MODERN RADIOLOGY eBook

Vascular Imaging

血管成像

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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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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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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血管成像

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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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/ Signage

<▪> CORE KNOWLEDGE

<!> ATTENTION

<↑> HYPERLINKS

>▪< FURTHER KNOWLEDGE

>|< COMPARE

<∞> REFERENCES

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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

Vascular Imaging

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章节大纲：

基于 ESR 课程的放射学教育

血管成像

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Introduction

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章节大纲：

简介

/ Introduction

Advances made over the last decade in vascular imaging have enabled us to uncover some of the underlying mechanisms of vascular diseases. Many efforts have been made to establish the evaluation of atherosclerotic plaque progression and vascular inflammatory changes in addition to other biomarkers and clinical manifestations.

Non-invasive cross-sectional imaging techniques play a crucial role in the assessment of the varied manifestations of vascular disease and intervention planning.

For general anatomical, histological and physiological information regarding the vascular system, please refer to your knowledge obtained during your studies in previous years.

This chapter addresses basic concepts of vascular imaging and the most relevant pathologies. Some vascular pathologies and their imaging aspects are already included in other e book chapters, e.g., cardiac imaging, small and large bowel imaging, central nervous system imaging, emergency radiology or chest imaging.

<∞> REFERENCE

> see respective eBook chapters

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章节大纲：

/ 简介

过去十年在血管成像方面取得的进展使我们能够揭示血管疾病的一些潜在机制。除了其他生物标志物和临床表现外，人们还做了许多工作来评估动脉粥样硬化斑块进展和血管炎症变化。

无创横断面成像技术在评估血管疾病的各种表现和制定干预措施中起着至关重要的作用。

有关血管系统的一般解剖学、组织学和生理学信息，请参考您在过去几年的学习中获得的知识。

本章阐述了血管成像的基本概念和最相关的病理学。一些血管病变及其成像方面的内容已经包含在电子书的其他章节中，例如心脏成像、小肠和大肠成像、中枢神经系统成像、急诊放射学或胸部成像。

<∞> 参考文献

> 请参阅相应的电子书章节

Vascular Imaging Techniques

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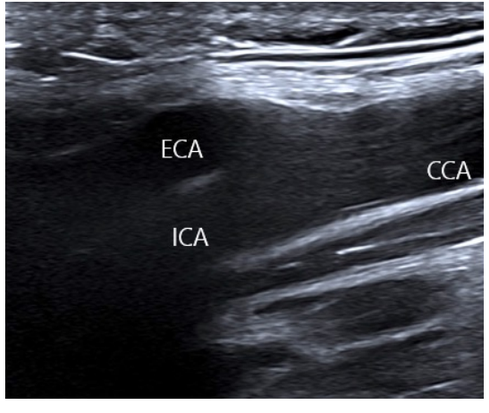
章节大纲：

血管成像技术

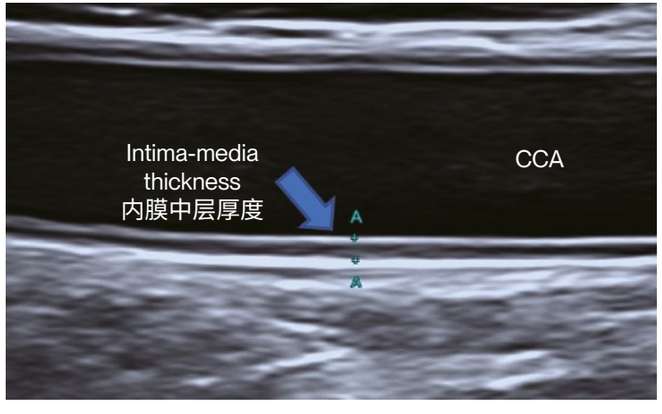
/ Ultrasound (US)

Ultrasound (US) is often the initial screening test for the evaluation of the peripheral vascular system and of the vasculature of some visceral organs, e.g., liver and kidneys.

The examination usually starts with the **B-mode or grayscale mode** - the "normal mode" which allows us to identify the vessel of interest, evaluate its walls, the presence of plaques and vessel narrowing/stenosis.



Sagittal grey-scale B-mode US image showing the common carotid artery (CCA) branching into the internal (ICA) and external carotid artery (ECA).



Sagittal grey-scale B mode US showing the left common carotid artery with a normal intima-media complex measuring 0.8 mm (> 1 mm is taken as abnormal).

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章节大纲：

/ 超声 (US)

超声 (Ultrasound，US) 通常是评价外周血管系统和某些内脏器官（如肝脏和肾脏）脉管系统的一线筛查方法。

检查通常以 **B 模式或灰度模式**（“正常模式”）开始，可识别目标血管，评估血管壁，确定是否存在斑块和血管变窄/狭窄。

矢状位灰度 B 型超声图像显示颈总动脉 (common carotid artery，CCA) 及其颈内动脉 (ICA) 和颈外动脉 (ECA) 分支。

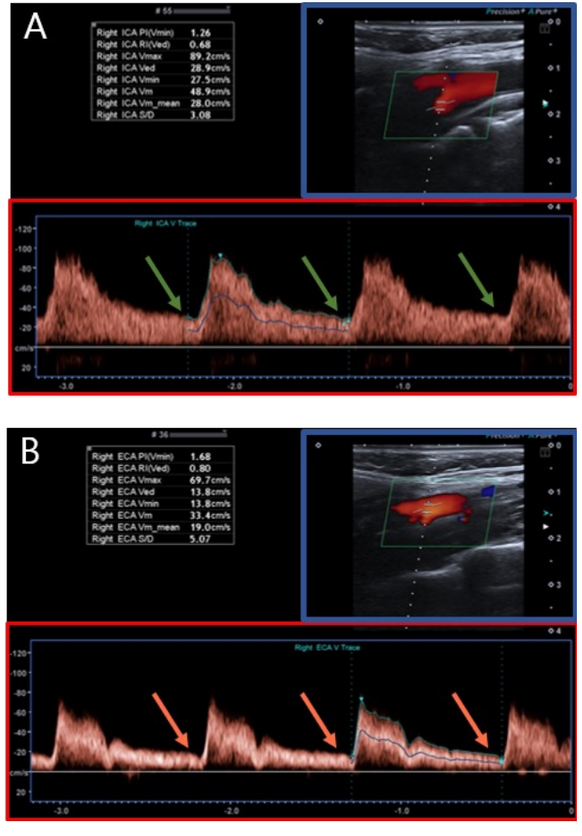
矢状位灰度 B 型超声显示左颈总动脉内膜中膜复合体正常，测量值为 0.8 mm（> 1 mm 视为异常）。

/ Doppler Ultrasound (Doppler-US)

To evaluate if the stenosis (i.e. due to an atherosclerotic plaque) is hemodynamically significant we employ more complex US modes like **Doppler imaging**.

Doppler imaging includes:

- **Colour Doppler – blue** (changes colour inside blood vessels depending on flow and speed of blood)
- **Spectral Doppler – red** (blood flow information is represented in a graph, as a waveform, where the quantitative values can be derived)



Triplex Doppler (M-Mode, Colour Doppler and Spectral Doppler) of the internal carotid artery (ICA) (A) and of the external carotid artery (ECA) (B). The ICA (A) demonstrates a low-resistance pattern with robust diastolic flow (arrows) because it is supplying the brain (which needs constant blood flow). The ECA (B) demonstrates a **high-resistance waveform** and a **low diastolic flow** (arrows).

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章节大纲：

/ 多普勒超声 (Doppler-US)

为了评估狭窄（动脉粥样硬化斑块导致）是否具有血流动力学意义，我们采用**多普勒成像**等更复杂的超声模式。

多普勒成像包括：

- **彩色多普勒 - 蓝色**（根据血流和速度改变血管内颜色）
- **频谱多普勒 - 红色**（血流信息在图中表示为波形，可从中得出定量值）

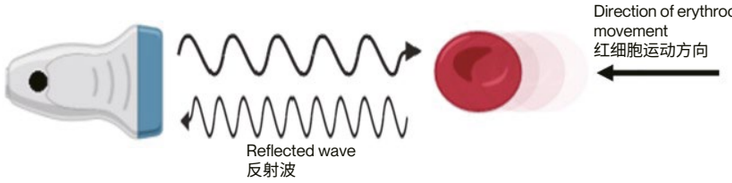
颈内动脉 (internal carotid artery，ICA) (A) 和颈外动脉 (external carotid artery，ECA) (B) 的三重多普勒（M 模式、彩色多普勒和频谱多普勒）。ICA (A) 显示低阻力模式和稳健的舒张期血流（箭头），因为它为大脑供血（需要恒定的血流）。ECA (B) 显示**高阻力波形**和**低舒张期血流**（箭头）。

When sound waves hit an object, some of the sound waves are reflected to the sound source. If the reflector is **stationary**, the **reflected sound waves** will **have the same frequency as the sound waves emitted by the sound source**.

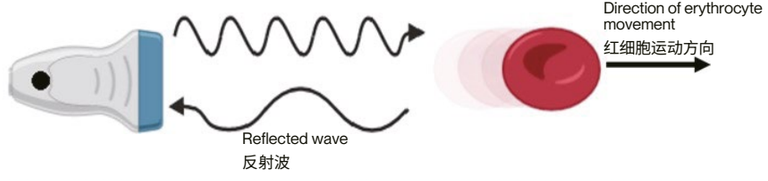
If the reflector is in **motion** - like **red blood cells (RBC)** inside the vessels - the **frequency of the reflected sound waves** will differ from the original emitted sound waves (by our probe).

This change in frequency is also known as the **Doppler effect**.

This change in frequency is then used to calculate the velocity and the direction of flow.



When the RBC are moving towards the probe, the reflected sound waves are compressed, which leads to shortening of the wavelength and thus an increase in frequency.



On the contrary, when the RBC are moving away from the probe, the reflected sound waves are stretched out, leading to an increase in wavelength and decreased frequency.

>=< FURTHER KNOWLEDGE

Christian Andreas Doppler (1803-1853) – the Austrian physicist who formulated the principle of the Doppler Effect

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章节大纲：

当声波撞击到物体时，一些声波会反射回声源。如果反射体**静止**，**反射的声波将与声源发射的声波频率相同**。

如果反射体处于**运动**状态 - 例如血管内的**红细胞 (red blood cell，RBC) - 反射声波的频率**将与最初发射的声波不同（通过探头检测）。

这种频率变化也称为**多普勒效应**。

可以利用这种频率变化计算流速和流向。

当红细胞向探头移动时，反射的声波被压缩，导致波长缩短，从而使频率增加。

相反，当红细胞远离探头移动时，反射的声波被拉伸，导致波长增加，频率降低。

>=< 进阶知识

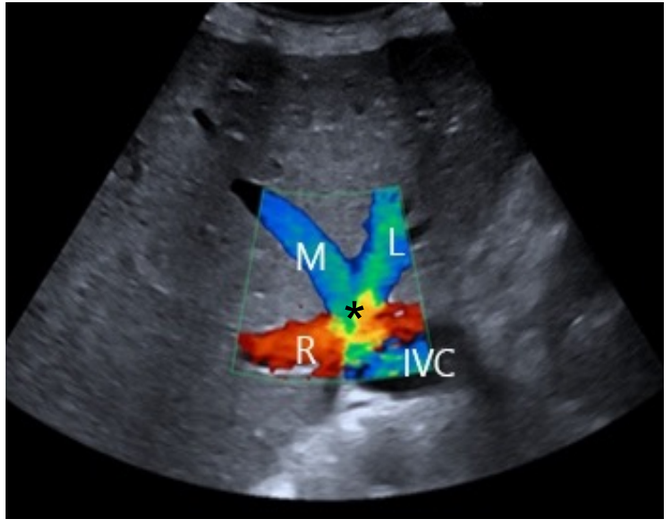
Christian Andreas Doppler (1803-1853) - 阐述多普勒效应原理的奥地利物理学家

This information can be colour coded into a normal ultrasound image. In colour coded Doppler ultrasound, colour type and intensity indicate the direction and speed of the blood flow. By convention:

- Blood flow running away from the probe is depicted in blue
- Blood flow running towards the probe is depicted in red

<!> ATTENTION

If you accidentally rotate the scanner probe by 180 degrees, the colours will switch! And as your probe approaches a 90-angle relative to the vessel, your Doppler signal vanishes altogether!



Hepatic vein sonography: Transverse view of the three main hepatic vein trunks (Right – R; Middle - M; Left – L) as they enter the inferior vena cava (IVC).

Blood inside the hepatic veins usually runs towards the IVC and - depending on the position of the probe - flow will go away from the probe (depicted in blue in the left and middle hepatic vein) or towards the probe (depicted in red in the right hepatic vein).

At the level of convergence of the three veins, the blood flow is turbulent – as seen by the area of aliasing effect (*). Aliasing results in the inability to record the direction and the velocity of blood flow accurately.

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章节大纲：

该信息可用颜色编码为正常超声图像。在颜色编码的多普勒超声中，颜色类型和强度可指示血流的方向和速度。常规：

- 远离探头的血流用蓝色表示
- 流向探头的血流用红色表示

<!> 注意

如果不小心将扫描仪探头旋转了 180 度，颜色将会互换！当探头与血管之间的角度接近 90 度时，多普勒信号将完全消失！

肝静脉超声检查：3 条肝静脉主干（右 - R；中 - M；左 - L）汇入下腔静脉 (inferior vena cava，IVC) 时的横轴位视图。

肝静脉内的血液通常流向 IVC，并且根据探头的位置，血流将远离探头（肝左静脉和肝中静脉中的蓝色所示）或流向探头（肝右静脉中的红色所示）。

在三条静脉会聚的水平，血流为湍流，如混叠效应区域 (*) 所示。混叠导致无法准确记录血流的方向和速度。

Using Spectral Doppler, we can assess the **peak systolic velocity (PSV)** throughout a vessel of interest.

The table on the right shows the reference PSV values in different vessels.

However, more important than the reference PSV values is the variation of velocities (i.e., when assessing a site for a possible stenosis).

BLOOD VESSEL	PSV (CM/S)
Abdominal aorta	100-150
Iliac arteries	100-120
Fermoral artery	80-110
Popliteal artery	50-80
FInternal carotid artery	80 -120
Vertebral artery	25-40
Vena cava	10-45

<!> ATTENTION

Keep in mind that numerous other reasons can account for discrepancies regarding the measured PSV values. Therefore, the proper examination technique, correct patient positioning and proper interpretation of results should be taken in account!

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章节大纲：

使用频谱多普勒，我们可以评估整个靶血管的收缩期峰值流速 (peak systolic velocity，PSV)。

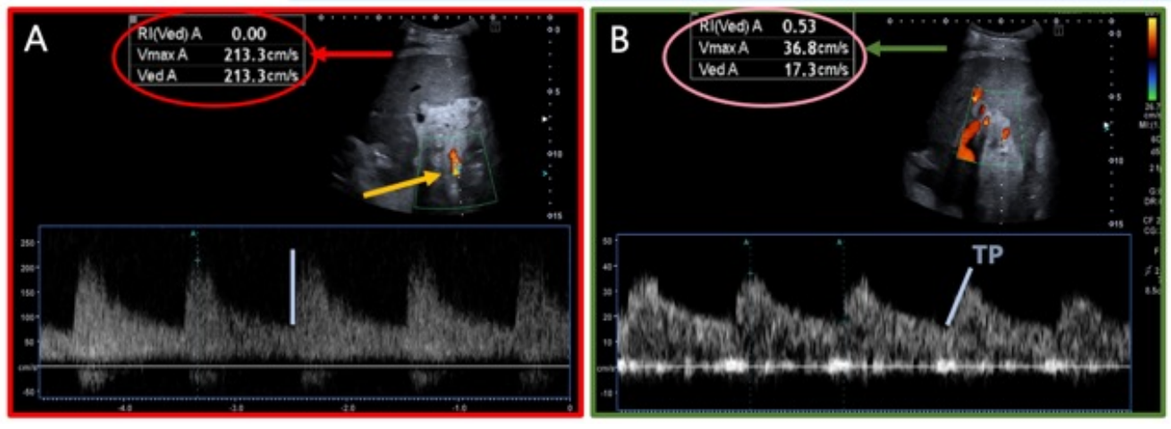
右侧表格显示了不同血管的参考 PSV 值。

然而，比参考 PSV 值更重要的是速度的变化（当评估一个部位有无狭窄时）。

血管	PSV (CM/S)
腹主动脉	100～150
髂动脉	100～120
股动脉	80～110
腘动脉	50～80
颈内动脉	80～120
椎动脉	25～40
腔静脉	10～45

<!> 注意

注意：有很多其他原因可能导致 PSV 测量值不一致。因此，需考虑适当的检查技术、正确的患者体位和正确的结果解读！



Usually the PSV:

- Before the stenosis → is slightly higher (yellow).
- At the site of stenosis → is significantly higher (red).
- After stenosis → is lower (green).

There are a few other "clues" we use to confirm that a site of stenosis is hemodynamically significant besides the variation in PSV:

The two images bellow exemplify a Triplex Doppler in a patient with a recent liver transplant:

- On **A**, the probe is located just above the stenosis; note the aliasing artifact in a segment of the hepatic artery. Spectral Doppler shows a significant elevation of the PSV (arrow)
- Downstream of the stenotic segment (**B**) we have a reduced PSV velocity, with a "Tardus Parvus" (TP) waveform (= prolonged systolic acceleration and small systolic amplitude with rounding of the peak) and a decreased Resistive Index (RI)

RI = (PSV- EDV)/ PSV; EDV = End Diastolic Velocity. The normal RI values vary from one artery to another as they depend on the target organs, which have different flow requirements.

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

通常情况下，PSV 值：

- 在狭窄前→略高（黄色）。
- 在狭窄部位→显著更高（红色）。
- 在狭窄后→较低（绿色）。

除了 PSV 的变化外，还有一些其他"线索"可证明狭窄部位有血流动力学意义：

上面两张图举例说明一例肝移植患者的三重多普勒：

- 在 **A** 中，探头位于狭窄处正上方；注意肝动脉段中的混叠伪影。频谱多普勒显示 PSV 值显著升高（箭头）
- 狭窄段下游 (**B**) 的 PSV 值降低，出现"小慢波"(Tardus Parvus，TP) 波形（= 收缩期加速时间延长，收缩期振幅小，峰值圆顿）和阻力指数 (Resistive Index，RI) 降低

RI = (PSV- EDV)/ PSV；EDV = 舒张末期流速。不同动脉的正常 RI 值不同，具体取决于不同血流需求的靶器官。

Indications for DSA (diagnostic and/or treatment):

- / Aneurysms
- / Thrombosis
- / Vascular abnormalities
- / Arteriovenous malformations and/or fistulas
- / Haemorrhage
- / Complications post-transplant
- / Tumours

>|< COMPARE

ADVANTAGES OF DSA:

- \+ Minimally invasive
- \+ Can be performed on an outpatient basis
- \+ Real time observation
- \+ DSA resolution is superior to the resolution of CTA and MRA
- \+ Ability to perform concurrent endovascular treatment of many pathologies

DISADVANTAGES AND COMPLICATIONS OF DSA:

- – Exposure to X-rays
- – Contrast-related allergic reactions
- – Acute kidney Injury (due to contrast media)
- – Haematoma, infection, thrombus, pseudoaneurysm at the puncture site
- – Vessel dissection (at the puncture site or in a distant location)

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

DSA 的适应证（诊断和/或治疗）：

- / 动脉瘤
- / 血栓形成
- / 血管异常
- / 动静脉畸形和/或瘘管
- / 出血
- / 移植后并发症
- / 肿瘤

>|< 比较

DSA 的优点：

- \+ 微创
- \+ 可在门诊进行
- \+ 实时观察
- \+ DSA 分辨率优于 CTA 和 MRA
- \+ 可同时对多种病变进行血管内治疗

DSA 的缺点和并发症：

- – X 线辐射暴露
- – 对比剂相关过敏反应
- – 急性肾损伤（对比剂所致）
- – 穿刺部位血肿、感染、血栓、假性动脉瘤
- – 血管夹层（穿刺部位或远处）

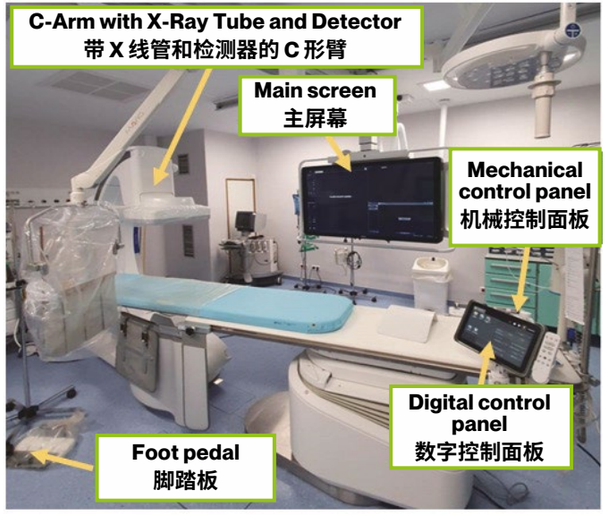
/ Digital Subtraction Angiography (DSA)

Digital Subtraction Angiography (DSA) is an imaging technique, where a catheter is inserted into a blood vessel (for arteriography usually the femoral artery) after which contrast material is injected through the catheter under fluoroscopic guidance. Local anaesthesia is administered at the puncture site.

The **goal** is to visualise blood vessels for diagnostic or radiologic interventional procedures.

First, a **mask** (non-contrast image) is obtained. Then, **consecutive images** of the area to be investigated are acquired at a set rate **during** the injection of contrast material. The mask is subtracted from these images to better visualise the filled vessels (by removing the distracting bony structures or other dense structures). The subtracted images can be seen in **real-time**.

After the DSA, haemostasis is applied at the puncture site and the immobilised patient is carefully observed during usually 4-6 h.



Angio-suite at Coimbra Hospital and University Centre

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 数字减影血管成像 (DSA)

数字减影血管成像 (DSA) 是一种成像技术，检查时将导管插入靶血管（用于动脉造影，通常是股动脉），然后在透视引导下通过导管注射对比剂。在穿刺部位进行局部麻醉。

目的是显示血管，以便进行诊断或放射介入手术。

首先获得**蒙片**（非增强图像）。然后，在注射对比剂**期间**以设定速率采集靶区的**连续图像**。从这些图像中减去蒙片以更好地显示充盈的血管（去除干扰观察的骨结构或其他致密结构）。减影后的图像可以**实时**查看。

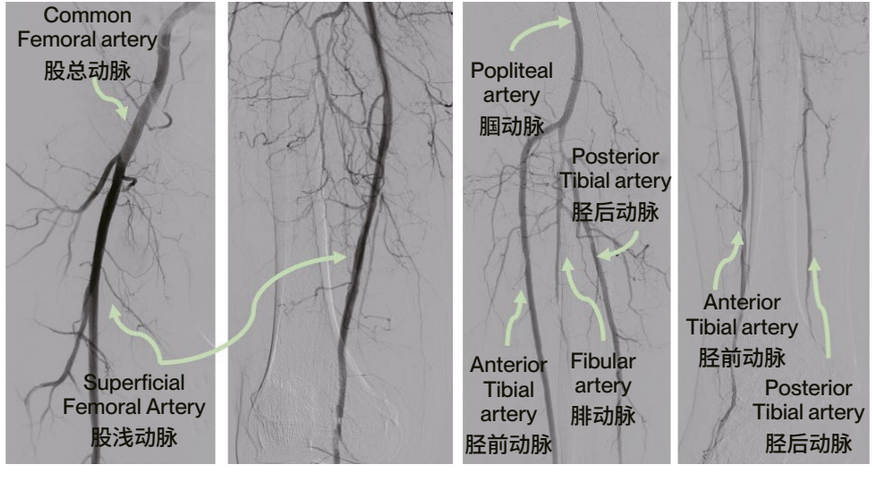
DSA 后，在穿刺部位进行止血，在 4~6 小时内仔细观察固定处。

科英布拉医院和大学中心的血管室

Before performing a DSA, several things must be considered:

- Arterial vs. venous
- Access site (arm, leg, neck etc.)
- Access side (right or left)
- Direction of puncture (antegrade or retrograde)

Access choice depends on the procedure whether it is **diagnostic angiography** or **interventional treatment**, and which is the target site (cerebral blood vessels, peripheral blood vessels, visceral blood vessels, etc.).



