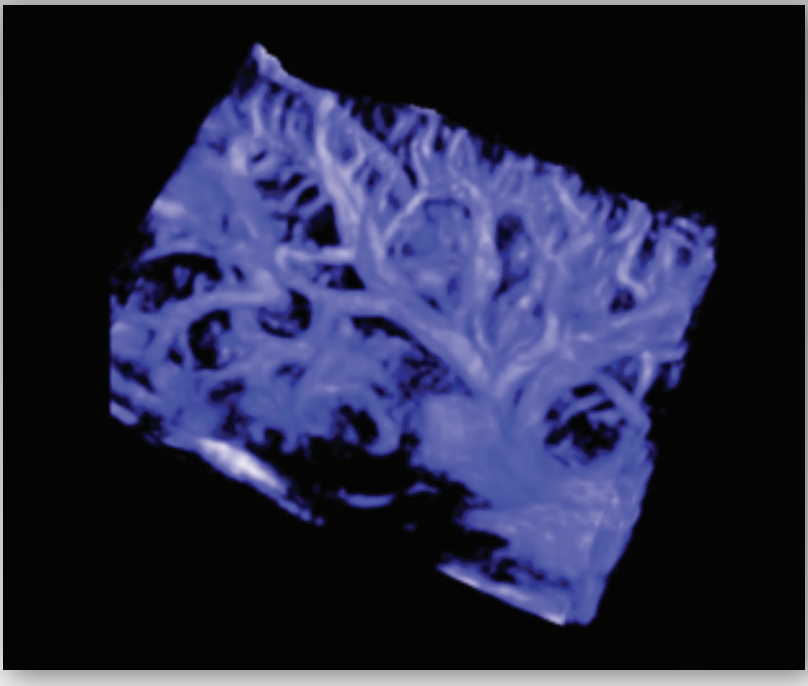
White Paper

Initial Experiences of 3D Superb Micro-Vascular Imaging (SMI)

Pediatric Radiology



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Doppler ultrasound is a non-invasive diagnostic tool to evaluate blood flow and hemodynamics. Due to clutter noise and motion artifacts, conventional Doppler has a limited ability to visualize low velocity blood flow. Recently, Canon Medical Systems introduced Superb Microvascular Imaging (SMI) which overcomes the limitations of conventional Doppler by enabling detection of low-velocity blood flow with high frame rates, reduced motion artifacts, and high resolution.

SMI is ideal for Pediatric Radiology as the high frame rates and reduced flash artifacts allow for easier acquisitions in active, young children. Also, no intravenous contrast agents are needed during an ultrasound exam with SMI. SMI can serve as a new problem-solving tool in Pediatric Radiology for diagnoses such as vesicoureteral reflux or testicular torsion.

In the Aplio™ Platinum Series Innovation 2016 release, Smart 3D is introduced and further expands the clinical utility of SMI. Smart 3D reconstructs 3D volumes from 2D SMI images using conventional 2D transducers. 3D SMI volumes are easy to acquire by either pivoting a convex transducer or sliding a linear transducer (Fig. 1), without needing to switch to a 3D transducer during the exam.

With only one button, 3D SMI images can be reconstructed immediately. As a result, Smart 3D provides a cost effective, time-saving solution of creating an entire, three-dimensional vasculature volume. 3D SMI images provide volumes with high resolution of the tissue vasculature with clear visualization of vessel branching and networks.

The following examples provide a sampling of clinical cases that highlight the clinical performance of 3D SMI on the Aplio Platinum series.

