Canon

Exploring new horizons in ultrasound – The new world of Aplio i-series

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Introduction

Aplio™ i-series, a new premium-class diagnostic ultrasound system, incorporates the latest technologies to provide a new level of image quality and advanced clinical applications. In this white paper, three important key differentiators of Aplio i-series are explained: 1) The newly developed ultra-wideband convex transducer PVI-475BX, 2) Smart Sensor 3D, a new technology that generates highly accurate volume data from a single scan using a 2D transducer, and 3) The ultra-high frequency linear transducer PLI-2004BX.

Ultra-wideband convex transducer

In routine ultrasound scanning, transducer changing may be necessary based on target regions or diagnostic objectives. In our institute, a 3MHz transducer (PVT-375BT) is used to screen for lesions and a 6MHz transducer (PVT-674BT) is used for more detailed evaluation. Innovative deve-lopments in system architecture, with new Intelligent Dynamic Micro-Slice (iDMS) transducer technology, have also led to the next generation of transducers. The newly introduced ultra-wideband convex transducer PVI-475BX, only available on Aplio i-series, covers both of the spectrums provided by two conventional convex transducers (PVT-375BT & PVT-674BT) with an even higher sensitivity. This transducer contains single crystal and re-engineered components which include a new lens, piezoelectric oscillator, new matching layers and backing material. The "2-in-1" transducer also utilizes the system's innovative iBeam-forming architecture to provide narrow, uniform and high density ultrasonic beams; where iDMS technology sharpens the beam in lens direction, ensuring continuous automated focus at every depth simultaneously. As a result, high quality and homogeneous images with high sensitivity, contrast and spatial resolution in axial, lateral and elevational dimensions can be obtained (Figure 2).

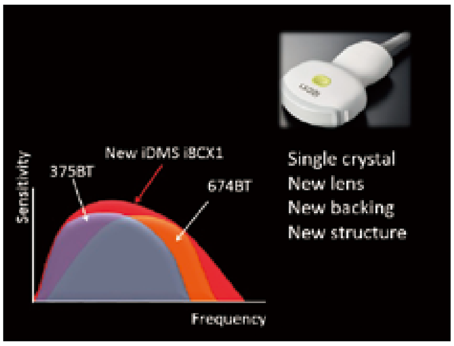

Figure 1. Ultra-wideband convex transducer PVI-475BX

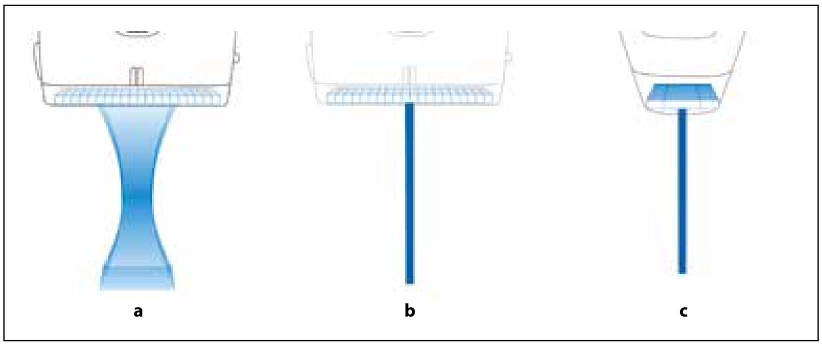

Figure 2. Conventional beam forming technology (a).
iBeam forming technology produces a sharp, uniform and thin ultrasonic beam that offers clinical images with higher resolution, more homogeneity, and reduced artifacts (b).
iDMS:iBeam-slicing in lens direction to enable continuous focus across all depths (c).

CASE STUDIES

Pancreatic Cancer

Small pancreatic tumors are often difficult to detect as the pancreas is located deep in the abdomen. The ability to visualize a hypoechoic tumor with the size of 1.5cm in diameter clearly demonstrates that the ultra-wideband convex transducer provides extraordinary resolution and penetration (Figure 3a). With the "2-in-1" transducer, images with higher signal-to-noise ratio (SNR) can be obtained. The contour of the tumor and the dilatation of pancreatic duct and its branches can be clearly visualized (Figure 3b).

Focal Liver Lesions using CEUS

Figure 4 shows a grayscale image (a) and a contrast enhanced ultrasound (CEUS) image (b) of a hepatocellular carcinoma (HCC) and a hepatic hemangioma acquired using the PVI-475BX transducer. The use of CEUS in deep regions can be challenging due to a decrease in sensitivity. It might also be difficult to characterize the early washout phenomenon in the late vascular phase, seen in dedifferentiated HCC. Furthermore, when using CEUS to delineate tumors located in deep regions, operators often tend to increase the gain to compensate for attenuation, however, this will increase signals from the tissue and affect the appropriate analysis of the contrast ultrasound.

The ultra-wideband transducer has a high sensitivity for contrast ultrasound and provides homogenous images even in deep regions. The early washout phenomenon identified only from HCC increases diagnostic accuracy.

Figure 3. Pancreatic cancer

Figure 4. A grayscale image (a) and a CEUS image (b) of a hepatocellular carcinoma (HCC) and a hepatic hemangioma.

