Precision Imaging of Focal Liver Lesions

Comparison With Conventional Sonography in Terms of Image Quality

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Objectives—The purpose of this study was to compare the Precision Imaging sonographic technique (Toshiba Medical Systems Corporation, Tokyo, Japan) with conventional sonography of liver lesions in terms of lesion conspicuity, margin sharpness, overall image quality, and posterior enhancement.

Methods—Sixty-nine focal liver lesions in 60 patients (age range, 14–76 years; mean age, 43 years) were prospectively evaluated. Each lesion was examined with Precision Imaging and conventional sonography. All images were reviewed and graded on a 3-point scale by 2 readers for lesion conspicuity, margin sharpness, and overall image quality. Posterior acoustic enhancement was also analyzed in cystic lesions. A Wilcoxon signed rank test was used for statistical comparisons of the techniques for all parameters.

Results—Statistical analysis showed that for margin sharpness, lesion conspicuity, and overall image quality, Precision Imaging was superior to conventional sonography ($P < .05$). In addition, according to lesion types and dimensions, Precision Imaging was significantly superior to conventional sonography for all parameters. For posterior enhancement, there was no significant difference between Precision Imaging and conventional sonography ($P \geq .05$).

Conclusions—In sonography of focal liver lesions, Precision Imaging provides better lesion conspicuity, better margin sharpness, and better overall image quality than conventional sonography. With respect to posterior enhancement of cystic lesions, Precision Imaging is not significantly different from conventional sonography. Precision Imaging may be used as a complementary method in the sonographic evaluation of focal liver lesions.

Key Words—image quality; liver lesions; sonography; techniques

Sonography is usually the initial diagnostic modality in the evaluation of patients with suspected abdominal disease. However, conventional sonography displays image artifacts that limit diagnostic accuracy.[1–3] Hence, various new technologies have been developed to improve the diagnostic value of this modality, such as tissue harmonic imaging, compound sonography, and speckle reduction techniques.[4–12] Precision Imaging (Toshiba Medical Systems Corporation, Tokyo, Japan) has recently been introduced, and in contrast to postprocessing techniques,[13–16] it is based on raw data. Conventional sonography acquires images only line by line. Precision Imaging, however, not only evaluates images line by line but also provides information from adjacent lines and enhances the amount of information obtained (Toshiba Medical

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Systems, written communication, 2010; Precision Imaging technology is currently under evaluation for patent applications). Thus, it improves definition of structures, provides more details, and diminishes image noise.

The purpose of our study was to investigate whether the theoretic benefits of Precision Imaging result in perceptible improvements in sonography of focal liver lesions with respect to lesion conspicuity, margin sharpness, overall image quality, and posterior enhancement.

Materials and Methods

Technical Aspects of Precision Imaging

Precision Imaging is a new multiresolution signal-processing technique that enhances ultrasonic data by including information from adjacent lines. If adjacent lines contain the same structure, there is a high probability that a signal is part of a structure. It considers such information over multiple lines by applying various analysis grids of different sizes to the raw ultrasonic data. Precision Imaging works in multiple image data-processing steps: (1) multiresolution image decomposition; (2) edge recognition in each decomposed image, thereby detecting the edge direction and intensity; (3) enhancement of structural information by sharpening edges and equalizing intensities; and (4) equalization of the intensities of areas with low structural contents (Toshiba Medical Systems, written communication, 2010). Thus, Precision Imaging allows early identification of diffuse random noise and enhances structural definition. As a result, it improves the signal to noise ratio, enhances the conspicuity of low-contrast lesions and the delineation of lesion margins, and provides more homogeneous and clearer images.

Study Population

Between February and December 2010, 60 selected patients (age range, 14–76 years; mean age, 43 years) with various focal liver lesions were examined with sonography. A total of 69 liver lesions were visualized with sonography and included in this study. The study was approved by the Institutional Review Board of our university, and informed consent was obtained from all patients.