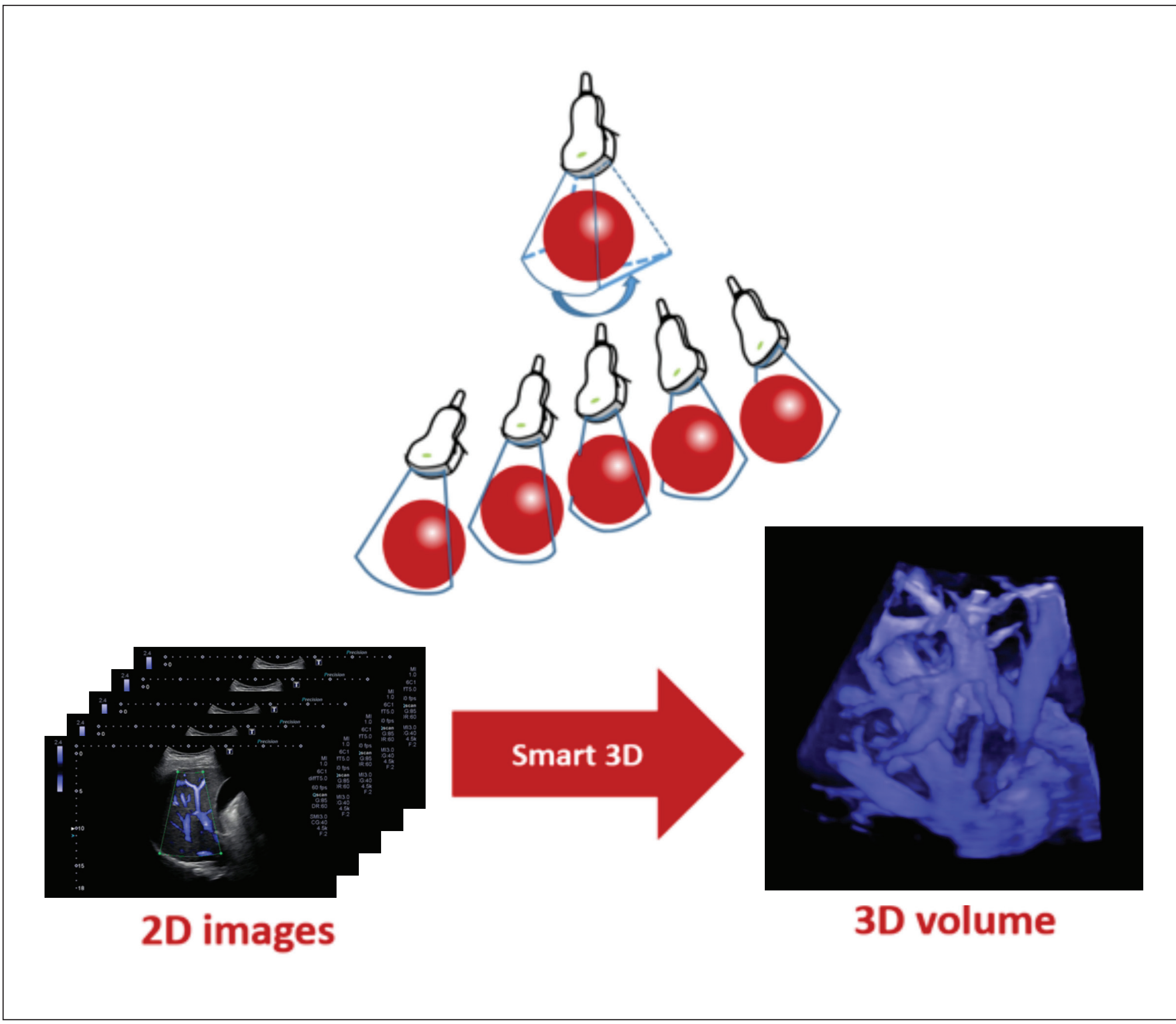

Figure 1: 3D SMI images constructed by moving a transducer on consecutive image frames.

CASE 1: TEENAGE BOY WITH SUSPICIOUS SHOULDER MASS

A 19 year-old boy presented with an enlarging, non-tender mass on the anterior aspect of his right shoulder. The patient denied trauma to the area, but complained that the mass had limited his range of motion in the right shoulder.

X-ray (Fig. 2.1) revealed soft tissue fullness but without bony involvement or calcifications. MRI (Fig. 2.2-2.3) showed a large, enhancing soft-tissue mass abutting the shoulder joint and expanding adjacent muscle bundles. The mass raised suspicions of sarcoma. PET imaging (Fig. 2.4) of the presumed malignancy showed mild F18-FDG uptake in the mass but less uptake than would be expected for an aggressive tumor. Strain elastography showed a typical benign pattern (Fig. 2.5) and SMI nicely visualized the highly vascular nature of the tumor (Fig. 2.6-2.7). The feeding vessels and draining veins outlined in detail using 3D SMI (Fig 2.8) allowed the interventional radiologist to safely plan a percutaneous biopsy. The ultrasound-guided biopsy was performed without any complications or embolization needed and pathology revealed a benign intramuscular hemangioma.

