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Medical Review

Intuitive. Intelligent. Innovative.

Aplio i-series

Evolution and Revolution of System Architecture with New Generation Technology

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Evolution and Revolution of System Architecture with New Generation Technology

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Introduction

Toshiba Aplio™ i-series diagnostic ultrasound systems are the result of intelligent implementation of innovative technologies that provide intuitive experience for its users from the very first moment. The new generation architecture and advanced transducer technology provide an extraordinary experience with fast and easy workflow combined with superb imaging and clinical applications.

Toshiba Aplio i700, i800, and i900 have been designed for whole body ultrasound examinations. The key differentiators of i-series are innovative beam forming technology (iBeam forming), front-end Intelligent Dynamic Micro-Slice technology (iDMS), powerful multiplexing technology and advanced volume matrix technology. The evolution and revolution of architecture with new generation technology provide a new level of image quality and clinical applications.

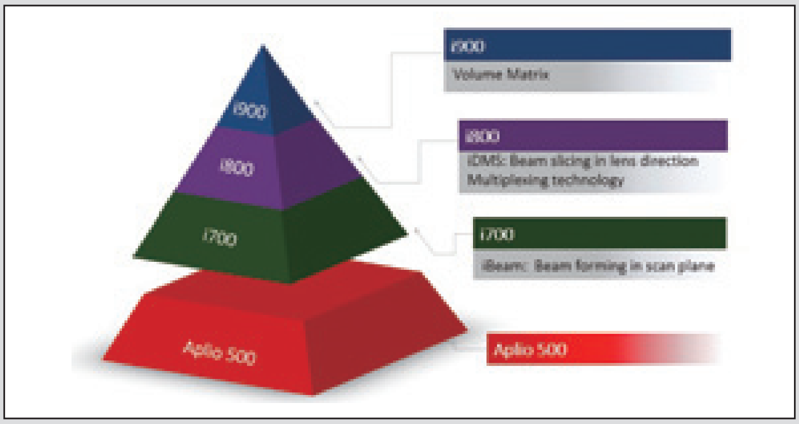

Figure 1. Toshiba's Aplio differentiation chart

Figure 2. Design concept of Aplio i-series

Architecture

More than fifty years of in-house ultrasound evolution has shaped the architectural base of the Aplio i-series. The architecture of Aplio i-series has been designed to prepare clinicians for the challenges of today and the future. In the following section, iBeam forming and multiplexing technology will be explained in more detail.

iBeam Forming

iBeam forming consists of 3 technologies that work together to cumulatively optimize efficiency of the ultrasonic beam: Multi-Sync Pulser (transmitting), Multi-Beam Receiver (receiving), and Multi-Harmonic Compounding (processing).

iBeam ensures the formation of a sharp, uniform and thin slice beam that offers clinical images with higher resolution, more homogeneity, and less artefacts. This revolutionary beam forming technology is able to offer excellent contrast resolution, temporal resolution and spatial resolution in all three aspects: axial, lateral and elevation (or azimuthal).

iBeam Transmission: Multi-Sync Pulser

To obtain high resolution clinical images, harmonic imaging is executed which means that fundamental signals are rejected and second harmonic signals are extracted. Tissue harmonic signals have a narrower beam, lower clutter noise with lower side-lobe levels and thus can form high resolution clinical images. Pure transmitting ultrasound waves are required to reduce artefacts and the clutter that create noisy frequency components in the tissue harmonic area. In the conventional Aplio system, a twin-pulser technique was used to transmit purer waves. However, in order to have perfectly pure waves that are artefact-free and homogeneous without decreasing the frame rate, the next gener-

