Ultrasound / White paper

New tools in ultrasound and their clinical application

Dr. Juan Pablo Niedmann
Imaging Department,
Clinica Alemana
Santiago, Chile

Introduction

Ultrasound, as an imaging diagnostic method, has undergone numerous advances that today allow it to be the method of choice for the diagnosis of many pathologies. In this permanent challenge to improve, new software has been developed that allows a significant improvement in the quality of the images obtained by ultrasound.

Canon has developed an all-new ultrasound system with an innovative software, iBeam+. This technology allows for better definition in ultrasound images, especially in the study of small superficial parts but also in deeper tissues. Providing a new homogeneity and detail to the resulting images, that provides more clarity and clinical confidence. In addition, the further advancement of the Superb Micro-vascular Imaging (SMI) tool has resulted in the improved version, SMI Generation 4 (SMI Gen 4). SMI makes it possible to detect low velocity flows that were previously not visible with color Doppler and power Doppler. Additionally, with the new SMI Gen 4 tool, velocity scale can be increased, which allows for masking of renal flow. I found that this facilitates the visualization of artifacts produced by lithiasis.

iBeam+

The technologies behind the three main components of the iBeam architecture (Multi-Sync Pulser, Multi-Beam Receiver and Multi-Harmonic Compounding) have been enhanced to create the all-new iBeam+ architecture, available on the Aplio i-series / Prism Edition. By incorporating newly developed signal processing hardware and high-performance CPU/GPU, the performance at all stages of the image forming process has been elevated by a factor of four. As a result, next generation image quality with better resolution, frame rate, uniformity and better penetration to visual structures in the far-field could be achieved (Fig. 1).

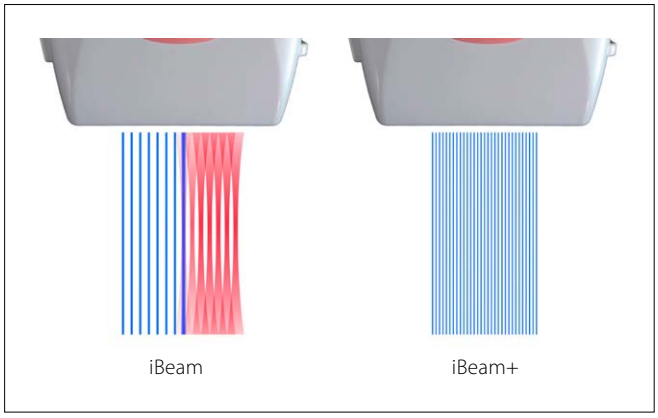

Figure 1 iBeam+

SMI Gen 4

SMI is a technology introduced to provide visualization of a wider range of blood flow velocities. This innovative technology allows for the detection of low-velocity blood flow with high framerate, less motion artifacts and high resolution. Achievable with an algorithm that is able to separate low flow signals from artifacts produced from overlaying tissue motion. This preservation of the low flow signals allows for visualization of flow in smaller vessels.

Since its introduction, the SMI technology has undergone improvements with each generation. In the Aplio i-series / Prism Edition, the SMI technology is now in its fourth and most powerful generation (SMI Gen 4). While the previous SMI technology was limited to the depiction of relatively low velocity ranges of blood flow, the new SMI Gen 4 technology expands the range of visible blood flow velocities. Further improvement in motion artifact suppression, and background B-mode image quality is also achieved. This is made possible with the new signal processing hardware and higher performance capabilities of the Aplio i-series / Prism Edition. Additionally, an SMI noise filter feature is available with the SMI Gen 4. This technology allows for the further reduction of artifacts from tissue interfaces, while keeping as much blood flow information as possible.

Case studies

During a five-month evaluation, eight radiologists with sub-specialties in ultrasound and 20-30 years' experience, carried out an evaluation of the capabilities of iBeam+ on the Aplio i-series / Prism Edition. A significant improvement in all image quality parameters was observed when scanning with the PLI-2004BX transducer.