Ultrasound examination using 3D SMI served as a useful clinical tool in differentiating features not typical of malignancy and in biopsy planning for this patient.

Figure 2.1: X-Ray.

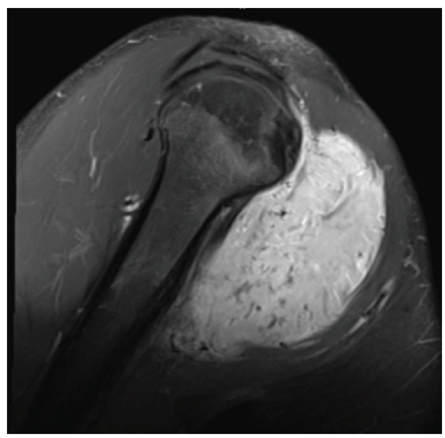

Figure 2.2: MRI

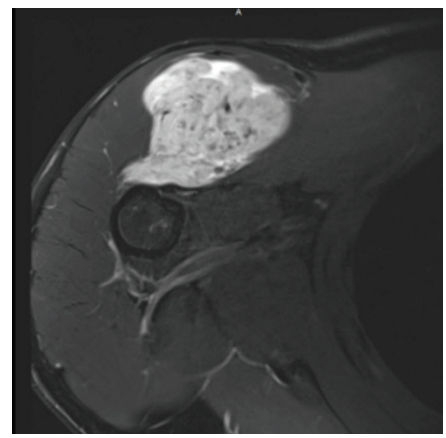

Figure 2.3: MRI

Figure 2.4: PET

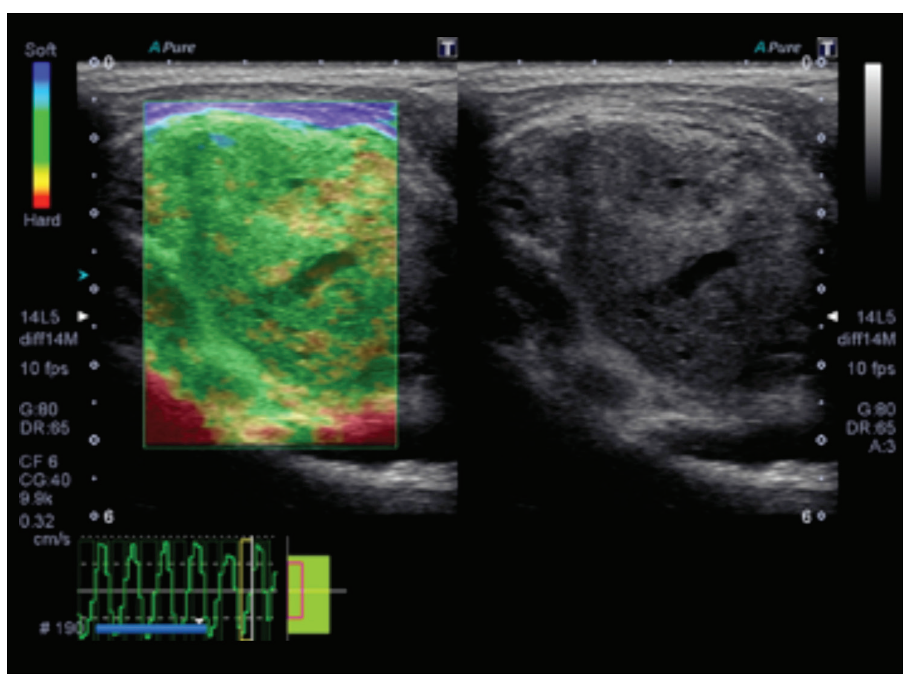

Figure 2.5: Strain Elastography

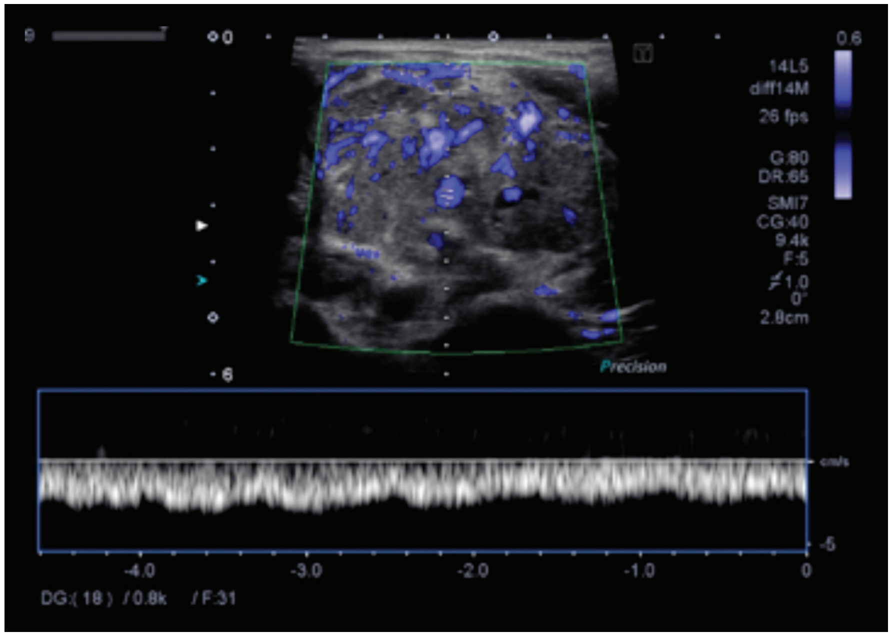

Figure 2.6: cSMI

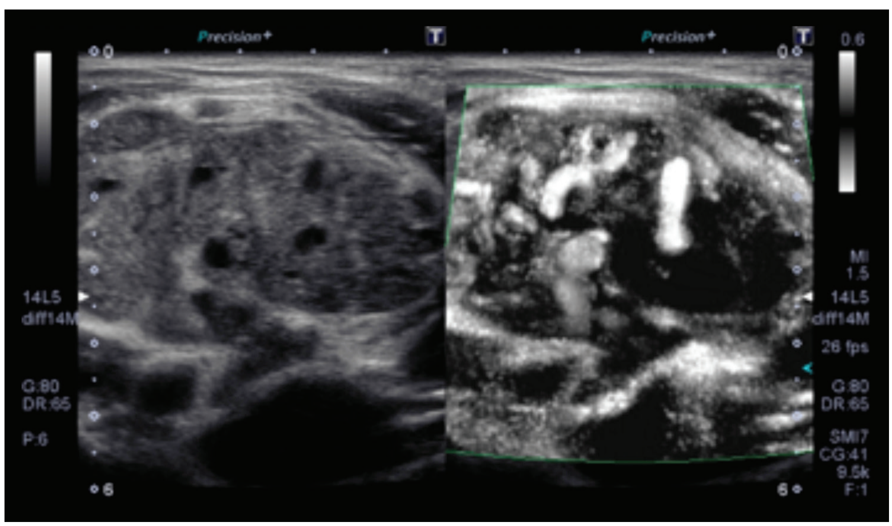

Figure 2.7: mSMI

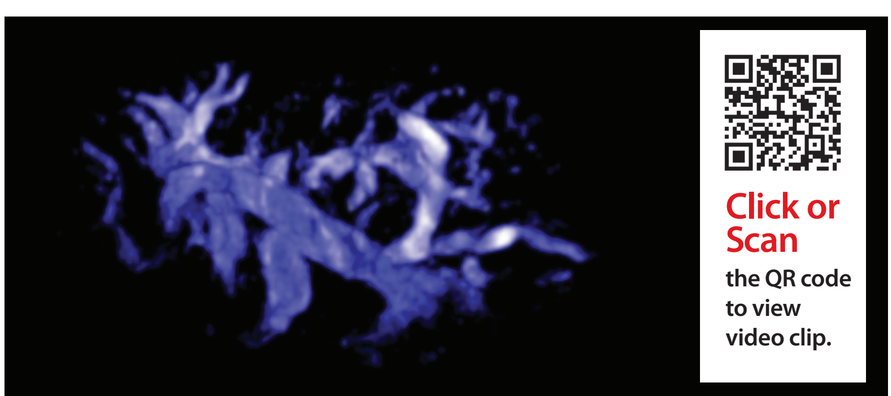

Figure 2.8

CASE 2: 3 WEEK-OLD INFANT WITH A SUSPECTED CYSTIC KIDNEY

A newborn infant was diagnosed with a cystic kidney from early gestation. A follow-up ultrasound was performed at 3 weeks of age to determine the status of the kidneys. On the infant's right