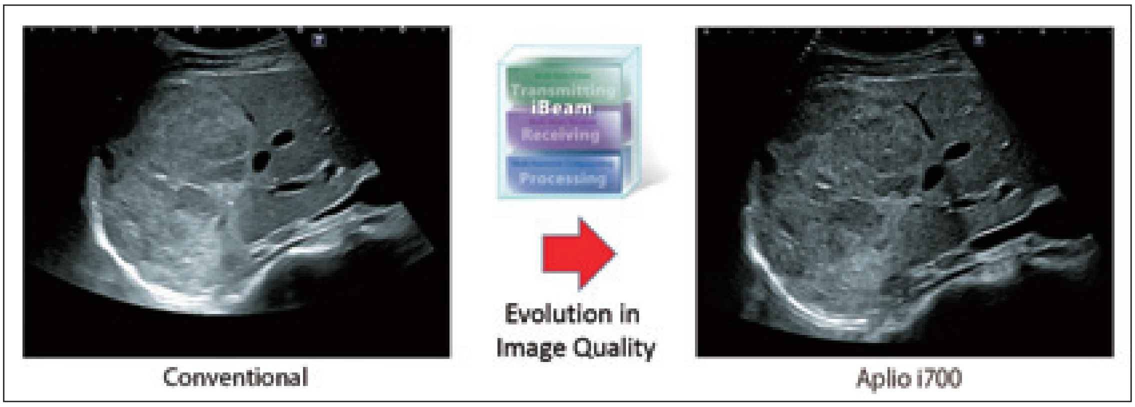

Figure 3. iBeam architecture

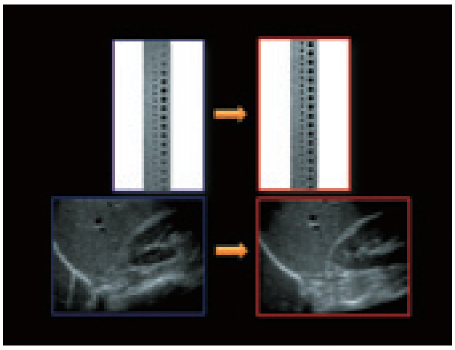

Figure 4. iBeam forming

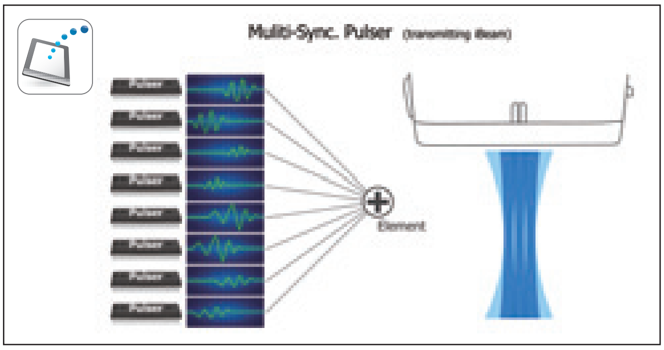

Figure 5. iBeam transmission: Multi-Sync Pulser

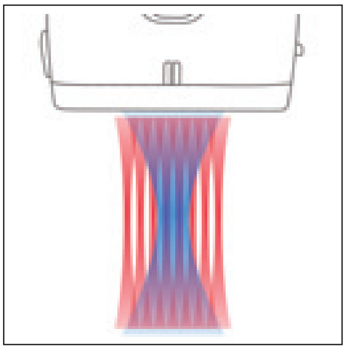

Figure 6. iBeam receiving: Multi-Beam Receiver

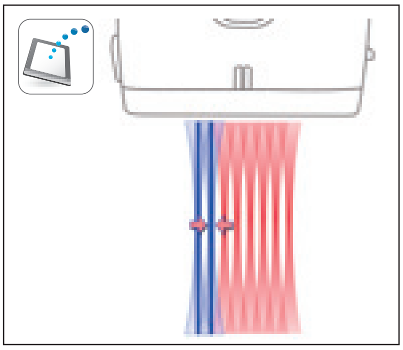

Figure 7. iBeam processing: Multi-Harmonic Compounding

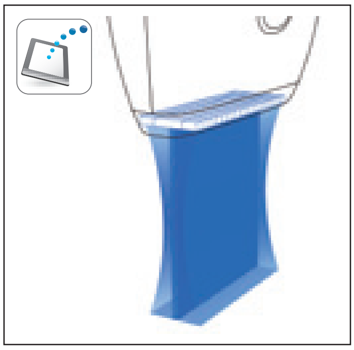

Figure 8. Intelligent Dynamic Micro-Slice (iDMS) technology

ation beam transmitting technology, Multi-Sync Pulser, has been developed. This new beam forming technology can generate symmetrical pulses with a flexible variation in aperture and delay curve for constructing the best artefact-free frequency component. As a result, ultrasound images with more penetration, higher spatial resolution and contrast resolution with reduced artefacts and clutter can be obtained.

iBeam Receiving: Multi-Beam Receiver

Quadrature signal processing (QSP) in conventional systems has an advantage of higher frame rate with one beam transmission because four signals can be received simultaneously. However the newly implemented Multi-Beam Receiver technology allows multiple beam lines to be received concurrently with one transmission, resulting in a uniform, high density field of scan lines that enable images with more homogeneity and higher frame rate.

iBeam Processing: Multi-Harmonic Compounding

Multi-Harmonic Compounding is a new beam shape forming technology made possible with the powerful processing capacity on the i-series platform. By compounding signals from the main beam and the adjacent beams, a finer, sharper and more uniform ultrasound beam can be generated, leading to precise clinical images with higher lateral resolution and higher frame rate. With Multi-Harmonic Compounding, the signal-to-noise ratio is increased, offering better image resolution and penetration.

Pioneering Transducer Technology