Case study 1: Median nerve (MSK)

Using iBeam+, a better spatial resolution is observed, both axially and laterally, in addition to an increase in the contrast of the different planes (Figs. 2-3). These improved the quality of the image and therefore the diagnostic value of the images.

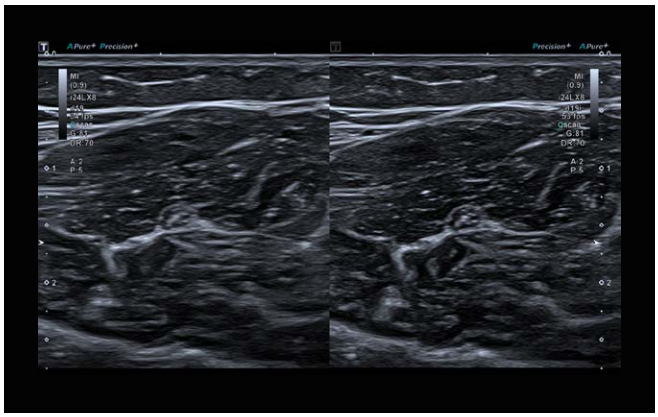

Figure 2 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right).

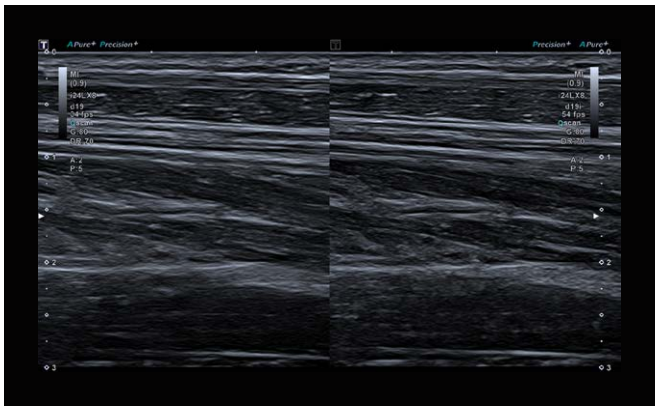

Figure 3 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right).

Case study 2: Thyroid (small parts)

Using iBeam+, better spatial resolution is demonstrated, both axially and laterally, as well as the contrast of the different planes. It also has better penetration. It is worth mentioning the improved detection of microcalcifications, shown with white arrows below, a crucial element in the characterization of nodules with a high risk of malignancy (Figs. 4-6). I believe this visualization of microcalcifications is a superior capability of the Aplio systems.

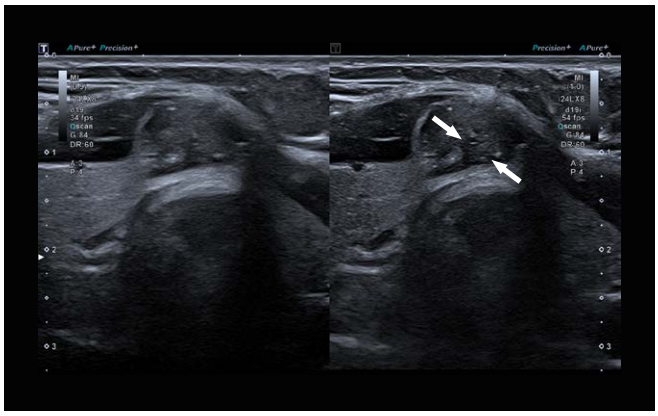

Figure 4 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right). White arrows indicating microcalcifications visualized.