side, ultrasound (Fig. 3.1) showed no recognizable renal tissue and a normal-appearing adrenal gland. On the infant's left side, ultrasound (Fig 3.2) showed a normal kidney which was at the upper range of normal in length. The right kidney had presumably involuted during gestation due to high grade obstruction or multicystic dysplasia.

3D SMI images of the solitary left kidney (Fig. 3.3-3.4) were useful to confirm a healthy kidney and exclude other commonly associated abnormalities, especially ureteropelvic junction obstruction, which is often due to a vessel crossing the renal pelvis. Other associated abnormalities were clearly excluded by the ultrasound exam with 3D SMI, which resulted in a more confident diagnosis for this patient.

CASE 3: TEENAGE BOY WITH A HISTORY OF CARCINOID TUMOR

A 17 year-old patient with a history of carcinoid tumor found during appendectomy, presented for follow-up to rule out recurrence or metastatic spread of carcinoid. Although the vast majority of appendiceal carcinoids behave in a benign fashion, they are considered malignant because of their potential for invasion, metastasis and production of physiologically-active substances.

At our institution tumor surveillance is initiated if poor prognostic factors such as nodal metastasis, lymphovascular invasion, mesoappendiceal invasion, or mixed pathology are identified. This patient was scanned with ultrasound and no

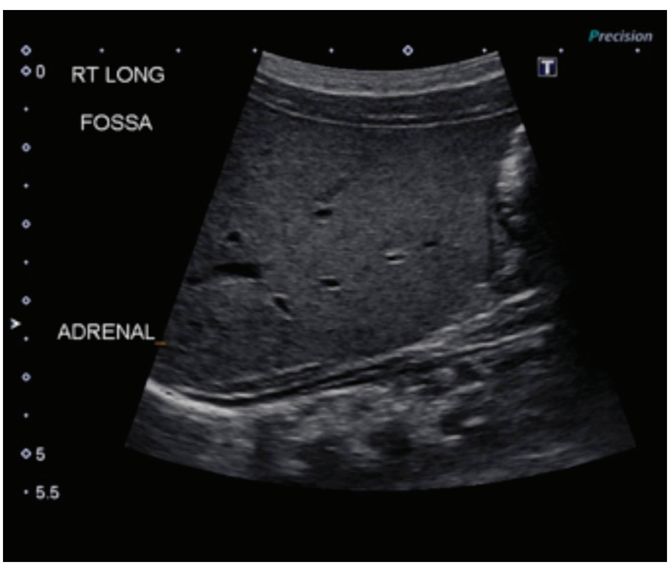

Figure 3.1: Right abdomen of 3 week old infant showing no recognizable renal tissue.

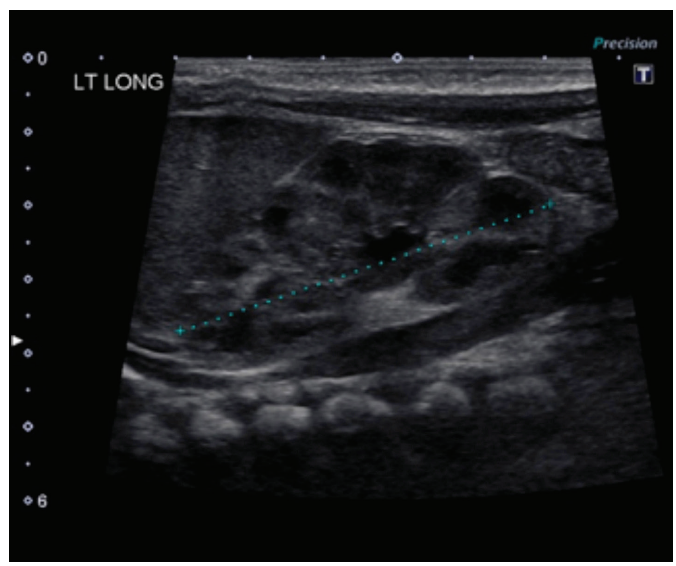

Figure 3.2: Solitary left kidney.