Von Meyenburg's Complex

Speckle noise is one of the most common artifacts in ultrasound images and this interferes image interpretation (Figure 5). Advanced image processing technologies such as ApliPure™+ and Precision Imaging can reduce speckle noise and enhance contour visualization respectively. Utilizing these two image processing methods in combination with the new generation transducers, a number of multiple reflections from minute cystic lesions can be depicted. These findings confirm that the lesion is composed of multiple, diffused cysts.

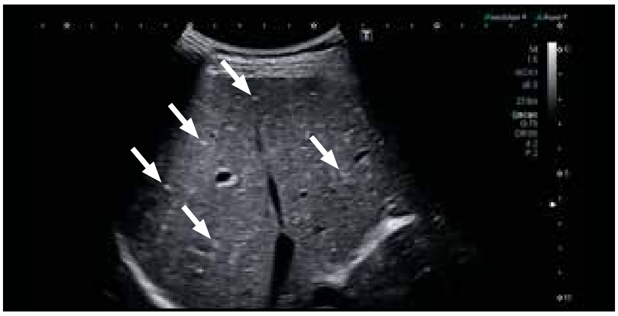

Figure 5. Von Meyenburg's Complex. A few of the multiple reflections are indicated with arrows.

Hepatic Hemangioma

The worm-like motion seen in hepatic hemangiomas is one of the important findings for the differential diagnosis. Using a 7MHz transducer (PLT-704SBT, Aplio 500) (Figure 6a), there might be a limitation to delineate the worm-like motion because the noise level is relatively high. Using the new ultra-wideband transducer in combination with ApliPure+ and Precision Imaging, the worm-like motion inside the lesion can be clearly visualized with a high SNR, confirming the diagnosis of hemangioma (Figure 6b). The combination of PVI-475BX and image processing methods can be very useful to help physicians characterize focal liver lesions, reducing costs and minimizing risk of further examinations.

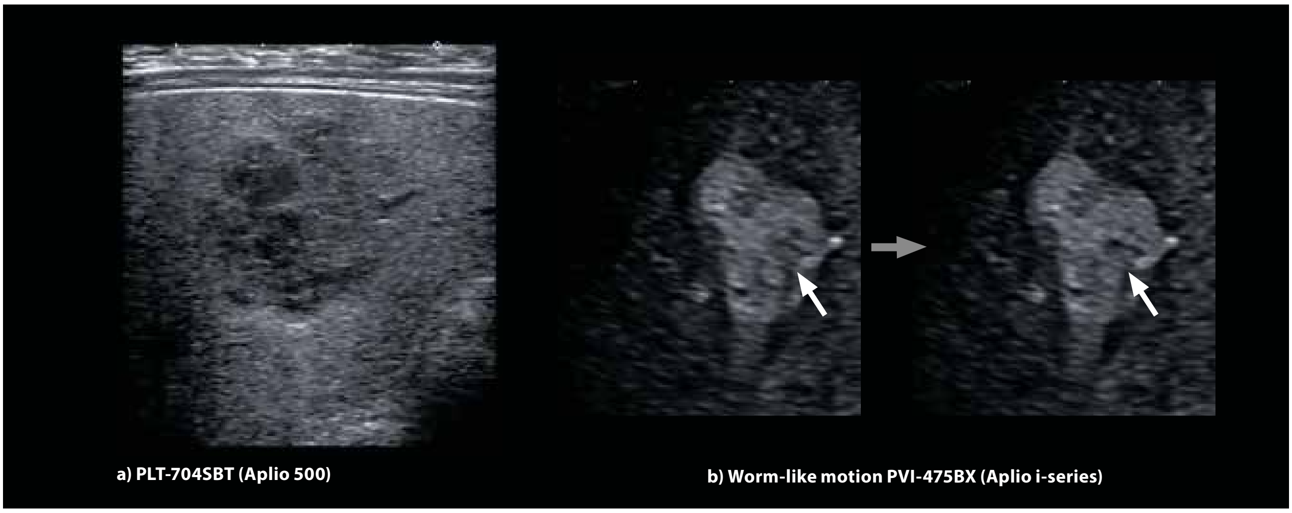

Figure 6. Hepatic hemangioma images acquired using PLT-704SBT (7MHz) (a) and PVI-475BX(5.5MHz) (b).

Renal Calculi

Multiple layers of diffuse calcification can be detected in the kidney using the ultra-wideband transducer (Figure 7). Compared with CT, ultrasound is commonly expected to have a lower detectability for calcification. Using the "2-in-1" ultra-wideband transducer, crystal-clear reflections from the renal calculi can be distinguished from speckle noise because of the outstanding spatial and contrast resolution. In comparison, only one of the relatively large calculi was detected by CT. As a result, ultrasound with this new transducer is considered to have a significant advantage in visualizing renal calculi.

Figure 7. Diffuse calcifications in the kidney. A few of the renal calculi are indicated with arrows.

Advanced Gastric Cancer and advanced rectal cancer

The ultra-wideband transducer shows fewer artifacts and offers a higher SNR. These features make it ideal for gastrointestinal ultrasound which almost always is affected by the artifacts produced by the multiple reflection from the body wall and by the side lobe from the intraluminal gas. In the case of advanced gastric cancer (Figure 8a), the focal wall thickening and loss of wall layer structure is clearly demonstrated. Similarly, in advanced rectal cancer (Figure 8b), focal wall thickening and loss of wall layer structure can be clearly observed.

Smart Sensor 3D

Smart Sensor 3D is a new volume scanning technology. Images acquired by free-hand scanning using a 2D transducer are combined to generate high-definition 3D images with precise positional information obtained by the magnetic field from the transmitter (Figure 9).