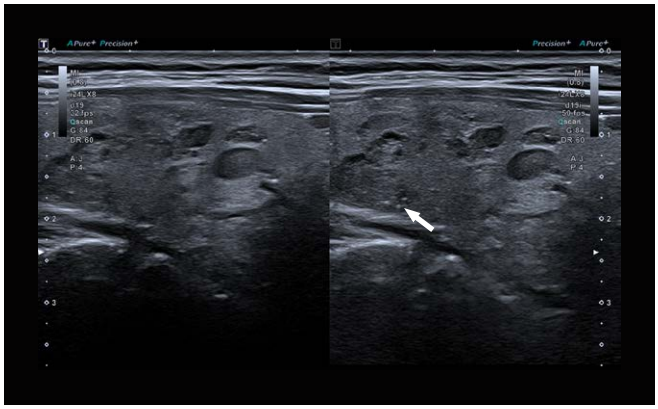

Figure 6 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right). White arrow indicating microcalcifications visualized.

Case study 3: Cervical lymph nodes (small parts)

The study of the lymph nodes, especially the superficial ones, with ultrasound plays an essential role, especially in the preoperative staging of thyroid cancer. iBeam+ allows the study of the internal structure of the lymph node, providing improved contrast between the tissues and resolution. Once again, it plays a primary role in the detection of microcalcifications and in the study of vascularization with SMI (Fig. 7).

Figure 5 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right).

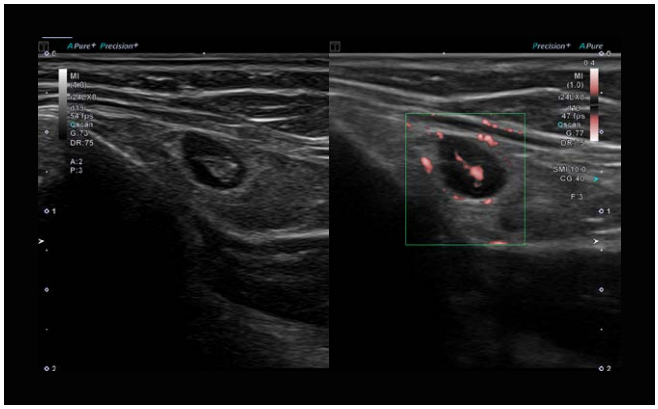

Figure 7 Image acquired with iBeam+ (left) and internal vasculature visualization shown with SMI (right).

Case study 4: Abdomen

When evaluating the PVI-475BX transducer on the Aplio i-series / Prism Edition. In all image quality aspects studied, namely resolution, contrast and penetration, a slight improvement was observed.

With the new iBeam+, the excellent resolution which could be obtained with the conventional iBeam, is further improved (Figs. 8-9). This plays an important role in the ability to adequately characterize focal liver lesions, such as hemangioma, on ultrasound imaging.

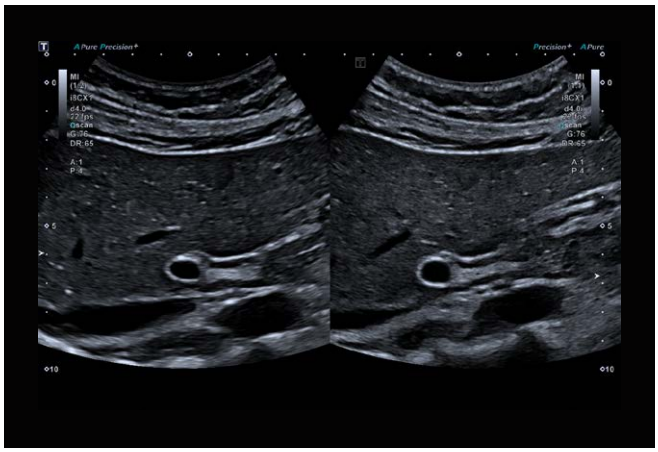

Figure 8 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right).