Lower Limb Angiography
下肢血管成像

Femoral artery angiography
股动脉血管成像
↓
Distal femoral and popliteal angiography
股骨远端和腘动脉血管成像
↓
Popliteal and proximal tibial angiography
腘动脉和胫骨近端血管成像
↓
Distal tibial and foot angiography
远端胫骨和足部血管成像

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

进行 DSA 前，必须考虑以下几点：

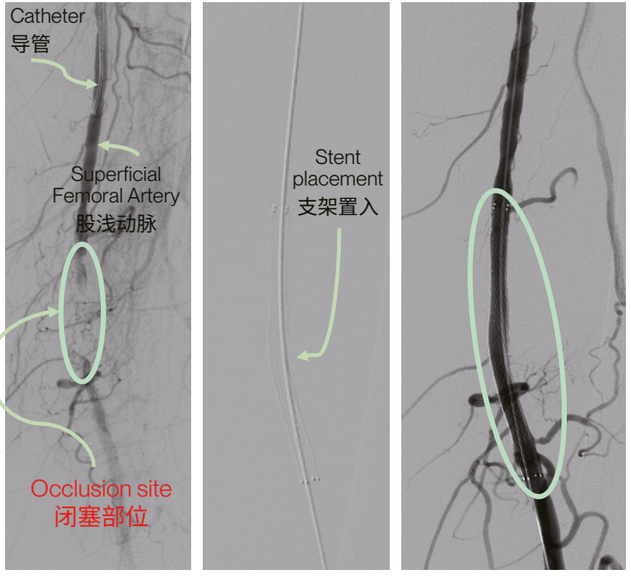
- 动脉 vs. 静脉
- 通路部位（手臂、腿部、颈部等）
- 通路侧（右侧或左侧）
- 穿刺方向（顺行或逆行）

通路的选择取决于手术是诊断性血管成像还是介入治疗以及目标部位（脑血管、外周血管、内脏血管等）。

Endovascular interventional procedures are performed by first getting access to a vessel, usually in the groin (most commonly the femoral artery).

After recanalisation of the stenotic or occluded segment, the artery is **dilated with a balloon** and, if necessary, recanalisation is followed by **stenting**.

Newer developments include **drug-coated balloons** to improve vessel patency and **atherectomy** to debulk calcifications.



Superficial Femoral Artery Stenosis → Stenting→ Post-stenting Result

>▪< FURTHER KNOWLEDGE

Sven Ivar Seldinger (1921-1998) - the Swedish interventional radiologist who pioneered the Seldinger Technique (= gold standard method for vessel catheterisation)

https://www.sciencedirect.com/topics/medicine-and-dentistry/seldinger-technique
Image from: https://www.jvir.org/article/S1051-0443%2821%2901195-7/pdf

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

血管内介入手术的操作步骤是首先进入血管，通常在腹股沟（最常见的是股动脉）。

狭窄或闭塞段再通后，用球囊扩张动脉，如有必要，在再通后置入支架。

较新的发展包括用于改善血管通畅性的药物涂层球囊和用于减少钙化的斑块切除术。

>▪< 进阶知识

Sven Ivar Seldinger (1921~1998) - 开创 Seldinger 技术的瑞典介入放射医生（= 血管导管插入术的金标准方法）

https://www.sciencedirect.com/topics/medicine-and-dentistry/seldinger-technique
图像来源：https://www.jvir.org/article/S1051-0443%2821%2901195-7/pdf

股浅动脉狭窄→支架植入→支架植入后结果

/ Visceral Angiography

It's also possible to access visceral organ arteries and perform DSA. To do so it is necessary to insert the catheter in the femoral artery and then "navigate" through the aorta until the catheter is placed in the desired artery and contrast media is injected.

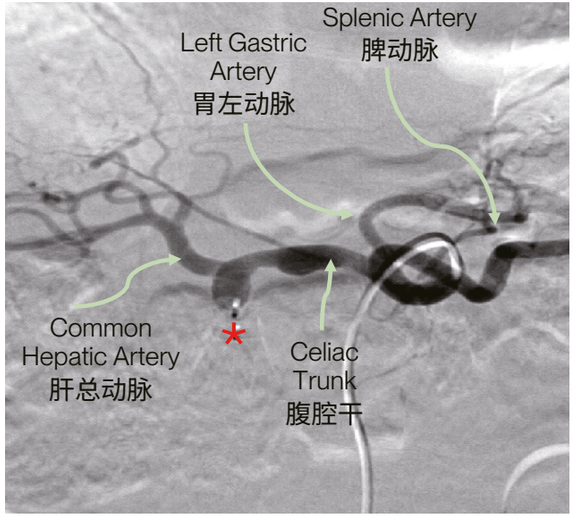
During visceral angiography one may also perform therapeutic interventions, like stenting, embolisation (with coils, «glue» or other materials).

<?> QUESTION

In this case shown on the left the patient had upper gastrointestinal bleeding treated by the deployment of a "metallic plug".

Can you identify the vessel where the plug was inserted?

> **Answer:** Gastroduodenal artery (*)



DSA of the celiac trunk and its branches:

/ Common hepatic artery
/ Left gastric artery
/ Splenic artery

<∞> REFERENCE

> see eBook chapter Interventional Radiology

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 内脏血管成像

此外，还可以进入内脏器官动脉并执行 DSA。为此，有必要将导管插入股动脉，然后向上穿过主动脉，直到将导管放入靶动脉并注射对比剂。

在进行内脏血管成像时，也可以进行治疗干预，如支架植入、栓塞（使用线圈、"凝胶"或其他材料）。

<?> 问题

在左图所示的病例中，通过放置"金属塞"治疗患者的上消化道出血。

你能识别插入塞子的血管吗？

> **答案：**胃十二指肠动脉 (*)

腹腔干及其分支的 DSA：

/ 肝总动脉
/ 胃左动脉
/ 脾动脉

<∞> 参考文献

> 请参阅《介入放射学》电子书章节

DSA of the celiac trunk **showing a stenosis of the proper hepatic artery**, right before it branches into the left and right hepatic arteries (**A**).
On the right you can see an angioplasty of the hepatic artery with **stent implantation** (**B**).

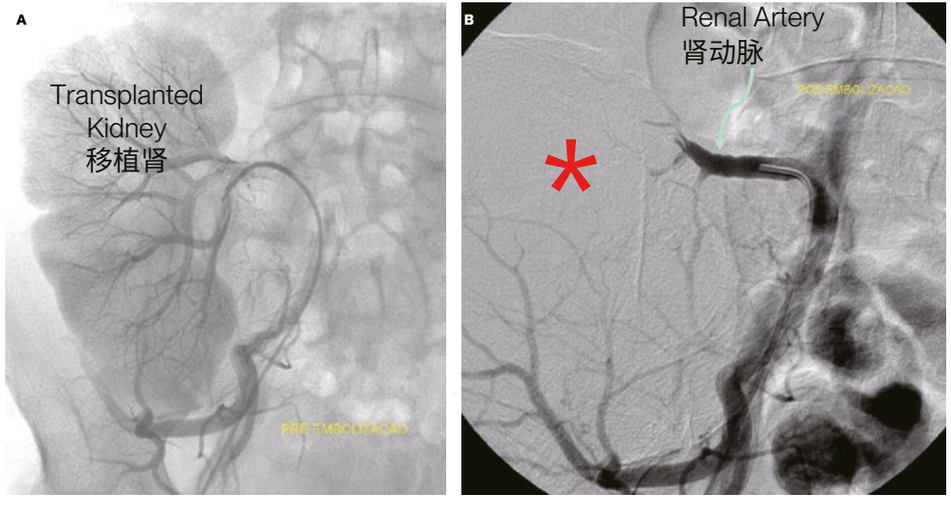
Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

腹腔干 DSA 显示**肝固有动脉狭窄**，恰好位于左右肝动脉分叉前 (**A**)。
在右侧可以看到肝动脉血管成形术及**支架植入** (**B**)。



Right renal angiography catheter access route:
右肾动脉血管成像导管入路：

Right femoral artery
右股动脉
↓
External iliac artery
髂外动脉
↓
Common iliac artery
髂总动脉
↓
Catheter in the right renal artery
右肾动脉导管

DSA of the renal artery of a non-functioning **transplanted kidney** (**A**). On **B** the kidney is no longer visible (*) as it was excluded by embolisation of the **renal artery** (arrow).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

无功能**移植肾**的肾动脉 DSA (**A**)。在 **B** 中，肾脏不再可见 (*)，因为通过**肾动脉**（箭头）栓塞将其清除。

DSA allows not only access to arteries, but we can also access veins!

By performing venography keep in mind in which direction the blood flows.

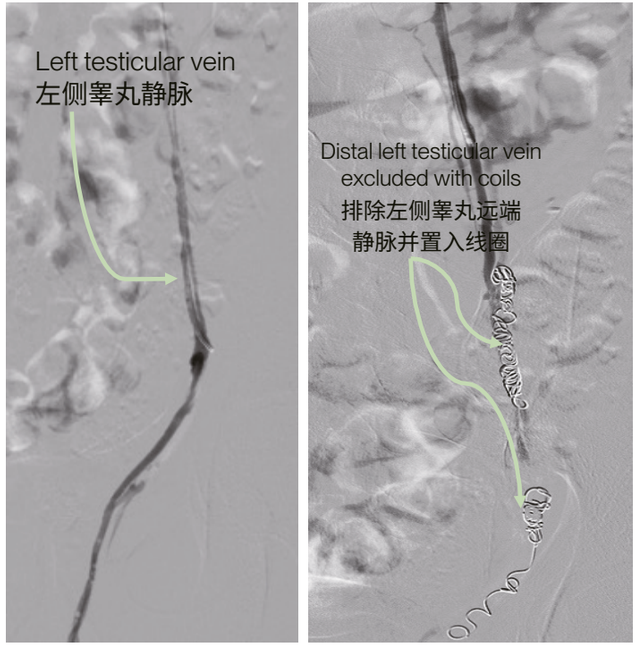
For lower limb and pelvic venography, access is gained through the popliteal vein.

It is also possible to perform interventions, like balloon dilatation, stent implantation, venous filter placement or embolisation.

On the images on the right, we have an example of a left varicocele embolisation via the right femoral vein with coiling of the left testicular vein.

<!> ATTENTION

Isolated right sided varicoceles should be further evaluated for the presence of retroperitoneal disease (e.g., renal cancer) as the right testicular vein drains directly into the inferior vena cava (IVC)!



Access route: Right femoral vein > Inferior vena cava > Left renal vein > Left testicular vein embolisation (coiling)

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

DSA 不仅可以进入动脉，也可以进入静脉！

进行静脉造影时，记住血液流向哪个方向。

下肢静脉和盆腔静脉造影的通路是腘静脉。

还可进行球囊扩张、支架植入、静脉滤器置入或栓塞等干预。

右侧图像中的示例显示通过右股静脉和左睾丸静脉弹簧圈栓塞术进行左侧精索静脉曲张栓塞。

<!> 注意

对于孤立性右侧精索静脉曲张，应进一步评估是否存在腹膜后疾病（如肾癌），因为右侧睾丸静脉直接引流至下腔静脉 (inferior vena cava，IVC)！

通路途径：右股静脉 > 下腔静脉 > 左肾静脉 > 左睾丸静脉栓塞术（弹簧圈栓塞术）

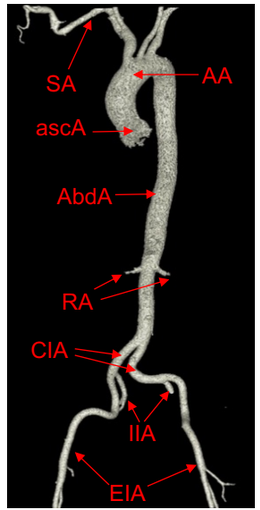
/ Computed Tomography Angiography (CTA)

Computed tomography (CT) angiography (CTA) is a powerful CT scanning technique used for the visualisation of **arteries and veins** (CT venography, CTV) following intravenous contrast injection. It is routinely used for the assessment of the cerebral and neck vessels, chest vessels, coronary arteries, splanchnic, pelvic and peripheral vessels. CTA is a cost-effective, widely available technique, which is less invasive than DSA.

>▪< FURTHER KNOWLEDGE

The actual procedure depends on **institutional protocols and guidelines**, as well as on the **area to be examined**. Nevertheless, the following applies for all different CTA examinations:

- The patient is in the supine position
- Iodinated contrast material is injected in an antecubital vein; the injection rate is about 4-5 ml/s for arterial imaging
- ECG gating can be used in some instances (coronary and chest CTA)
- Arterial phase images are obtained either by monitoring arrival of contrast bolus in the region of interest (bolus tracking) or by administering a test bolus to calculate the optimal scan delay; alternatively pre-defined scan intervals can be used (especially for splanchnic CTA)
- In addition to the axial acquired images, two-dimensional (2D) multiplanar reconstructions (MPR), Maximum Intensity Projections (MIP) and volume rendering (VR) or surface shaded displays (SSD) are used for data analysis



CTA with 3D SSD reconstruction of the entire aorta with the ascending aorta (ascA), aortic arch (AA), subclavian artery (SA), abdominal aorta (AbdA), renal arteries (RA), common iliac arteries (CIA), internal iliac arteries (IIA), external iliac arteries (EIA).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 计算机断层扫描血管成像 (CTA)

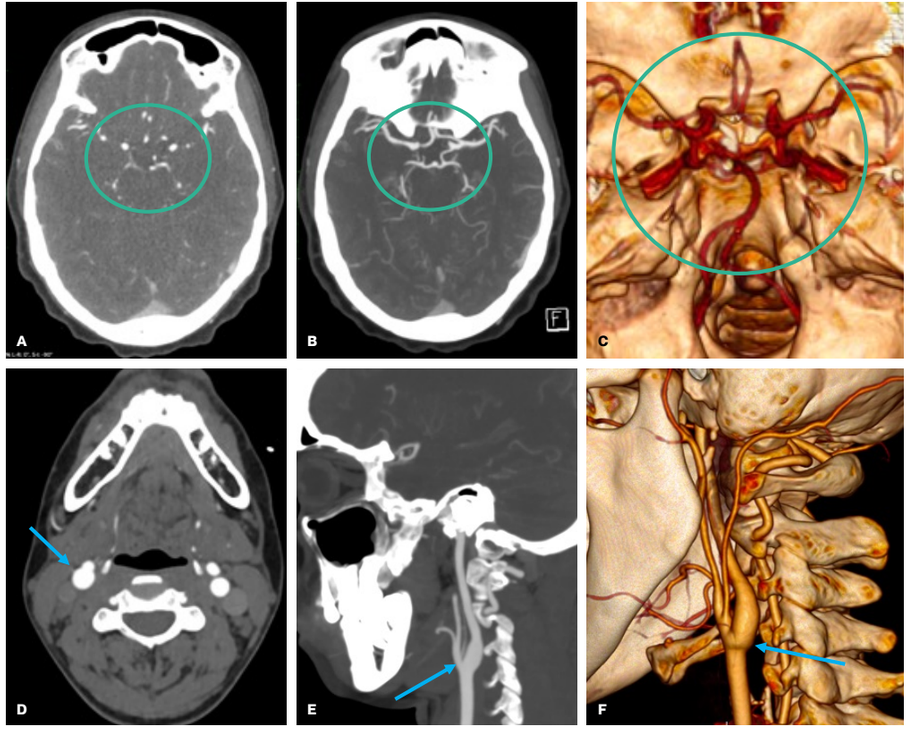
计算机断层扫描 (Computed tomography，CT) 血管成像 (angiography，CTA) 是一种强大的 CT 扫描技术，用于静脉注射对比剂后**动脉和静脉**的成像（CT 静脉造影，CTV）。这种技术常规用于评估脑和颈部血管、胸部血管、冠状动脉、内脏、盆腔和外周血管。CTA 是一种性价比高、应用广泛的技术，其侵入性小于 DSA。

>▪< 进阶知识

实际操作取决于**机构方案和指南**以及**检查靶区**。尽管如此，以下适用于所有不同的 CTA 检查：

- 患者处于仰卧位
- 在肘前静脉注射碘对比剂；用于动脉成像的注射速率约为 4~5 mL/s
- 在某些情况下可使用心电门控（冠状动脉和胸部 CTA）
- 动脉期图像可通过监测对比剂到达靶区（对比剂跟踪）或给予试验对比剂以计算最佳扫描延迟来获得；也可以使用预定义的扫描间隔（特别是对于内脏 CTA）
- 除轴位图像外，还使用二维 (two-dimensional，2D) 多平面重组 (multiplanar reconstruction，MPR)、最大密度投影 (Maximum Intensity Projection，MIP) 和容积再现 (volume rendering，VR) 或表面阴影显示 (surface shaded display，SSD) 进行三维重建后处理分析

整个主动脉的 CTA 及 3D SSD 重建，包括升主动脉 (ascending aorta，ascA)、主动脉弓 (aortic arch，AA)、锁骨下动脉 (subclavian artery，SA)、腹主动脉 (abdominal aorta，AbdA)、肾动脉 (renal arteries，RA)、髂总动脉 (common iliac arteries，CIA)、髂内动脉 (internal iliac arteries，IIA)、髂外动脉 (external iliac arteries，EIA)。



Different types of CTA reconstructions can be obtained from the same contrast-enhanced CT acquisition. In this figure, reconstructions of the polygon of Willis (green circle, **A-C**) and of the right carotid bifurcation (blue arrow, **D-F**) are shown. Both the polygon and the carotid arteries are normal.

The goal in this CTA examination is to achieve maximum contrast enhancement in the arteries with minimal or no enhancement in the venous system.

A and **D**: axial contrast enhanced CT images obtained in the arterial phase (0.75 mm slice thickness).

Axial (**B**) and sagittal (**E**) MIP

3D VR view of the polygon of Willis (green circle) seen from above (**C**) and lateral view of the right carotid bifurcation (blue arrow, **F**).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

一次增强 CT 扫描可获得不同的 CTA 三维重建图像。该图显示脑动脉环（绿色圆圈，**A**～**C**）和右颈动脉分叉（蓝色箭头，**D**～**F**）的重建。脑动脉环和颈动脉均正常。

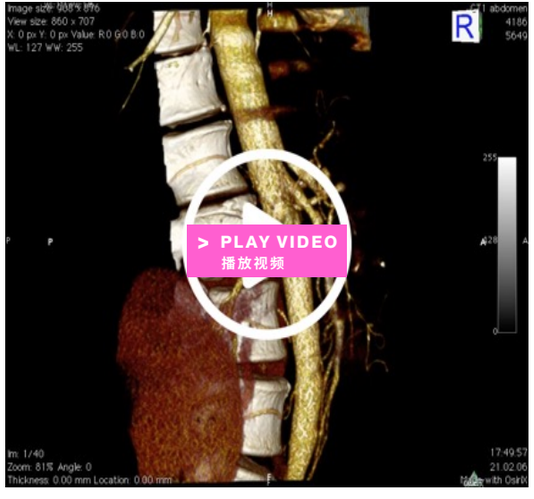
该 CTA 检查的目的是实现动脉的最大对比增强，同时静脉系统的增强最小或不显示。

A 和 **D**：动脉期获得的轴位增强 CT 图像（0.75 mm 层厚）。

轴位 (**B**) 和矢状位 (**E**) MIP 图像

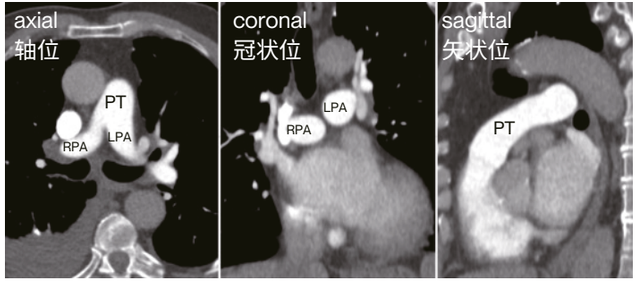
从上方看到的脑动脉环（绿色圆圈）的 3D VR 视图 (**C**) 和右颈动脉分叉的侧视图（蓝色箭头，**F**）。

Figures illustrating normal CTA reconstructions from different anatomical regions, as used in clinical routine.



CTA 3D VR of the aorta, celiac trunk, superior mesenteric and renal arteries.

Click to Play Video in Browser (External)



Normal CT pulmonary angiogram with 2D MPR in the axial (**A**), coronal (**B**) and sagittal planes (**C**). This examination is done to exclude pulmonary emboli. The goal is to opacify the pulmonary artery and its branches. Pulmonary trunk (PT); right pulmonary artery (RPA); left pulmonary artery (LPA).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

图示为不同解剖区域的正常 CTA 重建，如临床常规中所用。

主动脉、腹腔干、肠系膜上动脉和肾动脉的 CTA 3D VR 图。

单击以在浏览器（外部）中播放视频

包含轴位 (**A**)、冠状位 (**B**) 和矢状位平面 (**C**) 2D MPR 的正常 CT 肺动脉成像。这项检查是为了排除肺栓塞。目的是使肺动脉及其分支显影。肺动脉干 (pulmonary trunk，PT)；右肺动脉 (right pulmonary artery，RPA)；左肺动脉 (left pulmonary artery，LPA)。

<!> ATTENTION

Vascular variants are common and can be seen in the aorta, superior and inferior vena cava and intracranially.

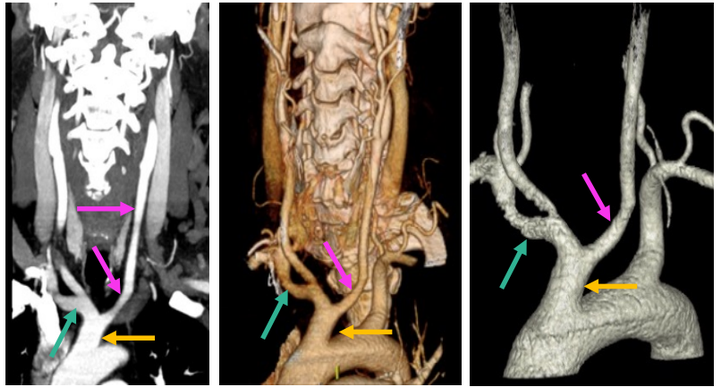
Even if patients are asymptomatic, it is important to recognise and precisely mention vascular variants in the radiologic report because of the following reasons:

- To avoid confusion with vascular pathology
- To adequately plan interventional procedures and surgery
- To suggest the presence of other associated abnormalities

>=< FURTHER KNOWLEDGE

Aortic arch branching patterns
https://www.sciencedirect.com/science/article/pii/S002252231500152X#fig1

Figure illustrating CTA reconstructions of vascular variants.