The lesions consisted of hemangiomas (n = 24), metastases (n = 9), liver cysts (n = 12), focal nodular hyperplasia and adenomas (n = 6), focal fatty infiltration and focal sparing (n = 13), and hepatocellular carcinomas (n = 5). Diagnoses were made by characteristic computed tomographic or magnetic resonance imaging findings for hemangiomas and by typical sonographic findings for cysts. The diagnosis of focal fatty infiltration or focal sparing was based on magnetic resonance imaging findings in all patients. Patients with hepatocellular carcinomas, focal nodular hyperplasia, and adenomas had histopathologic diagnoses. The diagnosis of metastasis was confirmed by biopsy in 4 patients, and the remaining metastases were confirmed by diagnostic imaging features (target appearance and multiple lesions) and by their enlarged size. The diameters of the lesions were 8 to 30 mm (mean, 20.1 mm) for metastases, 5 to 45 mm (mean, 18.7 mm) for hemangiomas, 20 to 72 mm (mean, 35 mm) for cysts, 22 to 49 mm (mean, 32.8 mm) for focal nodular hyperplasia and adenomas, 10 to 22.5 mm (mean, 16.2 mm) for focal fatty infiltration and focal sparing, and 12 to 55 mm (mean, 29.1 mm) for hepatocellular carcinomas. According to the longest dimension, each lesion was categorized into 1 of 2 groups (≤15 and >15 mm). The lesion diameters were 5 to 15 mm in 25 lesions and 16 to 72 mm in 44.

Image Acquisition

All images were obtained with a Toshiba Aplio XG system and a 2–5-MHz convex transducer. This device was equipped with Precision Imaging. Each patient was evaluated with both conventional sonography and Precision Imaging, which were performed by a single experienced radiologist. The sonographic plane was maintained as constantly as possible. Imaging parameters and instrument settings were not adjusted between different modes with the exception of gain settings, which were optimized for each image by the radiologist performing the examination.

The order of the image acquisitions was determined randomly. Representative images of lesions on conventional sonography and Precision Imaging were saved in a picture archiving and communication system.

Image Analysis

Two abdominal radiologists, whose levels of experience in abdominal sonography were 10 and 22 years, respectively, independently analyzed the sonograms retrospectively on a picture archiving and communication system workstation. For both techniques, all lesions were assessed in terms of conspicuity, margin sharpness, posterior acoustic enhancement, and overall image quality and scored from 1 to 3. Lesion conspicuity and overall image quality were graded 3 for excellent, 2 for good, and 1 for fair. Margin sharpness was graded as 3 for well defined, 2 for partially obscured, and 1 for poorly defined. Posterior enhancement was graded 3 for white with good demarcation, 2 for faint, and 1 for absent. The overall image quality was defined by a general assessment, including spatial resolution or detail, contrast of solid and fluid-filled structures, and absence of noise. Lesion conspicuity was defined by the visibility and clarity of the lesion.

Statistical Analysis

The scores of each radiologist were analyzed separately, and interobserver agreement between the radiologists was calculated by weighted κ statistics. We considered κ values of 0.81 or greater to represent almost perfect agreement and values of 0.61 to 0.80 and 0.41 to 0.60 to represent substantial and moderate agreement, respectively. Values of 0.40 or less were considered to represent fair agreement.[17] A Wilcoxon signed rank test was used for comparisons of the techniques for all variables. In addition, a comparative statistical analysis of the images from both techniques according to the lesion types and dimensions was performed with the Wilcoxon signed rank test. Statistical analyses were performed with a commercially available statistical software program, and $P < .05$ was considered significant.

Results

The interobserver agreement between the radiologists in terms of conventional sonographic findings was fair for margin sharpness (κ = 0.378), and lesion conspicuity (κ = 0.218), substantial for overall image quality (κ = 0.645), and perfect for posterior enhancement (κ = 0.913). On the other hand, interobserver agreement between the radiologists in terms of Precision Imaging findings was moderate for margin sharpness (κ = 0.549), fair for lesion conspicuity (κ = 0.378), and perfect for overall image quality (κ = 0.964) and posterior enhancement (κ = 1.000).