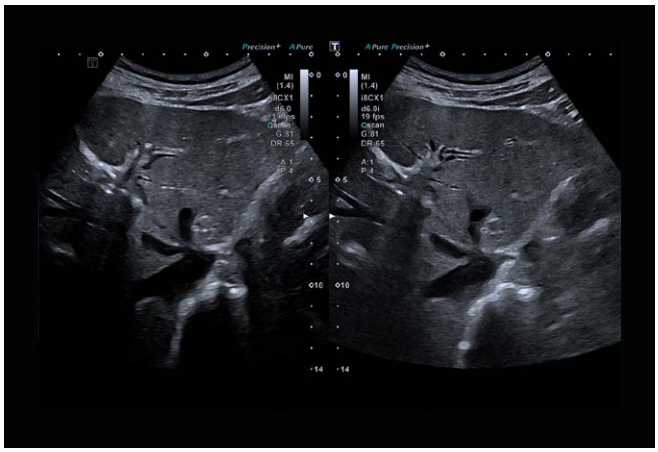

Figure 9 Image acquired with iBeam (left) and image acquired with the new iBeam+ (right).

SMI Gen 4 and the "twinkle" artifact

The twinkle artifact produced by color Doppler ultrasound imaging has the potential to improve renal stones detection; however, the inconsistent appearance of such artifacts has limited the clinical utility. The SMI tool, with B-mode image subtraction mode, allows visualization of twinkle artifact not visible on color Doppler or power Doppler. The artifact can be well-appreciated on the image, subtracted from the renal parenchyma, as a bright point in the middle of the renal vasculature (Fig. 10).

Case 1:

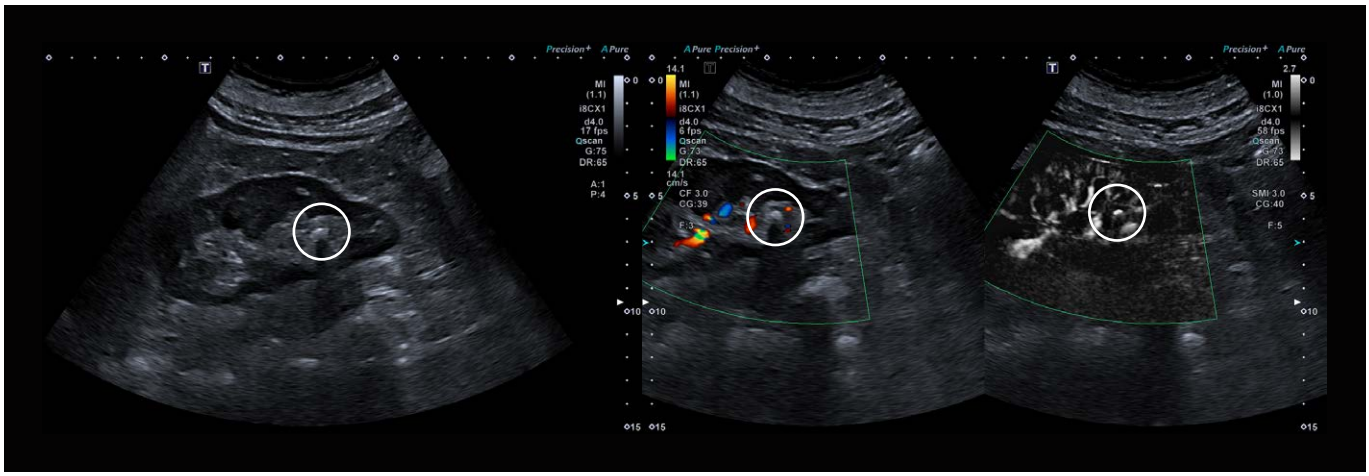

Figure 10 Image acquired with B-mode (left), image acquired with color mode (middle) and image acquired with monochrome SMI (mSMI) (right). White circle indicating location of renal stone.

Case 2:

SMI Gen 4 allows for the increase of pulse repetition frequency (PRF), which removes vascular structures from showing on the image. Without the vascular information, the artifact from the calcification can be better visualized (Fig. 11). This results in a significant improvement in the sensitivity of the method. Specificity is pending especially in cases with calcifications less than 3 mm in size.

