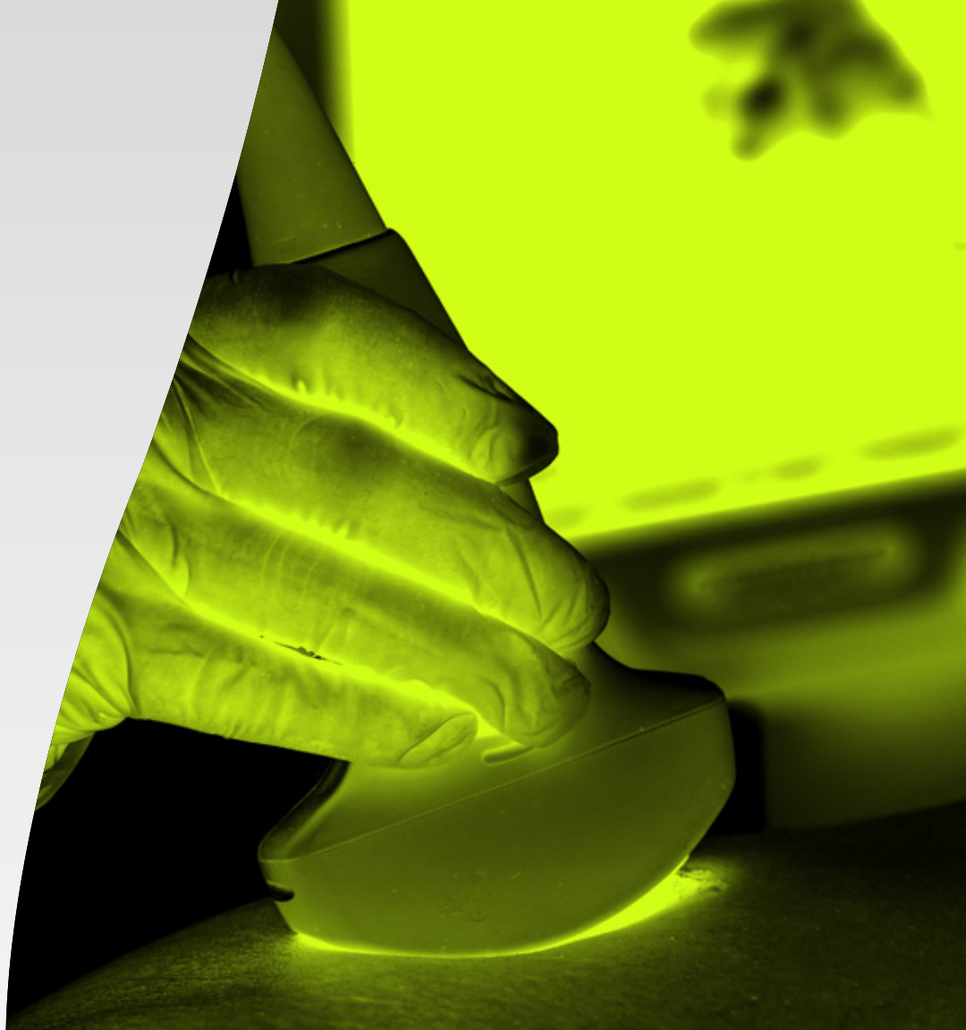
MODERN RADIOLOGY eBook

Ultra-sound

超声



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

Ultra-sound

CHAPTER OUTLINE:

超声

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。

Minerva Becker，编辑
瑞士日内瓦大学放射学教授

Copyright and Terms of Use

How to cite this work:

European Society of Radiology,
Jonathan Cohen, Caroline Ewertsen (2024)
ESR Modern Radiology eBook:

Ultrasound.
DOI 10.26044/esr-modern-radiology-03

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

版权和使用条款

本作品引用方式：

European Society of Radiology, Jonathan Cohen,
Caroline Ewertsen (2024) ESR Modern Radiology eBook:

Ultrasound.
DOI 10.26044/esr-modern-radiology-03

Translation Credits

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

ORIGINAL TITLE:
Ultrasound

TRANSLATED BY:
Prof. Jiaqi Zhao, Shanghai Fourth People's Hospital

COORDINATED BY:
Prof. Shiyuan Liu, Shanghai Changzheng Hospital
Prof. Yi Xiao, Shanghai Changzheng Hospital

ENDORSED BY:
Chinese Society of Radiology

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

Ultra-sound

CHAPTER OUTLINE:

超声

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。

原文标题：
超声

翻译：
赵佳琦教授，上海市第四人民医院

联合翻译：
刘士远教授，长征医院
萧毅教授，长征医院

审定：
中华医学会放射学分会

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。

/ Signage

<▪> CORE KNOWLEDGE

<!> ATTENTION

<↑> HYPERLINKS

>▪< FURTHER KNOWLEDGE

>|< COMPARE

<∞> REFERENCES

<?> QUESTIONS

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 导示

<▪> 核心知识

<!> 注意

<↑> 超链接

>▪< 进阶知识

>|< 比较

<∞> 参考文献

<?> 问题

MODERN RADIOLOGY eBook

Based on the ESR Curriculum for Radiological Education

Ultra-sound

AUTHORS

Jonathan Cohen | Caroline Ewertsen

AFFILIATION

Department of Radiology, Copenhagen University Hospital (Rigshospitalet), Copenhagen, Denmark

<↑> HYPERLINK

mailjonathancohen@gmail.com
caroline.ewertsen@dadlnet.dk

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

基于 ESR 课程的放射学教育

超声

作者

Jonathan Cohen | Caroline Ewertsen

所属机构

丹麦哥本哈根，哥本哈根大学医院 (Rigshospitalet) 放射科

<↑> 超链接

mailjonathancohen@gmail.com
caroline.ewertsen@dadlnet.dk

Chapter Outline

- Ultrasound Basics
  - Physics
- Signal to Image
  - Equipment
  - Enhancing the Image
- Artefacts
  - Acoustic Shadowing
  - Enhancement
  - Anisotropy
- The Doppler Effect
  - Basic Physics
  - Use in Medical Ultrasound
- Contrast-Enhanced Ultrasound
  - Indications and Contraindications
- Strengths and Limitations
- Take-Home Messages
- References
- Test Your Knowledge

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

章节大纲

- 超声基础知识
  - 物理学原理
- 信号成像原理
  - 设备
  - 图像增强
- 伪像
  - 声影
  - 回声增强
  - 各向异性
- 多普勒效应
  - 物理学基础知识
  - 在医学超声中的应用
- 超声造影
  - 适应证和禁忌证
- 优势和局限性
- 核心要点
- 参考文献
- 知识测试

Ultrasound Basics

Ultra-sound

超声

CHAPTER OUTLINE:

章节大纲：

超声基础知识

/ Ultrasound Basics

Sonography is a non-invasive painless procedure, which uses **ultrasound waves** to produce images of organs, blood vessels or soft tissues for medical analysis. The terms **sonography and ultrasound** are often used **interchangeably**. A sonogram is an image generated by ultrasound.

