed enhancement can shed light on the differential diagnosis of several different cardiac pathologies.

FIGURE 26

Cardiac MRI in a case of acute myocardial infarction (AMI):

A and B: T2 weighted with fat suppression images showing an increased signal of the anterior, lateral and anteroseptal wall (**arrows**), due to the presence of oedema.

C and D: LGE (late gadolinium enhancement) sequences showing pathological parietal enhancement of the same segments (**arrows**), due to the presence of necrosis, with a transmural distribution pattern.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

<!> 注意

对比剂注射 15-20 分钟后在坏死区域的积聚现象，称为钆延迟强化（DE 或 LGE），引起了人们的关注，且极具诊断价值。不同的延迟强化模式可为多种心脏疾病的鉴别诊断提供依据。

图 26

急性心肌梗死 (AMI) 患者的心脏 MRI 表现：

A 和 B： T2 加权脂肪抑制图像显示，前壁、侧壁和前间壁信号增高（箭头），提示水肿存在。

C 和 D： LGE（钆延迟强化）序列显示同一节段的心肌壁病理性强化（箭头），呈透壁分布模式，提示坏死组织。

<!> ATTENTION

The pattern of late gadolinium enhancement (LGE) can differentiate infarction (subendocardial or transmural) from non-ischaemic dilated cardiomyopathy (mid-wall or subepicardial) and infiltrative diseases (scattered or subepicardial).

FIGURE 27

(A) LGE (late gadolinium enhancement) sequences showing pathological parietal enhancement of the anterior, anteroseptal and lateral wall, due to the presence of necrosis/fibrosis, with a subendo-me-socardial distribution pattern, in a patient with myocardial infarction. (B) LGE sequences showing subepicardial and midwall parietal enhancement in a patient with long-standing dilated cardiomy-opathy. (C) Scattered pathological enhancement in a patient with Anderson – Fabry disease.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

<!> 注意

钆延迟强化 (LGE) 模式可以鉴别梗死（心内膜下或透壁性）与非缺血性扩张型心肌病（壁中层或心外膜下）和浸润性疾病（弥漫性或心外膜下）。

图 27

(A) 一例心肌梗死患者的 LGE（钆延迟强化）序列显示前壁、前间隔壁及侧壁病理性强化，由坏死/纤维化所致，呈心内膜下-心肌中层分布模式。(B) 一例长期扩张型心肌病患者的 LGE 序列显示心外膜下及心壁中层强化。(C) 一例安德森-法布里病患者呈弥漫性病理性强化。

/ Complications of Myocardial Infarction

The main complication of myocardial infarction are intracardiac thrombi, aneurysm/pseudoaneurysm and heart failure.

/ Aneurysm and pseudaneurysm: chest X-ray may show a localised bulge along the ventricular wall, with or without a thin rim of calcification. CT, MRI and echocardiography are more specific in the identification of myocardial morphologic alterations.

/ Thrombi: they can be easily detected by echocardiography, which is the first line exam. CT is able to distinguish cardiac masses from thrombi, as the latter lack contrast enhancement. The same information can be provided by MRI with the use of gadolinium contrast.

/ **Heart failure (HF):** Chest X-ray can demonstrate some indirect features of HF, such as cardiomegaly, pleural effusion, Kerley B lines and interstitial oedema. Echocardiography is the first-line exam and can evaluate cardiac chamber volumes, valvular function, ejection fraction and pericardial effusion. Cardiac CT also provides information about left and right ventricular structure and function, cardiac venous anatomy and pulmonary venous system. MRI is particularly useful in distinguishing the cause of HF and providing information about prognosis, especially when echocardiographic findings are inconclusive.

<∞> REFERENCE

Diagnostic and Interventional Imaging (2012) Volume 93, Issues 7–8, 578-585

/ **Cardiac Imaging**

CHAPTER OUTLINE:

/ **心脏影像学**

/ 心肌梗死的并发症

章节大纲：

心肌梗死的主要并发症包括心内血栓、室壁瘤/假性室壁瘤和心力衰竭。

/ **室壁瘤**和**假性室壁瘤：**胸部 X 线可显示沿心室壁的局部膨出，伴或不伴薄层钙化边缘。CT、MRI 和超声心动图在识别心肌形态学改变方面更具特异性。

/ **血栓：**超声心动图作为一线检查很容易检测血栓。CT 能鉴别心脏肿块与血栓，因为后者缺乏对比增强。使用钆对比剂的 MRI 也可提供相同信息。

/ **心力衰竭 (HF)：**胸部 X 线可显示一些 HF 的间接征象，如心脏肥大、胸腔积液、Kerley B 线及间质性水肿。超声心动图作为一线检查，可以评估心腔容积、瓣膜功能、射血分数和心包积液。心脏 CT 还可提供有关左右心室结构和功能、心脏静脉解剖和肺静脉系统的信息。当超声心动图结果不明确时，MRI 尤其有助于鉴别 HF 病因并提供预后信息。

<∞> 参考文献

Diagnostic and Interventional Imaging (2012) Volume 93, Issues 7–8, 578-585

<!> ATTENTION

In order to distinguish true aneurysms from pseudoaneurysms (one is surrounded by myocardium and the other is a contained rupture lined by pericardium) MRI is the best option, showing a dyskinetic segment with focal bulging of the pericardium, in the case of pseudoaneurysm.

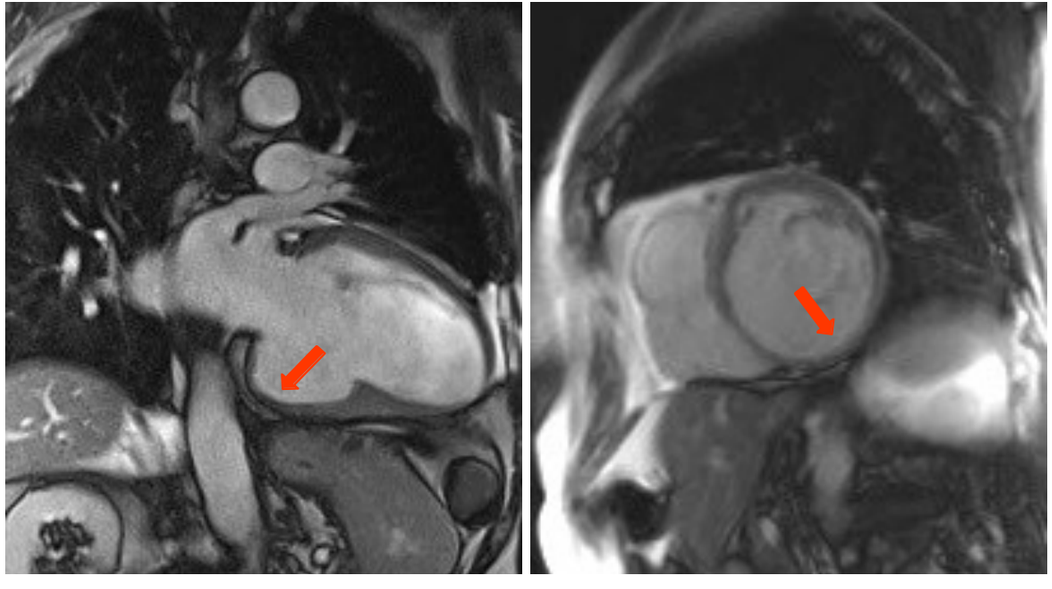


FIGURE 28

Cardiac MRI performed one year post AMI, showing presence of an aneurysm of the infero-basal wall.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

<!> 注意

为鉴别真性室壁瘤与假性室壁瘤（前者由心肌包绕，后者为心包包裹的局限性破裂），MRI是最佳检查方式——假性室壁瘤表现为节段性运动障碍伴心包局限性膨出。

图 28

AMI 后 1 年行心脏 MRI 检查，显示下基底壁室壁瘤形成。

FIGURE 29

(**A** and **B**) Cardiac CT multi-planar reconstruction of a pseudoaneurysm of the inferior wall (**arrows**) in a patient with a previous AMI. (**C**) Cardiac MR movie of the same patient. The pseudoaneurysm is indicated by an asterisk and a large thrombus is indicated by the blue arrow.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 29

（**A** 和 **B**）既往 AMI 患者下壁假性室壁瘤（箭头）的心脏 CT 多平面重建图像。(**C**) 同一患者的心脏 MR 电影。星号标记为假性室壁瘤，蓝色箭头所示为巨大血栓。

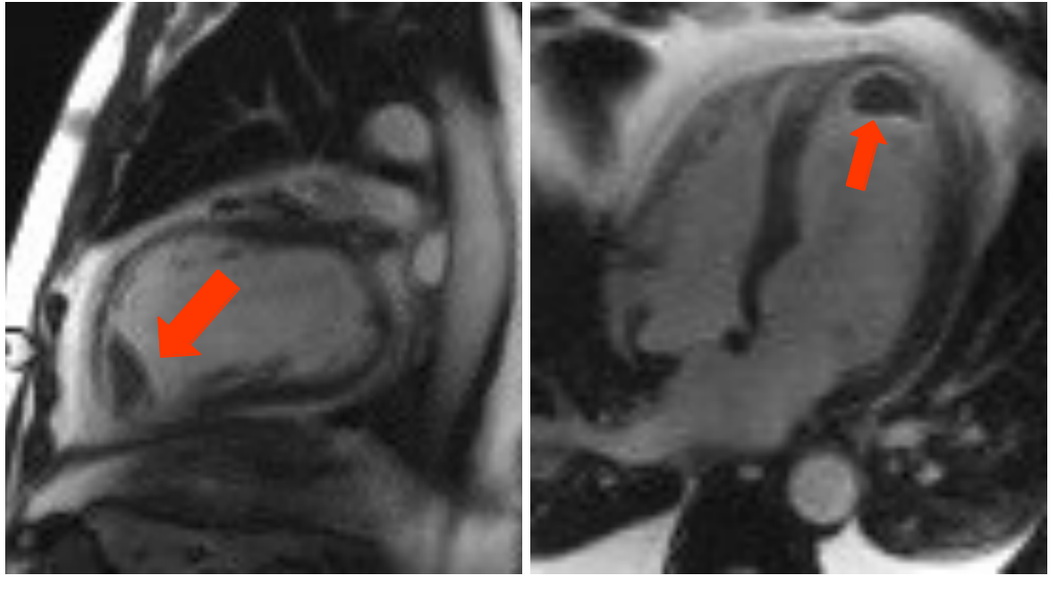


FIGURE 30

Cardiac MRI: LGE sequences showing the presence of a sizeable apical thrombus (**arrows**) in a patient with a previous apical AMI.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 30