The bovine arch is the most common variant of the aortic arch in which the innominate artery (green) has a common origin (orange) as the left common carotid artery (pink). It is present in about 15% of the population and it is mostly asymptomatic. It can be associated with an aberrant left subclavian artery (also called arteria lusoria), which can cause dysphagia by compressing the oesophagus (dysphagia lusoria).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

<!> 注意

血管变异很常见，可见于主动脉、上下腔静脉和颅内。

即使患者无症状，在放射诊断报告中准确提及血管变异也很重要，原因如下：

- 避免与血管病变混淆
- 充分计划介入操作及手术
- 提示存在其他相关异常

血管变异的 CTA 重建图示。

无名动脉与左颈总动脉共干是最常见的主动脉弓变异，其中无名动脉（绿色）与左颈总动脉（粉红色）具有共同起源（橙色）。人群中约 15% 的人存在这种变异，大多无症状。可伴有异常的左锁骨下动脉（也称为 arteria lusoria），可通过压迫食管引起吞咽困难（食管受压性吞咽困难）。

>=< 进阶知识

主动脉弓分支模式
https://www.sciencedirect.com/science/article/pii/S002252231500152X#fig1

/ CT Venography (CTV)

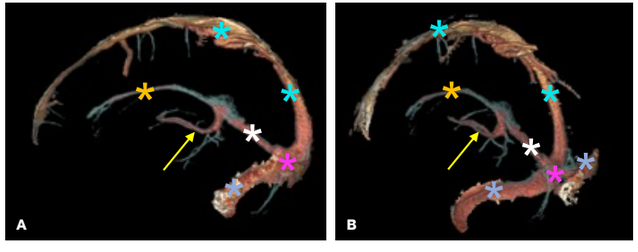
CT venography (CTV) of the head (also called cerebral CTV) is performed to visualise the cerebral veins and venous sinuses filled with contrast.

The goal is to assess their patency in suspected cerebral venous thrombosis and to assess the venous anatomy prior to cranial surgery.

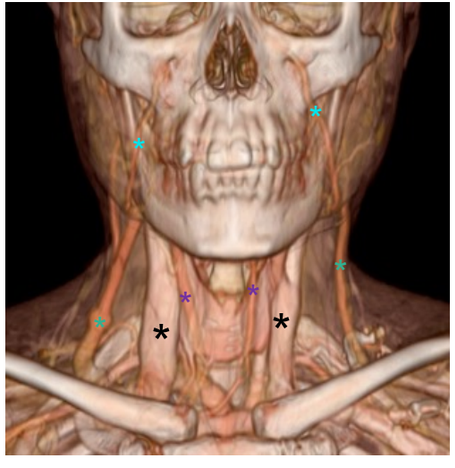
CTV is also done to assess other venous vascular structures in the body, e.g., the internal jugular veins, subclavian or iliac veins.

>=< FURTHER KNOWLEDGE <!> ATTENTION

In CTV, the scan delay must be adapted (later acquisition compared to CTA). Usually, the scan delay is about ≥ 45 s after injection. Reconstructions are similar as for CTA (see previously).



Sagittal (**A**) and sagittal oblique (**B**) 3D VR of a normal cerebral CTV. Superior sagittal sinus (turquoise asterisk); Inferior sagittal sinus (orange asterisk); Straight sinus (white asterisk); Confluence of sinuses (pink asterisk); Transverse sinus (blue asterisk); Great cerebral vein (yellow arrow).



CTA 3D VR of the venous system of the neck. Internal jugular veins (*); external jugular veins (green asterisk); anterior jugular veins (purple asterisk); facial veins (turquois asterisk).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ CT 静脉造影 (CTV)

进行头部 CT 静脉造影 (CTV)（也称为脑 CTV）是为了显示充满对比剂的脑静脉和静脉窦。目的是评估疑似脑静脉血栓患者的静脉通畅性，并在颅脑术前评估静脉解剖结构。

CTV 也用于评估体内其他静脉的血管结构，例如颈内静脉、锁骨下静脉或髂静脉。

>=< 进阶知识 <!> 注意

在 CTV 中，必须采用延迟扫描（与 CTA 相比，采集时间较晚）。通常情况下，注射后扫描延迟时间约 ⩾ 45 s。图像重建与 CTA 相似（见上文）。

正常脑 CTV 的矢状位 (**A**) 和矢状斜位 (**B**) 三维 VR 图像。上矢状窦（蓝绿色星号）；下矢状窦（橙色星号）；直窦（白色星号）；窦融合（粉红色星号）；横窦（蓝色星号）；大脑大静脉（黄色箭头）。

颈静脉系统的 CTA 三维 VR 图。颈内静脉 (*)；颈外静脉（绿色星号）；颈前静脉（紫色星号）；面静脉（蓝绿色星号）。

/ Main indications

<!> ATTENTION

Main indications for CTA are:

- / Vessel stenosis
- / Thrombosis / occlusion
- / Detection of ongoing bleeding
- / Aneurysms
- / Dissection
- / Vascular malformations
- / Vascular anomalies & variants
- / Trauma
- / Vascular tumours and non-invasive assessment of feeding arteries of tumours prior to their resection
- / Guide interventional radiologists and surgeons prior to stent placing or other surgical interventions
- / Evaluation of vessel patency after treatment

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 主要适应证

<!> 注意

CTA 的主要适应证有：

- / 血管狭窄
- / 血栓形成/闭塞
- / 持续出血的检测
- / 动脉瘤
- / 夹层
- / 血管畸形
- / 血管异常和变异
- / 外伤
- / 血管肿瘤和肿瘤切除前肿瘤的供血动脉的无创评估
- / 在支架置入或其他手术前指导介入和外科医生
- / 治疗后血管通畅性评价

/ Magnetic Resonance Angiography (MRA)

Magnetic resonance angiography (MRA) is an imaging method that uses a powerful magnetic field and radio waves to produce detailed images of blood vessels in the body.

Unlike traditional CTA or DSA, which use X-rays, **MRA does not use ionising radiation**.

Also, it's possible to obtain MR angiography **with** or **without** contrast media, depending on indications.

MRA is used to visualise blood vessels in almost any part of the body, including the brain, heart, kidneys, and leg blood vessels, although some limitations occur, and technical parameters have to be adjusted to perform such examinations.

<!> ATTENTION

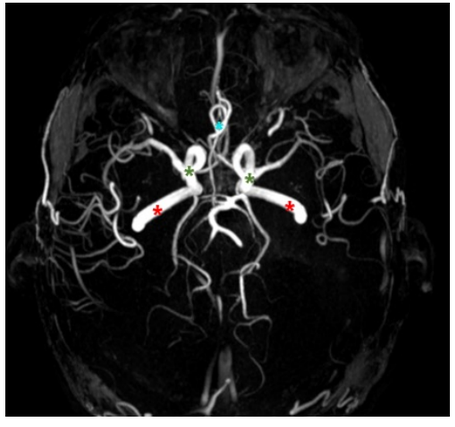
Always make sure that there are no contraindications for MRI!

Due to the strong magnet field, MRI cannot be always performed, for example in patients with:

- Certain types of pacemakers
- Certain intracranial clips
- Certain types of cochlear implants
- Any type of ferromagnetic metal implants

<∞> REFERENCE

> see eBook chapter on MRI



MRA using a 3D TOF sequence **WITHOUT contrast media** showing the intracranial blood vessels.

Internal carotid arteries (red asterisk); Middle cerebral arteries (green asterisk); anterior cerebral arteries (turquoise asterisk).

>▪< FURTHER KNOWLEDGE

Anatomy of the Polygon of Willis and Common Variants
https://doi.org/10.53347/rID-51777

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 磁共振血管成像 (MRA)

磁共振血管成像 (magnetic resonance angiography，MRA) 是一种强大的体内血管成像方法。

不同于使用 X 线的传统 CTA 或 DSA，**MRA 成像没有电离辐射**。

此外，根据适应证，MRA 可以**使用**或**不使用**对比剂。

MRA 可显示几乎任何身体部位的血管，包括脑、心脏、肾脏和腿部血管，但存在一些局限性，并且必须调整技术参数才能进行此类检查。

<!> 注意

始终确保没有 MRI 禁忌证！

由于存在强磁场，有些患者始终不能进行 MRI 检查，例如：

- 安装了某些类型的起搏器
- 某些颅内金属夹
- 某些类型的人工耳蜗
- 任何类型的铁磁性金属植入物

使用 3D TOF 序列（**不使用对比剂**）进行 MRA 显示颅内血管。
颈内动脉（红色星号）；大脑中动脉（绿色星号）；大脑前动脉（蓝绿色星号）。

<∞> 参考文献

> 请参阅 MRI 电子书章节

>▪< 进阶知识

脑动脉环的解剖及常见变异
https://doi.org/10.53347/rID-51777

/ Without Contrast Media

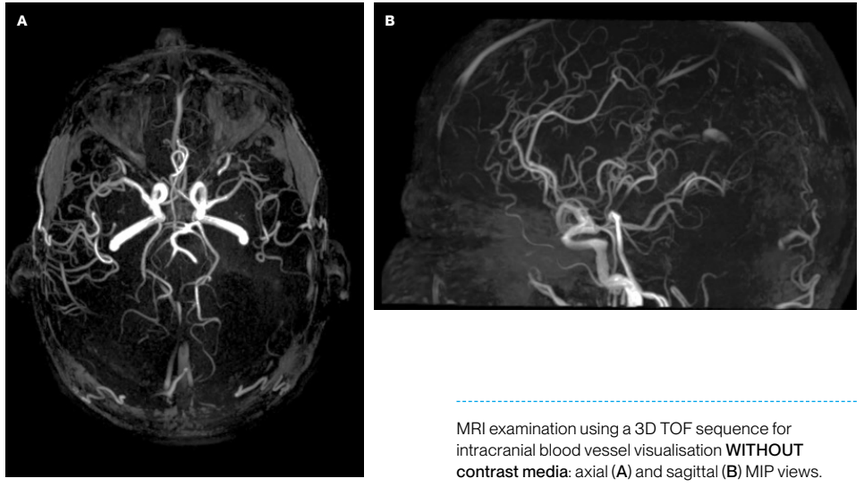
The most commonly used MRI sequence to assess blood vessels without contrast media is a **3-dimensional (3D) time-of-flight (TOF) sequence**. This technique assesses the differences between stationary tissues and blood flow.

It is important to keep in mind that with this sequence we don't really see the intraluminal changes, but we see **blood flow changes inside the blood vessels**.

<!> ATTENTION

Blood flow intracranially can be influenced by numerous factors:

- Carotid artery stenosis
- Low ejection fraction in heart
- Competitive flow from other blood supply regions
- Anatomical variations of Circle of Willis



MRI examination using a 3D TOF sequence for intracranial blood vessel visualisation **WITHOUT contrast media**: axial (**A**) and sagittal (**B**) MIP views.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 不使用对比剂

不使用对比剂时，评估血管最常用的 MRI 序列是三维 (3-dimensional，3D) 飞行时间 (time-of flight，TOF) 序列。该技术可评估静止组织和血流之间的差异。

需要注意的是，使用这种序列时，我们并没有真正看到腔内变化，而是看到**血管内的血流变化**。

<!> 注意

颅内血流受多种因素的影响：

- 颈动脉狭窄
- 心脏射血分数低
- 来自其他供血区域的竞争性血流
- 脑动脉环的解剖变异

使用 3D TOF 序列进行颅内血管显影的 MRI 检查（**不使用对比剂**）：轴位 (**A**) 和矢状位 (**B**) MIP 视图。

/ Without Contrast Media

Contrast enhanced MRA (CE-MRA) is in many ways, like CTA, but a gadolinium-based contrast agent (instead of iodinated contrast) is used.

CE-MRA is an excellent alternative to CTA for vascular evaluation and follow-up without requiring iodinated contrast material and ionising radiation.

Indications for MRA:

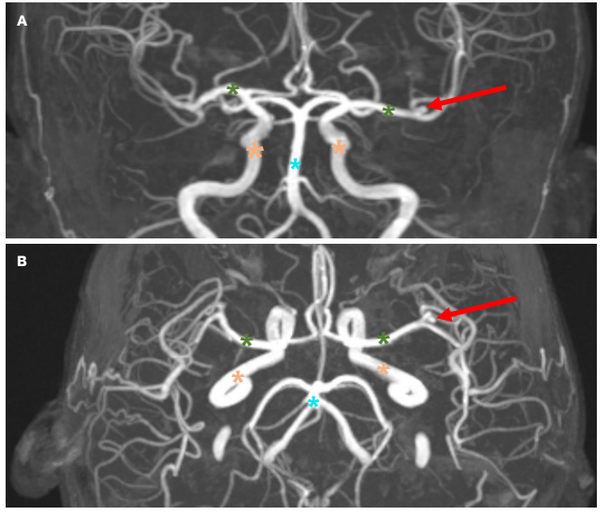
- Aneurysms
- Vasculitis
- Cerebral artery occlusion or stenosis (non-acute setting)
- Vascular malformations (AVM)
- Neurovascular conflict assessment
- Vascular anatomical variations, that could cause clinical symptoms

<!> ATTENTION

MRA represents a great imaging option in patients with allergy to iodine-based contrast material!

<∞> REFERENCE

> see eBook chapter on Contrast Media



MRA WITH contrast media (MIP reconstruction) is particularly good for the detection of aneurysms. Frontal (**A**) and axial (**B**) views. Note focal dilatation of the left MCA (green asterisk) representing an aneurysm (arrow).

Internal carotid arteries (orange asterisk); Middle cerebral arteries, MCAs (green asterisk); Basilar artery (turquoise asterisk).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 不使用对比剂

对比增强 MRA（contrast enhanced MRA，CE-MRA）在许多方面与 CTA 一样，但需使用钆对比剂（而不是碘对比剂）。

CE-MRA 是 CTA 的极好替代方法，可用于血管评估和随访，无需碘对比剂，没有电离辐射。

MRA 的适应证：

- 动脉瘤
- 血管炎
- 大脑动脉闭塞或狭窄（非急性情况）
- 血管畸形 (AVM)
- 神经血管冲突评估
- 可能引起临床症状的血管解剖变异

<!> 注意

对于碘对比剂过敏的患者，MRA 是很好的替代成像选择！

<∞> 参考文献

> 请参阅《对比剂》电子书章节

使用对比剂的 MRA（MIP 重建）尤其适合检测动脉瘤。正面 (**A**) 和轴位 (**B**) 视图。注意左侧 MCA 的局部扩张（绿色星号）代表动脉瘤（箭头）。

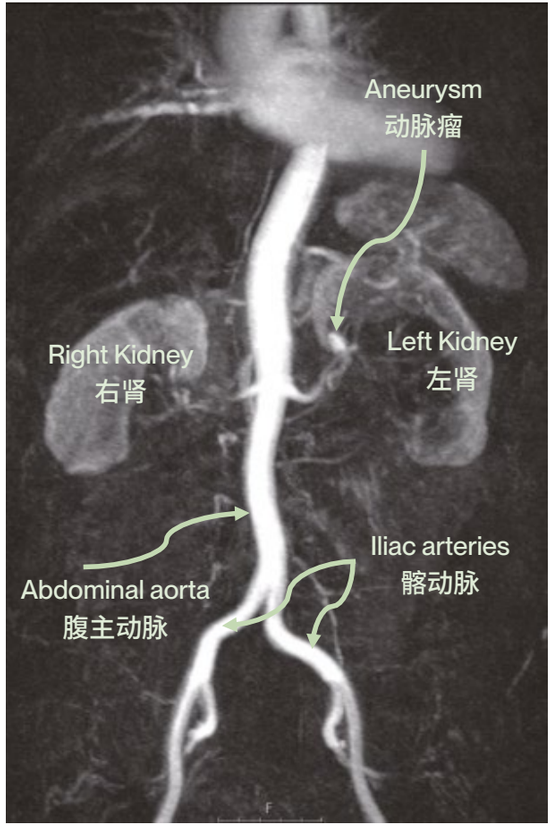
颈内动脉（橙色星号）；大脑中动脉 (Middle cerebral arteries，MCA)（绿色星号）；基底动脉（蓝绿色星号）。

/ With Contrast Media

Rapid gradient echo sequences are particularly useful when **swift image capture is needed** (scenarios where movement might compromise image quality, such as dynamic studies).

This type of quick MR sequences has various clinical applications, including:

- / Angiography
- / Cardiac imaging
- / Abdominal imaging (i.e., liver, kidneys, bowel)



MRA renal 3D reconstruction depicting a **left renal artery aneurysm**

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 使用对比剂

快速梯度回波序列在**需要迅速捕获图像**时（移动可能损害图像质量的情况，如动态研究）特别有用。

这种快速 MR 序列具有多种临床用途，包括：

- / 血管成像
- / 心脏成像
- / 腹部成像（即肝脏、肾脏、肠道）

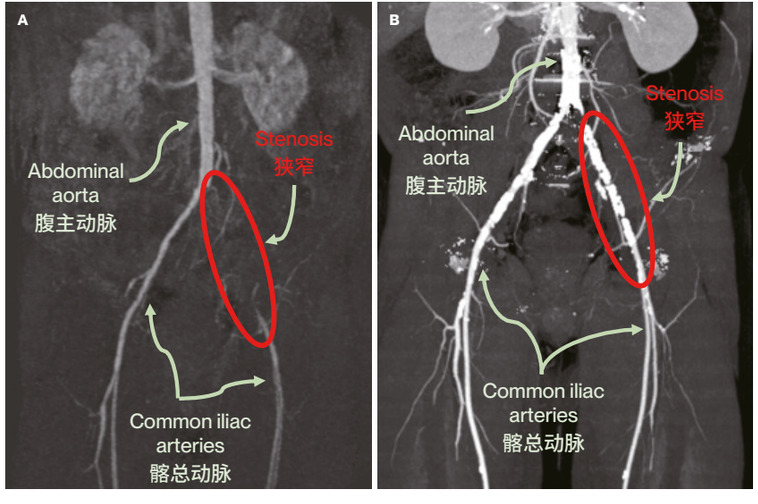
显示**左肾动脉瘤**的 MRA 肾脏 3D 重建

MRA provides a 3D alternative to CTA for the evaluation of peripheral arterial disease (PAD). Although CTA has a high diagnostic performance to detect arterial stenoses and occlusion, calcifications and metallic stents can hinder the evaluation of vessel patency. **> see figure on the right.**

Newer technical developments, e.g., image subtraction and/or energy subtraction, as well as ultra-high-resolution CT are increasingly used to overcome the current limitations of conventional CTA.

MRA can also better evaluate run-off vessels because of its ability to detect blood flow with lower velocities than other imaging modalities.

MRA is equally considered the gold standard in inflammatory or degenerative changes of vessel walls.



MRA of the proximal part of the lower limbs (**A**) versus conventional CTA (**B**) of the same region in the same patient. Note improved visualisation of a long segment stenosis of the left common iliac artery on the MRA in comparison to the conventional CTA. Extensive calcifications on the left impair assessment of vessel patency on the conventional CTA image.

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

MRA 是 CTA 的 3D 替代方法，用于评估外周动脉疾病 (peripheral arterial disease，PAD)。虽然 CTA 对检测动脉狭窄和闭塞具有较高的诊断效能，但钙化和金属支架会妨碍其对血管通畅性的评估。**> 参见右图。**

新技术发展（例如图像减影和/或能量减影以及超高分辨率 CT）越来越多地突破常规 CTA 目前的局限性。

与其他成像模式相比，MRA 能够检测速度较低的血流，因此也能更好地评估流出血管。

MRA 同样被视为评估血管壁炎性或退行性变化的金标准。

同一患者同一区域下肢近端 MRA (**A**) 与 CTA (**B**) 的比较。与常规 CTA 相比，MRA 显示的左髂总动脉长段狭窄更清晰。左侧广泛钙化会影响常规 CTA 图像中狭窄程度的评估。

/ Positron Emission Tomography Computed Tomography (PET CT)

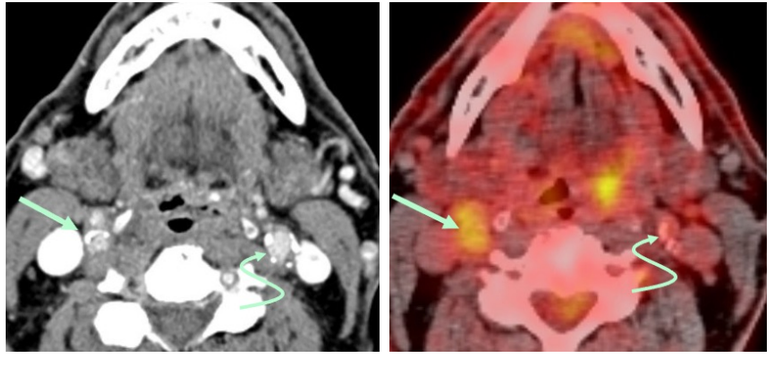
FDG PET CT (> see chapter on nuclear medicine) is a well-established hybrid imaging technique mainly used for oncologic indications. Nevertheless, PET CT can also be used to image inflammatory and infectious conditions.

The **main indications for FDG PET CT in vascular diseases** include atherosclerosis, vasculitis and complications of vascular grafts.

Because an atheromatous plaque represents an area of dynamic inflammation (see next pages), FDG PET CT can characterise the inflammatory state of a plaque. Vulnerable active plaques with a high risk of rupture accumulate FDG whereas calcified inactive plaques do not.

<!> ATTENTION

Higher FDG uptake in carotid plaques is associated with a higher risk of stroke.



Focal, patchy FDG uptake in an active atherosclerotic plaque at the right carotid bifurcation (straight arrows) seen on a PET CT scan performed for follow-up purposes of a head and neck squamous cell carcinoma patient. Note that although both carotid bifurcations have mixed plaques, FDG uptake is seen only on the right. Mixed inactive plaque (curved arrows) on the left.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 正电子发射计算机断层扫描 (PET-CT)

FDG PET-CT（> 请参阅有关核医学的章节）是一种成熟的混合成像技术，主要用于肿瘤等适应证。PET-CT 也可用于炎症和感染性疾病的成像。

血管疾病中 **FDG PET-CT 的主要适应证**包括动脉粥样硬化、血管炎和支架植入后并发症。

由于动脉粥样硬化斑块代表一个动态炎症区域（见下面几页），FDG PET-CT 可描述斑块的炎症状态。破裂风险高的活动性易损斑块可蓄积 FDG，而钙化的非活动性斑块则不会。

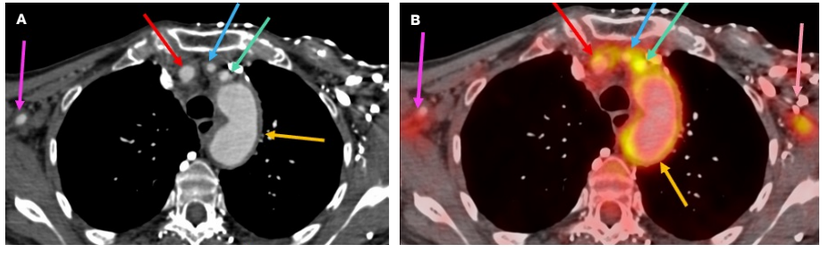
<!> 注意

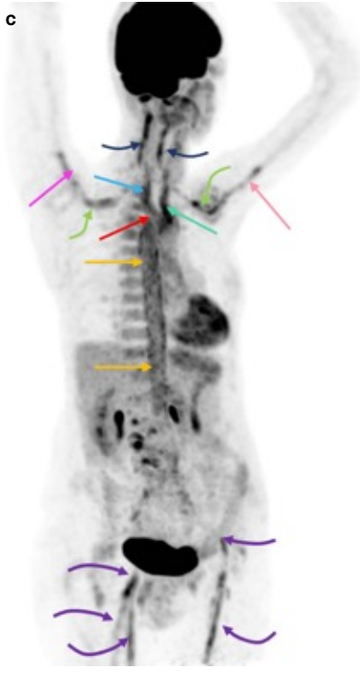
颈动脉斑块中 FDG 摄取较高与卒中风险较高相关。

对头颈部鳞状细胞癌患者进行的 PET-CT 扫描随访中，可观察到右侧颈动脉分叉处的活动性动脉粥样硬化斑块，存在局灶性、片状 FDG 摄取（直箭）。需注意，虽然双侧颈动脉分叉均可见混合斑块，但 FDG 摄取仅见于右侧斑块中。左侧为混合的非活动性斑块（弯箭）。

FDG PET CT can detect vessel wall inflammation in **Large Vessel Vasculitis** (LVV) before the development of obvious morphologic vessel wall changes. Typically, FDG PET CT in LVV reveals smooth, continuous and circumferential FDG uptake of the large vessel walls as opposed to the focal and discontinuous uptake in atherosclerosis.