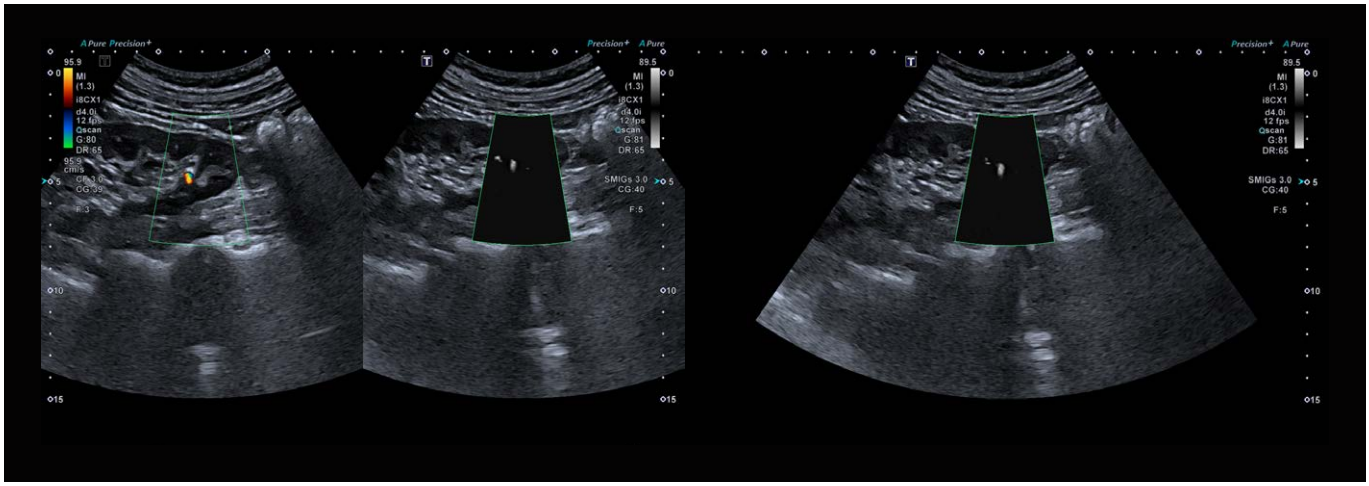

Figure 11 Image acquired with color mode (left) and image acquired with mSMI (middle, right).

Case 3:

The new SMI Gen 4 software allows the increase of the velocity (PRF), thus masking the renal flow, and able to highlight the twinkle artifact produced by lithiasis within the thickness of the parenchyma. This becomes clearer when we use the parenchyma subtraction option (Fig. 12).