Revolutionary i-series architecture leads to next generation transducer technology that can deliver images with more clinical benefits, such as an increased penetration for difficult patients, and a higher resolution that helps to make a diagnosis faster. Aplio i-series transducers can be distinguished from conventional transducers by Intelligent Dynamic Micro-Slice (iDMS) and Volume Matrix technology.

The newly developed low attenuation lens, high performance piezoelectric oscillator and optimized matching layer form the foundation for Intelligent Dynamic Micro-slice technology. iDMS is incorporated in the new 1.5D array transducers in Aplio i800 and i900 series for producing sharp and uniform beams in the lens direction, i.e. providing ultra-thin and uniform slices for enhanced elevation resolution. iDMS is a ground-breaking transducer technology that provides high-flexibility electronic focusing in the lens direction. With iDMS, focusing is not only done by aperture control but also by time delay and weighting control between center and adjacent elements. This technology, generates a continuous focused beam in the lens direction at all depths. The result is a sharp and homogeneous slice thickness with high sensitivity, contrast and elevation resolution.

Ultra-wideband Transducers

Aplio i-series transducers have a significantly wider bandwidth and can cover the frequency range normally requiring two transducers.

The 2-in-1 ultra-wideband transducers contain single crystal and re-engineered materials including a new lens, piezoelectric oscillator, and matching layer. This provides optimum resolution and penetration in one transducer, thereby improving the clinical capability, decreasing examination times, and potentially reduce the financial burden ensuring more effective management of transducers. The innovative ultra-wideband transducers are available for both convex and linear to cover a wide variety of clinical applications.