Ultrasound waves have frequencies higher than the upper limit of human hearing. In medical ultrasound, frequencies typically fall in the 1 to 20 MHz range, while the upper limit of human hearing is around 20 kHz.

The basic ultrasound principle (Fig. 1):

- An ultrasound transducer emits an ultrasound signal.
- The transducer listens for the echo generated by the structures that the wave encounters.
- The echo is turned into an image based on characteristics of the echo, such as timing, amplitude and frequency.

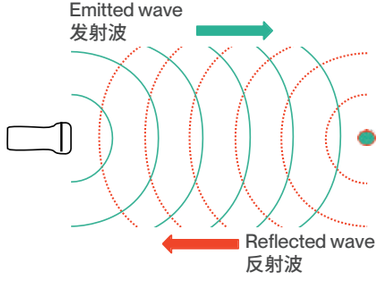


FIGURE 1

Schematic representation of the basic ultrasound (sonography or ultrasonography) principle

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 超声基础知识

超声检查是一种无创且无痛的检查方法，它利用**超声波**对器官、血管或软组织进行成像，以供医学分析。**“超声检查 (sonography)”和“超声 (ultrasound)”**两个术语通常可**互换**使用。声像图 (sonogram) 是由超声生成的图像。

超声波的频率高于人类听觉的上限。在医学超声领域，其频率通常在 1 到 20 MHz 范围内，而人类听觉的上限约为 20 kHz。

基本超声原理（图 1）：

- 超声换能器发射超声信号。
- 换能器接收由超声波所遇到的结构产生的回声。
- 根据回声的特性，如时间、振幅和频率，回声转化为图像。

图 1

超声检查基本原理示意图

Ultrasound interacts with tissues in different ways:

- **Reflection** – waves are reflected back to the transducer.
- **Absorption** – waves are absorbed by the tissue and the energy is converted to heat.
- **Scattering** – waves are reflected in multiple different directions.
- **Refraction** – the direction of waves is changed.

>▪< FURTHER KNOWLEDGE

Each type of tissue has a particular **impedance – a resistance to the propagation of sound** which depends on the tissue density and the speed of sound in the tissue.

The amount of generated reflection depends on differences in impedance between tissues.

As an example, if the ultrasound wave travels from fat (low impedance) to bone (high impedance) a large difference in impedance is encountered, and a powerful echo will be generated.

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

超声与组织之间相互作用方式不同：

- **反射** —— （超声）波被反射回换能器。
- **吸收** —— （超声）波被组织吸收，能量转化为热能。
- **散射** —— （超声）波向多个不同方向反射。
- **折射** —— （超声）波的传播方向发生改变。

>▪< 进阶知识

每种组织都有特定的声阻抗 —— **对声波传播的一种阻力**，取决于组织密度以及声波在组织中的传播速度。

产生反射的程度取决于组织之间的声阻抗差异。

例如，如果超声波从脂肪（声阻抗低）传播到骨骼（声阻抗高），就会遇到较大的声阻抗差异，继而产生强烈的反射回声。

Structures that elicit a powerful echo appear bright on our screen – we call them **hyperechoic** (Fig. 2).

Structures that elicit a weak echo appear dark on our screen – we call them **hypoechoic** (Fig. 3).

Structures that elicit an echo similar to their surrounding structures are called **isoechoic**.

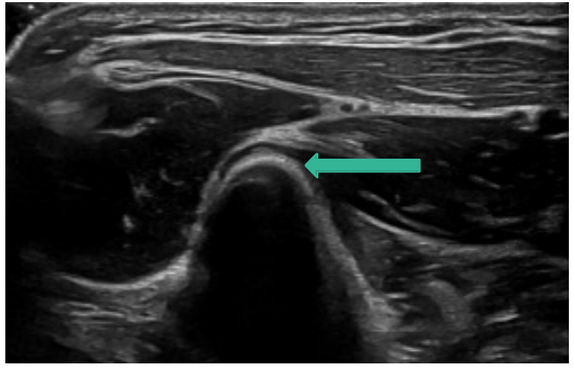


FIGURE 2

Cortical bone is strongly hyperechoic (**green arrow**) and casts an acoustic shadow (more on that later).

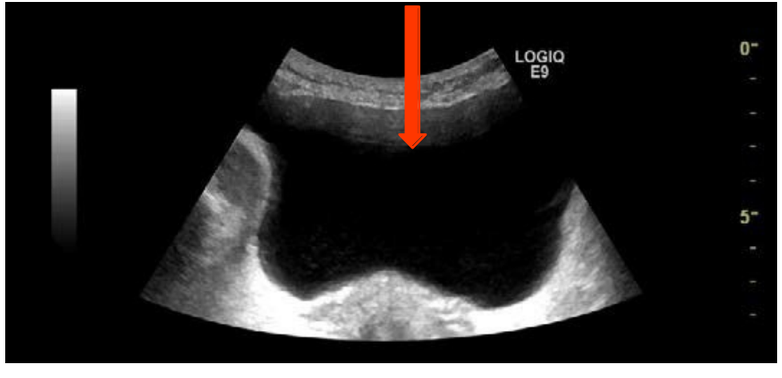


FIGURE 3

Urinary bladder filled with hypoechoic fluid (**red arrow**).

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

产生强烈回声的结构在屏幕上显示为亮色，我们称之为**高回声**（图 2）。

产生微弱回声的结构在屏幕上显示为暗色，我们称之为**低回声**（图 3）。

产生与周围结构类似回声的结构称为**等回声**。

图 2

骨皮质呈强回声（**绿色箭头**），伴声影（稍后详述）。

图 3

膀胱内充满低回声尿液（**红色箭头**）。

Signal to Image

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

信号成像原理

/ Signal to Image

The ultrasound equipment generates an electrical signal (Fig. 4) which is sent through a cable to the **ultrasound transducer** (sometimes called an **ultrasound probe**). In the transducer, an array of **piezoelectric crystals** translate the signal to sound waves, which propagate from the probe outwards (Fig. 4). Piezoelectric crystals are crystals which have the ability to generate an electric charge when mechanical pressure is applied (e.g., quartz).