The mean scores for each sonographic technique for the evaluated parameters are summarized in Table 1. The results of the comparative statistical analyses of the techniques for the different lesion types and dimensions are presented in Table 2. Statistical analysis showed that for margin sharpness, lesion conspicuity, and overall image quality, Precision Imaging was judged significantly superior to conventional sonography ($P < .05$). In addition, for different lesion groups and lesions measuring 15 mm or smaller, Precision Imaging was significantly superior to conventional sonography for all 3 parameters evaluated. For liver cysts, differences between Precision Imaging and conventional sonography were not statistically significant with regard to posterior enhancement ($P = .102$).

Table 1. Mean Scores for the Techniques

Parameter	Conventional Sonography	Precision Imaging
Margin sharpness	1.46 ± 0.608	2.96 ± 0.205
Lesion conspicuity	1.70 ± 0.754	2.97 ± 0.169
Overall image quality	1.75 ± 0.695	2.99 ± 0.120
Posterior enhancement	2.21 ± 0.699	2.57 ± 0.514

Values are presented as mean ± SD, scored on a scale of 1 (indicating the worst image) to 3 (indicating the best image).

Discussion

In this study, we investigated the potential value of Precision Imaging in sonography of focal liver lesions. As a result, we found that Precision Imaging was superior to conventional sonography for lesion conspicuity, margin sharpness, and overall image quality. Furthermore, Precision Imaging provided higher interobserver agreement than conventional sonography for all parameters.

The results of our study support previous studies demonstrating better interobserver reproducibility by suppressing the speckle in various organs.[8,9,11,15,16,18–20] Speckle noise results from interference of acoustic fields generated by the scattering of the ultrasound beam from tissue reflectors, and it is responsible for the grainy appearance on sonograms. Speckle noise reduces image contrast and detail resolution and diminishes the ability to distinguish normal from abnormal tissue.[21,22] In our experience, we noticed that with speckle reduction, the usual sonographic appearance of structures was altered on images obtained with Precision Imaging (Figure 1), but this change did not result in loss of detail in the smoothed images. On the contrary, the conspicuity of liver lesions was improved with Precision Imaging (Figures 2 and 3). This improvement in the conspicuity was likely due to the factors described previously, including both noise reduction and improved delineation of tissue borders.

Precision Imaging provided the best delineation of focal fatty infiltration and focal sparing areas in fatty liver (Figure 4). We think that Precision Imaging improves visualization of the internal structure of these lesions, as it enhances the amount of data obtained. In addition, it clearly shows contrast boundaries between tissues and lesions. This feature may be advantageous for ruling out liver metastases in fatty liver.

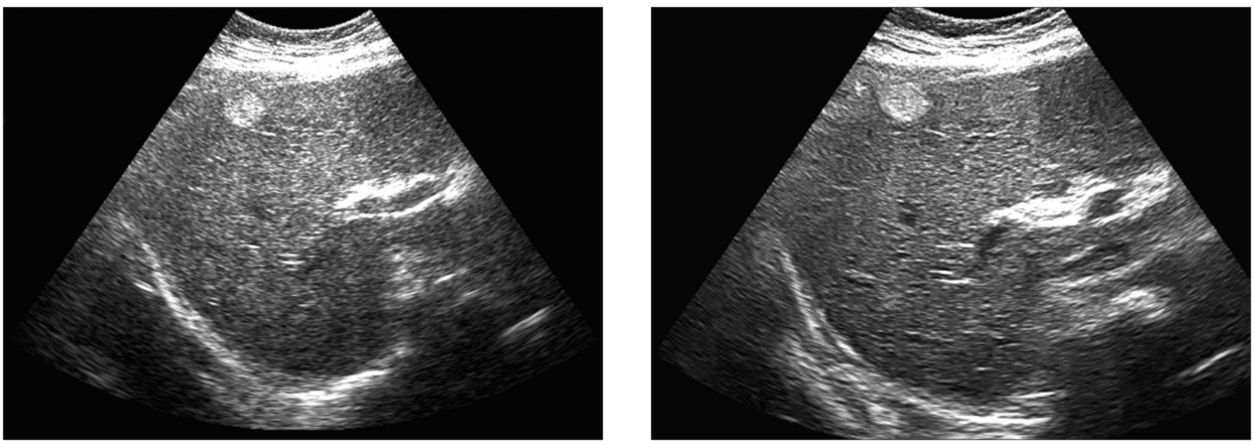
In our study, we found that Precision Imaging was useful for obtaining superior detail and delineation of lesion boundaries. These findings show close correspondence with the theoretic advantages of Precision Imaging. On the other hand, our results showed no significant difference between conventional sonography and Precision Imaging for posterior enhancement. This result might be explained by the dimensions (≥2 cm) and small sample