心脏 MRI：LGE 序列显示，既往心尖部 AMI 患者存在相当大的心尖部血栓（箭头）。

Cardio-myopathies and Myocarditis

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

心肌病和心肌炎

/ Non-Coronary Artery Diseases

Myocarditis

/ MRI (diagnostic and prognostic role)

Cardiomyopathies

/ Echocardiography (first diagnostic and functional evaluation)

/ MRI (comprehensive diagnostic, functional and prognostic evaluation)

Valvulopathies

/ Echocardiography (diagnostic role and quantification of flow defects)

/ CT (morphological study, detection of calcifications, important preoperative role)

/ MRI (thorough flow rate and functional study)

Pericardial Diseases

/ Echocardiography (detection of pericardial effusion)

/ CT (detection of pericardial effusion and calcifications)

/ MRI (differential diagnosis of pericardial thickening)

Congenital Heart Disease

/ Echocardiography (morphological and functional evaluation)

/ Cardiac MRI and Magnetic resonance angiography (thorough anatomical and functional assessment)

/ CT angiography (best anatomical characterisation)

Cardiac Masses

/ Echocardiography (detection of the abnormality)

/ CT (best anatomical characterisation)

/ MRI (follow up)

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

/ 非冠状动脉疾病

章节大纲：

心肌炎

/ MRI（诊断和预后评估作用）

心肌病

/ 超声心动图（初步诊断与功能评估）

/ MRI（全面诊断、功能及预后评估）

瓣膜病

/ 超声心动图（诊断作用及血流异常定量分析）

/ CT（形态学研究、钙化检测，重要术前评估作用）

/ MRI（完整血流动力学与功能研究）

心包疾病

/ 超声心动图（心包积液检测）

/ CT（心包积液与钙化检测）

/ MRI（心包增厚的鉴别诊断）

先天性心脏病

/ 超声心动图（形态学及功能学评估）

/ 心脏 MRI 和磁共振血管成像（全面解剖与功能评估）

/ CT 血管成像（最佳解剖结构显示）

心脏肿块

/ 超声心动图（异常病变检测）

/ CT（最佳解剖结构显示）

/ MRI（随访监测）

/ Myocarditis

Myocarditis is inflammation of the myocardium, it is usually either infectious or autoimmune in aetiology and can have a wide spectrum of different clinical presentations, ranging from a completely asymptomatic course to acute cardiac failure, with chest pain being a common symptom in most cases.

The population affected is typically younger than the one more at risk for myocardial infarction, the differential diagnosis between the two conditions is anyway very important, and can be troublesome, as myocarditis typically shows elevation of cardiac enzymes and alterations of the ECG as well. It shouldn't come as a surprise therefore, that myocarditis underlies many cases of acute chest pain with completely negative coronary angiograms.

<∞> REFERENCE

Chetrit M, Friedrich MG. The unique role of cardiovascular magnetic resonance imaging in acute myocarditis. F1000 Res. 2018;7:F1000 Faculty Rev-1153. Published 2018 Jul 30.

Baeßler B, Schmidt M, Lücke C etal. Modern Imaging of Myocarditis: Possibilities and Challenges. Fortschr Röntgenstr 2016; 188: 915 – 925.

While the gold standard in the diagnosis of myocarditis remains endomyocardial biopsy, cardiac MRI is a fundamental diagnostic tool in this setting.

- In the acute setting cardiac MRI shows presence of intramyocardial oedema and delayed enhancement. Distinction of myocardial infarction and myocarditis is allowed by the distribution of the enhancement, subendocardial and dependent on coronary artery distribution in myocardial infarction, subepicardial and irrespective of coronary arteries in myocarditis.
- In the chronic setting, oedema will disappear, while the myocardial scar will remain visible as a stripe of delayed enhancement.
- Useful prognostic information comes from cardiac MRI thanks to several parameters, including extension of delayed enhancement, degree of functional compromise and involvement of the right ventricle. The utility of designing follow-up scans is still being debated, as several cases heal completely while other go on to develop ventricular dilation and congestive heart failure.

Cardiac CT can only be useful to exclude other causes of analogous clinical presentation.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心肌炎

心肌炎是心肌的炎症，病因通常是感染性或自身免疫性，临床表现多样，从完全无症状到急性心力衰竭，其中胸痛是大多数病例的常见症状。

受累人群通常比心肌梗死高危人群更年轻，但两者的鉴别诊断至关重要且可能具有挑战性，因为心肌炎同样可出现心肌酶升高和心电图改变。因此，许多冠状动脉造影完全阴性的急性胸痛病例最终确诊为心肌炎并不罕见。

虽然心肌炎诊断的金标准仍然是心内膜心肌活检，但心脏 MRI 是这种情况下的重要诊断工具。

- 急性期心脏 MRI 显示存在心肌内水肿和延迟强化。心肌梗死与心肌炎的鉴别依据强化分布模式，心肌梗死呈心内膜下分布且与冠状动脉供血区域分布一致，心肌炎则呈心外膜下分布且与冠状动脉供血区域无关。
- 慢性期水肿消退，而心肌瘢痕仍表现为条带状延迟强化。
- 心脏 MRI 通过多项参数提供有价值的预后信息，包括延迟强化范围、心功能受损程度及右心室受累情况。设计随访扫描的实用性仍存争议，因部分病例可完全康复，而另一些可能进展为心室扩张和充血性心力衰竭。

心脏 CT 仅适用于排除其他类似临床表现的疾病。

<∞> 参考文献

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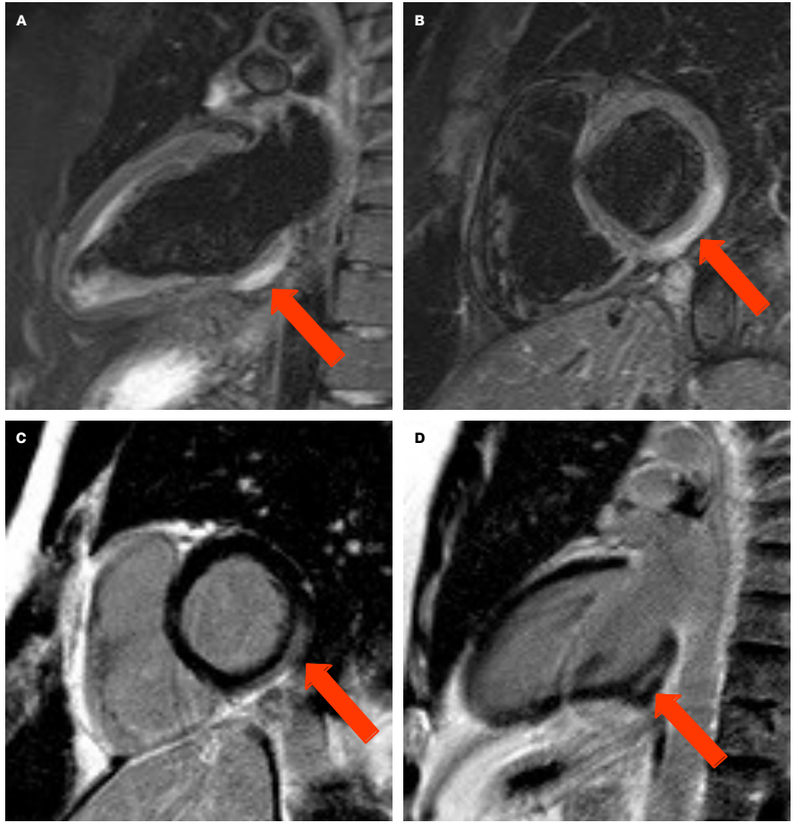

FIGURE 31

Cardiac MRI in a case of acute myocarditis:

A and **B**: T2 fat suppressed images showing an increased signal of the inferior and infero-lateral wall, due to the presence of oedema, with a subepimesocardial distribution pattern.

C and **D**: LGE sequences showing pathological parietal enhancement of the same segments, due to the presence of necrosis/fibrosis, with a subepimesocardial distribution pattern.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 31

急性心肌炎患者的心脏 MRI 表现：

A 和 **B**：T2 脂肪抑制图像显示下壁及下侧壁信号增高，呈心外膜下分布模式，提示水肿存在。

C 和 **D**：LGE 序列显示同一节段的心肌壁病理性强化，呈心外膜下分布模式，提示坏死组织/纤维化。

/ Cardiomyopathies

Cardiomyopathies form a heterogeneous group of diseases in which the heart is abnormal in structure or function in the absence of ischaemic, valvular, hypertensive and congenital causes.