The same crystals convert the returning ultrasound echo into an electrical signal, which the ultrasound system then converts to an image.

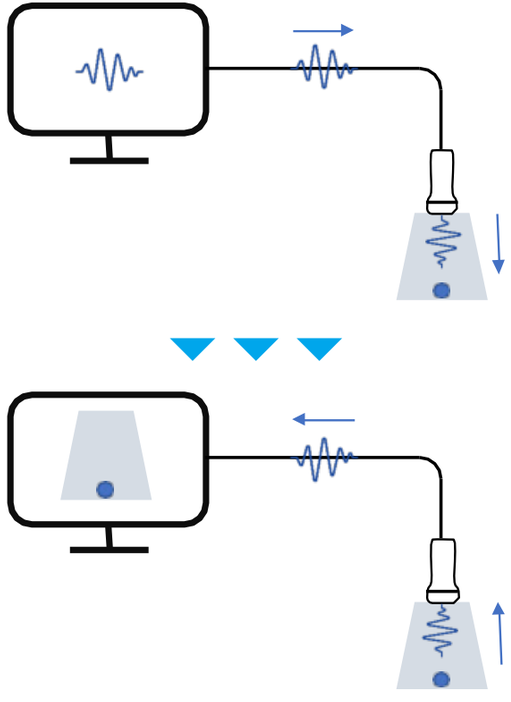


FIGURE 4

Schematic representation of the process by which an ultrasound image (sonogram or ultrasonogram) is generated.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 信号成像原理

超声设备产生电信号（图 4），该信号通过电缆传送至**超声换能器**（有时也被称作**超声探头**）。在换能器中，一组**压电晶体**将电信号转换为声波，声波从探头发射并向外传播（图 4）。压电晶体是一类在受到机械压力时能够产生电荷的晶体（例如石英）。

同样是这些晶体，将返回的超声回声转换为电信号，随后超声系统再将该电信号转换为超声图像。

图 4

超声图像生成过程示意图。

Different ultrasound transducers (Fig. 5) have different strengths and limitations, and therefore different applications. Below is an overview of the most common transducer types and their typical applications.

Curved, 1-5 MHz

ADVANTAGES:

+ Good penetration, wide field of view.

DISADVANTAGES:

– Low resolution.

/ Abdominal, deep structures.

Linear, 3-12 MHz

ADVANTAGES:

+ High resolution.

DISADVANTAGES:

– Poor penetration.

/ Musculoskeletal, superficial structures, neck.

Phased array, 1-5 MHz

ADVANTAGES:

+ Wide field of view with small transducer surface.

DISADVANTAGES:

– Low resolution.

/ Echocardiography, intercostal views.

FIGURE 5

Advantages, disadvantages and main applications of different types of ultrasound transducers.

/ Ultrasound

CHAPTER OUTLINE:

/ 超声

不同超声换能器（图 5）各有优势与不足，因而应用场景也不同。以下概述最常见的换能器类型及其典型应用。

章节大纲：

	凸阵探头，频率 1 - 5 MHz	线阵探头，频率 3 - 12 MHz	相控阵探头，频率 1 - 5 MHz
	优点：	优点：	优点：
	+ 穿透性好，视野宽广。	+ 高分辨率。	+ 探头接触面小，但视野宽广。
	缺点：	缺点：	缺点：
	– 低分辨率。	– 穿透性差。	– 低分辨率。
	/ 适用于腹部及深部结构检查。	/ 适用于肌肉骨骼、浅表结构及颈部检查。	/ 适用于超声心动图检查、肋间扫查。

图 5

不同类型超声换能器的优缺点及主要应用。

Modern ultrasound systems continually and automatically optimise the image while you scan.

Some parameters can be adjusted by the user to further optimise the image.

- **Gain:** high gain increases the overall brightness of the image, but also increases noise.
- **Frequency:** high frequency means better image quality, but poorer penetration. Most transducers have a set centre frequency, around which the frequency can be adjusted slightly.
- **Depth:** larger depth gives better overview, but details appear less visible.
- **Focus:** improves the appearance of the ultrasound image at the depth at which the focus is set.

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

现代超声系统在扫描时会持续自动优化图像。

一些参数可由用户自行调整，进一步优化图像。

- **增益：**高增益可提高图像整体亮度，但同时也会增加噪声。
- **频率：**高频率能提高图像质量，但穿透性会下降。大多数换能器都有一个设定的中心频率，可围绕该频率进行微调。
- **深度：**深度较大可提供更好的整体视野，但细节显示可能会变差。
- **焦点：**改善设定焦点深度处超声图像的效果。

Artefacts

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

伪像

/ Artefacts

Interactions between the ultrasound equipment and the body often cause **artefacts**. In ultrasound, some artefacts can be used to gain information about what you are scanning.

The following slides illustrate some of the most common artefacts encountered: **acoustic shadowing**, **enhancement** and **anisotropy**.

Acoustic shadowing (Fig. 6) corresponds to low signal behind structures that strongly absorb or reflect ultrasound waves.

<!> ATTENTION

Knowledge of artefacts is imperative when performing ultrasound, as wrong interpretations of artefacts can lead to misdiagnosis!

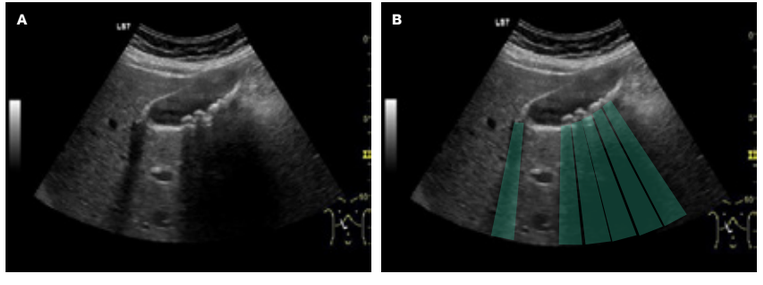


FIGURE 6

Gall bladder containing multiple gall stones which display acoustic shadowing (**A**). In image **B**, acoustic shadowing is rendered by green overlay.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 伪像

超声设备与人体之间的相互作用常常会产生**伪像**。在超声检查中，有些伪像可用于获取扫查信息。

以下幻灯片展示了一些最常见的伪像：**声影、回声增强和各向异性**。

声影（图 6）指的是在强烈吸收或反射超声波的结构后方出现的低信号区域。

<!> 注意

在进行超声检查时，了解伪像至关重要，因为错误解读伪像可能会导致误诊！

图 6

胆囊内有多发胆结石，显示后方伴有声影（图 A）。图 B 中的绿色区表示声影。

Enhancement (Fig. 7) corresponds to increased signal below structures that transmit sound well (e.g., fluid).