Table 2. Comparative Statistical Analysis of the Techniques According to Lesion Types and Dimensions

Parameter	Result
Margin sharpness	
Hemangiomas	Precision Imaging > conventional sonography
Metastases	Precision Imaging > conventional sonography
Cystic lesions	Precision Imaging > conventional sonography
Steatosis	Precision Imaging > conventional sonography
Focal nodular hyperplasia/adenomas	Precision Imaging > conventional sonography
Hepatocellular carcinomas	Precision Imaging > conventional sonography
Lesions ≤15 mm (n = 25)	Precision Imaging > conventional sonography
Lesion conspicuity	
Hemangiomas	Precision Imaging > conventional sonography
Metastases	Precision Imaging > conventional sonography
Cystic lesions	Precision Imaging > conventional sonography
Steatosis	Precision Imaging > conventional sonography
Focal nodular hyperplasia/adenomas	Precision Imaging > conventional sonography
Hepatocellular carcinomas	Precision Imaging > conventional sonography
Lesions ≤15 mm (n = 25)	Precision Imaging > conventional sonography
Overall image quality	
Hemangiomas	Precision Imaging > conventional sonography
Metastases	Precision Imaging > conventional sonography
Cystic lesions	Precision Imaging > conventional sonography
Steatosis	Precision Imaging > conventional sonography
Focal nodular hyperplasia/adenomas	Precision Imaging > conventional sonography
Hepatocellular carcinomas	Precision Imaging > conventional sonography
Lesions ≤15 mm (n = 25)	Precision Imaging > conventional sonography
Posterior enhancement	
Cystic lesions	Precision Imaging = conventional sonography

Figure 1. Images from a 35-year-old woman with liver hemangioma. **A**, Conventional sonography shows hyperechoic hemangioma. **B**, Precision Imaging provides a reduction in the speckle (grainy appearance) and results in a smoother image.