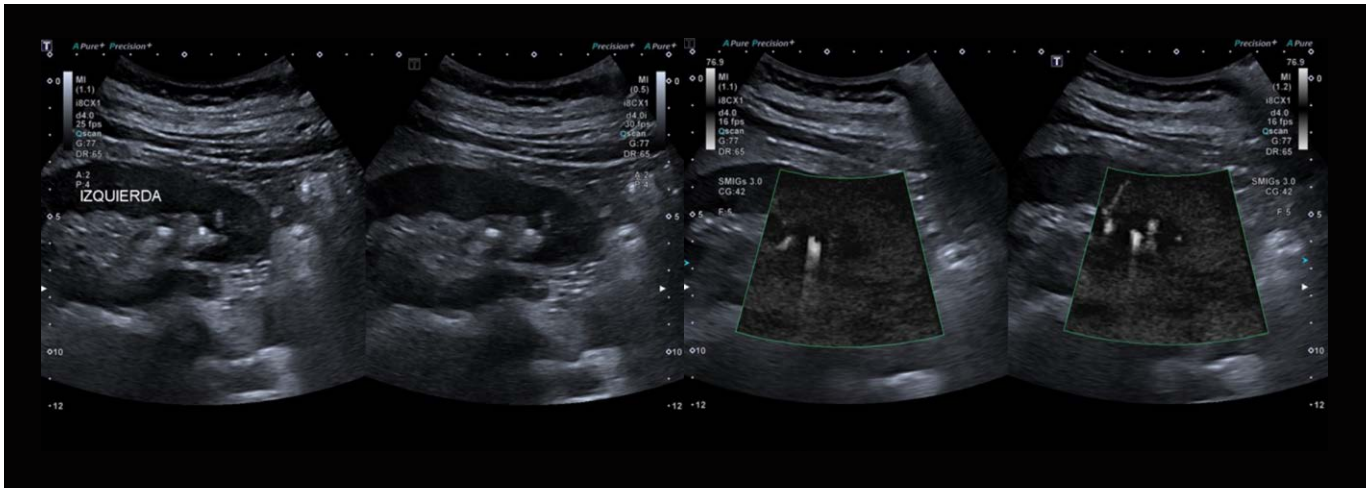

Figure 12 Image acquired with B-mode (left) and image acquired with mSMI (right).

Case 4:

SMI Gen 4 is useful in the detection of kidney stones using twinkle artifacts, with high sensitivity. The new SMI Gen 4 software allows the increase of the velocity (PRF), thus masking the renal flow, and able to highlight the twinkle artifact produced by lithiasis within the thickness of the parenchyma. This becomes clearer when we use the parenchyma subtraction option (Fig. 13).

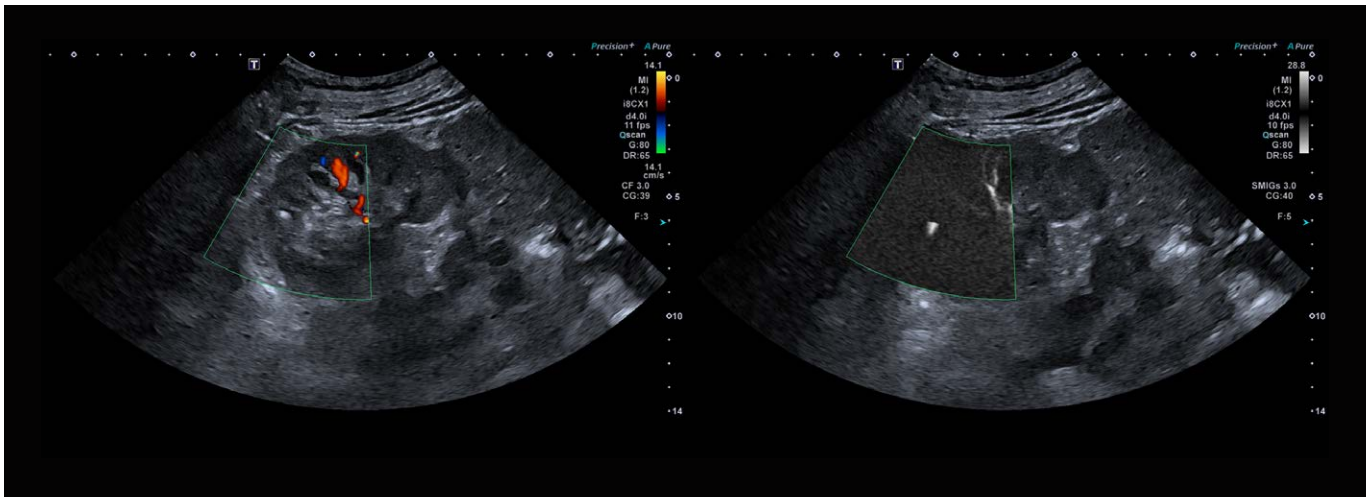

Figure 13 Image acquired with color mode (left) and image acquired with mSMI (right).

Conclusion

Canon's new ultrasound system, Aplio i-series / Prism Edition presents software tools that improve spatial and contrast resolution, which allows radiologists to increase their diagnostic confidence of pathologies. In all image characteristic aspects studied, an improvement was observed in resolution, contrast, penetration as well as in persistence. Further improving the excellent resolution obtainable with existing study protocols. SMI Gen 4 is a powerful tool in the detection of micro-vascularization. Particularly, it was observed that it can help to improve sensitivity in the detection of kidney stones, using twinkling artifacts produced. Findings should be studied further to understand its specificity.

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