Cardiomyopathies are most commonly classified according to their phenotype as dilated cardiomyopathy, non-dilated left ventricle cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy and restrictive cardiomyopathy, irrespective of their true aetiology.

- Echocardiography is commonly the first test used to find abnormalities in these patients, but it can only provide broad morphological and functional information, with no insights on aetiology and prognosis.
- Cardiac MRI is an invaluable tool in many of these diseases, as it gives the best functional evaluation, important morphological information and crucial prognostic and etiological classification.

Hypertrophic cardiomyopathy is most often genetic in origin but can also result from amyloidosis or Fabry disease. It is characterised by increased wall thickness (hypertrophy), characteristically asymmetrical and often associated to outflow tract obstruction. Microscopically we can appreciate fibrosis and disarray of the muscular fibres, which are the likely cause of the increased risk of sudden death.

Cardiac CT can only be useful to exclude other causes of analogous clinical presentation.

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Arbelo, E., Protonotarios, A., Gimeno, J. R., Arbustini, E., Barriales-Villa, R., Basso, C., ... & Kaski, J. P. (2023). 2023 ESC Guidelines for the management of cardiomyopathies: Developed by the task force on the management of cardiomyopathies of the European Society of Cardiology (ESC). European heart journal, 44(37), 3503-3626.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心肌病

/ 心脏影像学

章节大纲：

心肌病是一组异质性疾病，其特征为在排除缺血性、瓣膜性、高血压性和先天性病因后，心脏存在结构或功能异常。

心肌病通常根据表型分为扩张型心肌病、非扩张型左室心肌病、致心律失常性右室心肌病和限制型心肌病，而不考虑其真实病因。

- 超声心动图通常是发现这些患者异常的首选检查，但仅能提供宏观的形态和功能信息，无法揭示病因和预后。
- 心脏 MRI 是评估这类疾病的重要工具，因其可提供最佳功能评估、重要形态学信息以及关键的预后和病因分类。

肥厚型心肌病多为遗传性，但也可由淀粉样变性或法布里病引起。其特征为室壁增厚（肥厚），呈非对称性，且常伴流出道梗阻。微观上可观察到纤维化及肌纤维排列紊乱，这可能是猝死风险增加的原因。

心脏 CT 仅适用于排除其他类似临床表现的疾病。

<∞> 参考文献

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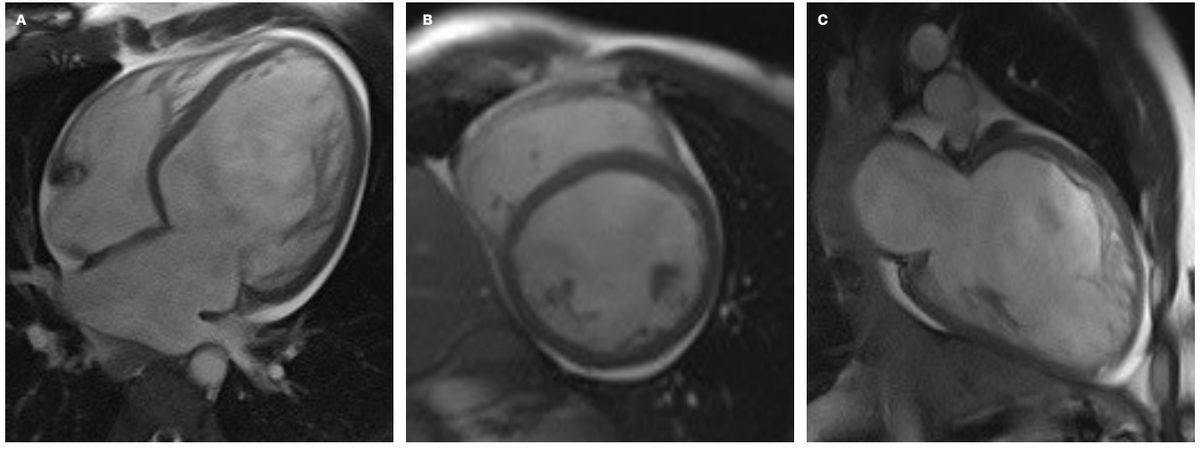

FIGURE 32

Cardiac MRI showing increased volumes of the cardiac chambers in a patient with dilated cardiomyopathy (Left ventricle parameters: EDV/Body surface area 151 mL/m² normal values in the same age and sex group: 53-97) on 4 chamber (**A**), short axis (**B**) and 2 chamber (**C**) plane.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 32

心脏 MRI 显示扩张型心肌病患者心腔容积增大（左心室参数：EDV/体表面积 151 mL/m²，高于同年龄同性别人群正常值：53-97），分别为四腔心切面 (**A**)、短轴切面 (**B**) 及两腔心切面 (**C**)。

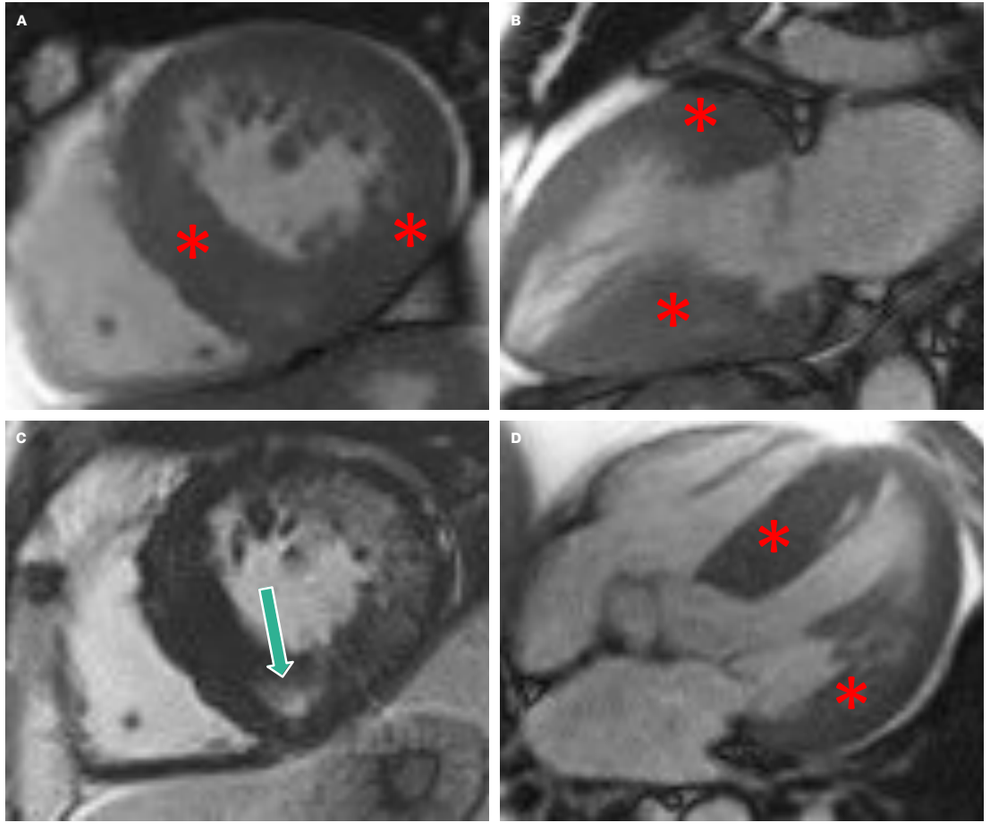

FIGURE 33

Cardiac MR of a patient with hypertrophic cardiomyopathy showing ventricular wall thickening (**asterisks**), mostly affecting septal and inferior wall, in short axis (**A** and **C**), 2 chamber (**B**) and 4 chamber (**D**) view. (**C**): LGE sequence showing an area of fibrosis in the inferior interventricular junction (**arrow**).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 33

肥厚型心肌病患者的心脏 MR 显示心室壁增厚（星号），主要累及间隔壁和下壁，分别为短轴切面（A 和 C）、两腔心切面 (B) 和四腔心切面 (D)。(C)：LGE 序列显示下壁室间隔交界处纤维化病灶（箭头）。

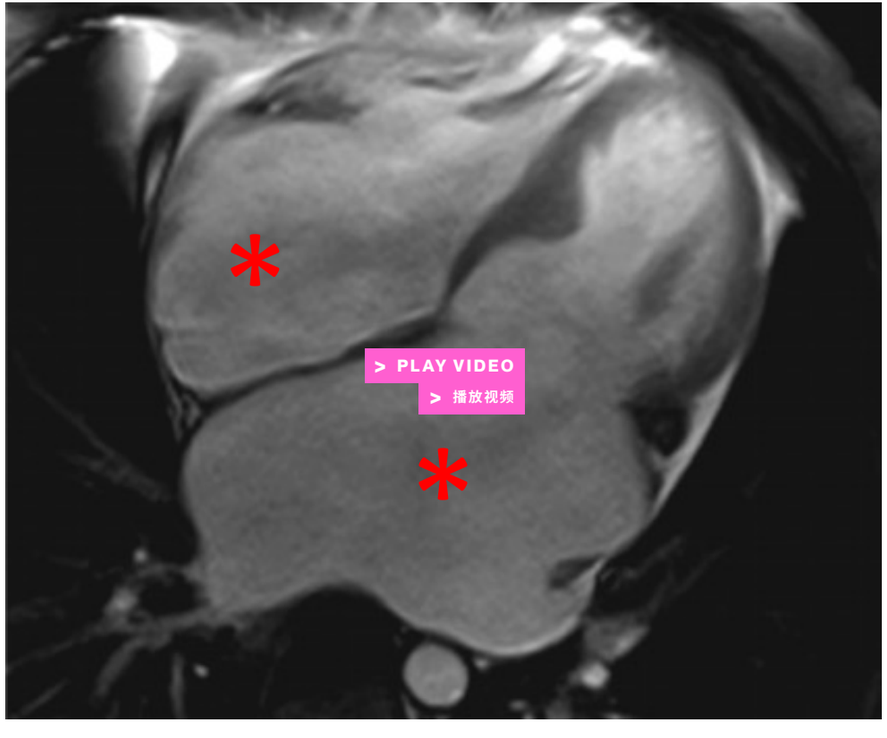

FIGURE 34

Cine-MRI in four chamber view, showing decreased compliance and impaired relaxation of the left ventricle in a patient with restrictive cardio-myopathy. Dilated atria (**asterisks**).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 34