>▪< FURTHER KNOWLEDGE

Ultrasound waves lose energy on their way through the body. Waves that are **reflected** from deeper structures lose more energy. To compensate for this, the ultrasound machine applies more **gain** to deeper echoes. If the deeper waves mainly travel through fluid, in which minimal energy is lost, the machine "overcompensates", and the resulting image appears "too bright".

FIGURE 7

Enhancement artefact below the urinary bladder (**asterisk**) containing hypoechoic fluid (**A**). The enhancement artefact is rendered in red in **B**.

Ultrasound

CHAPTER OUTLINE:

超声

章节大纲：

回声增强（图 7）指在透声良好的结构（如液体）后方出现的信号增强现象。

>▪< 进阶知识

超声波在穿过人体的过程中会损失能量。从较深结构**反射**回来的声波损失的能量更多。为弥补这一点，超声设备会对较深部位的回声施加更大**增益**。如果较深部位的声波大部分穿过的是能量损失极小的液体，设备就会“过度补偿”，导致图像显得“过亮”。

图 7

膀胱（**星号所示**）内充满低回声尿液，其下方出现回声增强伪像（图 **A**）。图 **B** 中的红色区表示回声增强伪像。

Anisotropy is an angle-generated artefact, which is mainly encountered in musculoskeletal ultrasound. Anisotropy refers to fibrillar structures such as a tendon or a ligament reflecting the ultrasound waves **away from the transducer**. (Fig. 8) The amount of echo is therefore reduced, and the structure seems hypoechoic.

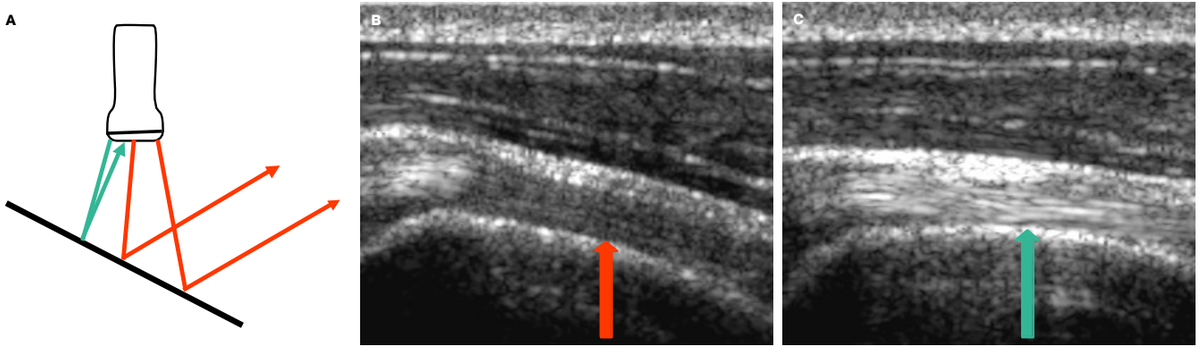
>=< FURTHER KNOWLEDGE

<!> ATTENTION

Anisotropy can lead to misinterpreting a tendon as hypoechoic and damaged, when it is in fact due to anisotropy. Anisotropy can be alleviated by changing the angle of the transducer relative to the subject.

FIGURE 8

A. Schematic drawing illustrating the formation of this angle-generated artefact. B and C. two pictures of the same tendon taken moments apart. Notice the change of echogenicity from hypoechoic (A) to hyperechoic (B). The only difference is the angle of the transducer relative to the tendon.



Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

各向异性伪像是一种由角度产生的伪像，主要出现在肌肉骨骼超声检查中。各向异性是指肌腱或韧带等纤维状结构，会使超声波反射方向偏离换能器。（图 8）因此回声量减少，该结构看起来呈低回声。

>=< 进阶知识

<!> 注意

各向异性伪像可能导致将肌腱误认为是低回声的损伤，而实际上这是由各向异性造成的。通过改变换能器相对于检查部位的角度，可减轻各向异性伪像。

图 8

A. 角度产生伪像形成过程的示意图。B 和 C 片刻后采集的同一肌腱的两张图片。注意回声情况从低回声 (A) 变为高回声 (B) 的变化。唯一的区别在于换能器相对于肌腱的角度。

The Doppler Effect

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

多普勒效应

/ The Doppler Effect

The Doppler effect is used extensively in ultrasound to detect and measure movement within the subject, especially blood flow within vessels.

The Doppler effect causes a **shift in the frequency of sound waves** when the emitting object is moving in relation to the observer (Fig. 9).

The perceived frequency of the sound increases when the emitter is moving towards the observer, and the frequency lowers when the emitter is moving away from the observer.

The classic example is that of an ambulance sounding its siren while passing by a bystander.

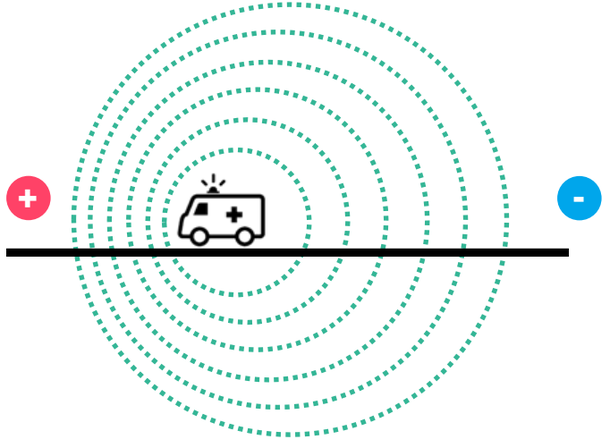


FIGURE 9

The bystanders (dots) perceive the siren pitch differently depending on whether the ambulance moves towards them or away from them.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 多普勒效应

多普勒效应在超声检查中被广泛应用于检测和测量目标内部的运动情况，尤其是血管内的血流。

当发出声波的物体相对于观察者运动时，多普勒效应会导致**声波频率发生变化**（图 9）。

当声波发射源朝着观察者移动时，听到的声音频率会升高；而当声波发射源远离观察者移动时，频率则会降低。

典型的例子就是鸣笛的救护车从路人身边驶过的场景。

图 9

旁观者（小点所示）会因救护车向其驶来或驶离方向不同，因而听到不同音调的鸣笛声。

In medical ultrasound, the frequency of the echo shifts when the reflecting tissue is moving relative to the transducer (Fig. 10).