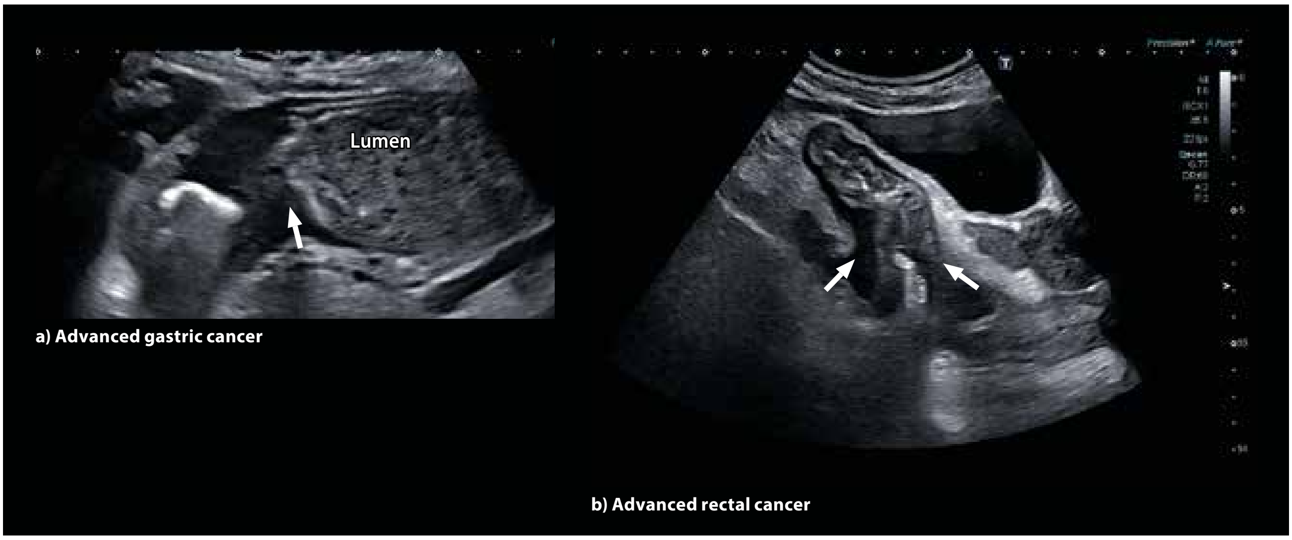

Figure 8. Advanced gastric cancer (a) and advanced rectal cancer (b)

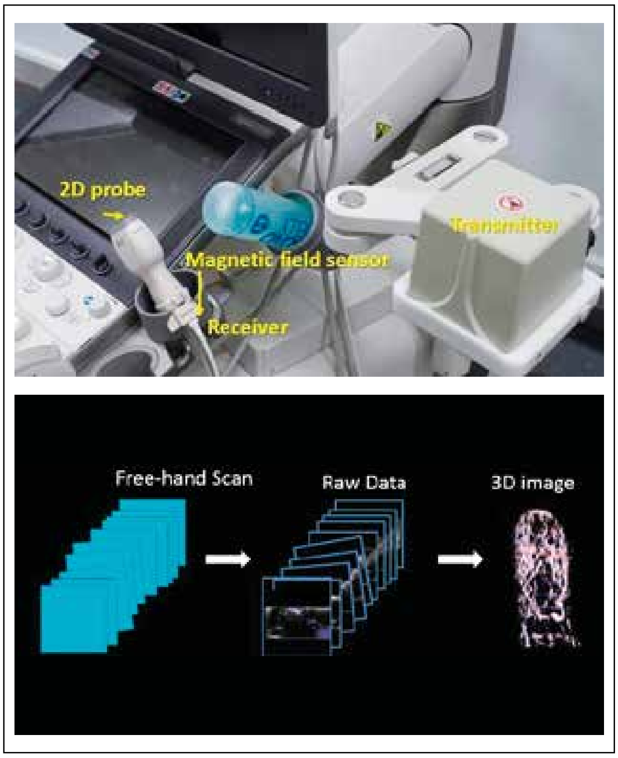

Figure 9. Basic principle of Smart Sensor 3D

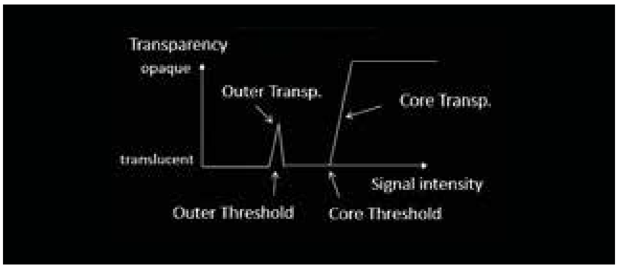

Figure 10. Principle of Shadow Glass

CASE STUDIES

Fetus

Shadow Glass is the new rendering technology which can be applied to images acquired with Smart Sensor 3D (Figure 10). This innovative display method allows internal structures to be observed, because it employs two different filters in order to generate a semi-transparent volume image. In comparison with conventional 3D images, Shadow Glass allows observation of entire structures more easily (Figure 11). In case of a fetus, Shadow Glass allows clear observation of the organs in relation to the overall anatomy.