Infection of vascular prosthetic grafts can be difficult to diagnose especially in cases with low-grade infection. FDG PET CT is very useful in this clinical situation as infected grafts typically show intense FDG uptake, either focal or focal-on-diffuse.





FDG PET CT in LVV. Contrast-enhanced CT (**A**) and corresponding fused PET CT image (**B**): regular thickening (3.9 mm) and smooth and linear FDG uptake of the wall of the aorta (orange arrow) and its branches (left common carotid artery (turquoise arrow), right common carotid artery (blue arrow), brachiocephalic trunk (red arrow)), right axillary (magenta arrow) and left axillary (light pink arrow) arteries. PET Maximum Intensity Projection (MIP) image (**C**): characteristic smooth linear increased FDG uptake (SUV max = 5.7) of the aorta and its branches. Note also FDG uptake of the subclavian (green arrow), vertebral (dark blue arrow) and common, superficial and profound femoral arteries (curved purple arrows) on this MIP.

Vascular Imaging

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血管成像

章节大纲：

FDG PET-CT 可以在出现明显的形态学血管壁变化之前检测到**大血管血管炎** (Large Vessel Vasculitis，LVV) 的血管壁炎症。LVV 的 FDG PET-CT 通常显示大血管壁平滑、连续的环状 FDG 摄取，而动脉粥样硬化中则为局灶性、不连续摄取。

人造血管移植物感染可能很难诊断，尤其是低级别感染病例。FDG PET--CT 在这种临床情况下非常有用，因为受感染的移植物通常显示很强 FDG 摄取，呈局灶性或局灶-弥漫混合性。

LVV 的 FDG PET-CT。对比增强 CT (**A**) 和相应的融合 PET-CT 图像 (**B**)：主动脉（橙色箭）及其分支（左颈总动脉（蓝绿色箭）、右颈总动脉（蓝箭）、头臂干（红箭））、右腋窝（品红色箭）和左腋窝（浅粉色箭））动脉壁规则增厚 (3.9 mm) 和平滑的线状 FDG 摄取。PET 最大密度投影 (Maximum Intensity Projection，MIP) 图像 (**C**)：主动脉及其分支的特征性平滑的线状 FDG 摄取增加 (SUV max = 5.7)。还可显示该 MIP图中锁骨下动脉（绿箭）、椎动脉（深蓝色箭）以及股总动脉、股浅动脉和股深动脉（紫色弯箭）的 FDG 摄取。

Arterial Disease

Vascular Imaging

动脉疾病

血管成像

CHAPTER OUTLINE:

章节大纲：

/ Atherosclerosis

Atherosclerosis is a progressive disease characterised by the accumulation of lipids and fibrous elements in large arteries. Atheromatous plaques **begin as fatty streaks composed of lipid-laden macrophages** (foam cells). This process begins in childhood but not all fatty streaks progress to plaques.

A **plaque is a raised focal lesion within the intima**. It consists of a necrotic core (lipids, foam cells and debris) surrounded by inflammatory cells, smooth muscle cells and neovascularisation can also be present. All of it is covered by a fibrous plaque. Plaques often undergo **calcification**.

The underlying pathogenesis is believed to involve **chronic endothelial injury (intima)** which results in an **inflammatory response**, accumulation of **lipids**, platelet aggregation and activation of smooth muscle cells.

Plaques form most commonly in large elastic arteries (e.g., aorta, carotid and iliac arteries), and large and medium-sized muscular arteries (e.g., coronary, renal, lower limb, mesenteric and cerebral vessels). They are most prominent at branching points and at ostia of major branches.

<!> ATTENTION

Vulnerable plaque = plaque susceptible to complications

Alternative acceptable terms include high-risk plaque, dangerous plaque, unstable plaque.

Plaque rupture is responsible for 70% of fatal acute myocardial infarction and/or sudden coronary death.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 动脉粥样硬化

动脉粥样硬化是一种进行性疾病，其特征为脂质和纤维成分在大动脉中积聚。动脉粥样硬化斑块**最初表现为由富含脂质的巨噬细胞**（泡沫细胞）组成的脂肪条纹。该过程始于儿童期，但并非所有脂肪条纹都会进展为斑块。

斑块是内膜内凸起的局灶性病变。其由坏死核心（含脂质、泡沫细胞和碎片）组成，外围为炎性细胞和平滑肌细胞，并可能伴有新生血管形成。这些全部被纤维斑块覆盖。斑块常发生**钙化**。

一般认为潜在的发病机制涉及**慢性内皮（内膜）**损伤，这种损伤导致**炎症反应、脂质**积聚、血小板聚集和平滑肌细胞活化。

斑块最常见于大型弹性动脉（如主动脉、颈动脉和髂动脉）以及大型和中型肌动脉（如冠状动脉、肾动脉、下肢动脉、肠系膜动脉和脑血管）。在分支点和主要分支开口处最为明显。

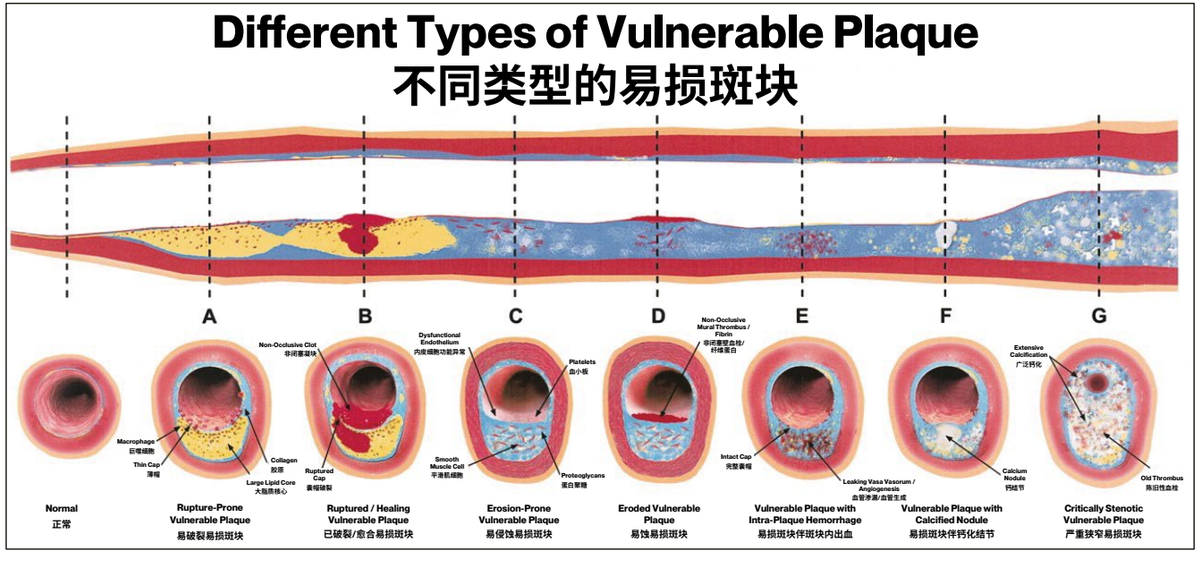
<!> 注意

易损斑块 = 易发生并发症的斑块

其他可接受的术语包括：高风险斑块、危险斑块、不稳定斑块。

斑块破裂是导致 70% 致命性急性心肌梗死和/或冠状动脉性猝死的原因。

The **different types of vulnerable plaques** are shown in the figure below.



A. Rupture-prone plaque with large lipid core and thin fibrous cap infiltrated by macrophages. B. Ruptured plaque with subocclusive thrombus and early organisation. C. Erosion-prone plaque with proteoglycan matrix in a smooth muscle cell-rich plaque. D. Eroded plaque with sub-occlusive thrombus. E. Intraplaque haemorrhage secondary to leaking vasa vasorum. F. Calcific nodule protruding into the vessel lumen. G. Chronically stenotic plaque with severe calcification, old thrombus and eccentric lumen.

<∞> REFERENCE

Figure reproduced from: Morteza Naghavi. From Vulnerable Plaque to Vulnerable Patient. Circulation 108 (14); 1664-1672
DOI: (10.1161/01.CIR.0000087480.94275.97)

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

不同类型的易损斑块如下图所示。

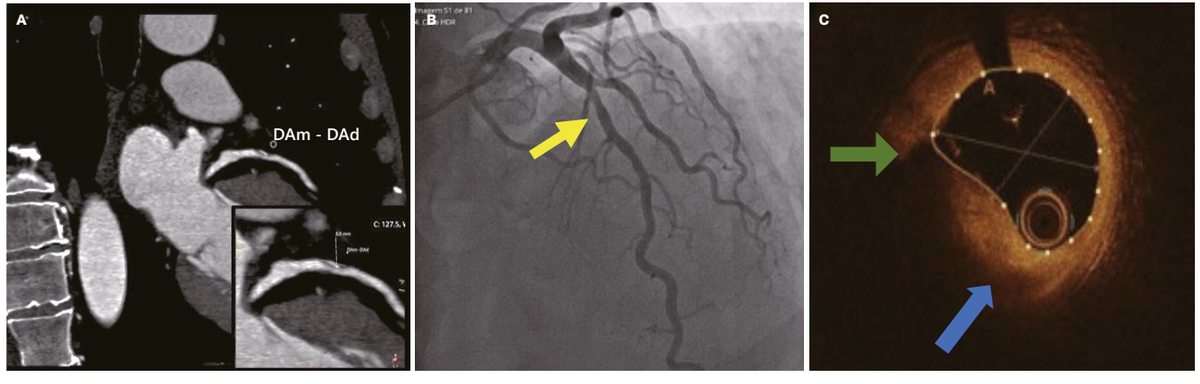
章节大纲：

A. 巨噬细胞浸润的具有大脂质核和薄纤维帽的易破裂斑块。B. 破裂的斑块，伴不完全闭塞的血栓和早期机化。C. 易侵蚀斑块，富含平滑肌细胞的斑块内伴有蛋白聚糖基质。D. 侵蚀的斑块，伴不完全闭塞的血栓。E. 滋养血管渗漏所致的斑块内出血。F. 钙化结节突入血管腔。G. 慢性狭窄斑块，伴严重钙化、陈旧性血栓和偏心管腔。

<∞> 参考文献

图片来源： Morteza Naghavi. From Vulnerable Plaque to Vulnerable Patient. Circulation 108 (14); 1664-1672
DOI: (10.1161/01.CIR.0000087480.94275.97)

CT, MRI, ultrasound (including **intravascular ultrasound**) and - more recently - **optical coherence tomography (OCT)** are used to analyse the atherosclerotic plaque structure, thus playing an important role in therapeutic decisions.



A. CT angiography of a patient with ECG changes (Biphasic T waves in precordial leads, and T wave inversion in precordial leads) showing mid left descending artery (LAD) moderate plaque lesion with unstable features with a 50-69% reduction of vessel calibre. **B.** Coronarography demonstrating a non-significant 40% stenotic segment of the LAD (yellow arrow). **C.** OCT at the stenotic segment showing a thin cap fibroatheroma (blue arrow) with a small rupture area (green arrow) and an overall 70% stenosis area.

<∞> REFERENCE

The role of optical coherence tomography in coronary intervention. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3295975/Terashima M, Kaneda H, Suzuki T. Korean J Intern Med. 2012 Mar;27(1):1-12. doi: 10.3904/kjim.2012.27.1.1 Epub 2012 Feb 28. PMID: 22403493; PMCID: PMC3295975.

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

CT、MRI、超声（包括血管内超声）以及最近的**光学相干断层扫描 (optical coherence tomography，OCT)** 均用于分析动脉粥样硬化斑块结构，从而在治疗决策中发挥重要作用。

A. 伴有心电图改变（心前区导联双相 T 波和T 波倒置）的患者的 CT 血管成像显示左前降支 (left descending artery，LAD) 中段中等狭窄斑块病变，具有不稳定斑块特征，管腔狭窄程度为 50%-69%。**B.** 冠状动脉造影显示 LAD 段 40% 狭窄，狭窄不明显（黄色箭头）。**C.** 狭窄处的 OCT 显示薄帽纤维粥样斑块（蓝色箭头），伴小范围破裂（绿色箭头），总体狭窄程度为 70%。

<∞> 参考文献

The role of optical coherence tomography in coronary intervention. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3295975/Terashima M, Kaneda H, Suzuki T. Korean J Intern Med. 2012 Mar;27(1):1-12. doi: 10.3904/kjim.2012.27.1.1 Epub 2012 Feb 28. PMID: 22403493; PMCID: PMC3295975.

A plaque can gradually enlarge, it can rupture and it can facilitate thrombus formation. The consequences are:

- **Critical stenosis** (= severe arterial narrowing with a significantly reduced maximal flow capacity in the distal vascular bed; typically, 60%-75% reduction in diameter of a large artery)
- **Ischaemia** (= insufficient blood flow to provide adequate oxygenation); ischaemia leads to tissue hypoxia or anoxia. Ischaemia can manifest with pain (e.g., angina, intermittent claudication) and/or loss of function (e.g., neurologic dysfunction)
- **Aneurysm formation** due to atrophy of the underlying media by the enlarging plaque

Atherosclerosis of the large intracranial arteries (typically affecting the middle cerebral artery, basilar artery, anterior or posterior cerebral arteries and the internal carotid artery) can cause a **transient ischaemic attack**, an **ischaemic stroke** or cognitive impairment due to **chronic white matter ischaemia**.

The role of **CTA in the acute setting** is:

- to identify the thrombus within a vessel, thus guiding intra-arterial thrombolysis or clot retrieval
- exclude intracranial haemorrhage
- identify the core infarct (i.e., the infarct part which does not recover despite recanalisation therapy) and the penumbra (potentially salvaged infarct zone)
- assess the status of collateral vessels (which are reliable predictors of clinical outcomes after endovascular interventional clot removal)

<∞> REFERENCE

> see eBook chapter on Central Nervous System

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

斑块可逐渐增大、破裂，并促进血栓形成。后果是：

- **严重狭窄**（= 重度动脉狭窄，远端血管床的最大容量显著降低；通常表现为大动脉直径减少 60%-75%）
- **缺血**（= 血流不足，无法提供充分的氧合）；缺血导致组织缺氧或无氧。缺血可表现为疼痛（如心绞痛、间歇性跛行）和/或功能丧失（如神经功能障碍）
- 由于斑块增大导致中膜萎缩，从而引起**动脉瘤形成**

颅内大动脉粥样硬化（通常累及大脑中动脉、基底动脉、大脑前动脉、大脑后动脉和颈内动脉）可导致**短暂性脑缺血发作**、**缺血性卒中**或由**慢性白质缺血**引起的认知障碍。

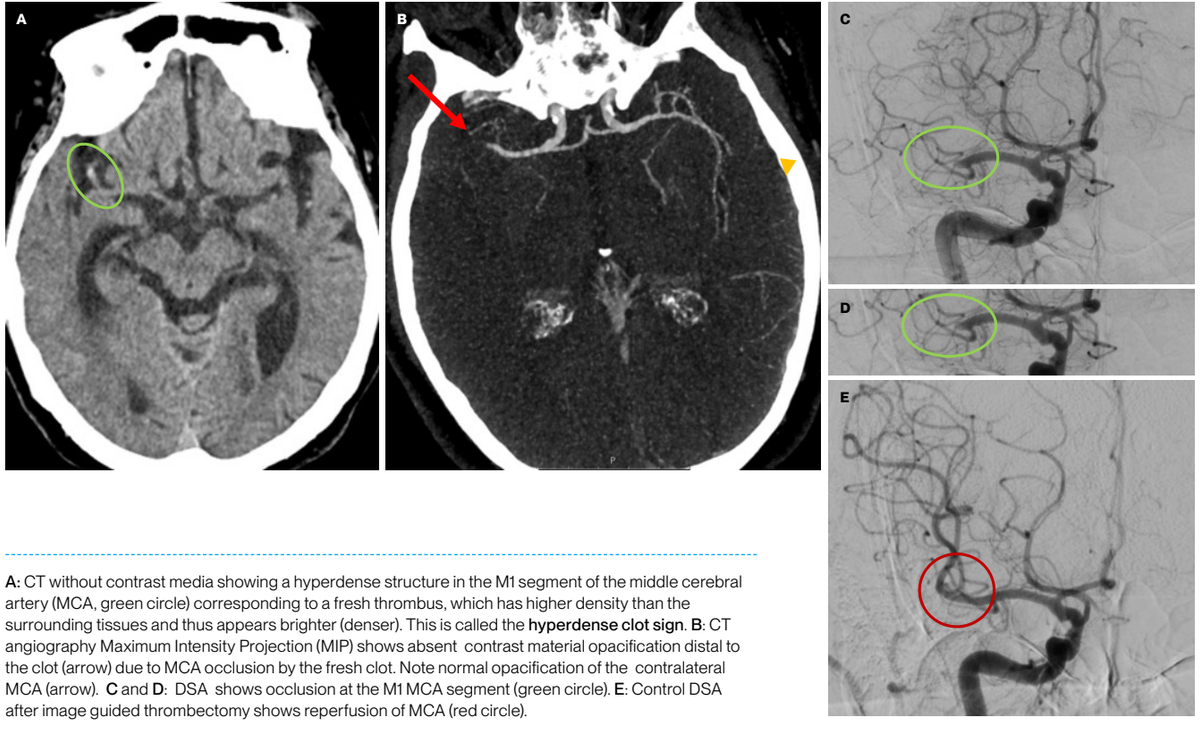
急性期 CTA 的作用是：

- 识别血管内的血栓，从而指导动脉内溶栓或凝块取出
- 排除颅内出血
- 识别核心梗死（即经再通治疗后仍未恢复的梗死部分）和半暗带（可能挽救的梗死区域）
- 评估侧支血管状态（侧支血管是血管内介取栓术后临床结局的可靠预测指标）

<∞> 参考文献

> 请参阅《中枢神经系统》电子书章节

/ Middle Cerebral Artery (MCA) Occlusion



A: CT without contrast media showing a hyperdense structure in the M1 segment of the middle cerebral artery (MCA, green circle) corresponding to a fresh thrombus, which has higher density than the surrounding tissues and thus appears brighter (denser). This is called the **hyperdense clot sign**. **B:** CT angiography Maximum Intensity Projection (MIP) shows absent contrast material opacification distal to the clot (arrow) due to MCA occlusion by the fresh clot. Note normal opacification of the contralateral MCA (arrow). **C** and **D:** DSA shows occlusion at the M1 MCA segment (green circle). **E:** Control DSA after image guided thrombectomy shows reperfusion of MCA (red circle).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 大脑中动脉 (Middle Cerebral Artery，MCA) 闭塞

A：平扫 CT 显示大脑中动脉 M1 段（MCA，绿色圆圈）存在高密度结构，符合新鲜血栓表现，其密度高于周围组织，因此显示更亮（密度更高）。这被称为**高密度血栓征**。**B：**CT 血管成像最大密度投影 (Maximum Intensity Projection，MIP) 显示血凝块远端（箭头）对比剂充盈缺损，这是由新鲜血凝块堵塞 MCA 所致。注意对侧 MCA 的正常显影（箭头）。**C** 和 **D：** DSA 显示 MCA 的 M1 段闭塞（绿色圆圈）。**E：**影像引导血栓切除术后对照 DSA 显示 MCA 再灌注（红色圆圈）。

Peripheral arterial disease (PAD) is a common condition caused by atherosclerosis. It manifests with stenosis and/or thrombus formation or complete occlusion.

PAD can lead to limb ischaemia, which can present clinically with intermittent claudication in mild to moderate PAD (ischaemic pain during exercise due to tissue hypoxia caused by higher oxygen demand), with rest pain, ischaemic ulcers or gangrene.

Typically, the femoral and popliteal arteries are most often affected. Calcified atherosclerotic plaques along the vessels are common.

Stenoses and occlusions can be single, multiple, with or without calcification, with or without collateral vessels.

<!> ATTENTION

Both CTA and MRA can be used to assess PAD manifestations (stenosis, occlusion and collateral vessels).

However, MRA tends to sometime overestimate stenosis severity.

DSA is considered the gold standard for assessing PAD manifestations. In addition to its diagnostic value, DSA also allows radiological interventional endovascular therapy.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

外周动脉疾病 (peripheral arterial disease，PAD) 是一种由动脉硬化引起的常见疾病。表现为狭窄和/或血栓形成或完全闭塞。

PAD 可导致肢体缺血，临床表现包括：轻中度 PAD 患者出现间歇性跛行（运动期间因需氧量增加导致组织缺氧而出现缺血性疼痛），严重者可出现静息痛、缺血性溃疡或坏疽。

一般情况下，股动脉和腘动脉最常受累。沿血管的钙化性动脉粥样硬化斑块很常见。

狭窄和闭塞可为单发、多发，伴或不伴钙化，伴或不伴侧支血管。

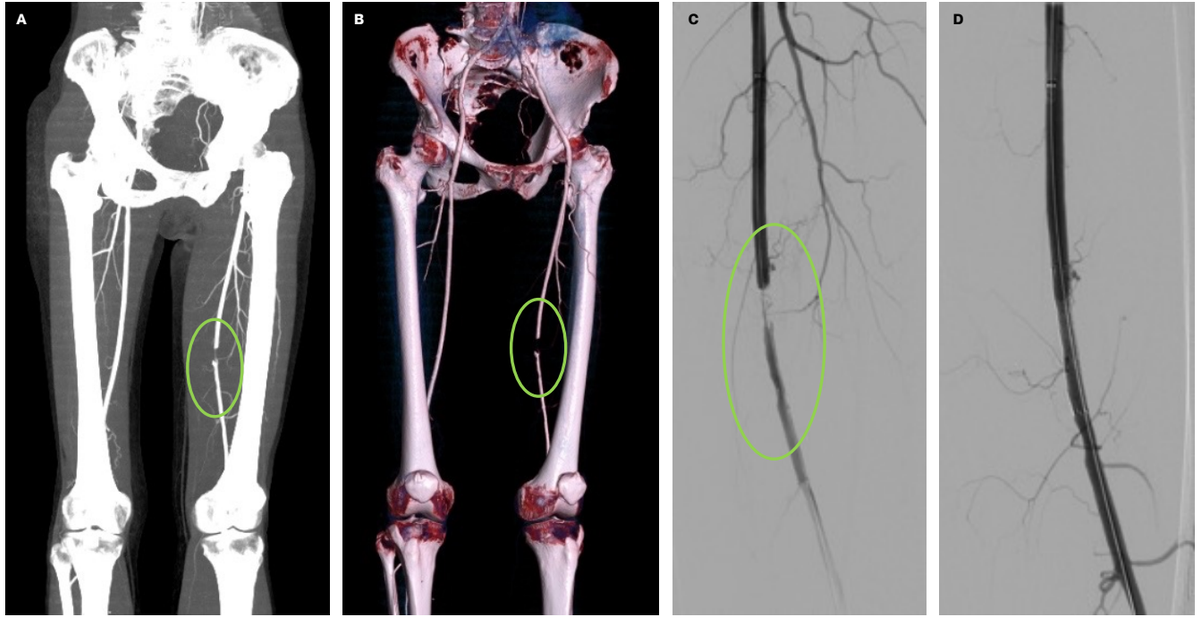
<!> 注意

CTA 和 MRA 都可用于评估 PAD 表现（狭窄、闭塞和侧支血管）。

然而，MRA 往往会高估狭窄的严重程度。

DSA 是评估 PAD 表现的金标准。DSA 不仅具有诊断价值，还可用于放射介入血管内治疗。

/ Superficial Femoral Artery Stenosis and Interventional Endovascular Radiologic Treatment



A and **B:** CTA with MIP and Volume rendering Technique (VRT) reconstruction depicting a left superficial artery stenosis (green circle). **C** and **D:** Lower limb DSA showing how interventional radiologic vascular treatment is performed with stenting (first passage of a guide wire – image **C**) and then stent placement (in **D**).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

/ 股浅动脉狭窄和介入放射学血管内治疗

章节大纲：

A 和 **B**：采用 MIP 和容积再现技术 (Volume rendering Technique，VRT) 重建的 CTA 图像，显示左侧浅动脉狭窄（绿色圆圈）。**C** 和 **D**：下肢 DSA，显示介入放射学血管治疗的步骤：首先导丝通过（图像 **C**），然后放置支架 (**D**)。

/ Pulmonary Embolism (PE)

Pulmonary embolism (PE) is defined as occlusion of a pulmonary artery or its branches. Most often it is caused by a clot traveling from the deep venous system (DVT emboli). Other rarer causes include fat, amniotic fluid, air or septic emboli.