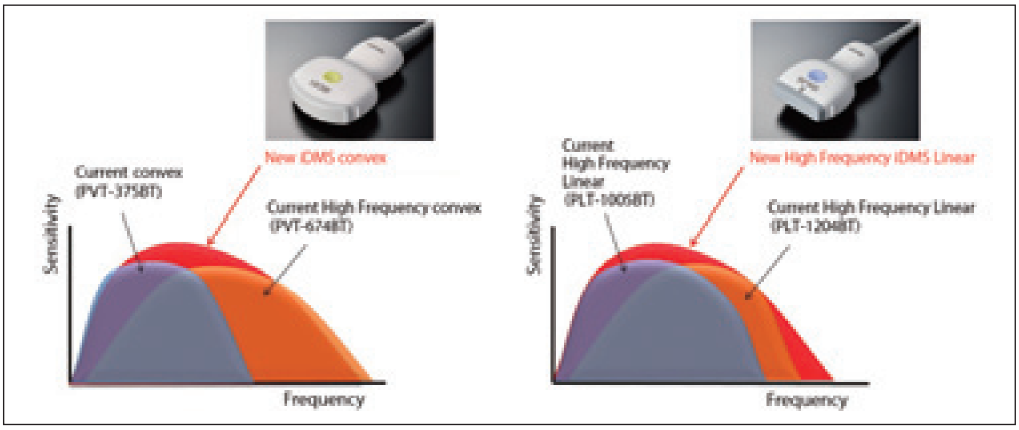

Figure 9. Ultra-wideband transducers

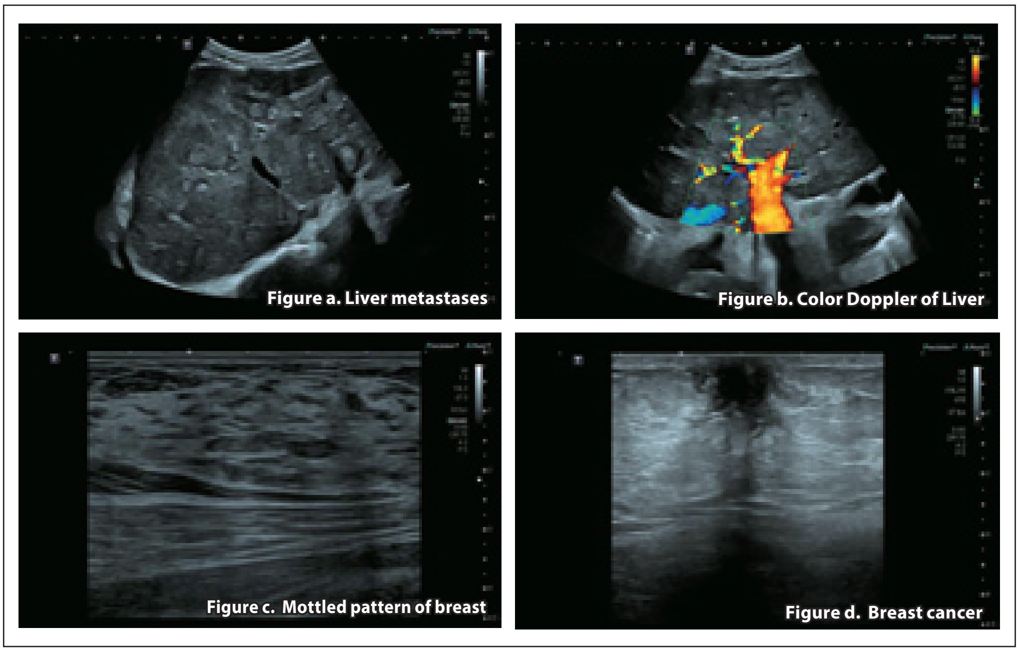

Figure 10. Courtesy of Professor David Cosgrove, MD.

Professor David Cosgrove, MD.
Imperial College School of Medicine and Consultant in Radiology, Hammersmith Hospital, London, the United Kingdom

"The ultra-wideband transducers i8CX1 and i18LX5 provide excellent images with high spatial resolution and contrast. With iBeam forming and iDMS technology, sharp and uniform images can be acquired easily. In addition, the new ultra-wideband transducer provide increased penetration at the same time.

The image of liver metastases (Figure a) acquired using the i8CX1 shows high resolution, contrast and penetration. The image is really uniform and contains extraordinary detail. The outline of the color Doppler signal has been enhanced (Figure b), allowing detailed observation of the vasculature.

The i18LX5 wideband transducer is an outstanding versatile transducer that bridges many small parts applications. The 2-in-1 transducer provides exceptional detail and high penetration. The mottled pattern in the breast (Figure c) can be observed with great contrast, resolution and uniformity, especially at depth. The invading margin of the breast cancer (Figure d) is clearly shown in detail with good penetration. "

* All images were provided by courtesy of Professor Adrian Lim, Imperial College London.