Fingers

Figure 12 shows images of a normal finger. The blood vessels, bones and nails can be recognized clearly by using Smart Sensor 3D (Figure 12a). Shadow Glass has also been found to be useful in orthopedic examinations, for example, in visualization of fractures. Shadow Glass images can be clinically more useful than conventional images because more information can be provided in one single image. In addition, the use of a Curved C plane generated by OmniView (Figure 12b) permits the blood vessels in the finger to be depicted with continuity. Thus, the continuity of the blood vessels can be evaluated by employing both 3D Shadow Glass (Figure 12c, d) and a 2D Curved C plane. It is expected that these images will prove to be useful in a wide range of clinical applications such as microsurgery.

Figure 11. Visualization of a fetus using Volume Rendering (a), Luminance (b) and Shadow Glass (c).

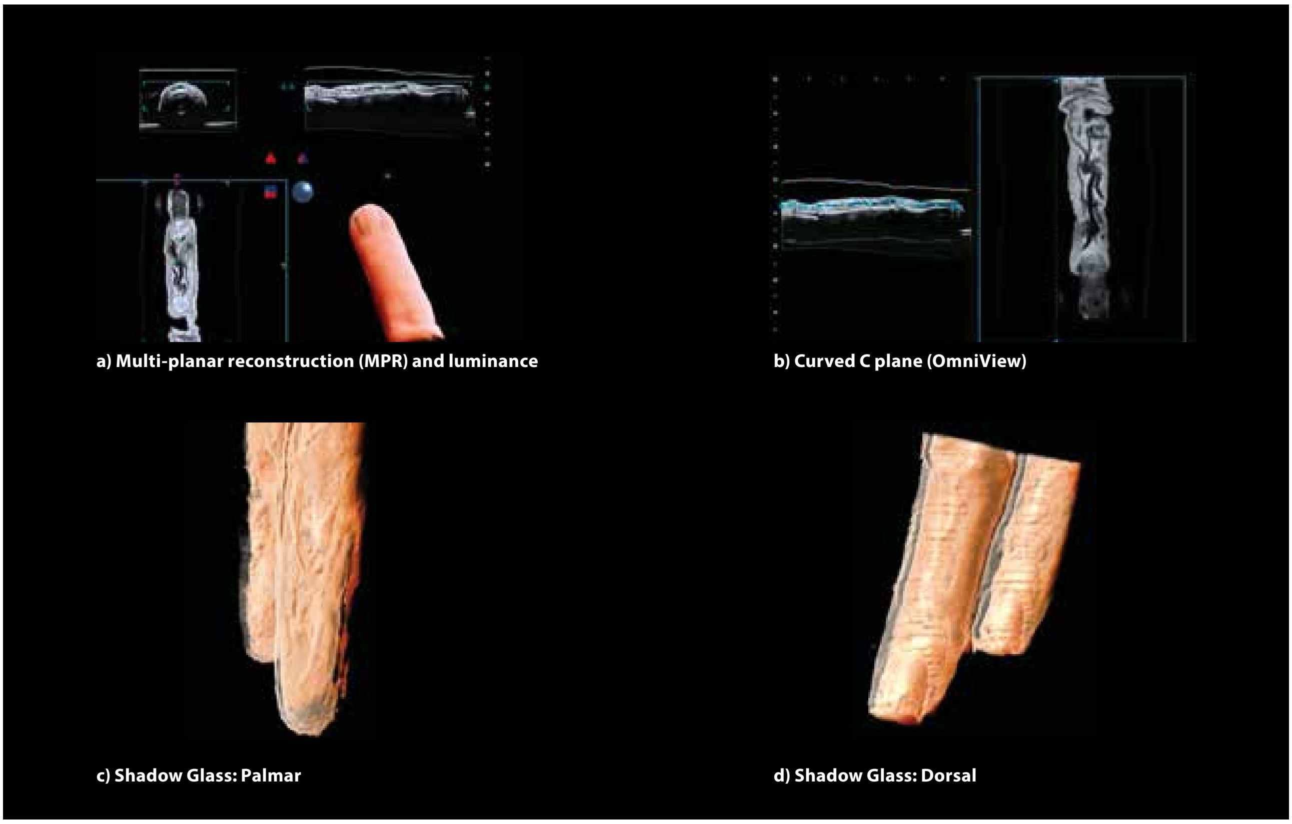

Figure 12. Normal fingers using Smart Sensor 3D

Cholangiocarcinoma

When evaluating the extent of infiltration of the cholangiocarcinoma, it is not possible to visualize the continuity of the bile duct in a single C plane image in 3D reconstructions (Figure 13b). However, by tracing additional points in the lumen and displaying it using Curved MPR, a Curved C plane can be created. In a Curved C plane (Figure 13c), the continuity of the bile duct can be clearly visualized, allowing easy evaluation of the lesion and the surrounding areas. In addition, Shadow Glass (Figure 13d) allows the posterior wall to be depicted, permitting clearer observation of the bile duct's entire structure.

Ultra-high Frequency Linear Transducer

The new i-series transducer PLI-2004BX has an ultra-high frequency (central: 24MHz) and broad spectrum to provide outstanding spatial resolution. The expanded frequency spectrum dramatically improves the image quality.