The frequency of the echo **increases** when the reflecting tissue is moving **towards** the transducer, and the frequency **lowers** when the reflecting tissue is moving **away** from the transducer.

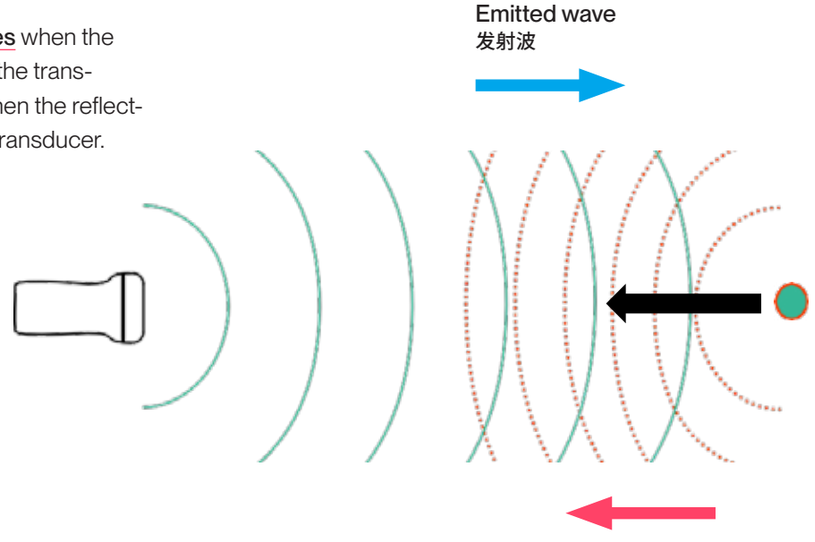


FIGURE 10

The Doppler effect in medical ultrasound. The reflecting tissue here (**green dot**) is moving towards the transducer.

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

在医学超声中，当反射超声波的组织相对于超声换能器运动时，超声换能器所接收到的回声频率就会发生改变（图 10）。

当反射组织**朝向**换能器移动时，回声频率**升高**；当反射组织**远离**换能器移动时，回声频率**降低**。

图 10

医学超声中的多普勒效应。反射组织（绿点）正朝着换能器移动。

This is an example of using colour Doppler overlay (Fig. 11). This ultrasound system colours objects, in this case blood, moving **towards** the transducer (positive Doppler shift) in **red**, and objects moving **away** from the transducer (negative Doppler shift) are coloured in **blue**.

<!> ATTENTION

The colours assigned can differ from machine to machine, so be careful!

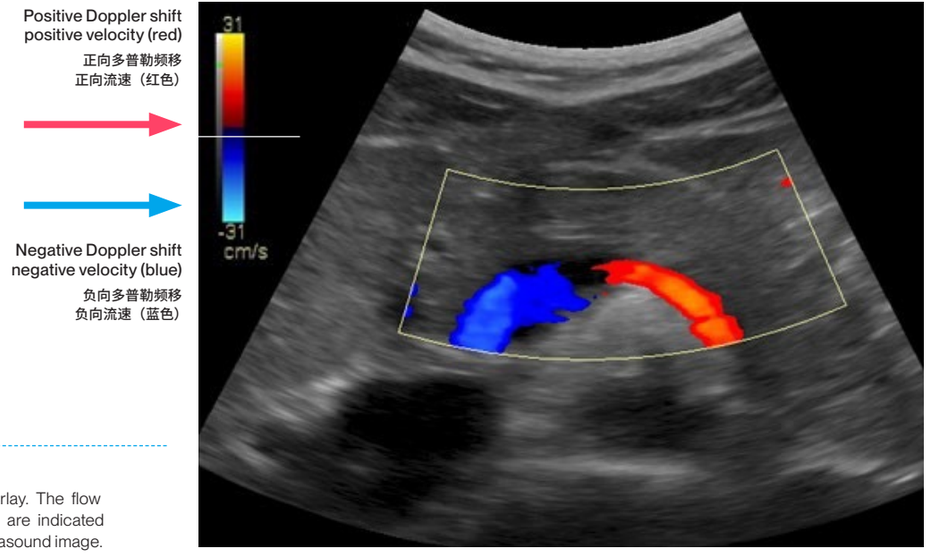


FIGURE 11

Splenic vein with colour Doppler overlay. The flow velocity (in cm/s) and flow direction are indicated in the scale on the left side of the ultrasound image.

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

使用彩色多普勒叠加的示例（图 11）。该超声系统将**朝向**换能器移动的物体（本例中为血液，即正向多普勒频移）显示为**红色**，将**远离**换能器移动的物体（负向多普勒频移）则显示为**蓝色**。

<!> 注意

不同超声设备所指定的颜色可能不同，所以务必留意！

图 11

彩色多普勒叠加显示的脾静脉。超声图像左侧的刻度显示了血流速度（单位：cm/s）和血流方向。

This is used to answer both qualitative and quantitative questions.
Here are some questions that can be answered with use of the Doppler effect:

Qualitative:

- Is there increased blood flow in the gallbladder wall as a sign of inflammation?
- Is there reduced blood flow in the testis as a sign of possible testicular torsion?

Quantitative:

- What is the flow rate through the patient's heart valve?
- What is the flow rate through the patient's carotid artery? Does the rate indicate stenosis?

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

它可用于解答定性和定量方面的问题。
以下是多普勒效应能够解答的一些问题：

定性问题：

- 胆囊壁血流增加是否为炎症的征象？
- 睾丸血流减少是否可能是睾丸扭转的征象？

定量问题：

- 通过患者心脏瓣膜的血流速度是多少？
- 通过患者颈动脉的血流速度是多少？该速度是否表明存在狭窄？

Contrast-Enhanced Ultrasound

超声造影

Ultra-sound

超声

CHAPTER OUTLINE:

章节大纲：

/ Contrast-Enhanced Ultrasound (CEUS)

CEUS uses a different contrast agent than CT or MRI.