Ultra-high Frequency Transducers

The new i-series transducer i24LX8 offers an ultra-high frequency (UHF) up to 24MHz with outstanding spatial resolution. The new lens, piezoelectric oscillator, matching layer and backing combination allow high frequency emission. The elevated frequency range expands the horizon for clinical applications especially for small parts, MSK and other potential clinical regions such as dermatology.

Professor Jiro Hata, MD.
Dept. Of Clinical Pathology and Laboratory Medicine, Kawasaki Medical School, Kurashiki, Japan

"For me, the i24LX8 transducer has become irreplaceable for diagnosis. The high frequency transducer has an extraordinary high spatial resolution that is useful for clinical regions such as thyroid, breast, vascular and MSK. At Kawasaki University, we receive a lot of requests for skin ultrasound. With the high resolution, the epidermis and dermis can easily be differentiated and the origin of the lesion can be diagnosed accurately. A malignant melanoma (Figure e, f) which is only 1 mm thick, can be observed in high resolution, followed by SMI to visualize its vasculature.

It is thought that penetration usually is a limitation for high frequency transducers, however, it is possible to examine the liver and gastrointestinal tract (Figure g, h) in clear detail with the 24L ultra-high frequency transducer.

SMI is a Toshiba unique Doppler method for delineating low velocity blood flow in high resolution and in real time. The 24L is excellent for visualizing low velocity flow in minute vessels and SMI in Aplio i-series provides an even higher resolution and more penetration (Figure i, j). Detail information about vasculature in deeper regions can be obtained and the use of SMI can be further expanded. I believe that knowledge about diagnosis and pathology can be increased based on these new capabilities. I strongly believe that there will be dramatic changes in every clinical region. "