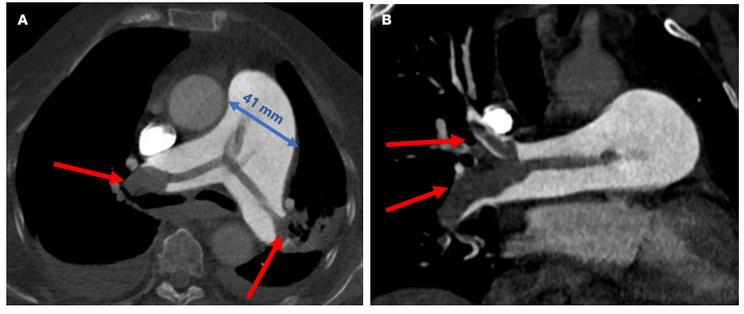
One should always suspect acute PE in a patient with a history of:

- Sudden onset dyspnea
- Pleuritic chest pain
- Tachycardia
- Hypoxia (proven by arterial blood gas test)

<!> ATTENTION

PE has a broad spectrum of symptoms. Several "scores" exist to stratify the probability of having PE (e.g., Well's score, Geneva Score).

CTA is the gold standard for the diagnosis of a suspected PE.



A (axial CT) and **B** (coronal CT image): CTA showing saddle pulmonary embolism (arrows) affecting the left and right pulmonary artery and segmental branches. Note enlargement of the pulmonary artery trunk (usually < 30 mm).

<!> ATTENTION **>▪< FURTHER KNOWLEDGE**

PE is stratified based on the haemodynamic burden to guide treatment and need for surgical intervention. PE is divided into 3 main severity groups:

- **High risk**-PE in the presence of hypotension (not caused by arrythmia)
- **Intermediate risk**-PE without hypotension but with signs of myocardial damage or right ventricle (RV) dysfunction
- **Low risk**-PE without hypotension or signs of myocardial damage or RV dysfunction

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 肺栓塞 (PE)

肺栓塞 (pulmonary embolism，PE) 定义为肺动脉或其分支闭塞。最常见的原因是来自深静脉系统血栓（DVT 栓子）的移行。其他更罕见的原因包括脂肪、羊水、空气或脓毒性栓子。

若患者有以下病史，都应怀疑急性 PE：

- 突发呼吸困难
- 胸膜炎性胸痛
- 心动过速
- 缺氧（经动脉血气分析证实）

<!> 注意

PE 具有广泛的症状。有几种"评分"可对 PE 概率进行分层（例如，Well 评分、Geneva 评分）。

CTA 是诊断疑似 PE 的金标准。

A（轴位 CT）和 **B**（冠状位 CT 图像）：CTA 显示鞍型肺栓塞（箭头），累及左右肺动脉及其段级分支。注意肺动脉干增宽（正常通常 < 30 mm）。

<!> 注意 **>▪< 进阶知识**

根据血流动力学负荷对 PE 进行分层，以指导治疗和确定手术干预的必要性。PE 按严重程度主要分为 3 组：

- **高危** - 伴低血压（非心律失常引起）的 PE
- **中危** - 不伴低血压，但有心肌损伤或右心室 (right ventricle，RV) 功能不全的 PE
- **低危** - 不伴低血压、心肌损伤或 RV 功能不全的 PE

<!> ATTENTION

PE treatment depends on risk stratification:

- **Low risk**- usually treated with anti-coagulation therapy
- **Intermediate risk**- can be treated with anti-coagulation alone or interventions (catheter guided thrombolysis and aspiration thrombectomy) depending on co-morbidities, evolution and other risk factors
- **High risk**- systemic thrombolysis or local interventions (aspiration thrombectomy / open surgical embolectomy

C: CTA (continuation of the figure shown on the previous slide). Note enlargement of the right ventricle (RV) with interventricular septal deviation towards the left ventricle (LV) – indicative of a **RV/LV ratio** > 1, indicative of **right ventricle dysfunction**. This is a case of an intermediate risk PE (also known as sub-massive). **D**: This patient underwent catheter guided thrombectomy of the bilateral thrombi (note filling defect of the right pulmonary artery – arrow). **E**: final result after thrombectomy with complete opacification of the bilateral pulmonary arteries by the injected contrast material.

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

<!> 注意

PE 治疗取决于风险分层：

- **低危** - 通常进行抗凝治疗
- **中危** - 可单独采用抗凝治疗或联合介入治疗（导管引导溶栓和抽吸血栓切除术），具体取决于合并症、病情演变和其他风险因素。
- **高危** - 全身性溶栓或局部介入（抽吸血栓切除术/开放性外科血栓切除术）

C：CTA（接上一页显示的图）。注意右心室 (right ventricle，RV) 增大伴室间隔向左心室 (left ventricle，LV) 偏移 - 提示 **RV/LV 比值** > 1，表明存在**右心室功能不全**。这是一例中危 PE（也称为次大面积肺栓塞）病例。**D**：该患者接受了导管引导的双侧血栓切除术（注意右肺动脉充盈缺损 - 箭头）。**E**：血栓切除术后最终结果：注入的对比剂使双侧肺动脉完全显影。

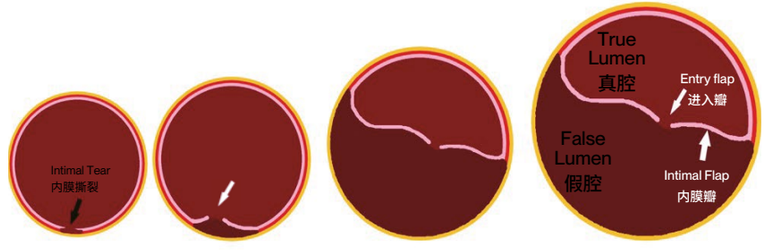
/ Dissection

Aortic dissection is defined as a **tear in the inner wall of the aorta**, with further inner layer separation (or dissection) **leading to the formation of a second blood-filled channel within the wall of the aorta**.

This can lead to a loss of blood flow to vital organs and can be life-threatening if not treated promptly.

Signs and symptoms of aortic dissection may include:

- Sudden chest or back pain
- Difficulty breathing
- Dizziness/loss of consciousness
- Blood pressure difference between both arms ≥ 20 mmHg



Pathogenesis and stages of aortic dissection:

1. Aortic dissection starts from an intimal tear within the aorta
2. Blood enters and infiltrates the media (arrow)
3. A false channel or lumen is created separating the intima from the rest of the aortic wall
4. The displaced intimal flap may cause obstruction of a branch vessel which may result in end-organ hypo-perfusion

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 夹层

主动脉夹层是指**主动脉内壁撕裂**，继而发生内膜层分离（或称剥离），**导致主动脉壁内形成第二个充满血液的腔道。**

若不及时治疗，可导致重要器官的血流中断，甚至危及生命。

主动脉夹层的体征和症状可能包括：

- 突发胸痛或背痛
- 呼吸困难
- 头晕/意识丧失
- 两臂间血压差值 ⩾ 20 mmHg

主动脉夹层的发病机制与分期：

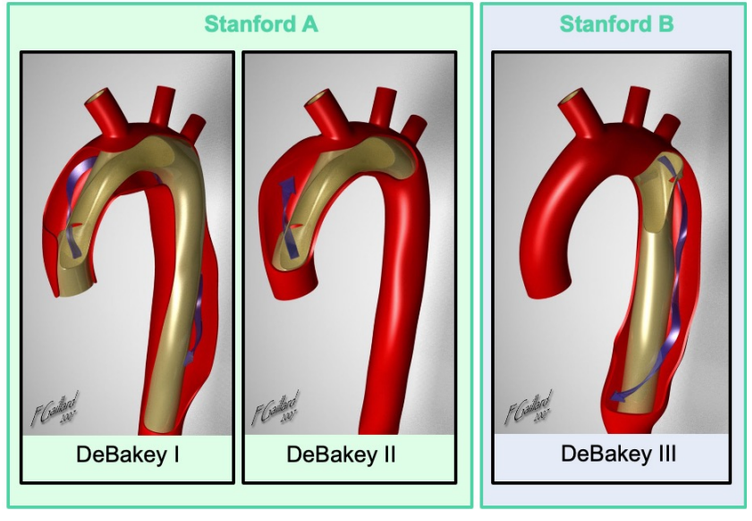
1. 主动脉夹层始于主动脉内膜撕裂
2. 血液进入并浸润中膜（箭头）
3. 形成将内膜与主动脉壁其余部分分开的假通道或假腔
4. 移位的内膜瓣可能引起分支血管阻塞，进而导致终末器官低灌注

/ Aortic Arch Dissection Classification

The most common aortic dissection classification systems are Standford and DeBakey.

Stanford classification is based on the location of the intimal tear:

- **Type A:** involves any part of the aorta proximal to the origin of the left subclavian artery (ascending aorta)
- **Type B:** Dissection involving the descending aorta (with proximal tear distal to the origin of left subclavian artery)



>▪< FURTHER KNOWLEDGE

Consensus statement from society of Vascular surgery and Society of Thoracic Surgeons
https://www.sciencedirect.com/science/article/pii/S000349751931687X?via%3Dihub

Figures: Case courtesy of Frank Gaillard, Radiopaedia.org, rID: 7640

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 主动脉弓夹层分类

最常见的主动脉夹层分型系统是 Standford 和 DeBakey。

Stanford 分型基于内膜撕裂位置：

- A 型：累及左锁骨下动脉起始处近端任何部位的主动脉（升主动脉）
- B 型：累及降主动脉（近端破口位于左锁骨下动脉起源以远）的夹层

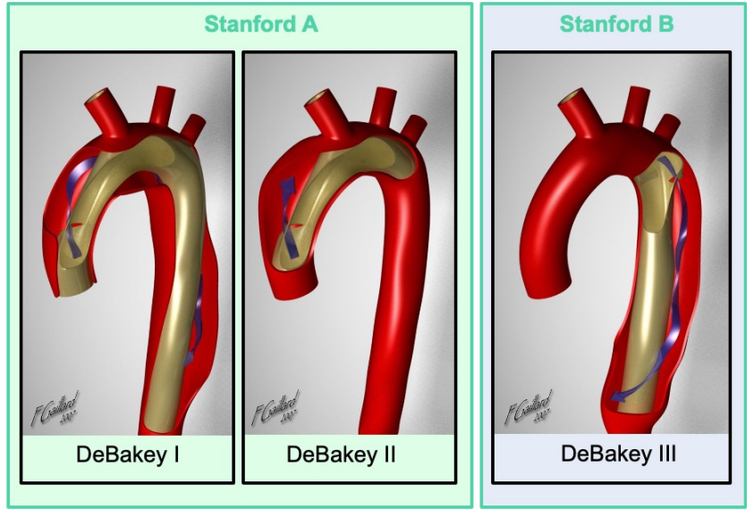
>▪< 进阶知识

血管外科学会和胸外科医师学会的共识声明
https://www.sciencedirect.com/science/article/pii/S000349751931687X?via%3Dihub

图：病例来源：Frank Gaillard，Radiopaedia.org，rID：7640

DeBakey classification (Type I-III):

- **Type** I: Ascending and Descending aorta (= Stanford A)
- **Type II:** involves ascending aorta only (= Stanford A)
- **Type III:** involves descending aorta only, starting after branching of the left subclavian artery (= Stanford B)



Figures: Case courtesy of Frank Gaillard, Radiopaedia.org, rID: 7640

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

DeBakey 分型（I～III 型）：

- **I 型：**升主动脉和降主动脉（= Stanford A）
- **II 型：**仅累及升主动脉（= Stanford A）
- **III 型：**仅累及降主动脉，始于左锁骨下动脉分支以远（ = Stanford B）

图：病例来源：Frank Gaillard，Radiopaedia.org，rID：7640

<!> ATTENTION

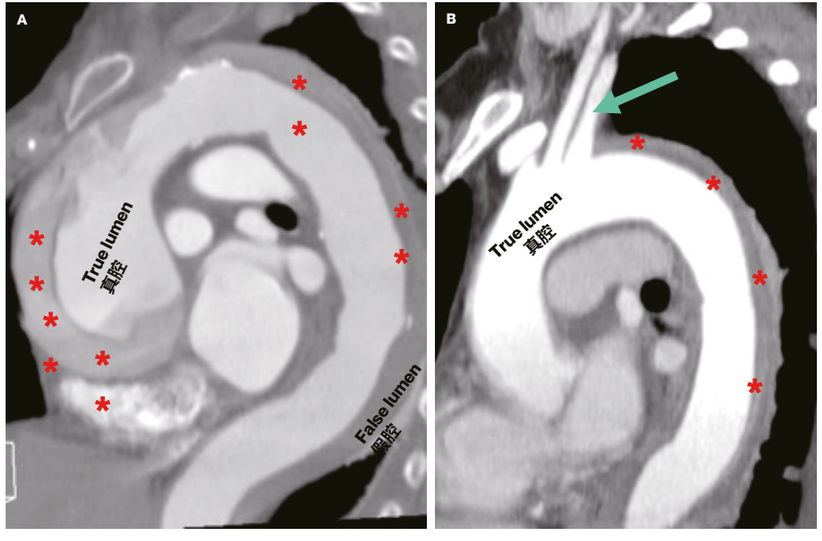
The division between Type A and Type B dissection is very important as it usually guides treatment:

Type A dissections can lead to thrombosis of the coronary arteries and have an increased risk of rupture and cardiac tamponade = **Urgent surgical intervention!**

Type B dissections are usually **treated conservatively** with blood pressure control.

Stanford **Type A** dissection
Stanford **A** 型夹层

Stanford **Type B** dissection
Stanford **B** 型夹层



CTA of the aorta in arterial phase: Oblique sagittal CTA reconstruction (**A**) showing dissection (*) of the ascending and descending aorta - Stanford Type A dissection (DeBakey I). Sagittal CTA reconstruction in a different patient showing dissection of the descending aorta, distal to the branching of the left subclavian artery (arrow)– Stanford Type B dissection (DeBakey III)

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

<!> 注意

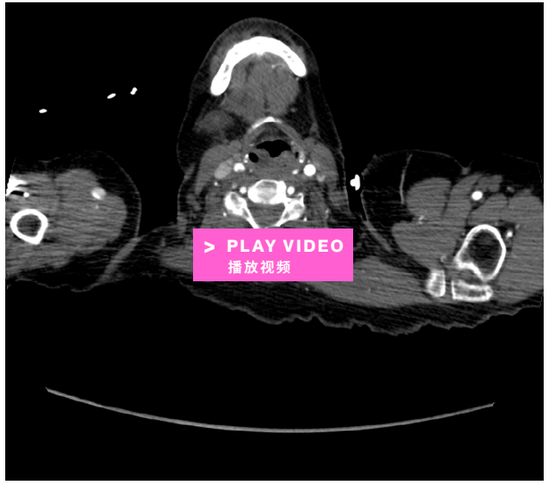
A 型与 B 型夹层的区分非常重要，因其通常直接影响治疗方案的选择：

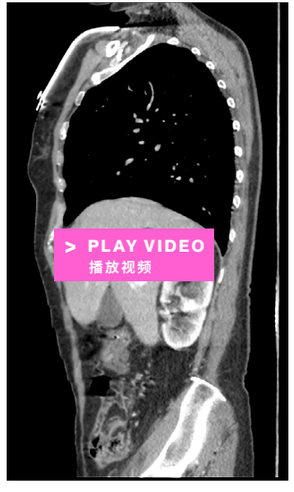
A 型夹层可导致冠状动脉血栓形成，破裂和心包填塞风险的增加 = 紧急手术干预！

B 型夹层通常通过血压控制进行保守治疗。

动脉期的主动脉 CTA：显示升主动脉和降主动脉夹层 (*) 的矢状斜位 CTA 重建 (**A**) - Stanford A 型夹层 (DeBakey I)。另一例患者的矢状位 CTA 重建显示降主动脉夹层，左锁骨下动脉分支远端（箭头）- Stanford B 型夹层 (DeBakey III)

Stanford **Type A** dissection





CTA of the aorta (videos): Axial and sagittal reconstructions showing the dissection starting in the ascending aorta and extending all the way to the suprarenal abdominal aorta – Stanford Type A dissection.
Click to Play Video in Browser (External)

<!> ATTENTION

Did you notice the right common carotid artery thrombosis?

/ Vascular Imaging

CHAPTER OUTLINE:

Stanford **A** 型夹层

/ 血管成像

章节大纲：

<!> 注意

你注意到右颈总动脉血栓形成吗？

主动脉 CTA（视频）：轴位和矢状位重建图像显示，夹层起源于升主动脉，一直延伸至肾上腹主动脉 - Stanford A 型夹层。单击以在浏览器（外部）中播放视频

Stanford **Type B** dissection

CTA of the aorta (videos): Axial and coronal reconstructions showing dissection starting bellow the left subclavian artery and extending to the infra-renal aorta – Stanford Type B dissection.

<!> ATTENTION >=< FURTHER KNOWLEDGE

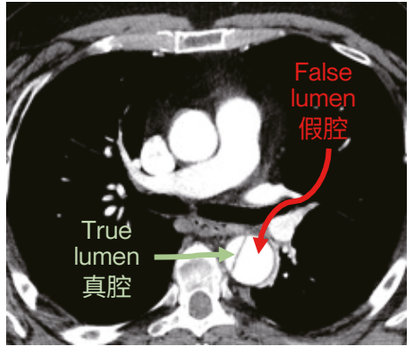
Some clues to distinguish the true lumen from the false lumen in a dissection:

False lumen:

- Larger than true lumen
- Delayed enhancement
- Outer curve of the arch
- Usually, origin of left renal artery
- Beak-sign (wedges around true lumen)

True lumen:

- Smaller than false lumen
- Surrounded by calcifications (when present)
- Usually origin of celiac trunk, superior mesenteric artery and right renal artery



Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

Stanford **B** 型夹层

<!> 注意 >=< 进阶知识

区分夹层真腔和假腔的一些提示：

假腔：

- 大于真腔
- 延迟增强
- 弓外弯
- 通常为左肾动脉起始处
- 鸟嘴征（真腔周围楔形改变）

真腔：

- 小于假腔
- 周围有钙化（如存在）
- 通常为腹腔干、肠系膜上动脉和右肾动脉起始处

主动脉 CTA（视频）：轴位和冠状位重建图像显示，夹层起源于左锁骨下动脉以远，并延伸至肾下主动脉 - Stanford B 型夹层。

/ Aneurysm

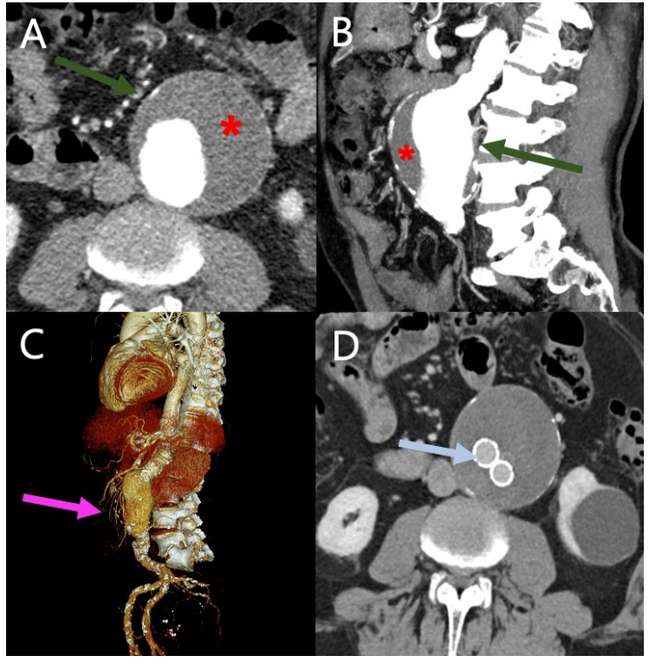
An aneurysm is an abnormal dilatation in a blood vessel due to the weakness of the vessel wall. While aneurysms can affect any blood vessel, they are most common in arteries rather than veins.

Aneurysms can be a **true** or **false**.

A **true** aneurysm contains all the three layers of the arterial wall (intima, media and adventitia)

On the other hand, a **false** aneurysm (also known as pseudoaneurysm), involves only the adventitia.

According to their shape, they can be **saccular** or **fusiform**.



Images **A**, **B**: CTA of a fusiform infra-renal abdominal aortic aneurysm (greenarrows) measuring 7 x 7 cm (axial) and 11 cm (cranio-caudal extension). There is circumferential thrombosis (area with no enhancement surrounding the lumen with contrast) (*) measuring 13 mm. **C**: 3D reconstruction demonstrating the aneurysm (pink arrow). **D**: CTA axial slice showing abdominal aneurysm excluded by an Endovascular aortic repair (EVAR) graft (blue arrow).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 动脉瘤

动脉瘤是由于血管壁薄弱引起的血管的异常扩张。虽然动脉瘤可以累及任何血管，但最常见于动脉而非静脉。

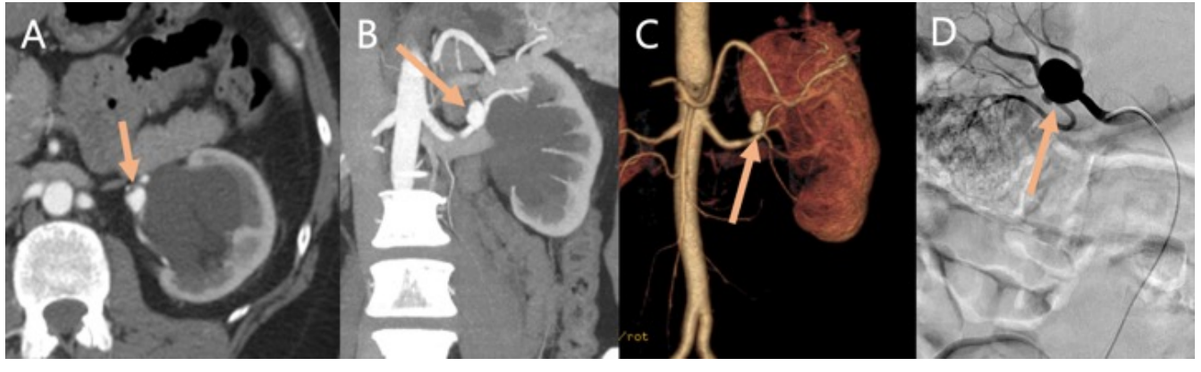
动脉瘤可以是**真性**或**假性**。

真性动脉瘤包含动脉壁的三层结构（内膜、中膜和外膜）

另一方面，**假性**动脉瘤（也称为假动脉瘤）仅累及外膜。

图像 **A**、**B**：梭状肾下腹主动脉瘤（绿色箭头）的 CTA，尺寸为 7 × 7 cm（轴位）× 11 cm（头尾延伸）。存在周向血栓形成（即造影后管腔周围无强化区域）(*)，测量厚度为 13 mm。**C**：三维重建图像显示动脉瘤（粉色箭头）。**D**：CTA 轴位图像显示，腹主动脉瘤已被主动脉腔内修复术 (EVAR) 移植物隔绝（蓝色箭头）。

/ Renal Artery Aneurysm



Images **A-D**: **Aneurysms of the renal arteries.**

A: Focal dilatation of the left renal artery at the renal hilum (arrow).