Different contrast agent formulations exist, but they are all solutions of gas containing microbubbles. The bubbles diffuse into the tissues in much the same way as other contrast agents, but they are strictly intravascular as opposed to other contrast agents.

Half life in the blood stream is around 5-15 minutes, and side effects are extremely rare.

Common indications for CEUS are:

- Characterisation of liver masses (Fig. 12)
- Perioperative visualisation of targets in ablation procedures
- Characterisation of masses in other organs

<∞> REFERENCE

> see also eBook chapter on contrast agents

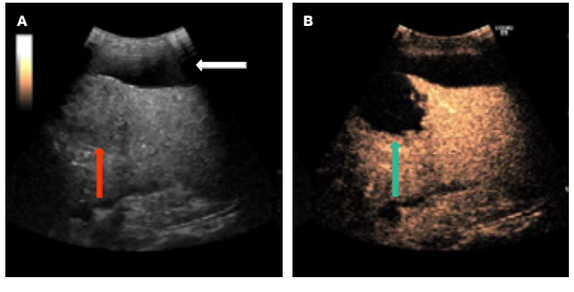


FIGURE 12

Regular US image (**A**) showing a slightly hypoechoic and heterogenous liver mass (**red arrow**) surrounded by normal liver parenchyma. CEUS (**B**) in portal venous phase reveals the mass (**green arrow**) to have distinct washout of contrast, strongly suggesting malignancy – this turned out to be a metastasis. Notice the hypoechoic area above the liver (**white arrow** in **A**) – this is ascites.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声造影 (CEUS)

超声造影 (CEUS) 所使用的对比剂与 CT 或 MRI 不同。

有各种同配方的对比剂，但它们都是含有微气泡的气体溶液。气泡扩散进入组织的方式与其他对比剂大致相同，但不同的是，它们严格局限于血管内。

其在血流中的半衰期约为 5 至 15 分钟，副作用极为罕见。

超声造影 (CEUS) 常见的适用证有：

- 肝脏肿物的特征鉴别（图 12）
- 消融术中对靶目标进行围术期可视化监测评估
- 其他器官肿物的特征鉴别

<∞> 参考文献

> 另请参阅《对比剂》电子书章节

图 12

常规超声 (US) 图像 (**A**) 显示，一个不均匀略低回声的肝脏肿物（**红色箭头**），周围为正常肝实质。超声造影 (CEUS) (**B**) 门静脉期显示肿物（**绿色箭头**）有明显的对比剂廓清，强烈提示为恶性病变 —— 结果证实为转移瘤。注意肝脏上方的低回声区域（图 **A** 中**白色箭头**所示）——腹水。

/ 超声

章节大纲：

CEUS is generally considered very safe.

Contraindications vary for different formulations. Below are a summarisation of contraindications that need to be considered when performing CEUS:

- Hypersensitivity to the active substances
- Known right-to-left cardiac shunt
- Severe pulmonary hypertension or uncontrolled systemic hypertension
- Acute respiratory distress syndrome
- Known egg allergy (only some formulations)

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

超声造影 (CEUS) 通常非常安全。

各种配方的对比剂禁忌证不同。超声造影 (CEUS) 需要考虑的禁忌证有：

- 对对比剂活性成分过敏
- 存在已知的心脏右向左分流
- 严重肺动脉高压或未控制的全身性高血压
- 急性呼吸窘迫综合征
- 已知鸡蛋过敏（仅适用于某些制剂）

Strengths and Limitations

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

优势和局限性

/ Strengths and Limitations

Strengths and limitations of ultrasound vary greatly with different applications.

Below is an outline of general strengths and limitations of ultrasound as opposed to other imaging modalities, such as CT and MRI, that one needs to consider when choosing between modalities.

STRENGTHS:

+ Low cost
+ High availability
+ High portability
+ Safe and non-invasive
+ Fast
+ Dynamic

LIMITATIONS:

– Highly operator dependant
– Highly patient dependant
– Difficult to reproduce
– Poor penetration in air and bone

<∞> REFERENCE

> see for specific applications also eBook chapters on bile ducts, small bowel, musculoskeletal, cardiac and paediatric imaging

/ Ultra-sound

CHAPTER OUTLINE:

/ 优势和局限性

/ 超声

章节大纲：

超声检查的优势和局限性会因应用的情况有很大差异。

以下概述了相较于 CT 和 MRI 等其他成像方式，在选择成像方式时需考虑的超声检查一般优势和局限性。

优势：

+ 低成本
+ 易获取
+ 便携性高
+ 安全无创
+ 检查快速
+ 可动态观察

局限性：

– 高度依赖于操作人员
– 高度依赖于患者情况
– 难以重复一致
– 对空气和骨骼穿透性差

<∞> 参考文献

> 有关特定的应用，参阅《胆管、小肠、肌肉骨骼、心脏和儿科影像学》电子书章节

/ Take-Home Messages

- / Ultrasound waves are sound waves with a high frequency.
- / We analyse the echoes to gain information about the subject matter and depict them as images on a screen.
- / Different transducers are used for different applications.
- / Ultrasound artefacts are important to be aware of, as they may influence your diagnosis.
- / The Doppler effect is used extensively to visualise movement and in particular blood flow.
- / CEUS is generally a safe way to characterise liver lesions and has also other applications.
- / Ultrasound has strengths and limitations that one needs to consider before performing an examination.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 核心要点

- / 超声波是高频声波。
- / 我们通过分析回声来获取有关检查对象的信息，并将其以图像形式显示在屏幕上。
- / 不同的应用场景使用不同的超声换能器。
- / 了解超声伪像很重要，因为它们可能会影响诊断结果。
- / 多普勒效应被广泛用于显示运动情况，尤其是血流。
- / 超声造影 (CEUS) 总体而言是一种安全的肝脏病变特征鉴别方法，且还有其他应用。
- / 在进行超声检查前，需要考虑超声检查本身的优势与局限性。

/ References and Further Reading

/ Rumack, C.M.; Wilson, S.R.; Charboneau, J.W. Diagnostic ultrasound. 2005, 3rd edition

/ Postema, M.; Kotopoulis, S.; Jenderka, K.-V. Physical Principles of Medical Ultrasound. EFSUMB Courseb. Ultrasound 2020, 1–23.

/ WFUMB ULTRASOUND BOOK Available online: http://wfumb.info/wfumb-ultrasound-book/additional- pages/html5_output/index.html (accessed on Aug 14, 2022).