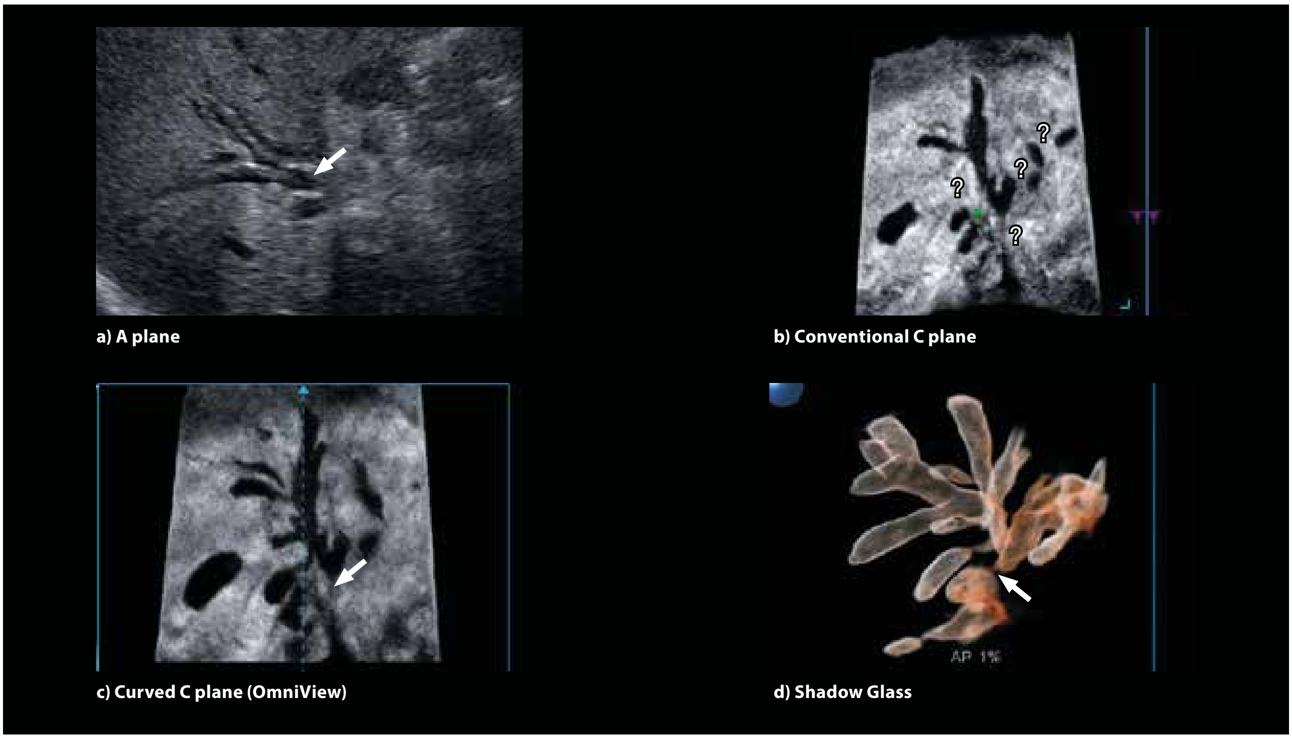

Figure 13. Cholangiocarcinoma using Smart Sensor 3D

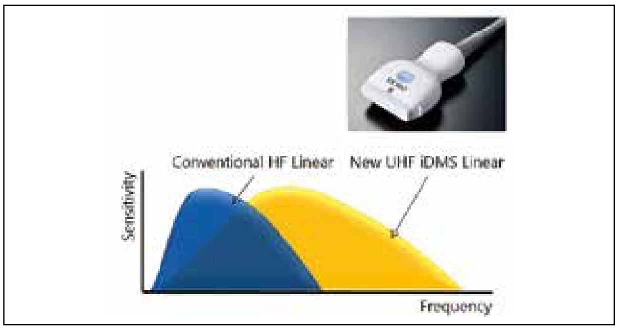

Figure 14. Ultra-high frequency linear transducer PLI-2004BX

CASE STUDIES

Rib Fracture

A 57-year-old, female patient had complained of right upper quadrant pain. Nevertheless, the cause of her pain has not been diagnosed despite multiple examinations.

When using the 7MHz transducer (PLT-704SBT, Aplio 500) (Figure 15a), the rib structure appeared to be normal. However, the ultra-high frequency transducer unveiled a slight fracture in the rib (Figure 15b), which was then identified as the cause of her pain. These slight fractures could not be diagnosed with other imaging modalities, underlining the clarity and detail provided by the PLI-2004BX.

Malignant Melanoma

When staging melanoma, it is important to determine whether the penetration depth of a lesion is more than 1mm because treatment may differ. The ultra-high frequency transducer provides unprecedented spatial resolution to visualize the lesion's penetration underneath the skin surface (Figure 16a). After measuring, the thickness of the melanoma is confirmed to be slightly larger than 1mm. Superb Micro-vascular Imaging (SMI), a Doppler technology which is able to depict low-velocity minute flow, shows an abundance of Doppler signals coming from the lesion, confirming this is a malignant melanoma (Figure 16b).

Mycosis Fungoides (Cutaneous T-cell Lymphoma)

In a case of mycosis fungoides, where the thickness of a lesion is only 0.4 mm, the ultra-high frequency transducer can clearly visualize a slightly thickened layer (Figure 17a). Because of the size, it is usually not easy to observe on grayscale. After applying Superb Micro-vascular Imaging (SMI), the lesion is clearly demarcated from the normal skin area since the lesion is definitely hypervascular (Figure 17b).