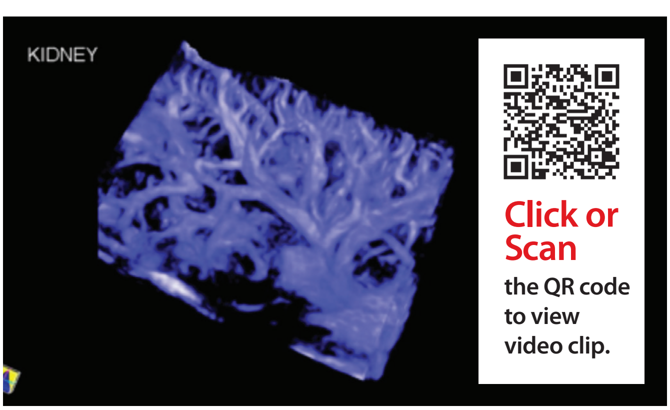

Figure 3.3: 3D SMI of the solitary left kidney.

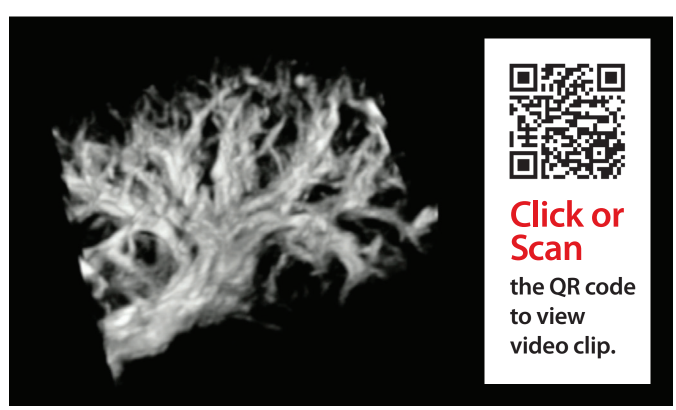

Figure 3.4: 3D SMI of the solitary left kidney

suspicious areas were seen. SMI was added to the ultrasound examination (Fig. 4.1-4.3) to improve the detection sensitivity for isoechoic liver metastases. Although the sensitivity of ultrasound in detecting liver metastasis is less than CT with contrast, the ionizing radiation and contrast needed for CT scans is a concern in young patients who may require additional follow-up imaging. Neuroendocrine tumor metastases to the liver can be hyper- or hypo-echoic to surrounding liver tissue, but are nearly always hypervascular. Ultrasound examination with 3D SMI improves our diagnostic confidence without having to give intravenous contrast agents or expose patients to ionizing radiation. Smart 3D with SMI enables a quick acquisition from large regions of tissue, like the liver, to display three-dimensional vascular details with high spatial resolution.

SUMMARY

SMI provides a novel, non-invasive, capability to detect low-velocity minute vessels. With Smart 3D, 3D SMI images can be reconstructed and allow a three-dimensional view of the target vasculature. The combination of SMI and Smart 3D allow a better visualization of vascular anatomy for improved biopsy planning and diagnostic confidence. 3D SMI has the potential to provide better detection of the crossing vessels in ureteropelvic junction (UPJ) obstructions, better definition of hypervascular tumors, and better detection of isoechoic lesions in solid organs such as liver, spleen, and kidney. In addition, 3D SMI may prove useful for assessing blood flow in transplant organs. Smart 3D with SMI delivers an easy-to-use, radiation-free and contrast-free method to improve diagnostic confidence in Pediatric Radiology.