/ Nolsøe, C.P.; Lorentzen, T. International guidelines for contrast-enhanced ultrasonography: ultrasound imaging in the new millennium. Ultrasonography 2016, 35, 89.

/ Appis, A.W.; Tracy, M.J.; Feinstein, S.B. Update on the safety and efficacy of commercial ultrasound contrast agents in cardiac applications. Echo Res. Pract. 2015, 2, R55.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 参考文献和拓展资料

/ Rumack, C.M.; Wilson, S.R.; Charboneau, J.W. Diagnostic ultrasound. 2005, 3rd edition

/ Postema, M.; Kotopoulis, S.; Jenderka, K.-V. Physical Principles of Medical Ultrasound. EFSUMB Courseb. Ultrasound 2020, 1–23.

/ WFUMB ULTRASOUND BOOK Available online: http://wfumb.info/wfumb-ultrasound-book/additional- pages/html5_output/index.html (accessed on Aug 14, 2022).

/ Nolsøe, C.P.; Lorentzen, T. International guidelines for contrast-enhanced ultrasonography: ultrasound imaging in the new millennium. Ultrasonography 2016, 35, 89.

/ Appis, A.W.; Tracy, M.J.; Feinstein, S.B. Update on the safety and efficacy of commercial ultrasound contrast agents in cardiac applications. Echo Res. Pract. 2015, 2, R55.

Test Your Knowledge

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

/ Test Your Knowledge

<?> QUESTION

1 Medical ultrasound typically uses which frequency range?

- ☐ The kHz range
- ☐ The MHz range
- ☐ The Hz range

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 问题

1 医用超声通常使用哪个频率范围?

- ☐ kHz 范围
- ☐ MHz 范围
- ☐ Hz 范围

/ Test Your Knowledge

<?> ANSWER

1 Medical ultrasound typically uses which frequency range?

- ☐ The kHz range
- ■ The MHz range
- ☐ The Hz range

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 回答

1 医用超声通常使用哪个频率范围?

- ☐ kHz 范围
- ■ MHz 范围
- ☐ Hz 范围

Test Your Knowledge

<?> QUESTION

2 Which of the following is not a way that ultrasound waves interact with the tissues within the body?

- ☐ Reflection
- ☐ Polarisation
- ☐ Refractionn
- ☐ Scattering
- ☐ Absorption

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

<?> 问题

2 以下哪一项不是超声波与人体内组织的相互作用方式？

- ☐ 反射
- ☐ 偏振
- ☐ 折射
- ☐ 散射
- ☐ 吸收

/ Test Your Knowledge

<?> ANSWER

2 Which of the following is not a way that ultrasound waves interact with the tissues within the body?

- ☐ Reflection
- ■ Polarisation
- ☐ Refraction
- ☐ Scattering
- ☐ Absorption

CHAPTER OUTLINE:

章节大纲：

/ 知识测试

<?> 回答

2 以下哪一项不是超声波与人体内组织的相互作用方式？

- ☐ 反射
- ■ 偏振
- ☐ 折射
- ☐ 散射
- ☐ 吸收

Test Your Knowledge

<?> QUESTION

3 Objects that appear bright on the ultrasound screen are referred to as what?

- ☐ Hypoechoic
- ☐ Isoechoic
- ☐ Hyperechoic

Ultra-sound

CHAPTER OUTLINE:

知识测试

<?> 问题

3 在超声仪屏幕上显示为亮色的物体被称作什么？

- ☐ 低回声
- ☐ 等回声
- ☐ 高回声

超声

章节大纲：

/ Test Your Knowledge

<?> ANSWER

3 Objects that appear bright on the ultrasound screen are referred to as what?

- ☐ Hypoechoic
- ☐ Isoechoic
- ■ Hyperechoic

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 回答

3 在超声仪屏幕上显示为亮色的物体被称作什么？

- ☐ 低回声
- ☐ 等回声
- ■ 高回声

Test Your Knowledge

<?> QUESTION

4 Which of the following common types of transducer yields images with a high resolution?

- ☐ Curved probe, 1-5 MHz
- ☐ Phased array transducer, 1-5 MHz
- ☐ Linear transducer, 3-12 MHz

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

<?> 问题

4 以下哪种常见类型的超声换能器能产生高分辨率图像？

- ☐ 凸阵探头，1 - 5 MHz
- ☐ 相控阵换能器，1 - 5 MHz
- ☐ 线阵换能器，3 - 12 MHz

Test Your Knowledge

<?> ANSWER

4 Which of the following common types of transducer yields images with a high resolution?

- ☐ Curved probe, 1-5 MHz
- ☐ Phased array transducer, 1-5 MHz
- ■ Linear transducer, 3-12 MHz

Linear, 3-12 MHz
线阵探头，频率 3 - 12 MHz

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

<?> 回答

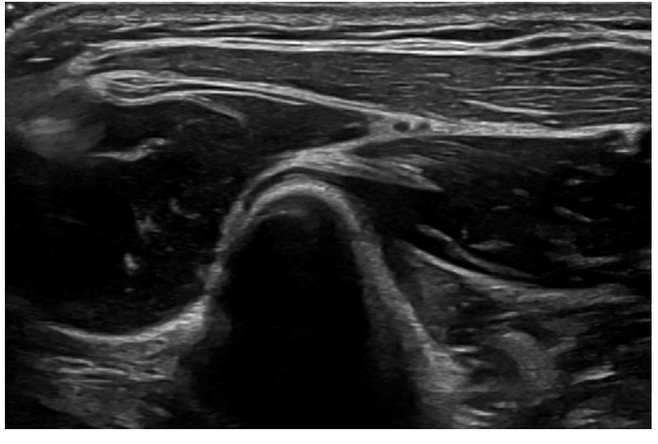
4 以下哪种常见类型的超声换能器能产生高分辨率图像？

- ☐ 凸阵探头，1 - 5 MHz
- ☐ 相控阵换能器，1 - 5 MHz
- ■ 线阵换能器，3 - 12 MHz

/ Test Your Knowledge

<?> QUESTION

5 Which common ultrasound artefact is seen here?



- ☐ Acoustic shadowing
- ☐ Enhancement
- ☐ Anisotropy

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲:

/ 知识测试

<?> 问题

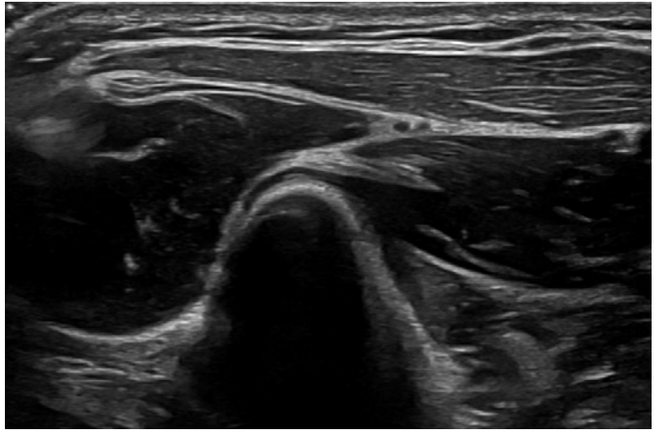
5 此处所见的是哪种常见的超声伪像?