Figure 17c shows a 3D image of two lesions. The avascular area between the lesions represents normal skin.

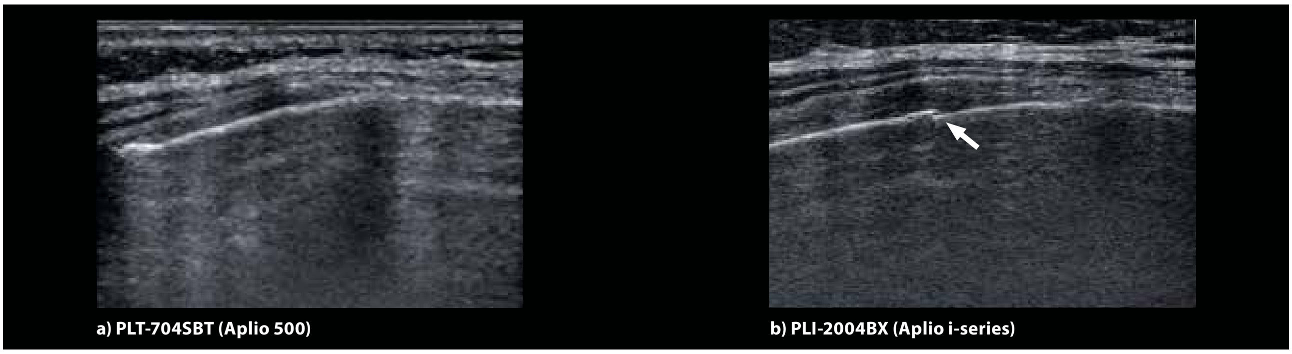

Figure 15. Rib fracture images acquired using PLT-704SBT (7MHz) (a) and PLI-2004BX (24 MHz) (b).

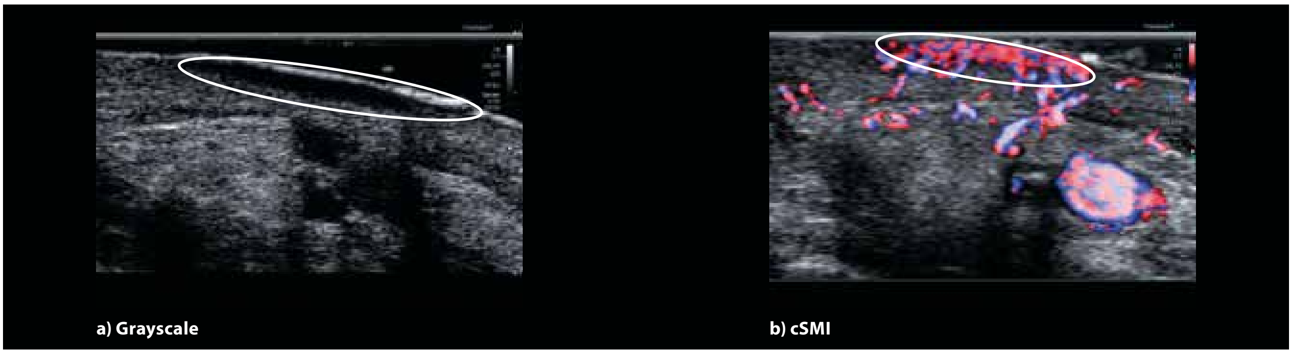

Figure 16. Malignant melanoma acquired using PLI-2004BX (24 MHz).