四腔心切面 cine-MRI 显示限制型心肌病患者左心室顺应性降低及舒张功能受损。心房扩大（星号）。

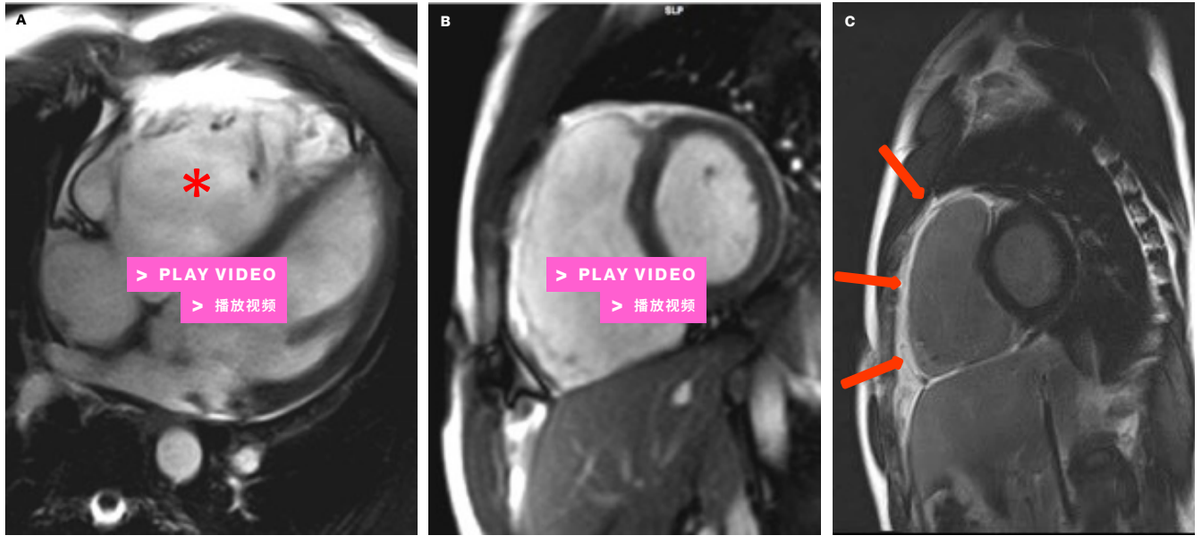

FIGURE 35

Cine-MRI (**A** and **B**) showing right ventricular dilatation (**asterisk**, Right ventricle (**asterisk**) end-dyastolic volume/body surface area:

171.8 mL/m^2 normal values for the same age and sex group : 67-111) with decreased Ejection Fraction (EF: 14%). Motility is clearly reduced.

C. LGE sequence showing diffuse pathological parietal enhancement of the right ventricular wall, due to fatty infiltration and fibrosis typical of arrhytmogenic right ventricular dysplasia (ARVD).

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

图 35

Cine-MRI（**A** 和 **B**）显示右心室扩张（星号），右心室（星号）舒张末期容积/体表面积：

171.8 mL/m^2，高于同年龄段同性别人群正常值：67-111），伴射血分数降低 (EF: 14%)。室壁运动明显减弱。

C. LGE 序列显示右心室壁弥漫性病理性强化，由致心律失常性右心室发育不良 (ARVD) 典型的脂肪浸润和纤维化所致。

Pericardial Disease

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

心包疾病

/ Pericardial Disease

Pericardial effusion results from accumulation of more than 50 mL in the pericardial sac, it is a common finding in a wide spectrum of pathologies.

- Chest X-ray can detect effusion only when pericardial fluid is more than 200 mL, and will be seen as a globular, enlarged cardiac silhouette (water bottle configuration)
- Echocardiography is accurate in describing the amount of effusion, that will appear as hypoechoic material between the two layers of pericardium, and will also give information on the haemodynamic effect on the heart of such effusion. Echocardiography is also useful to plan and guide pericardiocentesis
- Detection of effusion at CT is very easy when you see material with the density of water surrounding the heart. CT can also very often give insights on the cause of effusion
- Effusion at MRI will be easily recognised as hyperintense material surrounding the heart on T2 sequences

Pericarditis can be seen as a thickening of the pericardium, that will be enhanced by the uptake of contrast

- CT and MRI are the only two modalities able to reliably identify pericarditis

Cardiac tamponade is caused by a rapidly developing pericardial effusion that compromises the functionality of the heart

- Echocardiography is the most important modality in this clinical scenario, as it allows for localisation of the effusion, assessment of the heart function and guidance of the pericardiocentesis

<∞> REFERENCES

Eur Heart Cardiovasc Imaging (2015) 16, 12-31

Insights Imaging. (2019); 10

Quant Imaging Med Surg. (2016) 6, 274–284

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心包疾病

/ 心脏影像学

章节大纲：

心包积液是指心包腔内液体量超过 50 mL，是多种疾病的常见表现。

- 胸部 X 线仅在积液量超过 200 mL 时才能检测出，表现为球形增大的心影（水瓶征）
- 超声心动图能准确评估积液量（显示为心包两层间的低回声区），并可分析积液对心脏的血流动力学影响。超声心动图还能用于规划及引导心包穿刺术
- CT 检测积液非常容易，表现为心脏周围水样密度影。且常能提示积液病因
- 在 MRI 的 T2 序列上，积液表现为心脏周围的高信号区域

心包炎可见心包增厚，增强后可见对比剂摄取

- CT 和 MRI 是仅有的能可靠识别心包炎的两种检查方式

心包填塞由快速进展的心包积液导致心脏功能受损引起

- 在此临床疾病中，超声心动图是最重要的检查手段，可对积液定位、评估心脏功能并引导心包穿刺

<∞> 参考文献

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Insights Imaging. (2019); 10

Quant Imaging Med Surg. (2016) 6, 274–284

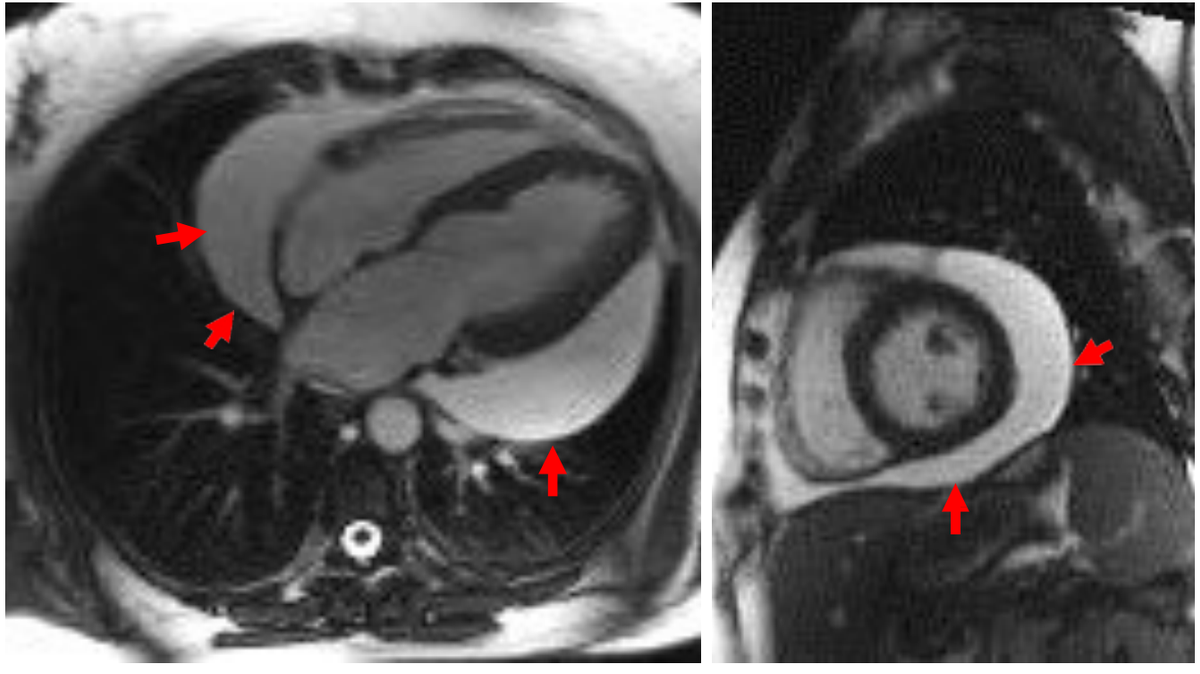

FIGURE 36

Cardiac MRI showing profuse circumferential pericardial effusion (**arrows**) in a patient with systemic lupus erythematosus (SLE).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 36