B: MIP coronal reconstruction showing enhancement of the blood vessels and of the left renal artery aneurysm (arrow).

C: 3D reconstruction of the abdominal aorta, left and right renal arteries with improved visualisation of the renal artery saccular aneurysm (arrow).

D is an example of a DSA of another patient with a right renal artery fusiform aneurysm involving the origin of the 3 renal branches (arrow).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 肾动脉动脉瘤

图像 A～D：**肾动脉动脉瘤。**

A：左肾动脉肾门处局灶性扩张（箭头）。

B：冠状位 MIP 重建图像显示血管和左肾动脉瘤强化（箭头）。

C：腹主动脉及双侧肾动脉的三维重建图像，可更清晰地显示肾动脉囊性动脉瘤（箭头）。

D 图为另一例患者的 DSA 图像，累及 3 支肾分支（箭头）的起始处。

/ Vasculitis

Vasculitis = generalised vessel inflammation. It can have many different clinical presentations and can involve any organ in the human body. Most vasculitis types are the consequence of immune related phenomena.

There are several classification systems, that partially overlap. The **Revised International Chapel Hill Consensus Conference Nomenclature of Vasculitis** distinguishes between primary and secondary vasculitis.

Primary vasculitis – The aetiology is unknown; these are heterogeneous, multi-system disorders characterised by inflammation and necrosis of large (e.g., Takayasu arteritis), medium (e.g., polyarteritis nodosa) and small blood vessels (e.g., granulomatosis with polyangiitis formerly called Wegener's granulomatosis). It also includes vasculitis affecting vessels only in a single organ (e.g., aortitis), as well as variable vessel vasculitis (e.g., Behçet syndrome).

Secondary vasculitis – The aetiology is known or is highly suggestive. It is subdivided into – **vasculitis associated with systemic disease** (lupus vasculitis, rheumatoid vasculitis, sarcoid vasculitis) and **vasculitis associated with a probable aetiology** (hepatitis C and B vasculitis, syphilis associated aortitis, vasculitis secondary to bacterial or viral infection).

>▪< FURTHER KNOWLEDGE

2012 Revised International Chapel Hill Consensus Conference Nomenclature of Vasculitis

https://onlinelibrary.wiley.com/doi/10.1002/art.37715

Jennette, J.C., Falk, R.J., Bacon, P.A., Basu, N., Cid, M.C., Ferrario, F., Flores-Suarez, L.F., Gross, W.L., Guillevin, L., Hagen, E.C., Hoffman, G.S., Jayne, D.R., Kallenberg, C.G.M., Lamprecht, P., Langford, C.A., Luqmani, R.A., Mahr, A.D., Matteson, E.L., Merkel, P.A., Ozen, S., Pusey, C.D., Rasmussen, N., Rees, A.J., Scott, D.G.I., Specks, U., Stone, J.H., Takahashi, K. and Watts, R.A. (2013), 2012 Revised International Chapel Hill Consensus Conference Nomenclature of Vasculitides. Arthritis & Rheumatism, 65: 1-11. https://doi.org/10.1002/art.37715

/ 血管炎

血管炎 = 全身性血管炎症。其临床表现多样，可累及人体任何器官。大多数血管炎类型是免疫相关现象的结果。

目前有数种分类系统，且部分存在重叠。《修订版国际 Chapel Hill 共识会议血管炎命名法》对原发性和继发性血管炎进行了区分。

原发性血管炎 - 病因未明；是异质性多系统疾病，以大血管（如大动脉炎）、中血管（如结节性多动脉炎）和小血管（如肉芽肿性多血管炎，之前被称为韦格纳肉芽肿）的炎症和坏死为特征。该分类还涵盖仅累及单一器官血管的血管炎（如主动脉炎），以及可变血管血管炎（如贝赫切特综合征）。

继发性血管炎 - 病因已知或高度提示。可细分为**全身性疾病相关的血管炎**（狼疮性血管炎、类风湿性血管炎、结节病性血管炎）和**可能病因相关的血管炎**（丙型肝炎和乙型肝炎血管炎、梅毒性主动脉炎、细菌或病毒感染继发性血管炎）。

>▪< 进阶知识

2012 年修订版国际 Chapel Hill 共识会议血管炎命名法

https://onlinelibrary.wiley.com/doi/10.1002/art.37715

Jennette, J.C., Falk, R.J., Bacon, P.A., Basu, N., Cid, M.C., Ferrario, F., Flores-Suarez, L.F., Gross, W.L., Guillevin, L., Hagen, E.C., Hoffman, G.S., Jayne, D.R., Kallenberg, C.G.M., Lamprecht, P., Langford, C.A., Luqmani, R.A., Mahr, A.D., Matteson, E.L., Merkel, P.A., Ozen, S., Pusey, C.D., Rasmussen, N., Rees, A.J., Scott, D.G.I., Specks, U., Stone, J.H., Takahashi, K. and Watts, R.A. (2013), 2012 Revised International Chapel Hill Consensus Conference Nomenclature of Vasculitides. Arthritis & Rheumatism, 65: 1-11. https://doi.org/10.1002/art.37715

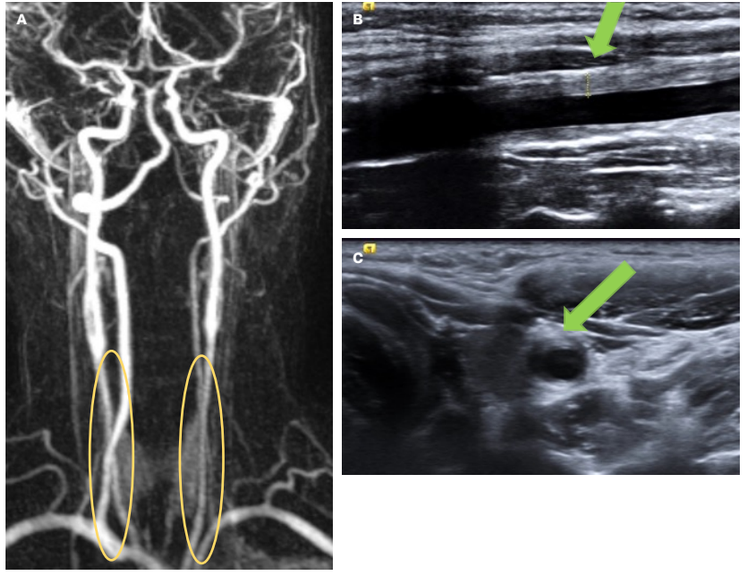
/ Takayasu Arteritis (Pulseless Disease)

= Large vessel granulomatous vasculitis typically affecting the aorta and its main branches, e.g., the common carotid arteries, brachiocephalic trunk and subclavian arteries.

After an initial systemic manifestation with fever, night sweats and arthralgia, follows a chronic phase with limb ischaemia, hypertension (renovascular), cardiac complications and pulmonary arterial involvement.

On US, there is thickening of the arterial wall ± secondary thrombus formation ± occlusion.

CT/MRI can additionally show vessel wall enhancement, aneurysm and pseudoaneurysm and diffuse narrowing of the distal aorta.



A. 3D Contrast-enhanced MRA (MIP) in a patient with Takayasu arteritis **shows stenoses of the common carotid arteries**, with normal sized internal and external carotids. Longitudinal (**B**) and axial US view (**C**) of neck vessels showing **thickening of left common carotid artery wall**.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 大动脉炎（无脉症）

= 通常累及主动脉及其主要分支（例如，颈总动脉、头臂干和锁骨下动脉）的大血管肉芽肿性血管炎。

初期表现为发热、盗汗和关节痛，随后进入慢性期，表现为肢体缺血、高血压（肾血管性）、心脏并发症和肺动脉受累。

超声检查可见动脉壁增厚 ± 继发性血栓形成 ± 闭塞。

CT/MRI 还可显示血管壁强化、动脉瘤和假性动脉瘤以及远端主动脉弥漫性狭窄。

/ 血管成像

章节大纲：

A. 一例大动脉炎患者的 3D 对比增强 MRA (MIP) **显示颈总动脉狭窄**，颈内动脉和颈外动脉正常。颈部血管的纵向 (**B**) 和轴位超声视图 (**C**) 显示**左颈总动脉壁增厚**。

/ Fibromuscular Dysplasia (FMD)

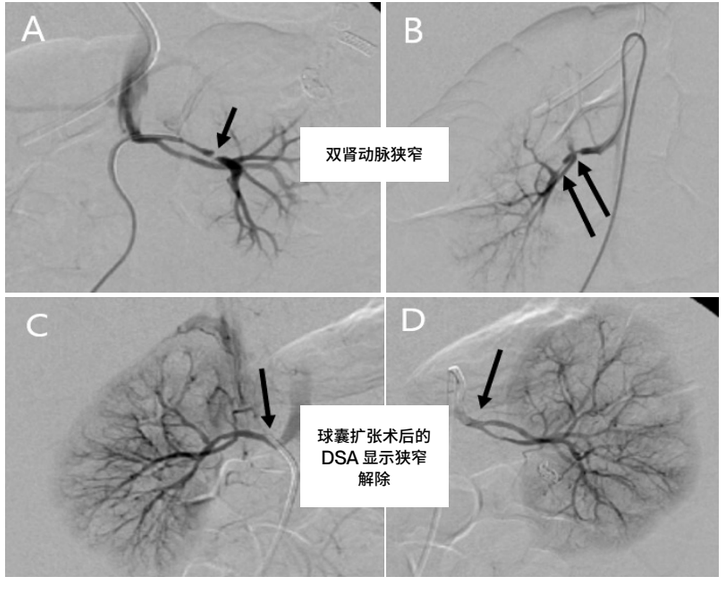
Fibromuscular dysplasia (FMD) is an idiopathic, focal, non-inflammatory and non-atherosclerotic disease that affects small and medium size arteries.

FMD most frequently affects the renal and neck arteries (carotid and vertebral). It's more prevalent in young women and is often asymptomatic.

Patients that are symptomatic usually present with:

- Hypertension (due to renal artery stenosis, which usually is bilateral)
- Headaches, TIA or even stroke (when the carotids and vertebral arteries are involved)
- Myocardial infarction or angina pectoris (due to coronary involvement)

Most common radiological findings include vessels with a “string of beads appearance” due to focal stenosis intercalating with small aneurysms typically affecting the mid segment of the vessel and sparing the origins.



Renal DSA of the left (**A**) and right (**B**) renal arteries in a patient with bilateral FMD of the renal arteries. For endovascular treatment, the interventional radiologist performs a DSA with insertion and subsequent inflation of a balloon dilation catheter at the site of stenosis, which usually results in stenosis resolution. Right renal artery (**C**) and left renal artery (**D**) after balloon dilatation. If dilatation failure, a stent can be placed.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 纤维肌性发育不良 (FMD)

/ 血管成像

章节大纲：

纤维肌性发育不良 (fibromuscular dysplasia，FMD) 是一种影响中小动脉的特发性、局灶性、非炎症性和非动脉粥样硬化性疾病。

FMD 最常累及肾动脉和颈部动脉（颈动脉和椎动脉）。它在年轻女性中更为普遍，且通常无症状。

有症状的患者通常表现为：

- 高血压（肾动脉狭窄所致，通常为双侧）
- 头痛、TIA 甚至卒中（颈动脉和椎动脉受累时）
- 心肌梗死或心绞痛（由于冠状动脉受累）

最常见的放射学表现为血管呈“串珠样”改变，由局灶性狭窄和微小动脉瘤交替出现所致，通常影响血管中段而不影响起始处。

一例双侧肾动脉 FMD 患者的左肾 (**A**) 和右肾 (**B**) 动脉 DSA 图像。在血管内治疗中，介入放射科医生会进行 DSA检查， 并在狭窄部位插入球囊扩张导管，进行扩张，通常可使狭窄解除。球囊扩张后的右肾动脉 (**C**) 和左肾动脉 (**D**)。如果扩张失败，可放置支架。

/ Arterial Compression Syndromes

Vascular compression syndromes can be divided into several groups: (1) a vascular structure is the "compresser"; (2) the vascular structure is the "compressee"; (3) a vascular structure compresses another vascular structure.

Examples of vascular compression syndromes include:

- / Anomalous origin of the coronary artery (which courses between the ascending aorta and the pulmonary trunk)
- / Hypothenar hammer syndrome (compression of the ulnar artery by the hypothenar muscles)
- / Eagle syndrome (see below) and many more

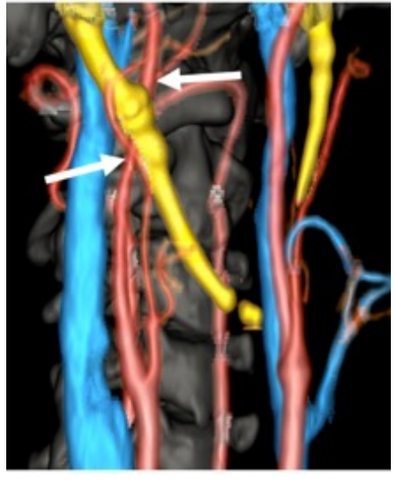
>▪< FURTHER KNOWLEDGE

Eagle Syndrome

= elongation of the styloid process causing pain due to compression of the cranial nerves IX (glossopharyngeal nerve) or X (vagus nerve) or due to compression of the carotid artery, in which case the pain is mediated by the sympathetic plexus along the carotid artery. Compression of the carotid artery can also lead to stroke.

An elongated styloid process measures > 3 cm. It can be unilateral or bilateral.

Not all patients with an elongated styloid process are symptomatic. In fact, the vast majority are asymptomatic. In symptomatic patients, resection of the styloid process is carried out, which leads to immediate symptom relief.



Eagle syndrome with compression of the internal carotid artery
Compression of the internal carotid artery (arrows) by the calcified stylohyoid ligament (rendered in yellow). Arteries are rendered in red, veins in blue. This is a 3D reconstruction from a contrast-enhanced CT.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 动脉压迫综合征

血管压迫综合征可分为几组：(1) 血管结构为“压迫者”；(2) 血管结构为“被压迫者”；(3) 某一血管结构压迫另一血管结构。

血管压迫综合征的例子包括：

- / 冠状动脉起始处异常（位于升主动脉和肺动脉干之间）
- / 小鱼际锤打综合征（小鱼际肌压迫尺动脉）
- / 伊格尔综合征（见下文）等

>▪< 进阶知识

伊格尔综合征

= 茎突过长压迫舌咽神经（ IX）、迷走神经 （X）或颈动脉，从而引起疼痛。若压迫颈动脉，疼痛由颈动脉交感神经丛介导。颈动脉受压也可导致卒中。

茎突延长 > 3 cm，可为单侧或双侧。

并非所有茎突延长的患者都有症状。事实上，绝大多数患者没有症状。对于有症状的患者，切除茎突可立即缓解症状。

伴有颈内动脉受压的伊格尔综合征
钙化的茎突舌骨韧带（呈黄色）压迫颈内动脉（箭头）。动脉呈现红色，静脉呈现蓝色。这是基于对比增强 CT图像 进行的 三维重建。

Venous Disease

Vascular Imaging

血管成像

CHAPTER OUTLINE:

章节大纲：

静脉疾病

/ Deep Vein Thrombosis (DVT)

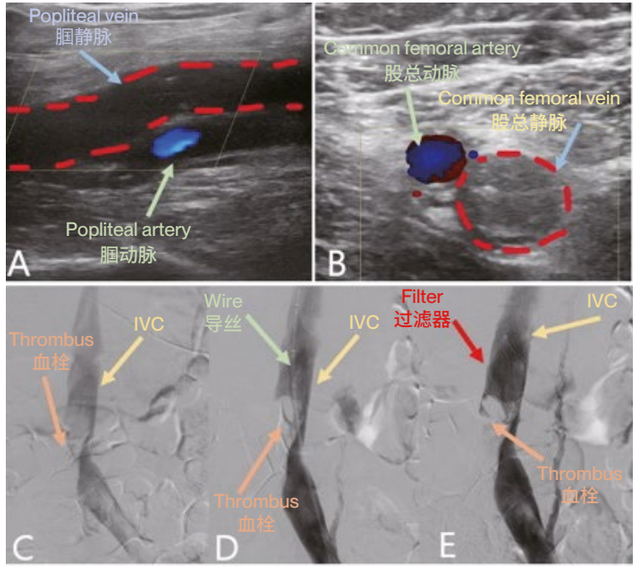
Clots within the deep veins are more likely to produce a clinically significant PE because these clots are usually larger than those in the superficial system. Also, because they are surrounded by muscle, the chance of the clot being dislodged during muscle contraction is higher than for a clot in the superficial veins. For these reasons, the focus in a venous duplex examination is on the deep system.

Don't forget that thrombosis can also happen on the upper limbs and neck vessels.

Doppler US is a perfect tool for identifying and evaluating blood clots, thus allowing physicians to take actions to minimise the risks of clot embolisation and pulmonary embolism.

>▪< FURTHER KNOWLEDGE

Inferior Vena Cava Filter
https://www.ncbi.nlm.nih.gov/books/NBK549900/



A and **B**: Doppler US of the thigh demonstrating occlusive thrombosis (**highlighted in red**) of the deep venous system of the left lower limb extending from the popliteal vein (**A**) to the left common femoral vein (**B**) and to the infra-renal inferior vena cava (IVC). Note only partly occlusive thrombus seen as a filling defect in **C** - arrow. This patient could not have anti-coagulation therapy, therefore an **IVC filter** was placed (**D**-**E**).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 深静脉血栓形成 (DVT)

深静脉内血凝块更可能引起临床上显著的肺动脉栓塞，因为这些血凝块通常比浅静脉内血凝块大。此外，由于它们被肌肉包围，肌肉收缩期间血凝块脱落的几率高于浅静脉中的血凝块。因此，静脉双功能超声检查的重点是深静脉系统。

别忘了，血栓也可发生在上肢和颈部血管。

多普勒超声是识别和评估血凝块的完美工具，它使医生可以采取措施，将血凝块栓塞和肺栓塞的风险降至最低。

>▪< 进阶知识

下腔静脉滤器
https://www.ncbi.nlm.nih.gov/books/NBK549900/

A 和 **B**：大腿多普勒超声显示左下肢深静脉系统从腘静脉 (**A**) 延伸至左股总静脉 (**B**) 和肾下水平的下腔静脉 (inferior vena cava，IVC) 的闭塞性血栓形成（**以红色突出显示**）。请注意，在 **C** 中，仅部分闭塞性血栓表现为充盈缺损（箭头）。该患者无法接受抗凝治疗，因此放置了 **IVC 滤器** (**D**～**E**)。

/ Portal Hypertension (PH)

Portal Hypertension (PH) is defined as increased pressure in the portal venous system. A hepa-to-venous pressure gradient (HVPG) > 5 mmHg or "in simpler terms" - a pressure gradient between one hepatic vein and the portal vein > 5 mmHg makes the diagnosis.

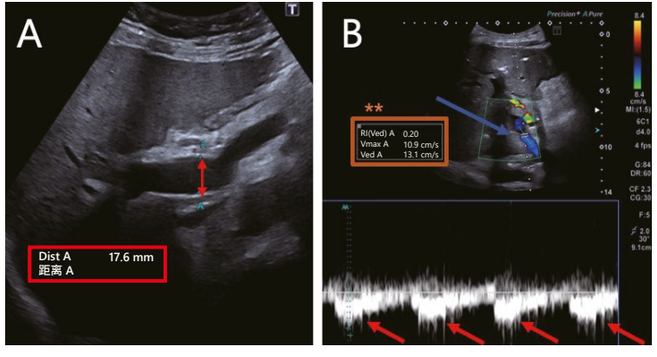
This becomes clinically important when the pres-sure gradient rises to over 10 mmHg, due to the increased risk of complications.

The causes of PH can be divided according to their relationship to the hepatic sinusoids into:

- **Pre-hepatic**: AV fistula, portal vein thrombosis
- **Hepatic**: cirrhosis (**most common**), hepatitis
- **Post-hepatic**: Budd-Chiari, congestive heart failure

Measuring the HVPG is an invasive task, and most of the time the diagnosis is made indirectly with surrogate markers of PH.

Duplex Doppler US, integrated with liver and spleen elastography represent the first line imag-ing method in suspected PH.



<!> ATTENTION

Most common findings of PH include:

- Portal vein dilatation (> 14 mm) – image **A**
- Splenomegaly (> 13 cm bipolar length)
- Ascites
- Low portal venous velocity (Doppler) < 16 cm/s (**)
- Porto-systemic shunts
- Reversal/hepatofugal flow in the portal vein (late finding)

Image **B** – colour mode shows **portal venous blood flow in blue**, and the **spectral waveform is displayed bellow the baseline** – meaning blood is moving away from the probe, i.e., portal blood is moving away from the liver when it should normally move towards the liver hilum!

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 门静脉高压 (PH)

门静脉高压 (PH) 定义为门静脉系统压力升高。诊断依据是肝静脉压力梯度 (HVPG) > 5 mmHg，或“更简单地说”，一条肝静脉和门静脉之间的压力梯度 > 5 mmHg。

当压力梯度升至 10 mmHg 以上时，在临床上变得重要，因为并发症风险增加。

根据 PH 与肝窦的关系，PH 的病因可分为：

- **肝前**：动静脉瘘、门静脉血栓形成
- **肝性**：肝硬化（**最常见**）、肝炎
- **肝后**：布加综合征、充血性心力衰竭

测量 HVPG 是一项有创性操作，目前大多采用 PH 的替代标志物进行间接诊断。

双功能多普勒超声结合肝脾弹性成像是疑似 PH 的一线影像学检查。

<!> 注意

PH 最常见的表现包括：

- 门静脉扩张 (> 14 mm) - 图像 **A**
- 脾肿大（双极长度 > 13 cm）
- 腹水
- 门静脉低流速（多普勒）< 16 cm/s (**)
- 门体分流
- 门静脉中逆转/离肝血流（晚期结果）

图像 **B** - 彩色模式显示**门静脉血流为蓝色，频谱波形在基线下方显示** - 这意味着血液正在远离探头移动，即门静脉血液正在远离肝脏，而正常情况下应该向肝门移动！

When the HVPG is above 10 mmHg, the pressure in the portal venous system (PVS) is so high that spontaneous porto-systemic collaterals begin to appear. These porto-systemic shunts or varices are connections between the portal venous system and the systemic circulation, allowing splanchnic blood to bypass the liver.

Most common varices include:

- Oesophageal and paraesophageal varices
- Left gastric varices
- Retro-gastric
- Paraumbilical vein recanalisation (so-called *Caput Medusae*)
- Superior rectal vein (haemorrhoids)
- Spleno-renal shunts

While these connections help alleviate the pressure in the PVS, they bring dire consequences to the patient:

- **Risk of rupture and massive bleeding**
- Hepatic encephalopathy
- Hepato-renal syndrome
- Hepatopulmonary syndrome

Axial contrast-enhanced CT slice of the portal phase (**A**) demonstrating an irregular and heterogenous liver (cirrhotic, *) with recanalisation of the paraumbilical vein (arrows). Axial contrast-enhanced CT slice of the portal phase (**B**) in another patient showing an increased spleen size (splenomegaly, arrow) and an abnormally engorged and tortuous varicose left gastric vein (arrow).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

当 HVPG > 10 mmHg 时，门静脉系统 (portal venous system，PVS) 的压力非常高，以至于开始出现自发性门体侧支循环。这些门体分流或静脉曲张是门静脉系统和体循环之间的连接，允许内脏血液绕过肝脏。

最常见的静脉曲张包括：

- 食管及食管旁静脉曲张
- 左胃底静脉曲张
- 胃后
- 脐旁静脉再通（称为*海蛇头征*）
- 直肠上静脉（痔疮）
- 脾肾分流

尽管这些连接有助于缓解 PVS 的压力，但它们会给患者带来严重后果：

- **破裂及大出血风险**
- 肝性脑病
- 肝肾综合征
- 肝肺综合征

门静脉期轴位对比增强 CT 图像 (A)，显示肝脏不规则和不均匀（肝硬化，*），伴脐旁静脉再通（箭头）。另一例患者的门静脉期轴位对比增强 CT 图像 (B)，显示脾脏增大（脾肿大，箭头）以及异常充血和迂曲的胃左静脉曲张（箭头）。

/ Budd-Chiari Syndrome (BCS)

Budd-Chiari syndrome (BCS) is a potentially life-threatening disorder characterised by occlusion of the hepatic outflow tract usually at the level of the hepatic veins or the inferior vena cava.