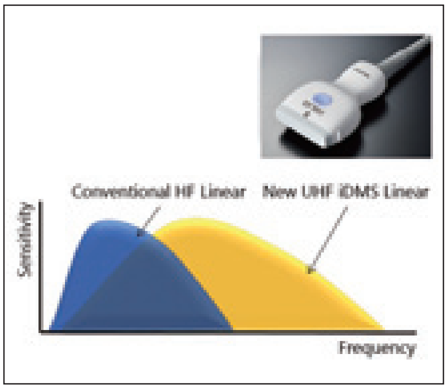

Figure 11. Ultra-high frequency

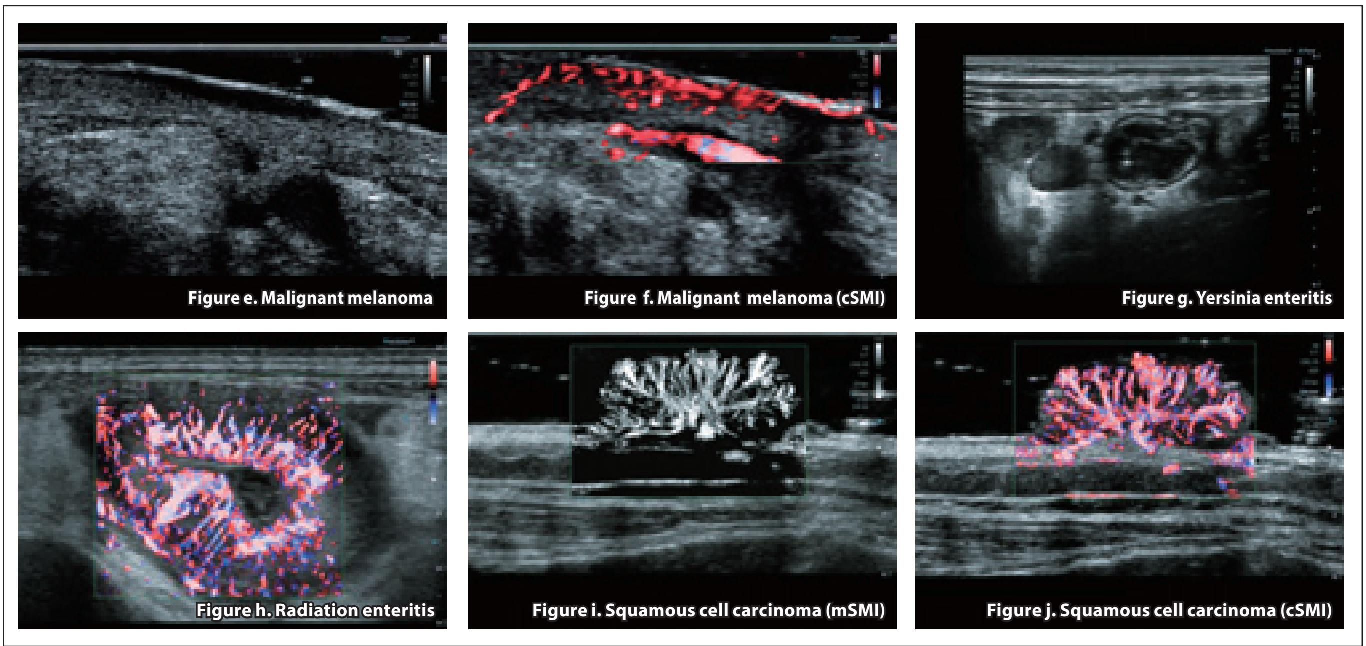

Figure 12. Courtesy of Professor Jiro Hata, MD.

Multiplexing Technology

Multiplexing technology is capable of handling large volumes of data at high speed, which allows parallel processing of multiple advanced operations. Controlling the elements of the new iDMS transducers requires 2-3 times more computing capacity compared to conventional transducers. In addition, increased volumes of receiving signal data, caused by real-time processing of complex clinical applications, make powerful parallel signal processing technology essential.

The extraordinary power of parallel signal processing allows execution of different advanced applications which need huge computational performance, such as Quad View, Shadow Glass, Smart Sensor 3D.

Professor Fuminori Moriyasu, MD.
Center for Cancer Ablation Therapy, International University of Health and Welfare, Sanno Hospital, Japan

"Fusion imaging is really important for ultrasound-guided RFA. The new Ultrasound-Ultrasound (US-US) fusion function on Aplio i-series offers easy-to-use and accurate orientation information to assist RFA (Figure k).

Another new advantage of Aplio i-series is the Quad display for Smart Fusion which presents CT/MR volume images, 3D body mark, US image, and blended US & CT/MR image respectively. The location of the transducer and the position of B-mode in relation with the volume is clearly demonstrated in the 3D body marker. This gives a clear understanding of 3D orientation (Figure l).

In shear wave elastography, a real-time propagation map, speed map, elasticity map, and B-mode image can also be displayed in Quad View, providing an intuitive overview for easy selection of ROI. Measuring using One-Shot acquisition delivers accurate, reproducible and reliable data for quantitative analysis. I believe that it will be widely used for diffuse liver disease, focal liver disease and other clinical regions (Figure m)."

Professor Jiro Hata, MD.
Dept. Of Clinical Pathology and Laboratory Medicine, Kawasaki Medical School, Kurashiki, Japan

"With Aplio 500, 3D images can be reconstructed using 2D transducers and Smart 3D. With 3D SMI, the entire vasculature in an area of interest can be visualized, potentially