系统性红斑狼疮 (SLE) 患者的心脏 MRI 显示大量环形心包积液（箭头）。

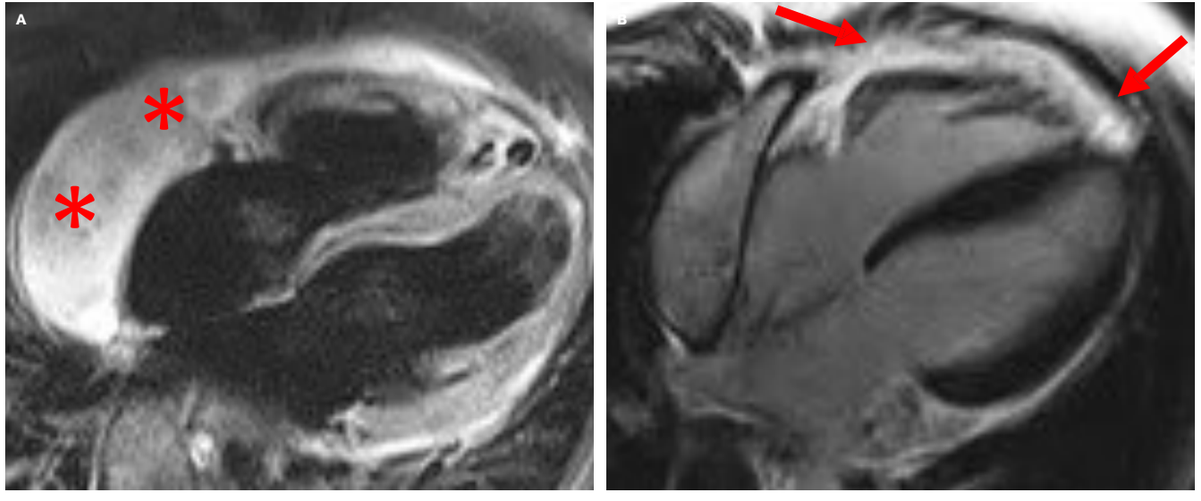

FIGURE 37

Cardiac MRI in a patient with pericarditis: **A**) T2 fat saturated sequence showing massive pericardial effusion (**asterisks**). **B**) LGE sequence showing enhancement of pericardial layers (**arrows**).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 37

心包炎患者的心脏 MRI 表现：**A**) T2 脂肪饱和序列，显示大量心包积液（星号）。**B**) LGE 序列显示心包层强化（箭头）。

Congenital Heart Disease

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

先天性心脏病

/ Congenital Heart Disease (CHD)

Congenital Heart Diseases are alterations in cardiac structures that are present at birth.

There are several congenital defects, mostly involving cardiac wall, heart valves or large blood vessels, with different clinical presentations, ranging from an asymptomatic picture to severe Heart Failure (HF).

They can be isolated, but more often there is an association with other congenital anomalies, in a syndromic clinical picture.

They can be distinguished on the basis of clinical features in Cyanotic and Acyanotic CHD, but the most useful classification is the physiopathological one, which comprehends:

- / CHD with increased pulmonary blood flow
- / CHD with reduced or normal pulmonary blood flow
- / CHD with reduced systemic flow

The most common CHD is the biscuspid aortic valve, followed by Interventricular Septum Defect and Interatrial Septum Defect.

The first step in evaluation of CHD is echocardiography, but it often detects just indirect signs of CHD, such as altered Qp/Qs values and/or cardiac chamber enlargement, and the suspicion of CHD has to be confirmed by a second-level modality, such as MRI.

MRI is the best modality in evaluating cardiac defects (with morphological sequences) and how they affect cardiac function(cine-MR). It is also useful in the follow-up of patients who underwent surgical correction of CHD.

<∞> REFERENCES

Br J Radiol. (2011) 84, S258–S268

Diagnostic and Interventional Imaging (2016) Volume 97, Issue 5, Pages 505-512

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 先天性心脏病 (CHD)

/ 心脏影像学

章节大纲：

先天性心脏病指出生时即存在的心脏结构异常。

这类疾病包含多种先天性缺陷，主要累及心壁、心脏瓣膜或大血管，临床表现多样，从无症状到重度心力衰竭 (HF) 不等。

此类疾病可单独存在，但更多情况下合并其他先天性异常，形成综合征表现。

根据临床特征可分为紫绀型和非紫绀型 CHD，但最有价值的分类是基于病理生理学分型：

- / 肺血流量增加的 CHD
- / 肺血流量减少或正常的 CHD
- / 体循环血流减少的 CHD

最常见的 CHD 是二叶式主动脉瓣，其次是室间隔缺损和房间隔缺损。

超声心动图是评估 CHD 的第一步，但通常仅能发现 CHD 的间接征象，如 Qp/Qs 值改变和/或心腔扩大，疑似病例需通过 MRI 等二级检查确诊。

MRI 是评估心脏缺陷（通过形态学序列）及其对心脏功能影响（电影序列）的最佳成像方式。该技术对 CHD 术后随访也具有重要价值。

<∞> 参考文献

Br J Radiol. (2011) 84, S258-S268

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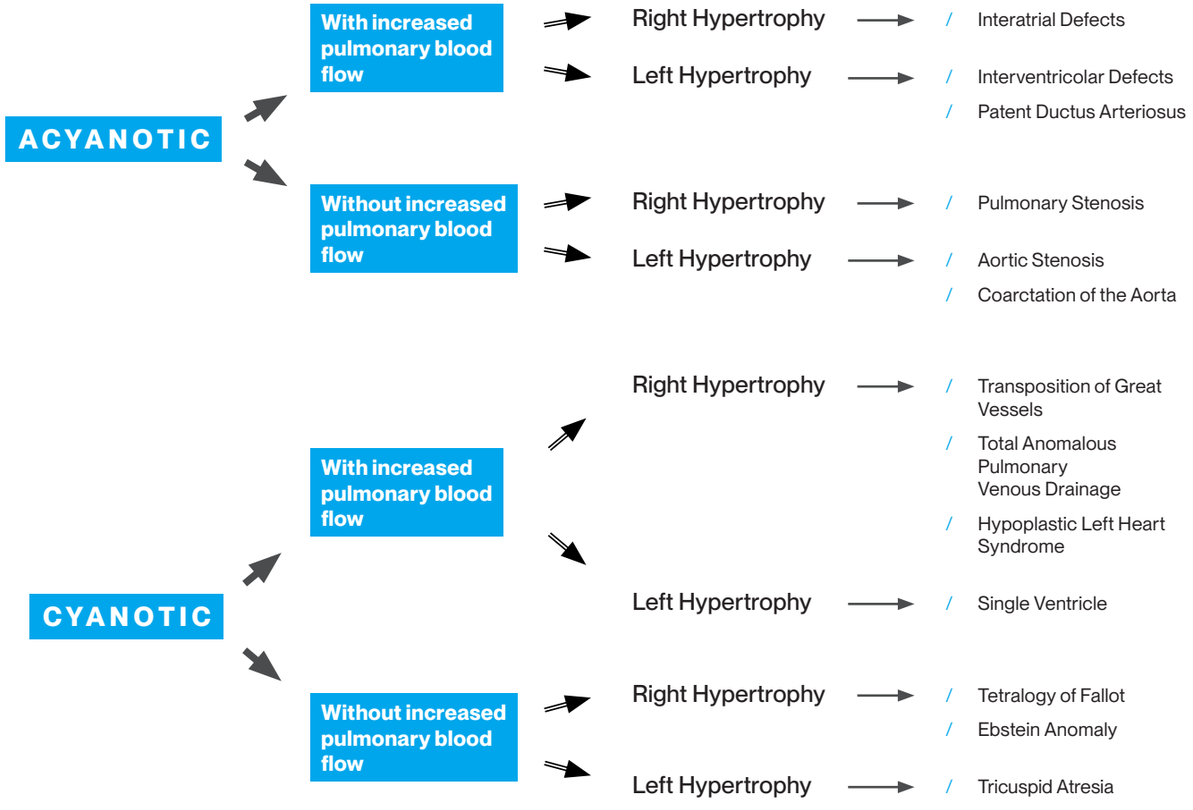
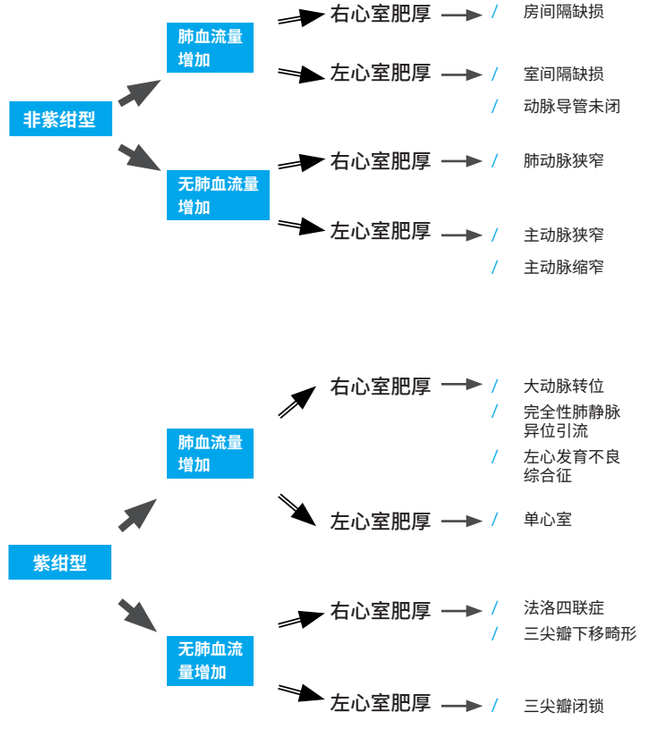


Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：



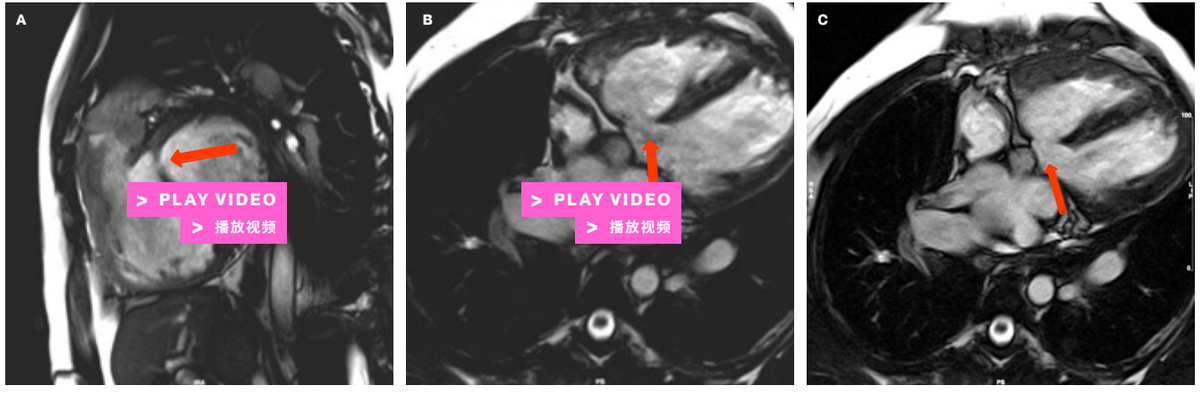


FIGURE 38

Cardiac MR images in short-axis (**A**) and four chambers (**B** and **C**) views, showing a large interventricular septum defect (**arrows**).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 38

心脏 MR 图像短轴切面 (A) 和四腔心切面（B 和 C），显示大型室间隔缺损（箭头）。

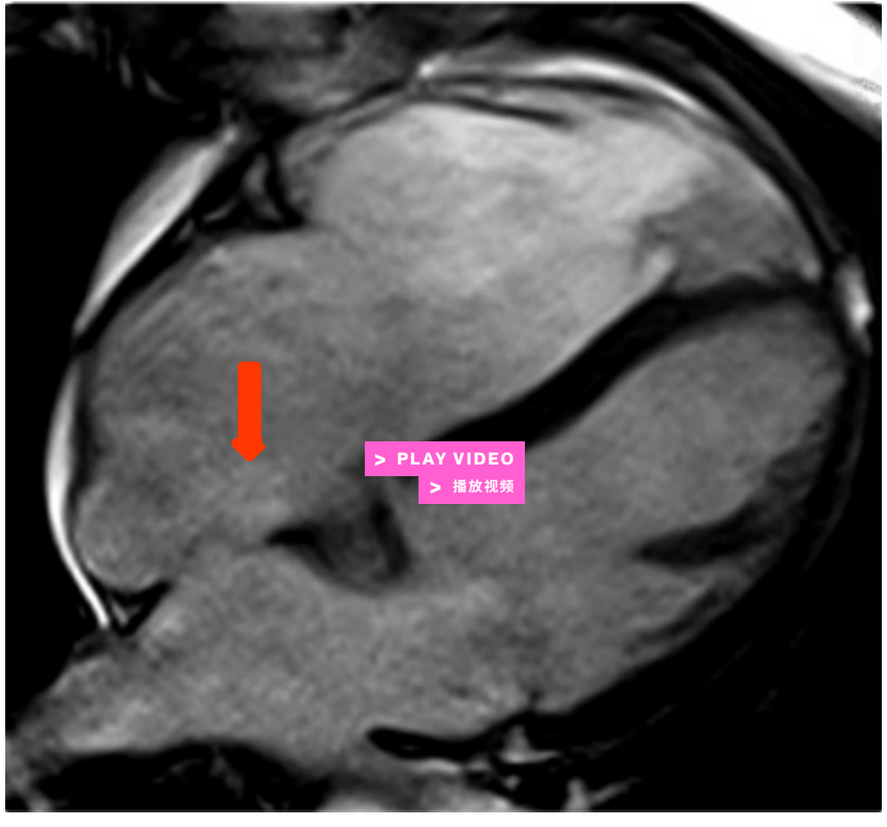


FIGURE 39

Cardiac MRI, in a four chamber view, showing a large interatrial septum defect (**Red arrow** points at the jet phenomenon due to blood turbulence on the cine series caused by the defect).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 39

心脏 MRI 四腔心切面显示大型房间隔缺损（**红色箭头**所指为电影序列中因缺损导致血流湍流形成的射流现象）。

Cardiac Masses

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

心脏肿块

/ Cardiac Masses

Cardiac masses can be divided in tumour and non-tumour ones. The most common finding is non-tumour masses, which comprehend thrombi and misinterpretation of normal variants of cardiac structures.

Tumours can be distinguished in **primary** cardiac tumours and cardiac metastases, which are more common. Primary cardiac tumours are exceedingly rare, usually originating from mesenchymal tissue and mostly benign.

The most common benign cardiac tumour is myxoma, although the most common malignant tumour is cardiac angiosarcoma. Non-mesenchymal tumours comprehend teratoma (which can be benign or malignant) and lymphoma.

Cardiac masses are usually first detected at echocardiography, but cardiac CT and MRI can reveal some characteristics useful in distinguishing tumour from non-tumour masses and benign from malignant tumours. These findings mostly comprehend location, size, margins, tissue composition, the presence of a feeding artery, calcification or pericardial effusion.

<∞> REFERENCES

Echo Res Pract. (2016) 3, R65–R77

Korean J Radiol. (2009) 10, 164–175. AJR Am J Roentgenol. (2011) 197(5), W837–W841

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/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 心脏肿块

心脏肿块可分为肿瘤性与非肿瘤性两大类。其中非肿瘤性占位（包括血栓和心脏结构正常变异的误判）更为常见。

肿瘤性病变又可分为**原发性**心脏肿瘤和更常见的心脏转移瘤。原发性心脏肿瘤极其罕见，通常起源于间充质组织，且多为良性。

最常见的良性心脏肿瘤是黏液瘤，最常见的恶性肿瘤则是心脏血管肉瘤。非间叶组织来源的肿瘤包括畸胎瘤（可以是良性或恶性）和淋巴瘤。

心脏肿块通常首先由超声心动图发现，但心脏 CT 和 MRI 可显示一些有助于鉴别肿瘤性与非肿瘤性占位以及良性与恶性肿瘤的特征。这些特征主要包括位置、大小、边缘、组织成分、是否存在供血动脉、钙化或心包积液。

<∞> 参考文献

Echo Res Pract. (2016) 3, R65–R77

Korean J Radiol. (2009) 10, 164–175. AJR Am J Roentgenol. (2011) 197(5), W837–W841

Curr Cardiovasc Imaging Rep. (2014) 7(8), 9281

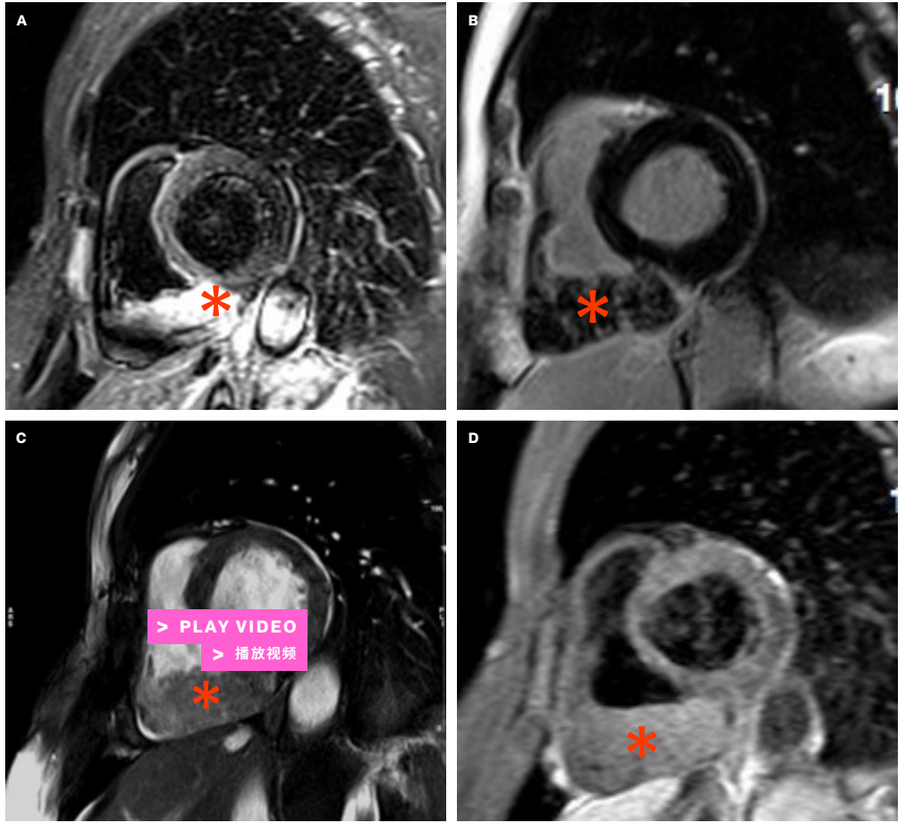


FIGURE 40

STIR (T2 fat suppresed) (**A**) LGE (**B**) cine-MR (**C**) and T1 (**D**) images in short axis view, showing a large cardiac metastasis (**asterisk**) in a patient with known melanoma.

