Technology Overview

An Introduction to Contrast-enhanced Ultrasound

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SIEMENS Healthineers

Contrast-enhanced Ultrasound – Technology and Clinical Utility

Since its approval for use by the American Food and Drug Administration in 2016, contrast-enhanced ultrasound (CEUS) has become increasingly popular worldwide. A safe and easily performed imaging technique – with no requirement for ionizing radiation and no risk of nephrotoxicity – it is on its way to become the method of choice for the visualization of sensitive blood flow and acquisition of tissue perfusion information.

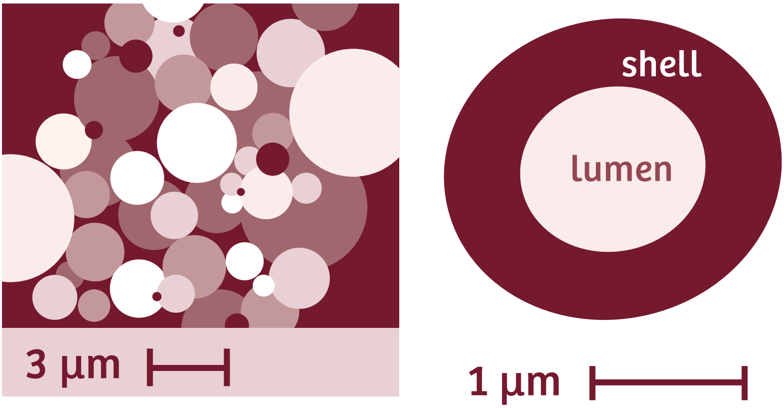


Figure 1: Contrast agents used in ultrasound are small micro-bubbles which enhance echo brightness of blood or blood-perfused tissue. They are characteristically very small (1–10 um) and have a gas core often with shells to preserve their life or influence their acoustic response.

Advantages of CEUS	Challenges
• Less costly • Radiation-free • Real-time, dynamic imaging • Portable • Expedient workflow • Better patient tolerance of the contrast agent	• Subjective nature of study • Sensitivity – the system's ability to detect the lowest concentration of agent in tissue • Specificity – the system's ability to distinguish the contrast agent from the tissue signal

Table 1: Advantages and Challenges of CEUS.

Introduction

Cadence contrast agent imaging offers a sophisticated comprehensive package for contrast enhanced ultrasound (CEUS).

CEUS utilizes microbubble contrast agents and dedicated imaging algorithms to provide useful insights into pathophysiology of disease difficult to discern on routine sonography.

CEUS takes advantage of the unique perfusion characteristics of tissue or, more simply put, its blood supply. A contrast agent (a micro-bubble, as described in Figure 1) is injected intravenously. Its behavior in a particular region of interest in the body, commonly a focal lesion in the liver, is observed and documented with diagnostic ultrasound.

Because of this, the study is highly dependent on the sophisticated interaction between the contrast agent and the ultrasound wave. Several modes are available to demonstrate this, the so-called "high-MI method" and "low-MI method", described in Figure 2.

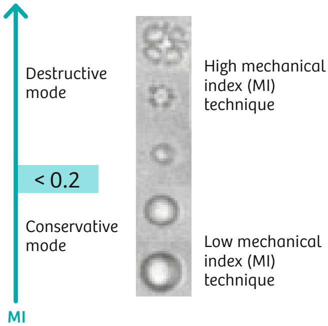


Figure 2: The destructive and conservative modes are used during a CEUS study to interrogate the contrast agent in specific ways to demonstrate perfusion characteristics of tissue.

The capability of micro-bubbles to traverse through microvasculature makes the technique uniquely sensitive to states of angiogenesis, perfusion, inflammation, and neoplasia. In addition, it offers unique real-time functional information between frames not otherwise available.

Ultrasound contrast agents are devoid of nephrotoxicity, making them safe to be administered to patients with renal compromise. They are also safe to be used in children.

Since the advent of this technology in echocardiography, the spectrum of potential clinical applications has widened to the abdomen, pelvis and vascular applications.