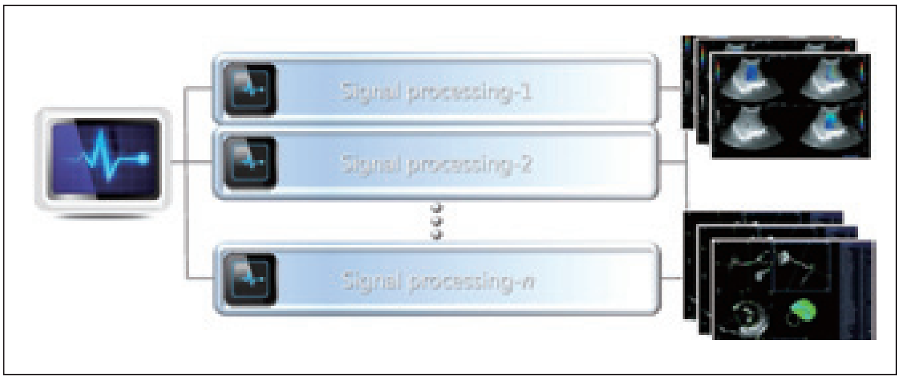

Figure 13. Multiplexing technology

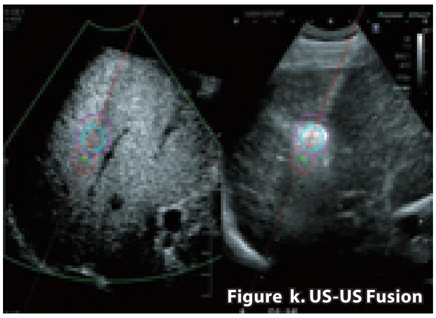

Figure k. US-US Fusion

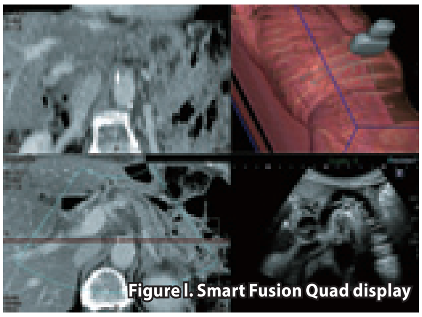

Figure l. Smart Fusion Quad display

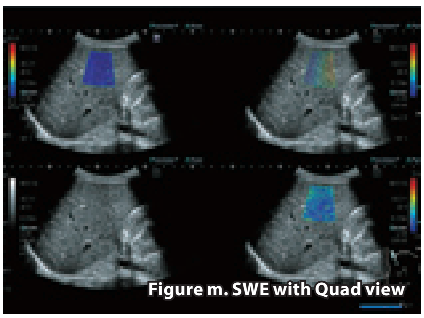

Figure m. SWE with Quad view

Figure 14. Courtesy of Professor Fuminori Moriyasu, MD.

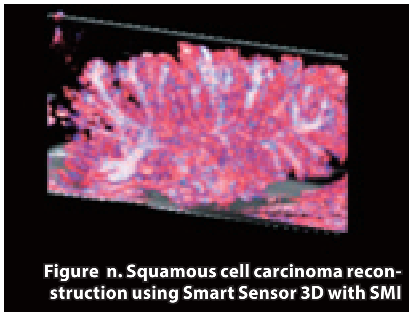

Figure n. Squamous cell carcinoma reconstruction using Smart Sensor 3D with SMI

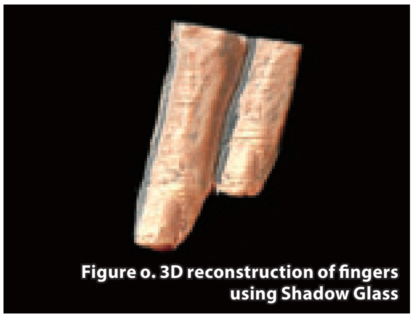

Figure o. 3D reconstruction of fingers using Shadow Glass

Figure 15. Courtesy of Professor Jiro Hata, MD.

allowing more effective surgical planning and treatment evaluation. Now, with Aplio i-series, 3D images with accurate positioning information can be acquired by utilizing Smart Sensor 3D technology. By adding this orientation data, measurements on 3D SMI volumes can be performed and accurate surgical planning is possible (Figure n).

One of Aplio i-series' new features for volume rendering is Shadow Glass. 3D semi-transparent volumes are reconstructed to observe tissue outlines (Figure o). These volumes can also be combined with 3D color images of vascular flow. This allows clear understanding of tissue in relation with location of vessels which is helpful for accurate surgical planning."