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 40

短轴位 STIR（T2 脂肪抑制）(**A**)、LGE (**B**)、电影序列 (**C**) 和 T1 (**D**) 图像，显示已确诊黑素瘤的患者出现巨大心脏转移瘤（星号）。

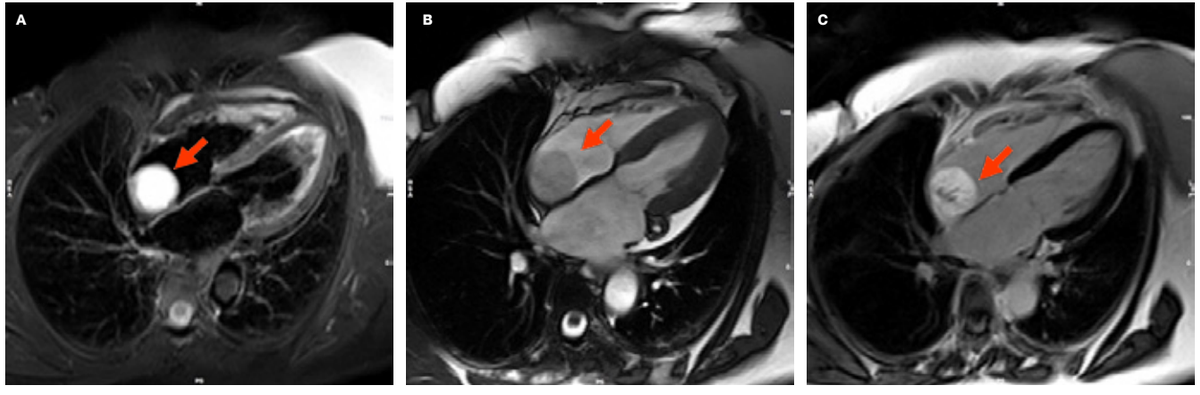


FIGURE 41

STIR (**A**), cine-MR (**B**) and LGE(**C**) images of a 4 chamber view showing a typical appearance of right atria myxoma (**arrows**).

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

图 41

四腔心切面 STIR (**A**)、电影序列 (**B**) 和 LGE (**C**) 图像显示右心房黏液瘤典型表现（箭头）。

Test Your Knowledge

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

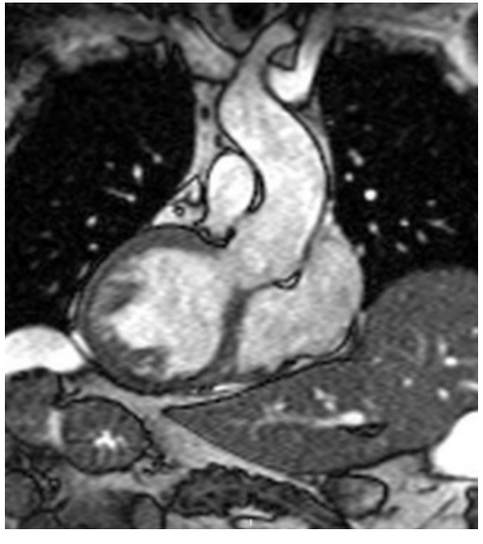
章节大纲：

知识测试

Test Your Knowledge

<?> QUESTION

1 Which anomaly do you see on this MRI-image?



Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

知识测试

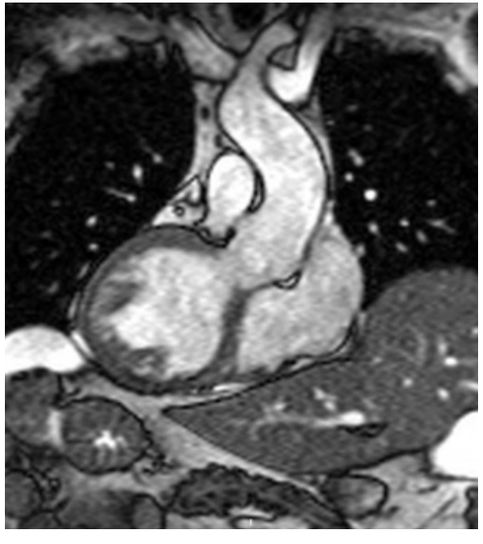
<?> 问题

1 该 MRI 图像显示何种异常？

/ Test Your Knowledge

<?> ANSWER

1 Which anomaly do you see on this MRI-image?



This is a case of situs inversus, as you can see by looking at the position of the different organs and at the directions towards which the heart is pointing.

CHAPTER OUTLINE:

章节大纲：

/ 知识测试

<?> 回答

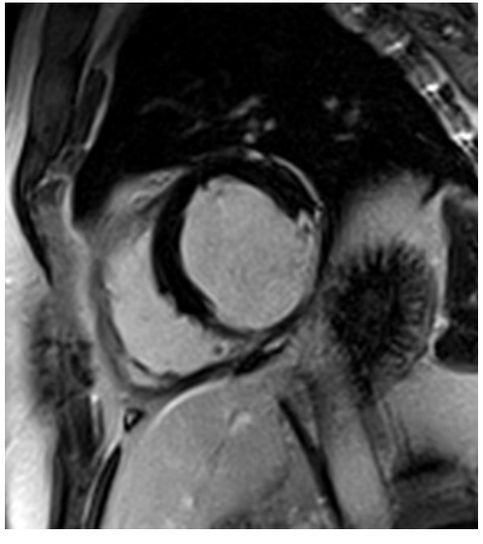
1 该 MRI 图像显示何种异常？

本例为内脏反位，可通过各器官位置及心脏指向的方向判断。

/ Test Your Knowledge

<?> QUESTION

2 How would you describe this cardiac MRI image?



/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 知识测试

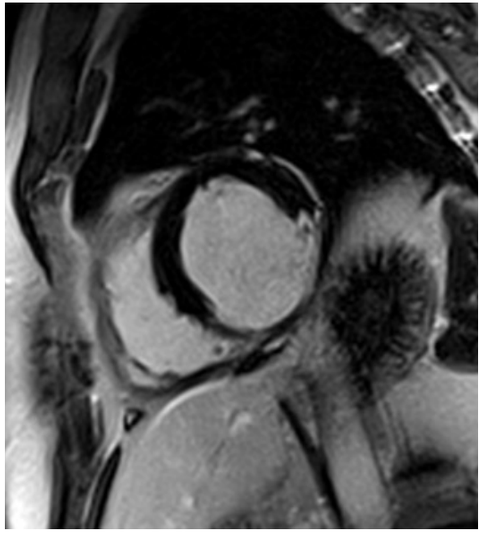
<?> 问题

2 如何描述这张心脏 MRI 图像?

/ Test Your Knowledge

<?> ANSWER

2 How would you describe this cardiac MRI image?



This is an LGE sequence, short axis view. The inferior wall of the left ventricle is markedly thinned, while the remaining segments seem unaffected.

/ Cardiac Imaging

CHAPTER OUTLINE:

/ 心脏影像学

章节大纲：

/ 知识测试

<?> 回答

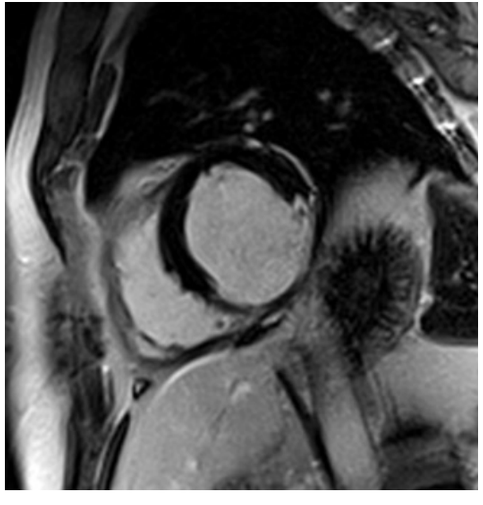
2 如何描述这张心脏 MRI 图像?

这是一个短轴切面的 LGE 序列。左心室下壁明显变薄，其余节段未见受累。

Test Your Knowledge

<?> QUESTION

3 Can you give an aetiopathological explanation of these findings? Which is the most likely cause?



Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

知识测试

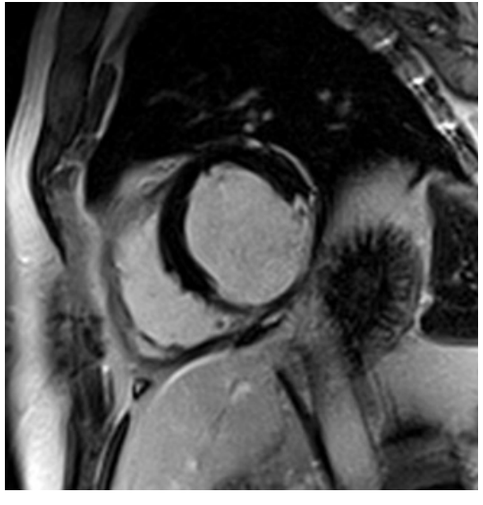
<?> 问题

3 如何解释这些表现的病因病理机制？最可能的病因是什么？

Test Your Knowledge

<?> ANSWER

3 Can you give an aetiopathological explanation of these findings? Which is the most likely cause?



This is the result of long-term remodelling of an area of myocardium subjected to ischaemia and, subsequently, to fibrosis. The most likely cause is a previous myocardial infarction.