High-MI methods (high power)

- Exploits the destruction of the bubbles to image the contrast agent

Specialized

Low-MI methods (low power)

- Exploits the highly non-linear behavior of the bubbles to image the contrast agent

Routine

Personalized Contrast Ultrasound

Siemens offers two contrast imaging modes: Cadence contrast pulse sequencing (CPS)technology and Cadence contrast harmonic (CHI) technology.

The two modes have been designed to allow the user to uniquely personalize the study, maximizing the interaction between the contrast agent and the imaging technology to optimize the study outcome.

Specification and usage are illustrated in Figure 3.

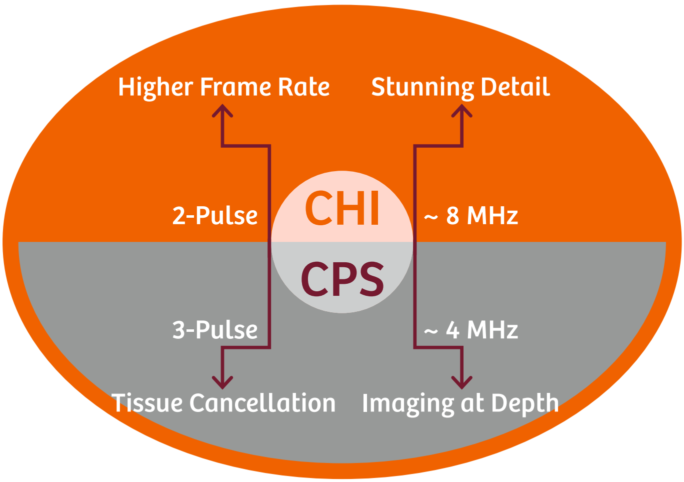


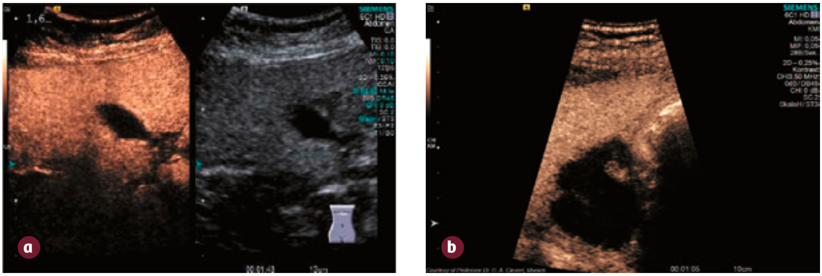
Figure 3: Two Cadence contrast imaging solutions uniquely available from Siemens.

Cadence Contrast Pulse Sequencing (CPS) Technology

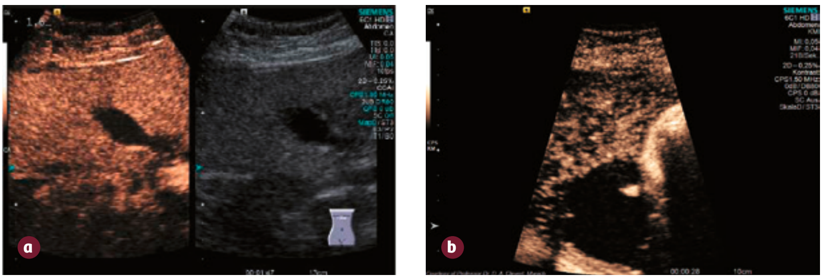
- Fundamental imaging mode
- Low MI-technique, designed for performance at depth
- Powerful 3-pulse sequence to maximize harmonic signals
- High specificity (contrast-to-noise ratio) for maximal tissue cancellation
- High sensitivity (signal-to-noise ratio)
- For use at depth

Cadence Contrast Harmonic Imaging (CHI)

- Second harmonic imaging mode
- Low MI-technique, designed for exquisite detail
- Sophisticated 2-pulse phase inversion to isolate second harmonic
- High frame rate, for visualization of low flow
- High spatial resolution, for use in small vessel studies
- Excellent bubble longevity