Volume Matrix

Aplio i-series' volume matrix transducers enables real-time volume imaging by steering the ultrasound beam in three dimensions. Volume matrix is based on 2D array transducer technology, combined with iDMS and Multiplexing architecture. Compared to conventional mechanical 4D transducers, volume matrix is superior for its high rendering power and flexible scan control, creating 4D images at higher volume rate and in multi-plane display.

Associate Professor Yoshihiro Seo, MD
Cardiovascular Division, University of Tsukuba, Japan

"The new 3D TEE volume matrix transducer is really small and light. The small acoustic head improves patient comfort. In addition, high resolution real-time 3D images can be acquired. The movement of mitral valve and aortic valve, or heart disease such as mitral valve prolapse can be observed easily (Figure p, q).

Also helpful is the online 3D Mitral valve analysis software which is available for Aplio i-series. The MV analysis is really useful for clinical diagnosis and follow-up (Figure r).

The accuracy of wall motion tracking by Toshiba was already superior, but got even better with the i-series. Strain measurement is highly accurate and the workflow for trace line is outstanding. I am very happy with the reduced analysis time and the reduction of inter-operative errors. (Figure s)"

Conclusion

Toshiba's Aplio i-series is both an evolution and revolution for system architecture and transducer technology, driving image quality to a new level. The highly improved image quality and advanced applications, innovative transducer technology and advanced ergonomic design of the Aplio i-series provide healthcare professionals more clinical confidence and increased clinical capabilities.

Figure 16. Volume matrix transducer

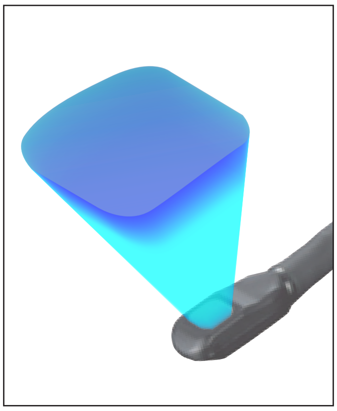

Figure 17. 3D beam steering

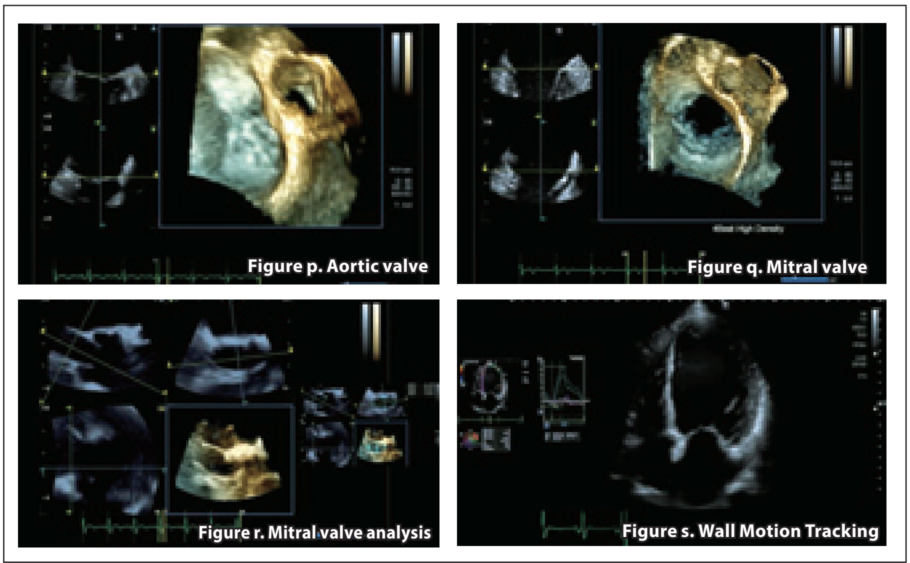

Figure 18. Courtesy of Associate Professor Yoshihiro Seo, MD.

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