Cardiac Imaging

CHAPTER OUTLINE:

心脏影像学

章节大纲：

知识测试

<?> 回答

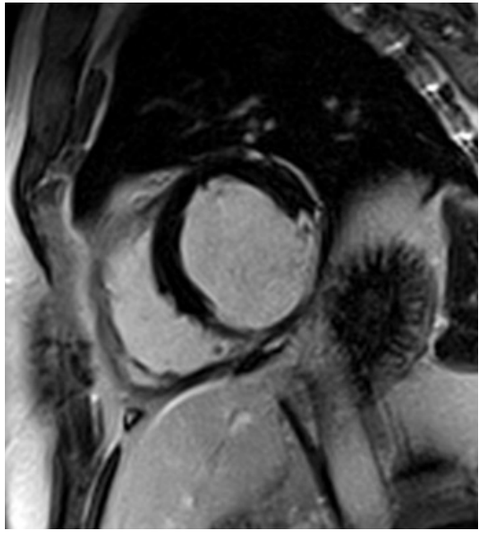
3 如何解释这些表现的病因病理机制？最可能的病因是什么？

这是心肌缺血区域长期重塑导致纤维化的结果。最可能的病因是既往心肌梗死。

/ Test Your Knowledge

<?> QUESTION

4 Can you guess which coronary artery was involved?



/ Cardiac Imaging

CHAPTER OUTLINE:

/ 知识测试

/ 心脏影像学

章节大纲：

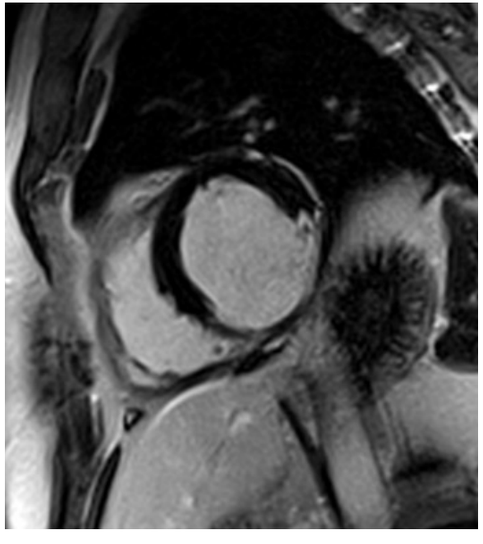
<?> 问题

4 推测受累的冠状动脉是哪一支？

/ Test Your Knowledge

<?> ANSWER

4 Can you guess which coronary artery was involved?



It was the right coronary artery, which typically perfuses the inferior and inferoseptal walls of the left ventricle.

/ Cardiac Imaging

CHAPTER OUTLINE:

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章节大纲：

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<?> 回答

4 推测受累的冠状动脉是哪一支？

受累血管为右冠状动脉，其通常供血左心室下壁及下间隔壁。

/ Test Your Knowledge

<?> QUESTION

5 A 50-year-old male arrives to the attention of his family doctor because of a complain of stable angina and exertional dyspnoea. He doesn't smoke, but is overweight and has a family history of major cardiovascular events. The physician prescribes an ECG stress test, but the results are inconclusive. Which is the best next step?

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<?> 问题

5 一名 50 岁的男性患者因稳定型心绞痛和劳力性呼吸困难就诊。患者无吸烟史，超重，有主要心血管事件家族史。负荷心电图结果不明确，下一步最佳检查是什么？

/ Test Your Knowledge

<?> ANSWER

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Given the young age of the patient and the inconclusive ECG stress test, the best next step is to perform a coronary CT angiogram.

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鉴于患者年龄较轻且负荷心电图结果不明确，下一步最佳检查为冠状动脉 CT 血管成像。

/ Test Your Knowledge

<?> QUESTION

6 Here is the major finding of this exam, can you describe it? Do you think it may be the cause of symptoms?

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<?> 问题

6 该检查的主要发现是什么？这可能是导致症状的原因吗？

/ Test Your Knowledge

<?> ANSWER

6 Here is the major finding of this exam, can you describe it? Do you think it may be the cause of symptoms?

This is an atherosclerotic plaque in the left anterior descending artery. The plaque is mixed and causes severe stenosis of the lumen (70%). The patient is at risk and should undergo invasive coronary angiography for further characterisation and possibly treatment of the stenosis.

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<?> 回答

6 该检查的主要发现是什么？这可能是导致症状的原因吗？

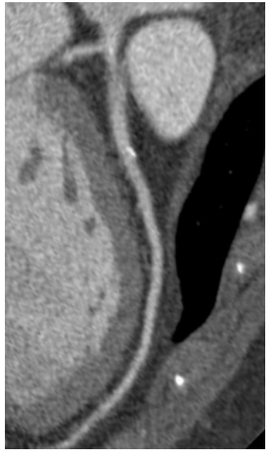
发现左前降支存在动脉粥样硬化斑块。此为混合性斑块，导致管腔重度狭窄 (70%)。患者存在风险，需行侵入性冠状动脉造影进一步评估并可能对狭窄进行治疗。

Test Your Knowledge

<?> QUESTION

7

A 32-year-old male arrives to the Emergency Department complaining of acute, compressive, chest pain radiating to the left arm. The LV function is depressed at echocardiography. The main clinical suspicion is acute myocardial infarction, but the ECG only shows non-specific anomalies of ventricular repolarisation. This finding, together with the young age of the patient, convince the physicians to perform a Triple-rule-out CT scan. The only pathological finding can be seen here, affecting the left anterior descending coronary artery, can you spot it?



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<?> 问题

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一名 32 岁的男性患者因突发压迫性胸痛并向左臂放射至急诊科就诊。超声心动图显示左心室功能减低。临床主要怀疑为急性心肌梗死，但心电图仅显示非特异性心室复极异常。这一发现结合患者年轻特点，促使医生进行胸痛三联征 CT 扫描。唯一病理性发现位于冠状动脉左前降支，您能识别吗？

/ Test Your Knowledge

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There is a small calcified plaque on the left anterior descending artery.

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左前降支动脉有小钙化斑块。

Test Your Knowledge

<?> QUESTION

8 The only abnormality seen on CT angiography was a small calcified plaque of the left anterior descending artery. Could it be responsible for the clinical presentation of chest pain?

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<?> 问题

8 CT 血管成像显示的唯一异常是左前降支动脉的小钙化斑块。这可能是导致胸痛临床表现的原因吗?

/ Test Your Knowledge

<?> ANSWER

8 The only abnormality seen on CT angiography was a small calcified plaque of the left anterior descending artery. Could it be responsible for the clinical presentation of chest pain?

The small calcified plaque is very unlikely to be responsible for the patient's symptoms.

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<?> 回答

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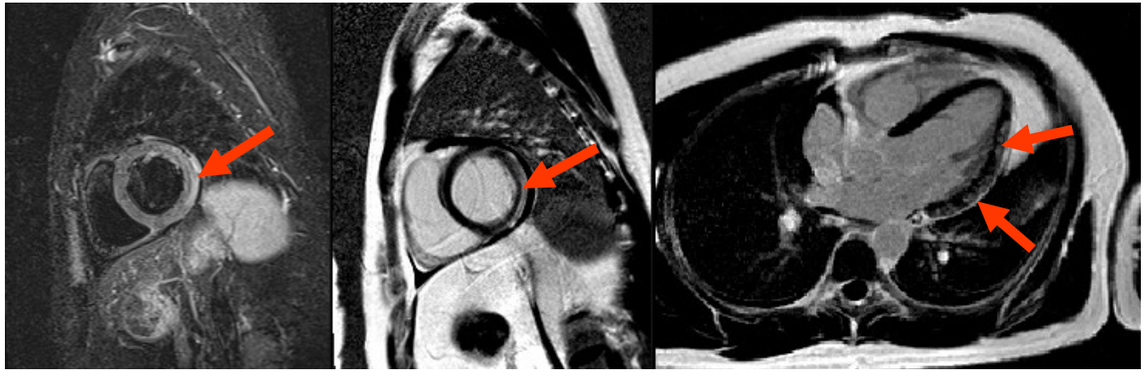
小钙化斑块不太可能是引起患者症状的原因。

/ Test Your Knowledge

<?> QUESTION

9 The acute symptomatology subsides, but the heart function remains depressed. The patient undergoes cardiac MRI 6 days after the acute episode. Here are some selected images from the MRI exam. What are the main findings?



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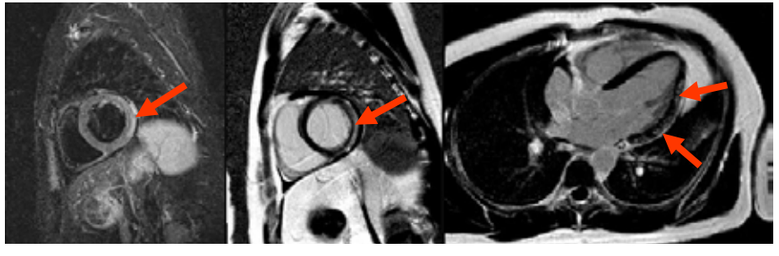

The STIR image (left) shows myocardial oedema in the inferolateral wall. LGE images (centre and right) show subepicardial enhancement, which has a patchy distribution. These findings are most likely consistent with myocarditis.

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STIR 图像（左图）显示下侧壁的心肌水肿。LGE 图像（中图和右图）显示心外膜下强化，呈斑片状分布。这些表现最符合心肌炎改变。