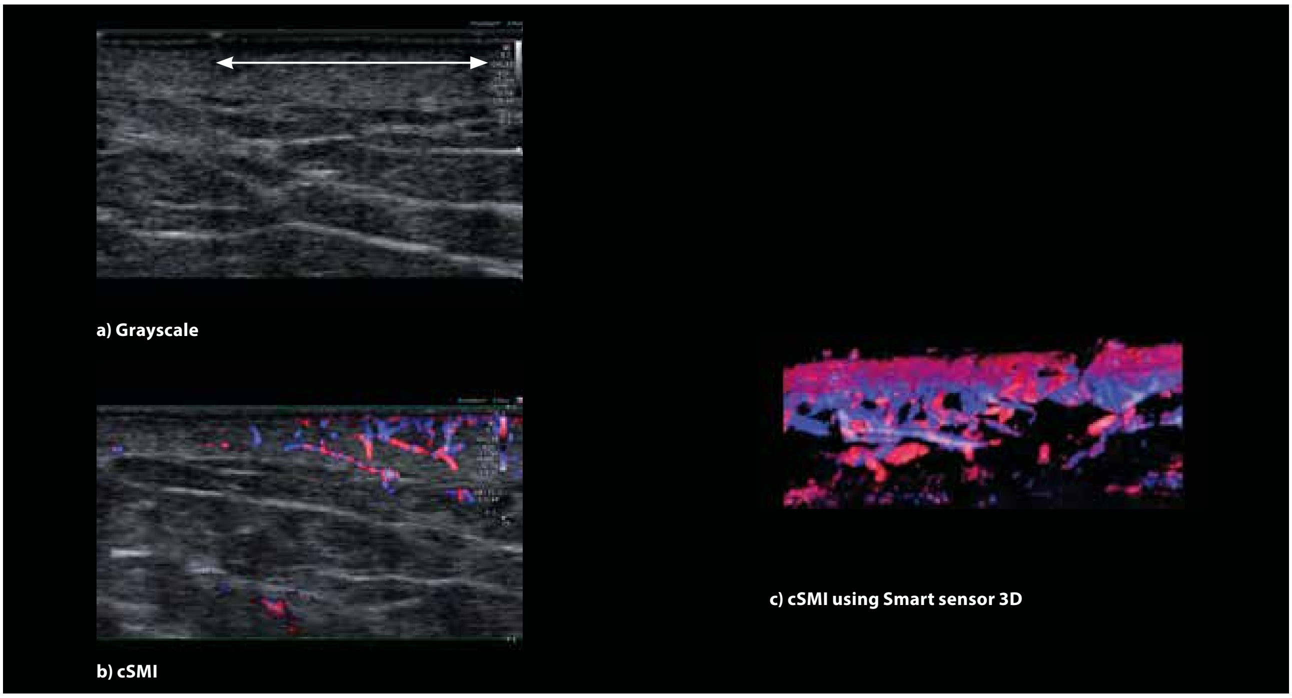

Figure 17. Mycosis Fungoides (Cutaneous T-cell Lymphoma)

Subcutaneous Abscess (caused by a dog-bite)

It is impossible to distinguish the range of abscess on the grayscale (Figure 18a). SMI clearly shows the hyperemia surrounding a small avascular area in a patient's ring finger (Figure 18b), which is strong indication for the presence of an abscess. The suspicion was confirmed at operation. The extraordinary grayscale resolution and minute vascular detail provided by SMI images cannot be seen using any other imaging modality.

Erysipelas

The image resolution delivered by PLI-2004BX clearly demonstrates subcutaneous edema at the lesion (Figure 19a). In color-coded SMI (cSMI) images, using a conventional linear transducer, it is difficult to visualize the details of the lesion and the hyperemia in the epidermis and dermal areas (Figure 19b). In contrast, the higher sensitivity of cSMI of ultra-high frequency transducer easily identifies the increase in blood flow due to severe inflammation (Figure 19c).