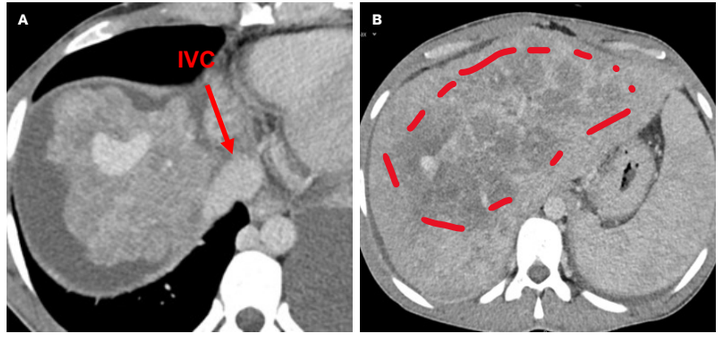
Most common causes include hypercoagulable conditions and myeloproliferative diseases resulting in thrombosis of at least two hepatic veins.

The classic acute presentation is the triad of ascites, abdominal pain and hepatomegaly.

While US is usually sufficient for confirming the diagnosis, CT and/or MRI is often necessary for planning further treatment. Imaging features depend on the extent and duration of the disease.

Most common findings include:

- No identifiable hepatic veins
- Hepatosplenomegaly
- Early enhancement of the caudate lobe
- “Flip-flop appearance”- i.e., delayed enhancement of the peripheral liver with a more hypodense central parenchyma



A and **B**: Axial contrast-enhanced CT (portal phase) demonstrating no apparent hepatic veins entering the IVC, associated with a very heterogenous liver showing different contrast enhancement between the peripheral and central liver parenchyma

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 布加综合征 (BCS)

布加综合征 (Budd-Chiari Syndrome，BCS) 是一种可能危及生命的疾病，特征为肝流出道阻塞，阻塞通常位于肝静脉或下腔静脉水平。

最常见的原因包括高凝状态和骨髓增殖性疾病，导致至少 2 条肝静脉血栓形成。

典型的急性表现为腹水、腹痛和肝肿大三联征。

虽然超声通常足以确诊，但往往需要进行 CT 和/或 MRI 来规划进一步的治疗。影像学特征取决于疾病的范围和持续时间。

最常见的表现包括：

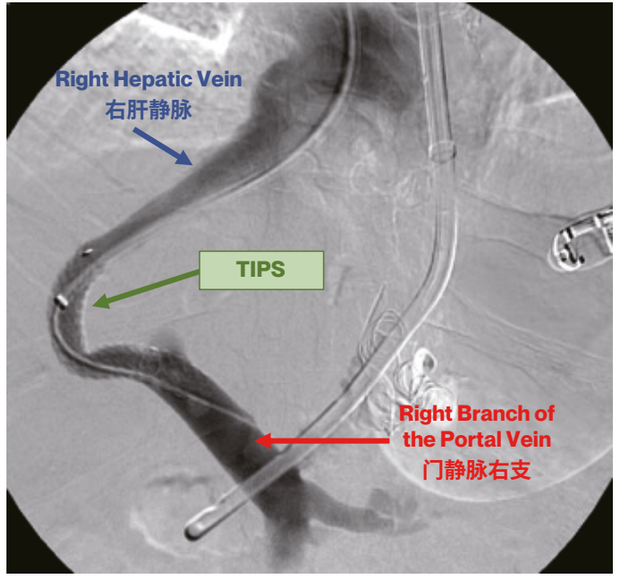
- 无可识别的肝静脉
- 肝脾肿大
- 尾状叶早期增强
- “翻转强化征”- 即，外周肝增强延迟，中央实质密度更低

A 和 **B**：轴位对比增强 CT（门静脉期）显示无明显肝静脉进入 IVC，伴有高度异质性肝脏，显示外周和中央肝实质之间的对比增强不同

Whilst anticoagulation is the corner-stone of treatment, most patients will need additional (more invasive) treatment like hepatic vein stenting, Transhepatic Intrajugular Portosystemic Shunt (TIPS) or liver transplantation due to PH.

<!> ATTENTION

In cases of severe PH with refractory variceal bleeding, hepatorenal syndrome or hepatic vein occlusion, an interventional radiologist can perform a TIPS procedure. This involves the creation of a "bridge" between a branch of a portal vein and one the hepatic veins (usually the right one) allowing for the splanchnic blood to bypass the liver and therefore reduce PH to "safer" levels.



DSA demonstrating a stent creating a connection between the right branch of the portal Vein (red arrow) and the right hepatic vein (blue arrow) – TIPS (green arrow).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

虽然抗凝是治疗的基础，但由于 PH，大多数患者需要额外的（更具侵入性）治疗，如肝静脉支架置入术、经颈静脉肝内门体分流术 (Transhepatic Intrajugular Portosystemic Shunt，TIPS) 或肝移植。

<!> 注意

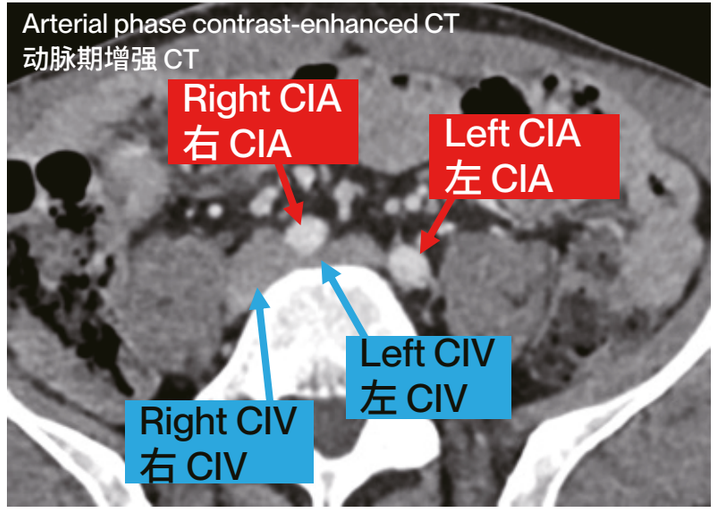
对于重度 PH 伴难治性静脉曲张出血、肝肾综合征或肝静脉闭塞的患者，介入放射科医生可行 TIPS。这涉及在门静脉分支和其中一条肝静脉（通常是肝右静脉）之间建立“桥梁”，使内脏血液绕过肝脏，从而将 PH 降低至“更安全”的水平。

DSA 显示支架在门静脉右支（红色箭头）和肝右静脉（蓝色箭头）之间建立了连接 - TIPS（绿色箭头）。

Venous Compression Syndromes

Venous compression syndromes include:

- May-Thurner syndrome (compression of the left common iliac vein, see below)
- Nutcracker syndrome (compression of the left renal vein by the superior mesenteric artery)
- Posterior nutcracker syndrome (trapping of the retro-aortic left renal vein between the aorta and vertebral column)
- Paget Schroetter syndrome («effort thrombosis» due to subclavian vein compression in the costoclavicular space)



>▪< FURTHER KNOWLEDGE

The May-Thurner syndrome is characterised by chronic compression of the left common iliac vein (CIV) against the lumbar vertebrae by the overlying right common iliac artery (CIA), with or without deep venous thrombosis.

Compression of the left CIV is more common than compression of the right CIV as the former has a more transverse course.

Pregnancy or long immobilisation are predisposing factors.

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

静脉压迫综合征

静脉压迫综合征包括：

- 髂静脉压迫综合征（左髂总静脉受压，见下文）
- 胡桃夹综合征（肠系膜上动脉压迫左肾静脉）
- 后胡桃夹综合征（主动脉后左肾静脉夹在主动脉和脊柱之间）
- 佩-施二氏综合征（肋锁骨间隙锁骨下静脉受压导致的“受挫性血栓形成”）

>▪< 进阶知识

髂静脉压迫综合征的特征是左髂总静脉 (left common iliac vein，CIV) 被覆盖的右髂总动脉 (right common iliac artery，CIA) 慢性压迫腰椎，伴或不伴深静脉血栓形成。

左侧 CIV 受压比右侧 CIV 受压更常见，因为前者的走行更偏横向。

妊娠或长期制动是易感因素。

Vascular Tumours and Malformations

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

血管肿瘤和畸形

/ Definitions and Classification

Based on improved diagnostic and genetic features, according to the **International Society for the Study of Vascular Anomalies (ISSVA)**, vascular anomalies are divided into vascular tumours and vascular malformations.

Vascular tumours are neoplastic lesions, which can regress spontaneously (e.g., infantile haemangioma). They show increased proliferation of endothelial and vascular cells. Vascular tumours are classified into:

- Benign tumours
- Locally aggressive or low metastatic risk intermediate malignant tumours and
- Malignant tumours

<!> ATTENTION

Use of the contemporary nomenclature is important to ensure appropriate management of vascular anomalies.

Therefore, the term “lymphatic malformation” should be used instead of the older terms “lymphangioma” or “cystic hygroma”. Likewise, the term “venous malformation” should be used instead of “cavernous haemangioma”.

US, CT and MRI play an essential role for the diagnosis of vascular tumours and malformations and are, therefore, pivotal for patient management.

Vascular malformations are non-neoplastic structural anomalies. They can be subdivided into:

- Simple malformations > capillary, venous, lymphatic, arteriovenous malformations (AVMs) and arteriovenous fistulae (AVF) versus combined malformations > having > than one vascular component, e.g., lymphatic and venous
- High-flow malformations > with an arterial component, e.g., AVMs, AVF versus low-flow malformations > without an arterial component, e.g., capillary, venous or lymphatic
- Channel type malformations = malformations of major vessels
- Malformations associated with syndromes, e.g., syndromes with venous malformations (Sturge-Weber, Klippel-Trénaunay, Proteus, blue rubber bleb naevus, Maffucci and Gorham-Stout) versus syndromes with high-flow malformations (Rendu-Osler-Weber, Cobb, Wyburn-Mason, Parkes Weber)

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 定义和分类

基于改进的诊断和遗传学特征，根据国际血管异常研究学会 (International Society for the Study of Vascular Anomalies，ISSVA)，血管异常分为血管肿瘤和血管畸形。

血管肿瘤是肿瘤性病变，可自发消退（例如婴幼儿血管瘤）。表现为内皮细胞和血管细胞增殖增加。血管肿瘤可分为：

- 良性肿瘤
- 局部侵袭性或低转移风险中度恶性肿瘤，以及
- 恶性肿瘤

血管畸形是非肿瘤性结构异常。它们可细分为：

- 单纯畸形 > 毛细血管、静脉、淋巴管、动静脉畸形 (arteriovenous malformation，AVM) 和动静脉瘘 (arteriovenous fistulae，AVF) vs. 合并畸形 > 有超过一种血管成分，如淋巴管和静脉
- 高血流畸形 > 有动脉成分，如 AVM、AVF vs. 低血流畸形 > 无动脉成分，如毛细血管、静脉或淋巴管
- 通道型畸形 = 主要血管畸形
- 与综合征相关的畸形，如静脉畸形综合征（Sturge-Weber、Klippel-Trénaunay、Proteus、蓝色橡皮泡痣、Maffucci 和 Gorham-Stout）vs. 伴高血流畸形的综合征（Rendu-Osler-Weber、Cobb、Wyburn-Mason、Parkes Weber）

<!> 注意

采用当代命名法对于确保恰当处理血管异常非常重要。

因此，应使用术语“淋巴管畸形”代替旧术语“淋巴管瘤”或“囊性淋巴管瘤”。同样，应使用“静脉畸形”一词，而不是“海绵状血管瘤”。

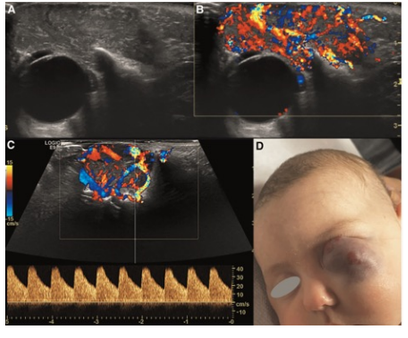
US、CT 和 MRI 在诊断血管肿瘤和畸形中起着至关重要的作用，因此对于患者管理具有重要意义。

/ Benign Vascular Tumours

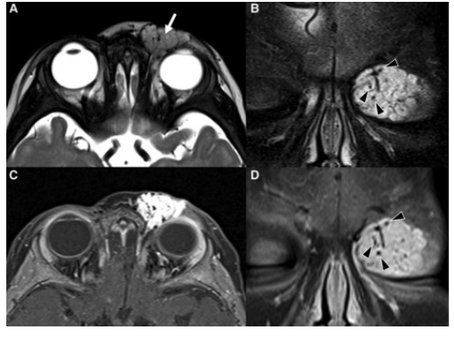
Benign vascular tumours include pyogenic granuloma, haemangioma and Masson tumours. **Haemangiomas** can be divided into infantile and congenital forms. Infantile haemangiomas (absent at birth) usually have a triphasic growth: rapid initial proliferation, stabilisation and then regression until total involution.

>▪< FURTHER KNOWLEDGE

At Doppler-US, the tumours are hypervascular. At MRI, haemangiomas in the proliferation phase are strongly hyperintense on T2, they show flow-voids and display major enhancement after iv. contrast administration. Involuting haemangiomas have a fibro-fatty aspect (high T1 signal) and they display decreased enhancement.



US of an infantile haemangioma (IH) of the left orbit in a 5-month-old boy, during the proliferative phase. B-mode US shows a hyperechoic mass with well-defined margins overlying the globe (**A**) and a very high vascular density at Colour-Doppler US (**B**). Spectral analysis revealed a low resistance arterial flow (**C**). The clinical appearance of the lesion is depicted in (**D**).



MR images of a left periorbital IH in a 1-year-old girl. Axial (**A**) and coronal fat-saturated (**B**) T2 weighted images show a well-defined hyperintense mass (arrow in **A**) with multiple internal flow voids (black arrowheads in **B** and **D**), extending from the anterior periorbital soft tissues into the orbit. Axial (**C**) and coronal (**D**) contrast-enhanced fat-saturated T1 weighted images show vivid homogeneous contrast enhancement of the vascular lesion.

Both figures are reproduced from: Colafati GS, Piccirilli E, Marrazzo A, Carboni A, Diociaiuti A, El Hachem M, Esposito F, Zama M, Rollo M, Gandolfo C, Tomà P. Vascular lesions of the paediatric orbit: A radiological walkthrough. Front Pediatr. 2022 Nov 30;10:734286. doi: 10.3389/fped.2022.734286. PMID: 36533238; PMCID: PMC9748295.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 良性血管肿瘤

良性血管肿瘤包括化脓性肉芽肿、血管瘤和马松瘤。**血管瘤**可分为婴儿型和先天性。婴幼儿血管瘤（出生时不存在）通常呈三相生长：初期快速增殖，稳定，然后消退直至完全消失。

>▪< 进阶知识

多普勒超声显示肿瘤血供丰富。在 MRI 中，增殖期的血管瘤在 T2 上呈强高信号，在静脉注射对比剂后显示流空现象，并显示出明显增强。消退期血管瘤有纤维脂肪表现（T1 高信号），且增强减弱。

一例 5 月龄男孩在增殖期的左眼眶婴幼儿血管瘤 (infantile haemangioma，IH) 的超声检查。B 超显示高回声团块，边界清晰，覆盖眼球 (**A**)，彩色多普勒超声显示血管密度非常高 (**B**)。频谱分析显示低阻力动脉血流 (**C**)。病变的临床表现见 (**D**)。

一例 1 岁女孩左眼眶周 IH 的 MR 图像。轴位 (**A**) 和冠状位脂肪饱和 (**B**) T2 加权图像显示边界清楚的高信号肿块（**A** 中的箭头），伴多个内部流空（**B** 和 **D** 中的黑色箭头），从前眶周软组织延伸至眼眶。轴位 (**C**) 和冠状位 (**D**) 对比增强脂肪饱和 T1 加权图像显示血管病变显著的均匀对比增强。

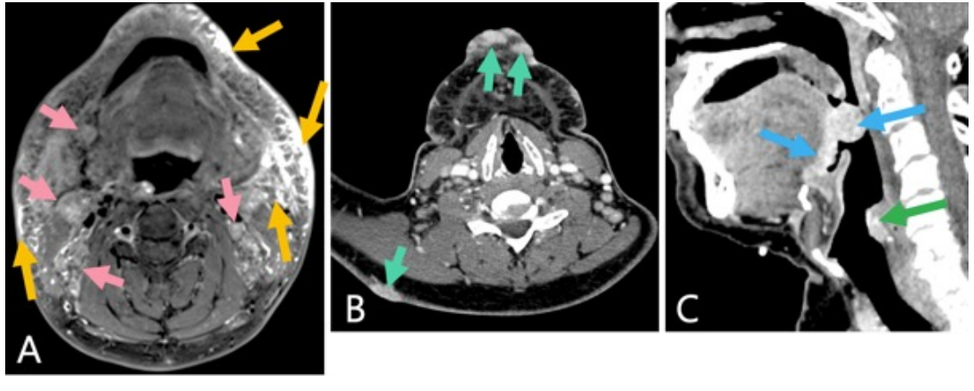
两图均摘自： Colafati GS, Piccirilli E, Marrazzo A, Carboni A, Diociaiuti A, El Hachem M, Esposito F, Zama M, Rollo M, Gandolfo C, Tomà P. Vascular lesions of the paediatric orbit: A radiological walkthrough. Front Pediatr. 2022 Nov 30;10:734286. doi: 10.3389/fped.2022.734286. PMID: 36533238; PMCID: PMC9748295.

/ Locally Aggressive Vascular Tumours

Locally aggressive vascular tumours include **kaposiform haemangioendothelioma** and **Kaposi sarcoma (KS)**.

KS arises from lymphatic endothelial cells. There are **four types of KS**: classic, post-organ transplant, AIDS-related and endemic (in Africa). Infection with the Human Herpes type 8 virus plays a major role in the aetiology of KS. The most common involvement in KS is subcutaneous and mucosal but deep organ involvement can also occur., e.g., the lungs. At CT and MR imaging, KS typically manifests with **strongly enhancing widespread cutaneous, subcutaneous and mucosal lesions**.

>▪< FURTHER KNOWLEDGE



Characteristic MRI (**A**) and CT appearance (**B** and **C**) of KS in three different patients. Note widespread cutaneous and subcutaneous enhancement (yellow arrows) on the fat saturated contrast-enhanced T1, as well as enlarged enhancing lymph nodes (pink arrows),, enhancing cutaneous nodules (turquoise arrows) at contrast-enhanced CT and nodular strongly enhancing mucosal masses involving the base of the tongue (blue arrows) and the posterior larynx (green arrow)..

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 局部侵袭性血管肿瘤

局部侵袭性血管肿瘤包括**卡波西样血管内皮瘤和卡波西肉瘤 (Kaposi sarcoma，KS)**。

KS 起源于淋巴管内皮细胞。KS 有**四种类型**：经典型、器官移植后型、艾滋病相关型和地方型（非洲）。人类疱疹病毒 8 型感染在 KS 的病因中起主要作用。KS 最常累及皮下和黏膜，但也可累及深部器官，如肺。在 CT 和 MR 成像时，KS 通常表现为**明显增强的泛发性皮肤、皮下和黏膜病变**。

>▪< 进阶知识

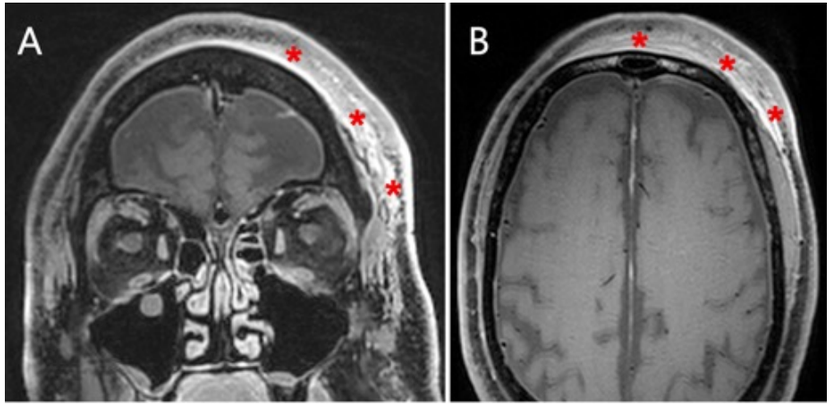
三例不同患者 KS 的特征性 MRI (**A**) 和 CT 表现（**B** 和 **C**）。注意脂肪饱和对比增强 T1 的广泛皮肤和皮下增强（黄色箭头），以及肿大的增强淋巴结（粉色箭头），对比增强 CT 的增强皮肤结节（蓝绿色箭头）以及累及舌根（蓝色箭头）和喉后部（绿色箭头）的结节状强增强黏膜肿块。

/ Malignant Vascular Tumours

Malignant vascular tumours include epitheloid haemangioendothelioma and angiosarcoma.

Angiosarcomas arise from vascular endothelial cells. Risk factors include lymphoedema, radiation therapy, exposure to toxic substances (e.g., vinyl chloride) and genetic predisposition (e.g., neurofibromatosis type I). Prognosis is poor. Angiosarcoma often involves the skin and subcutaneous vessels of the scalp. It can also involve the aorta and pulmonary arteries, the heart, chest wall and breast. Extravascular extension and metastases are common. Angiosarcomas are FDG avid.

>▪< FURTHER KNOWLEDGE



Characteristic MRI (A and B) appearance of an angiosarcoma of the scalp. Note infiltrative **cutaneous, subcutaneous and galea enhancement extending to the periosteum of the frontal bone** on the fat saturated contrast-enhanced coronal and axial T1-weighted images (A and B). At histology, the tumour invaded the galea aponeurotica and the periosteum of the frontal bone.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 恶性血管肿瘤

恶性血管肿瘤包括上皮样血管内皮瘤和血管肉瘤。

血管肉瘤起源于血管内皮细胞。风险因素包括淋巴水肿、放疗、接触有毒物质（如氯乙烯）和遗传倾向（如 I 型神经纤维瘤病）。预后差。血管肉瘤通常累及头皮的皮肤和皮下血管。还可能累及主动脉和肺动脉、心脏、胸壁和乳房。血管外扩散和转移常见。血管肉瘤为 FDG 高摄取。

>▪< 进阶知识

头皮血管肉瘤的特征性 MRI（A 和 B）表现。在脂肪饱和对比增强冠状位和轴位 T1 加权图像（A 和 B）上，注意**延伸至额骨骨膜的浸润性皮肤、皮下和帽状腱膜增强**。在组织学上，肿瘤侵犯帽状腱膜和额骨骨膜。

/ Vascular Malformations

Venous malformations are the **most common vascular** anomalies. They usually present early in life and do nor regress spontaneously. Most often, they involve multiple anatomic spaces and they are heterogeneous at imaging.