Figures 4(a)(b): Cadence CHI technology



Figures 5(a)(b): Cadence CPS technology

Signal-optimized Transducer Technology

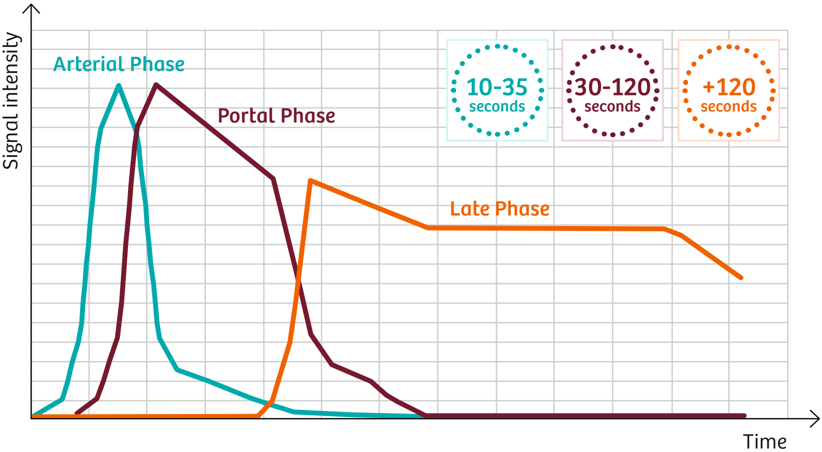
The success of contrast imaging relies on how well the technology complements the microbubble characteristics and behavior. Table 2 indicates the transducers supported for CEUS on the ACUSON S Family ultrasound systems.

The transducer technology is designed to harmonize with the signal from the contrast agent. Features that optimize image quality, such as Multi-hertz technology, take full advantage of the nonlinear resonance exhibited by micro-bubbles for best imaging response. The use of high-density (HD) element arrays can also have a considerable impact on study outcomes by maximizing image quality.

Using CEUS in the liver is a good example to illustrate the critical relationship between transducer technology, ultrasound signal and micro-bubbles. The transducer, ultrasound system and contrast agent must all harmonize to demonstrate optimal sensitivity throughout all three hepatic perfusion phases, as seen in Figures 6 and 7. The unique ability of the ACUSON S Family ultrasound systems to capture still images during clip capture is important because it allows data from each phase to be expertly captured in real-time, reducing the need for retrospective cine loop data review, which saves time.

Transducer	
4C1	
6C1 HD	
9L4	
MC9-4	

Table 2: Transducer portfolio designed and optimized for CEUS.



*Ham et al. 1994 Focal Liver Lesions: Characterization with Nonenhanced and Dynamic Contrast Material-enhanced MR. Imaging Radiology 1994; 190:417-423

Figure 6: Three unique perfusion phases of the liver. Cadence contrast imaging technology is optimized to ensure bubble sensitivity throughout these phases, up to and beyond three minutes.

Conclusion

Contrast-enhanced ultrasound is an exciting and dynamic field. It is an established part of the diagnostic pathway in many parts of the world, particularly throughout Europe.

The clinical applications, whilst first approved by the United States Food and Drug Administration (FDA) for applications in echocardiography, are now expanding into radiology.

The first contrast imaging applications for radiology, specifically for the detection of focal liver lesions in adults and children, were approved by the FDA in 2016. This was then supplemented in 2017 by a further approval by the FDA for use of contrast agent imaging in vesicoureteral reflux (VUR) indications in children.

The recognition that contrast agent imaging is an important tool for diagnosis, and a cost-effective, safe, straight-forward and expedient workflow tool continues to gain global momentum. As an increasing number of ultrasound users gain experience with this unique technology the market will adopt this quick and easy-to-apply addendum to routine exams. Cadence CHI and CPS contrast imaging technologies have been optimized for seamless interaction between transducer, ultrasound system and contrast agent. This allows users to personalize their CEUS exam to their individual patient's needs.

The products/features are not commercially available in all countries. Due to regulatory reasons their future availability cannot be guaranteed. Please contact your local Siemens Healthineers organization for further details.

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