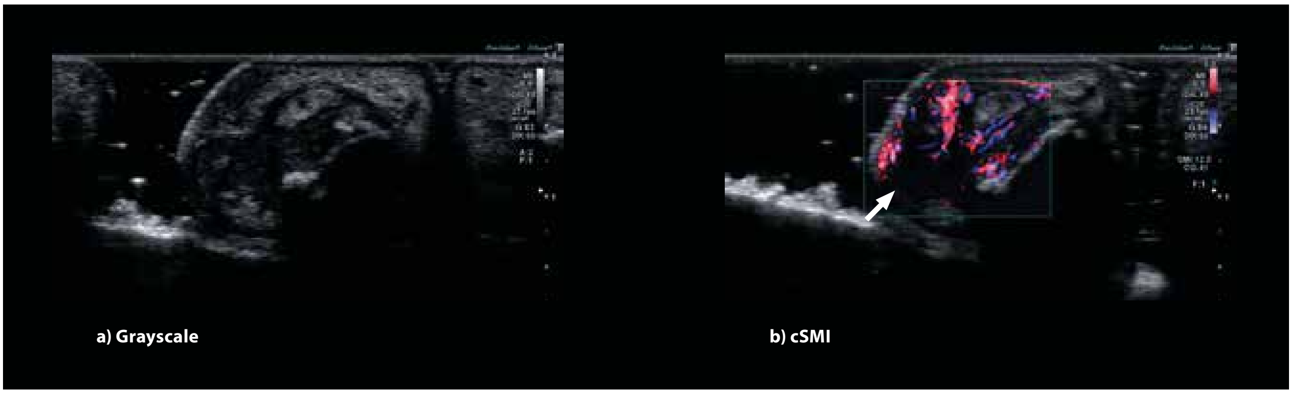

Figure 18. Subcutaneous Abscess caused by a dog-bite

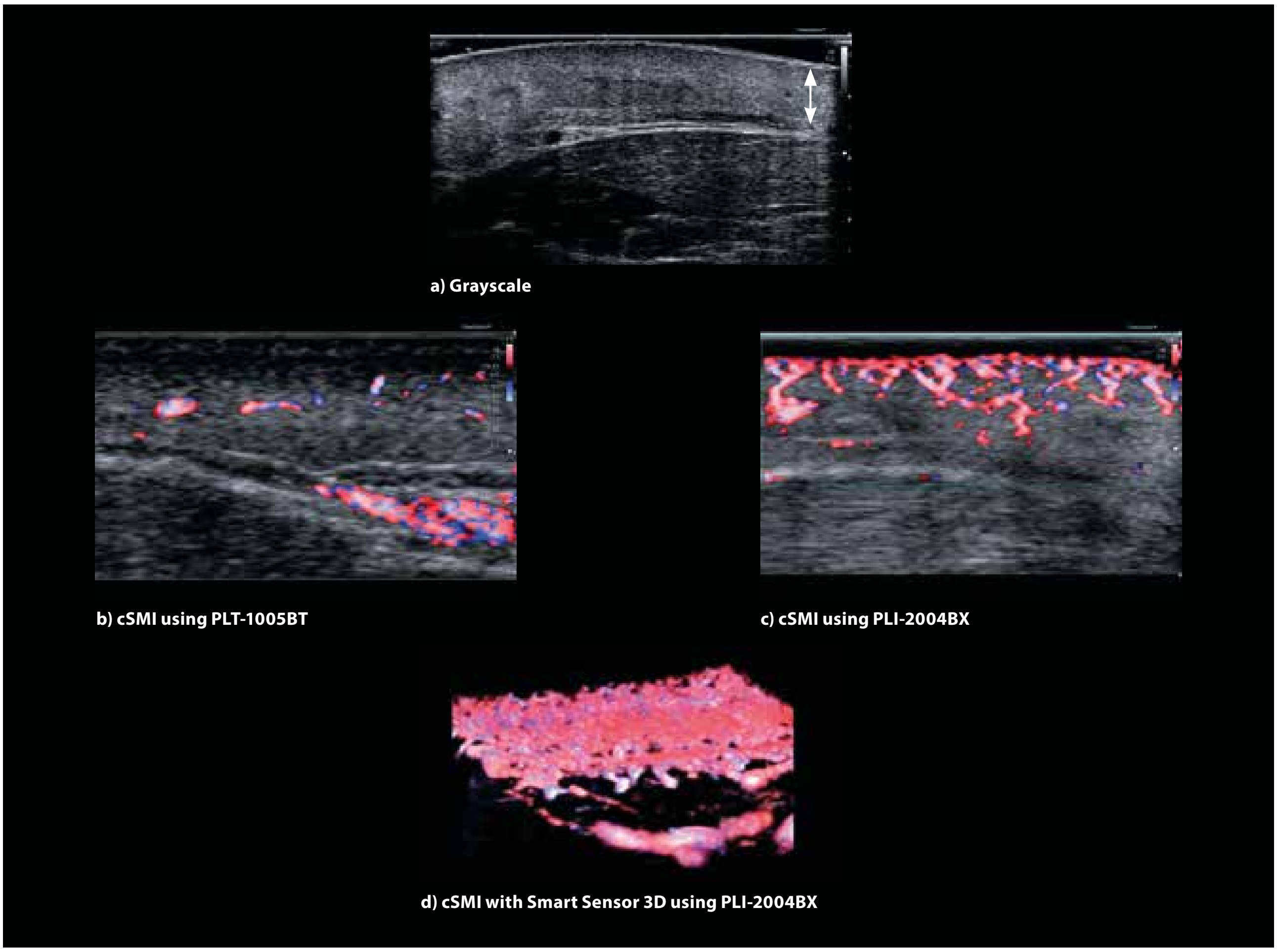

Figure 19. Erysipelas acquired using PLI-2004BX (24 MHz) (a, c, d) and PLT-1005BT (12 MHz) (b).

In addition, the 3D cSMI image acquired using PLI-2004BX with Smart Sensor 3D showed the entire vasculature immediately (Figure 19d). The ultra-high frequency transducer has great potential in dermatology and is expected to fully demonstrate its outstanding capabilities of delineating minute structures.

Ruling out the possibility of Biliary Atresia

The diagnosis of pediatric biliary atresia is challenging in all modalities and yet it is one of the most important clinical applications in ultrasound imaging. There are four main types of biliary atresia, but almost all types can be ruled out if patency of the bile duct from the porta hepatis to the common bile duct can be confirmed. Since the diameter of the pediatric bile duct is approximately 1 mm (arrow), it is extremely difficult to clarify its patency with conventional transducers. Using the new ultra-high frequency probe, the patency of the extrahepatic bile duct can be confirmed and biliary atresia therefore ruled out with confidence (Figure 20). New generation transducers of Aplio i-series increase clinical confidence of diagnosis and can avoid invasive additional diagnostic procedures.

Figure 20. Pediatric biliary tract in a case of suspected biliary atresia using PLI-2004BX (24 MHz).

Tumor Seeding of Gastric Cancer

These images are taken from a patient with advanced gastric cancer. In this patient, the diagnosis of tumor seeding is very important to avoid unnecessary surgery. With a 12 MHz transducer (Figure 21a), it was difficult to confirm the presence of tumor seeding. However, PLI-2004BX clearly demonstrates the seeding nodules (arrow), allowing the cancer to be confidently identified as Stage 4 cancer (Figure 21b). The patient was therefore diagnosed as not to be a candidate for surgery. In such patients, it is also important to thoroughly examine the peritoneum because peritoneal metastasis from gastric carcinoma are common. The ultra-high frequency transducer is strongly recommended for more precise examination.

Figure 21. Gastric cancer images acquired using PLT-1005BT (12 MHz) (a) and PLI-2004BX (24 MHz) (b).

Conclusion

The newly developed ultra-wideband convex transducer PVI-475BX provides optimum spatial resolution and penetration for a wide variety of clinical applications ranging from screening to diagnosis of lesions. This “2-in-1” transducer reduces cost and improves transducer management and workflow by eliminating the need to switch transducers.

Smart Sensor 3D provides clinically applicable multi-planar reconstruction images and 3D images with high-definition. Advanced 3D rendering tools such as Shadow Glass can be applied for different perspectives for diagnosis.

The ultra-high frequency linear transducer PLI-2004BX can be used to scan any anatomical regions and offers unprecedented spatial resolution and enhanced sensitivity for new advanced Doppler technologies such as SMI. The extended frequency range expands clinical applications, including intraoperative ultrasound.

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Toshiba Medical has changed its company name to Canon Medical Systems Corporation as of January 4th, 2018.
This document was created prior to the name change and therefore the former company name may still be referred to within the document.

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