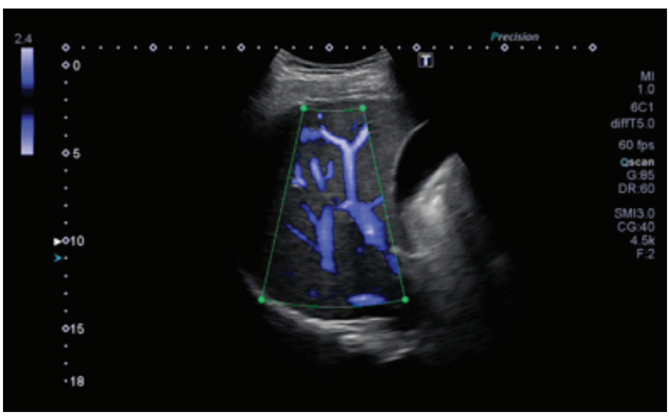

Figure 4.1: cSMI

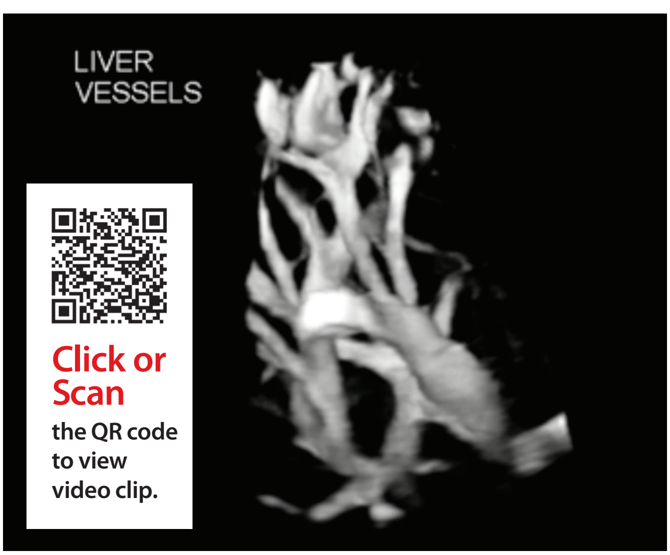

Figure 4.3: 3D SMI

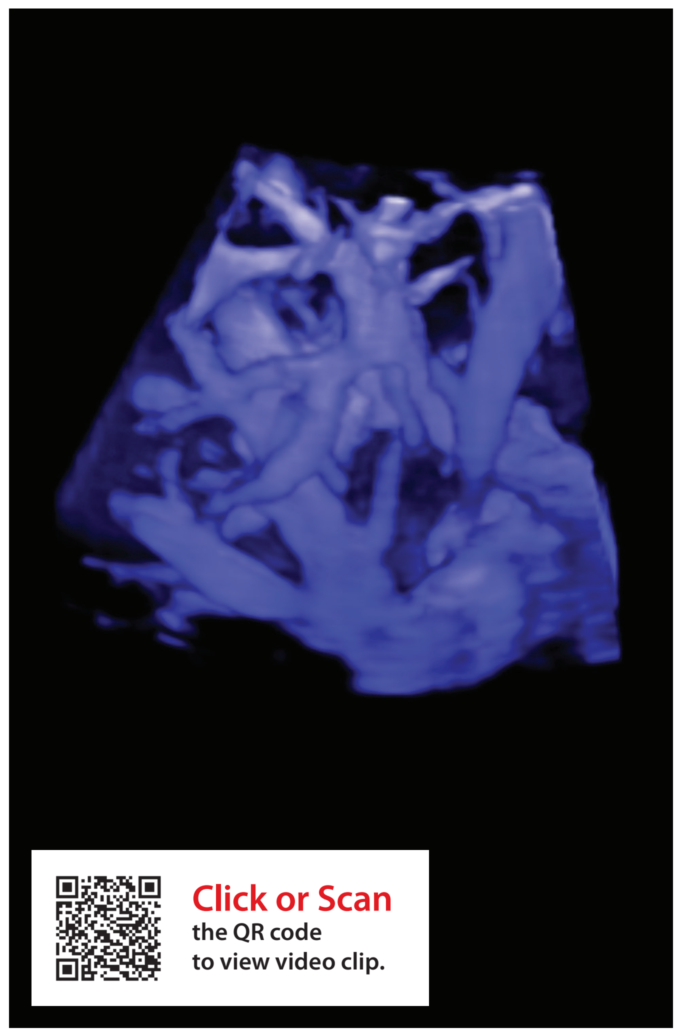

Figure 4.2: 3D SMI

The clinical results described in this paper are the experience of the authors. Results may vary due to clinical setting, patient presentation and other factors.

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