>=< FURTHER KNOWLEDGE

Characteristic imaging features include:

- US => venous flow or no flow
- Phleboliths (which can be seen at US, CT and MRI) in about 40% of cases
- MRI: high T2 signal and **absent** flow voids (as opposed to haemangiomas)
- Contrast enhancement: variable
- Contrast-enhanced **dynamic time-resolved** MRA: no arterial enhancement but gradual, persistent and late enhancement

Axial T2-weighted (**A**) and contrast enhanced fat saturated T1-weighted (**B**) images show the typical features of a venous vascular malformation of the masseter muscle. Note high signal on T2 (**A**) and patchy contrast enhancement (**B**). Thin arrows point at phleboliths. CT image in another patient (**C**) with a venous vascular malformation of the parapharyngeal space shows the typical aspect of phleboliths (arrows).

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 血管畸形

静脉畸形是最常见的血管异常。它们通常发病较早且不会自发消退。病变最常累及多个解剖空间，在影像学上具有异质性。

>=< 进阶知识

特征性影像学表现包括：

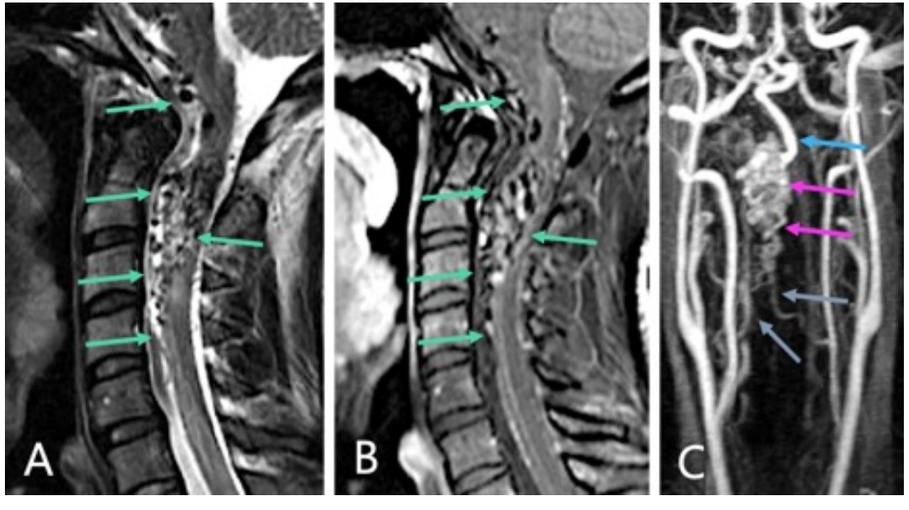
- 超声 => 静脉血流或无血流
- 约 40% 的病例可见静脉石（超声、CT 和 MRI 检查可见）
- MRI：T2 信号高且无流空（与血管瘤相反）
- 对比增强：可变
- 对比增强**动态时间分辨** MRA：无动脉增强，但逐渐、持续的晚期增强

轴位 T2 加权 (**A**) 和对比增强脂肪饱和 T1 加权 (**B**) 图像显示咬肌静脉血管畸形的典型特征。注意 T2 上的高信号 (**A**) 和片状对比增强 (**B**)。细箭头指向静脉石。另一例咽旁间隙静脉血管畸形患者的 CT 图像 (**C**) 显示静脉石的典型表现（箭头）。

High-flow vascular malformations include AVMs and AVF, which **connect arteries and veins, bypassing the capillary bed**.

- **AVMs** - mostly congenital - have a dilated feeding artery, a nidus (tangle of vessels) and a dilated draining vein. They tend to increase in size over time.
- In contrast, **AVF** are most often acquired (post-traumatic) and they do not have a nidus => i.e., there is a direct communication between a dilated artery and a vein.

>▪< FURTHER KNOWLEDGE



Sagittal T2-weighted (A) and contrast enhanced fat saturated T1-weighted (**B**) images show the typical features of a spinal AVM. Note flow voids (turquoise arrows) on T2 (**A**) and T1 (**B**) due to dilated feeding arteries and draining veins and no discernible soft-tissue component. MRA (coronal MIP image) in the same patient (**C**) shows the typical aspect of an AVM with a dilated vertebral artery (blue arrow) and dilated draining veins (gray arrows) and a nidus (pink arrows).

Images courtesy Maria Isabel Vargas, Geneva University Hospitals, Geneva University

Vascular Imaging

CHAPTER OUTLINE:

血管成像

高血流血管畸形包括 AVM 和 AVF，它们绕过毛细血管床连接动脉和静脉。

- **AVM**（多为先天性）具有扩张的供血动脉、血管巢（血管缠结）和扩张的引流静脉。它们的大小往往会随着时间的推移而增大。
- 相比之下，**AVF** 通常是后天获得的（创伤后），它们没有血管巢 => 即，扩张的动脉和静脉之间直接连通。

章节大纲：

>▪< 进阶知识

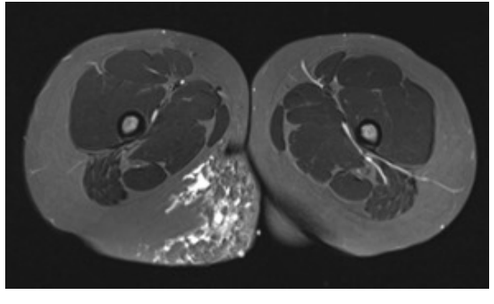
矢状位 T2 加权 (A) 和对比增强脂肪饱和 T1 加权 (**B**) 图像显示脊柱 AVM 的典型特征。注意由于扩张的供血动脉和引流静脉，以及没有明显的软组织成分，T2 (**A**) 和 T1 (**B**) 上存在流空（蓝绿色箭头）。同一患者的 MRA（冠状位 MIP 图像）(**C**) 显示 AVM 的典型表现，包括扩张的椎动脉（蓝色箭头）、扩张的引流静脉（灰色箭头）和血管巢（粉色箭头）。

图片由日内瓦大学医院 Maria Isabel Vargas 提供

Lymphatic malformations are **low-flow** malformations that most often present in childhood; they tend to involve multiple anatomic spaces and structures. They do not communicate with normal lymph vessels and are most often seen in the head and neck subcutaneously. Lymphatic malformations can cause osseous hypertrophy and can, therefore, lead to discrepancy in limb length. Lymphatic malformations can be macrocystic (= multiple large cysts) or they can be microcystic (= multiple tiny cysts).

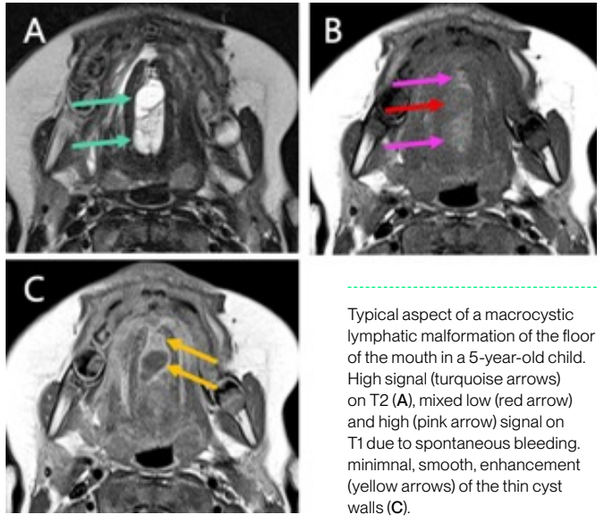
Superficial lesions are diagnosed clinically whereas deep lesions require imaging for diagnosis. The **main complications** of lymphatic malformations are bleeding and infection.

>▪< FURTHER KNOWLEDGE



Lymphatic malformation of the right buttock. The subcutaneous lymphatic cysts, which are of high T2 signal, are of varying sizes and there is additional fat present between the cysts.

Image reproduced from: Gibson CR, Barnacle AM. Vascular anomalies: special considerations in children. CVIR Endovasc. 2020 Nov 22;3(1):60. doi: 10.1186/s42155-020-00153-y. PMID: 32886264; PMCID: PMC7474047.



Typical aspect of a macrocystic lymphatic malformation of the floor of the mouth in a 5-year-old child. High signal (turquoise arrows) on T2 (**A**), mixed low (red arrow) and high (pink arrow) signal on T1 due to spontaneous bleeding. minimnal, smooth, enhancement (yellow arrows) of the thin cyst walls (**C**).

Vascular Imaging

CHAPTER OUTLINE:

血管成像

章节大纲：

淋巴管畸形是低血流畸形，最常出现在儿童期；其往往累及多个解剖空间和结构。它们不与正常淋巴管相通，最常见于头颈部皮下。淋巴管畸形可引起骨肥大，从而导致肢体不等长。淋巴管畸形可以是大囊型（= 多个大囊肿），也可以是小囊型（= 多个小囊肿）。

浅表病变可临床诊断，而深部病变的诊断需要影像学检查。淋巴管畸形的**主要并发症**是出血和感染。

>▪< 进阶知识

右臀部淋巴管畸形。皮下淋巴囊肿的 T2 信号较高，大小不一，囊腔间还有脂肪。

影像来源： Gibson CR, Barnacle AM. Vascular anomalies: special considerations in children. CVIR Endovasc. 2020 Nov 22;3(1):60. doi: 10.1186/s42155-020-00153-y. PMID: 32886264; PMCID: PMC7474047.

一例 5 岁儿童口底大囊型淋巴管畸形的典型表现。由于自发性出血，T2 上高信号（蓝绿色箭头）(**A**)，T1 上混合低（红色箭头）和高（粉色箭头）信号。薄囊壁显示微弱、平滑的增强（黄色箭头）(**C**)。

/ Take-Home Messages

- Vascular imaging includes intraluminal, vessel wall and extraluminal space evaluation.
- Blood vessels can be visualised with ultrasound, DSA, CTA and MRA, and each modality has advantages and disadvantages, including indications and contraindications to be taken in consideration.
- Ultrasound is a good initial diagnostic tool to assess blood vessels, being readily available and having low costs.
- CTA has a higher radiation dose than non-enhanced CT and uses iodinated contrast media. It has a high diagnostic accuracy in multiple vascular pathologies, e.g., atherosclerosis, arterial stenosis/occlusion, dissection, aneurysm, Budd-Chiari, PE, vascular compression, vascular tumours and many others.
- MRA can be performed in any body part and can be used with or without contrast media. MRA is a very versatile non-invasive imaging technique allowing screening, evaluation and follow-up of a multitude of vascular pathologies, e.g., arterial aneurysms, AV malformations, arterial dissection, arterial stenosis, neurovascular conflicts, PAOD and many more.
- During DSA not only diagnostic but also interventional radiologic therapeutic procedures can be performed.
- Sometimes it is necessary to combine information from different vascular imaging modalities.
- Distinction between vascular tumours and vascular malformations is essential and imaging plays an important role for diagnosis and treatment of these entities.

/ Vascular Imaging

CHAPTER OUTLINE:

/ 血管成像

章节大纲：

/ 核心要点

- 血管成像包括对腔内、血管壁和腔外空间的评估。
- 血管可以通过超声、DSA、CTA 和 MRA 进行显示，每种方式都有优缺点，需要综合考虑适应证和禁忌证。
- 超声是一种评估血管较为优秀的初步诊断工具，其优势在于容易获得且成本较低。
- CTA 的辐射剂量高于非增强 CT，且需要使用碘对比剂。该技术对多种血管病变的诊断准确性很高，例如动脉粥样硬化、动脉狭窄/闭塞、动脉夹层、动脉瘤、布加综合征、PE、血管压迫和血管肿瘤等。
- MRA 可适用于全身任何部位，且无论是否使用对比剂均可实施。MRA 是一种应用非常广泛的无创成像技术，可以对多种血管病变进行筛查、评估和随访，例如动脉瘤、AV 畸形、动脉夹层、动脉狭窄、神经血管压迫、PAOD 等。
- 在 DSA 期间，不仅可以进行诊断性操作，还可以进行介入放射学治疗操作。
- 有时需要结合不同血管成像模态所提供的信息进行诊断。
- 准确区分血管肿瘤和血管畸形至关重要，影像学检查在这些疾病的诊断和治疗中发挥着重要作用。

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Test Your Knowledge

Vascular Imaging

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章节大纲：

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Test Your Knowledge

<?> QUESTION

1 What are potential risks associated with DSA (several answers possible)?

- ☐ Allergic reaction
- ☐ Vessel damage from the catheter
- ☐ Infection at the site of catheter insertion
- ☐ Acute kidney injury

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<?> 问题

1 与 DSA 相关的潜在风险有哪些（可多选）？

- ☐ 过敏反应
- ☐ 导管损伤血管
- ☐ 导管插入部位感染
- ☐ 急性肾损伤

Test Your Knowledge

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Test Your Knowledge

<?> QUESTION

2 How is DSA of the renal artery usually performed (several answers possible)?

- ☐ A small incision is made in the skin and a catheter is inserted into the femoral artery
- ☐ Contrast media is injected into the bloodstream via the catheter
- ☐ Sequential X-ray images are acquired to visualise and document the blood vessels
- ☐ The procedure is always performed under general anaesthesia

Vascular Imaging

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章节大纲：

<?> 问题

2 肾动脉的 DSA 通常如何进行（可多选）？

- ☐ 在皮肤上做一个小切口，将导管插入股动脉
- ☐ 将对比剂通过导管注入血液
- ☐ 通过获取连续 X 线图像来显示和记录血管
- ☐ 该操作通常在全身麻醉状态下进行

/ Test Your Knowledge

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Test Your Knowledge

<?> QUESTION

3 To perform MR angiography, is it always necessary to inject contrast media?

- ☐ True
- ☐ False

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<?> 问题

3 进行 MR 血管成像一定要注射对比剂吗？

- ☐ 对
- ☐ 错

血管成像

章节大纲：

/ Test Your Knowledge

<?> ANSWER

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- ☐ True
- ■ False

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<?> 回答

3 进行 MR 血管成像一定要注射对比剂吗？

- ☐ 对
- ■ 错

/ 血管成像

章节大纲：

Test Your Knowledge

<?> QUESTION

4 To perform CT angiography, is it always necessary to inject contrast media?

- ☐ True
- ☐ False

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<?> 问题

4 进行 CT 血管成像一定要注射对比剂吗？

- ☐ 对
- ☐ 错

血管成像

章节大纲：

/ Test Your Knowledge

<?> ANSWER

4 To perform CT angiography, is it always necessary to inject contrast media?

- ■ True
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/ 知识测试

<?> 回答

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- ☐ 错

/ Test Your Knowledge

<?> QUESTION

5 How are blood velocity values at a site of a major arterial stenosis as compared to a normal artery?

- ☐ Decreased
- ☐ Increased
- ☐ Not changed
- ☐ Variable

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<?> 问题

5 与正常动脉期比，动脉严重狭窄部位的血流速度如何？

- ☐ 降低
- ☐ 升高
- ☐ 无变化
- ☐ 多变

/ Test Your Knowledge

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/ Vascular Imaging

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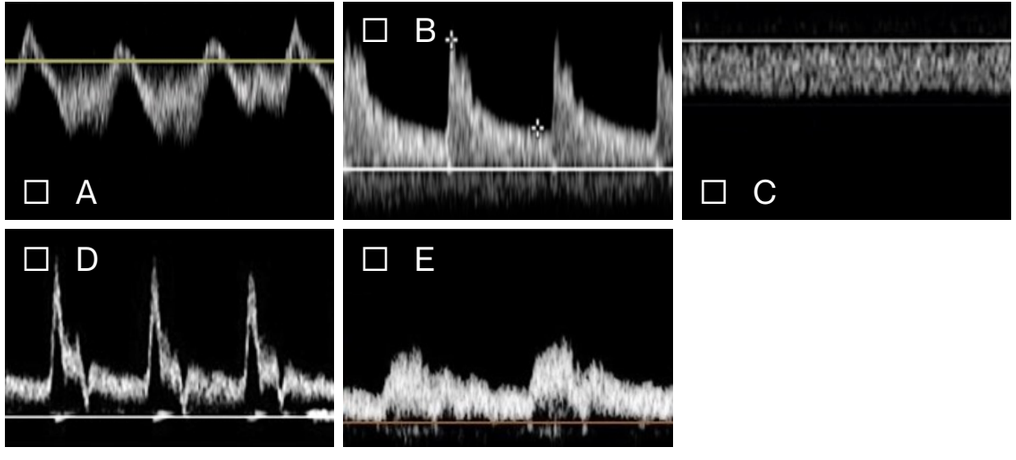
Test Your Knowledge

<?> QUESTION

6 What type of waveform can you see at Doppler-US after a major arterial stenosis?



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<?> 问题

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/ Test Your Knowledge

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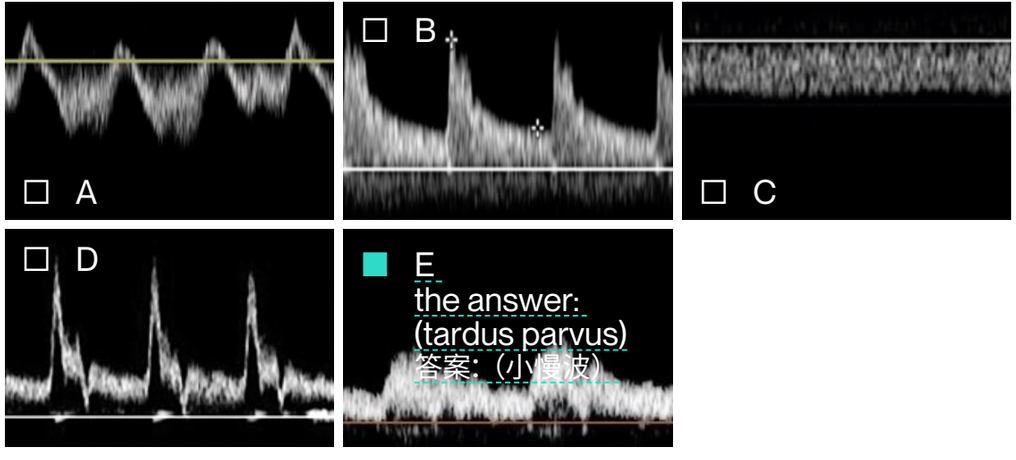

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<?> 回答

6 动脉发生严重狭窄后，在多普勒超声上能看到哪种类型的波形？

Test Your Knowledge

<?> QUESTION

7 What imaging features can you see in the false lumen of an aortic dissection compared to the true lumen (several answers are possible)?

- ☐ Larger than the true lumen
- ☐ Less enhancement than the true lumen
- ☐ Beak sign
- ☐ Surrounded by calcifications (if present)

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章节大纲：

<?> 问题

7 与真腔相比，在主动脉夹层的假腔中可以看到哪些影像学特征（可多选）？

- ☐ 大于真腔
- ☐ 强化程度弱于真腔
- ☐ 鸟嘴征
- ☐ 周围有钙化（如有）

/ Test Your Knowledge

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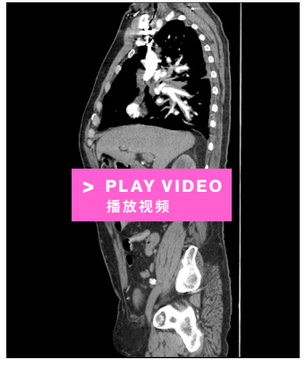
- ☐ 周围有钙化（如有）

/ Test Your Knowledge

<?> QUESTION

8 What type of aortic dissection is this (see videos)?

- ☐ DeBakey I
- ☐ Stanford B
- ☐ DeBakey III
- ☐ Stanford A or DeBakey II



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8 这是什么类型的主动脉夹层（见视频）？

- ☐ DeBakey I
- ☐ Stanford B
- ☐ DeBakey III
- ☐ Stanford A 或 DeBakey II

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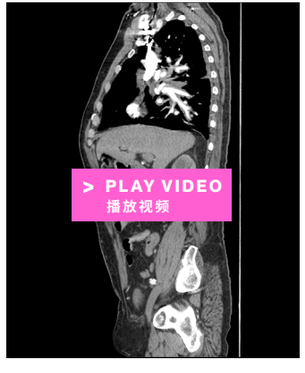

CTA of aorta (videos). Sagital and coronal reconstructions showing Stanford type A dissection (DeBakey II) affecting the ascending aorta.

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- ■ Stanford A 或 DeBakey II

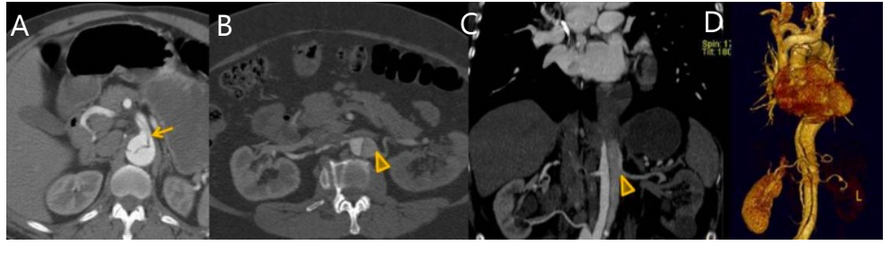
主动脉 CTA（视频）。矢状位和冠状位重建显示累及升主动脉的 Stanford A 型夹层 (DeBakey II)。

/ Test Your Knowledge

<?> QUESTION

9 **Which statements regarding the CTA images below obtained in the emergency setting are correct?**

- ☐ The arrow in A shows that the dissection involves the celiac trunk
- ☐ The arrowhead in B points at the true lumen
- ☐ The arrowhead in C shows that the left renal artery arises from the true lumen
- ☐ Image D shows perfusion impairment of the left kidney



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- ☐ A 中的箭头表示夹层累及腹腔干
- ☐ B 中的箭头所指为真腔
- ☐ C 中的箭头表示左肾动脉起源于真腔
- ☐ 图 D 显示左肾灌注受损

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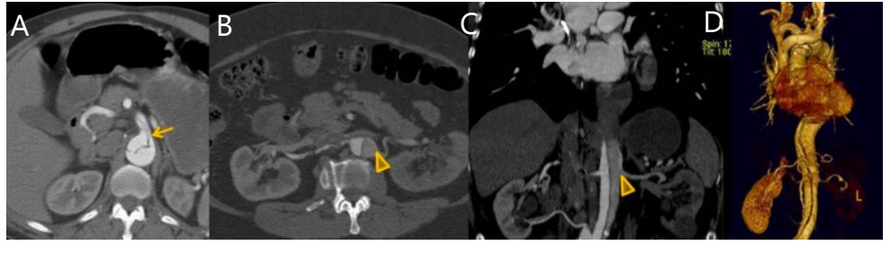

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Test Your Knowledge

<?> QUESTION

10 Which statements regarding the MR images below obtained in a 20-year-old patient are correct?

- ☐ The orbital lesion is strongly hyperintense on T2 and enhances substantially
- ☐ There are flow voids suggesting an AVM
- ☐ This is most likely a haemangioma
- ☐ This is most likely a low-flow venous malformation

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<?> 问题

10 关于以下一例 20 岁患者的 MR 图像，哪些表述是正确的?

- ☐ 眼眶病变在 T2 上呈明显高信号，并显著强化
- ☐ 存在流空信号，提示 AVM
- ☐ 极有可能是血管瘤
- ☐ 极有可能是低流量静脉畸形

/ Test Your Knowledge

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10 Which statements regarding the MR images below obtained in a 20-year-old patient are correct?

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- [x] This is most likely a low-flow venous malformation

<!> ATTENTION

DO NOT use the term haemangioma which is a neoplastic lesion! See ISSVA classification to avoid confusion!

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- [ ] 极有可能是血管瘤
- [x] 极有可能是低流量静脉畸形

<!> 注意

不要使用“血管瘤”这个术语，它是肿瘤性病变！请参阅 ISSVA 分型，以避免混淆！