- ☐ 声影
- ☐ 回声增强
- ☐ 各向异性

/ Test Your Knowledge

<?> ANSWER

5 Which common ultrasound artefact is seen here?



- [x] Acoustic shadowing
- [ ] Enhancement
- [ ] Anisotropy

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 回答

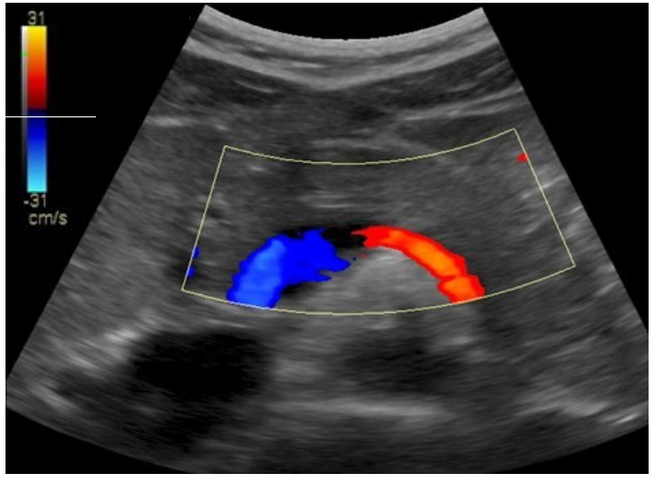
5 此处所见的是哪种常见的超声伪像？

- [x] 声影
- [ ] 回声增强
- [ ] 各向异性

/ Test Your Knowledge

<?> QUESTION

6 In which direction does the blood flow through this vein?



- ☐ Left to right
- ☐ Right to left

(note: colouring conventions used are as explained on slide no. 19.)

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 问题

6 血液在该静脉中的流动方向是什么？

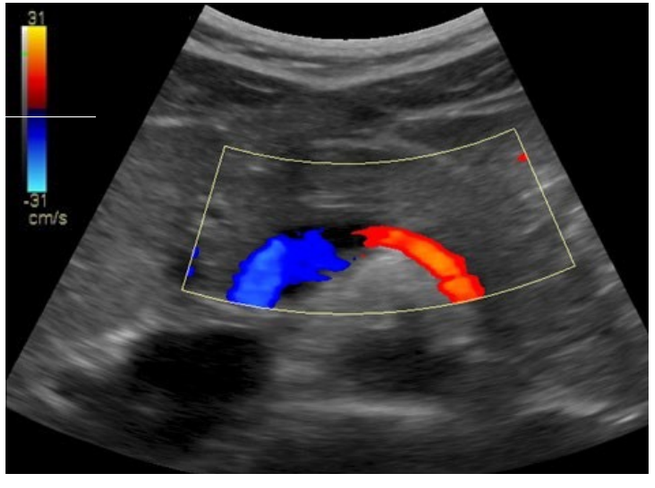
- ☐ 从左至右
- ☐ 从右到左

（注：使用的颜色规则在第 19 张幻灯片中解释）

/ Test Your Knowledge

<?> ANSWER

6 In which direction does the blood flow through this vein?



- ☐ Left to right
- ■ Right to left

(note: colouring conventions used are as explained on page no. 19.)

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 回答

6 血液在该静脉中的流动方向是什么？

- ☐ 从左至右
- ■ 从右到左

（注：使用的颜色规则在第 19 张幻灯片中解释）

Test Your Knowledge

<?> QUESTION

7 Which of the following is **not** a contraindication for CEUS?

- ☐ Known right-to-left cardiac shunt
- ☐ Severe pulmonary hypertension or uncontrolled systemic hypertension
- ☐ Acute respiratory distress syndrome
- ☐ Hepatic tumour of unknown type

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

<?> 问题

7 以下哪一项**不是超声造影 (CEUS) 的禁忌证?**

- ☐ 存在已知的心脏右到左分流
- ☐ 严重肺动脉高压或未控制的全身性高血压
- ☐ 急性呼吸窘迫综合征
- ☐ 不明类型的肝脏肿瘤

Test Your Knowledge

<?> ANSWER

7 Which of the following is **not** a contraindication for CEUS?

- ☐ Known right-to-left cardiac shunt.
- ☐ Severe pulmonary hypertension or uncontrolled systemic hypertension
- ☐ Acute respiratory distress syndrome
- ■ Hepatic tumour of unknown type

Ultra-sound

CHAPTER OUTLINE:

超声

章节大纲：

知识测试

<?> 回答

7 以下哪一项**不是**超声造影 (CEUS) 的禁忌证?

- ☐ 存在已知的心脏右到左分流
- ☐ 严重肺动脉高压或未控制的全身性高血压
- ☐ 急性呼吸窘迫综合征
- ■ 不明类型的肝脏肿瘤

/ Test Your Knowledge

<?> QUESTION

8 Name three general strengths and three general limitations of medical ultrasound.

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 问题

8 请列举医用超声的三个总体优势和三个总体局限。

/ Test Your Knowledge

<?> ANSWER

8 Name three general strengths and three general limitations of medical ultrasound.

STRENGTHS:

- Low cost
- High availability
- High portability
- Safe and non-invasive
- Fast
- Dynamic

LIMITATIONS:

- Highly operator dependant
- Highly patient dependant
- Difficult to reproduce
- Poor penetration in air and bone

/ Ultra-sound

CHAPTER OUTLINE:

/ 超声

章节大纲：

/ 知识测试

<?> 回答

8 请列举医用超声的三个总体优势和三个总体局限。

优势：

- 低成本
- 易获取
- 便携性高
- 安全无创
- 检查快速
- 可动态观察

局限性：

- 高度依赖于操作人员
- 高度依赖于患者情况
- 难以重复一致
- 对空气和骨骼穿透性差