A B



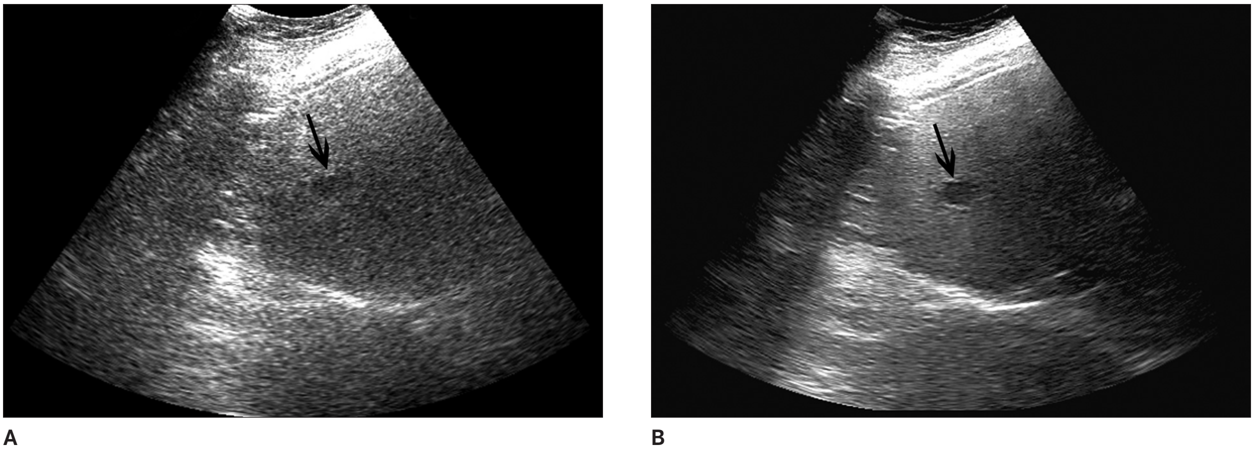


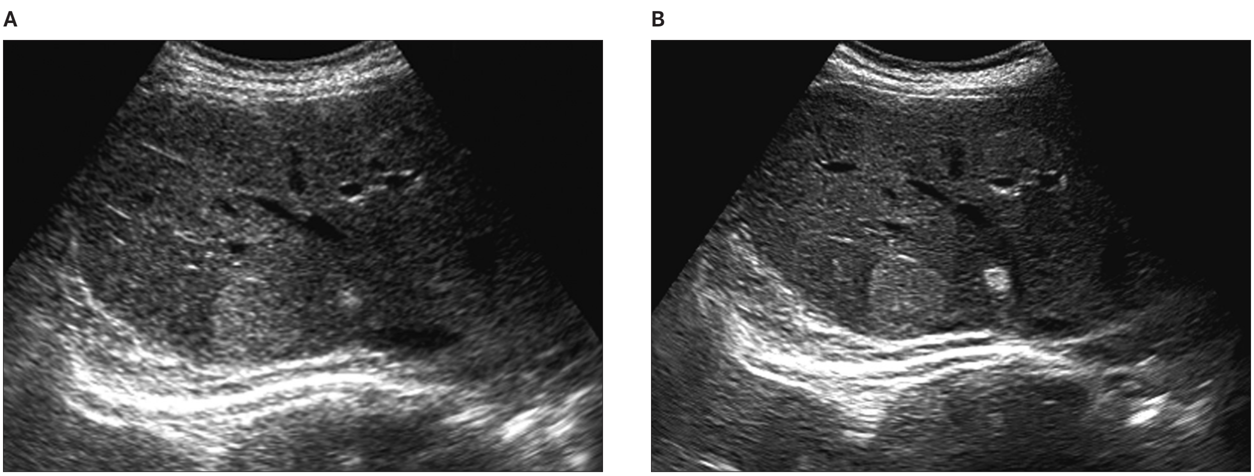
Figure 2. Images from a 48-year-old woman with hepatocellular carcinoma. **A**, Conventional sonography shows a lesion with low contrast (arrow). **B**, Precision Imaging shows better delineation of tumor boundaries and better lesion conspicuity than conventional sonography (arrow).

size of cystic lesions in this study. According to the initial clinical experience, Precision Imaging improves the ability to image small lesions, and it was better than conventional sonography for small lesions in our study as well.

Our study had several limitations. First, because only a single radiologist obtained the sonograms, the image analysis process could have been affected. Second, we did not combine Precision Imaging with tissue harmonic imaging and compound imaging because the image quality might have been affected by these imaging techniques. Further studies should be performed to evaluate the usefulness of combining Precision Imaging with the other techniques. Third, our study was not designed to compare the diagnostic performance of radiologists with respect to characterization of liver lesions. Therefore, we could not analyze the data in separate categories of benign and malignant lesions.

In conclusion, our study shows that for focal liver lesions, Precision Imaging has better image quality than conventional sonography. Additional research is required to determine whether Precision Imaging affects the characterization of these lesions.

Figure 3. Images from a 44-year-old woman with liver hemangioma. **A**, Conventional sonography shows hyperechoic hemangioma. **B**, Precision Imaging provides better delineation of lesion boundaries than conventional sonography and reveals the hyperechogenicity of the lesion more clearly than conventional sonography.



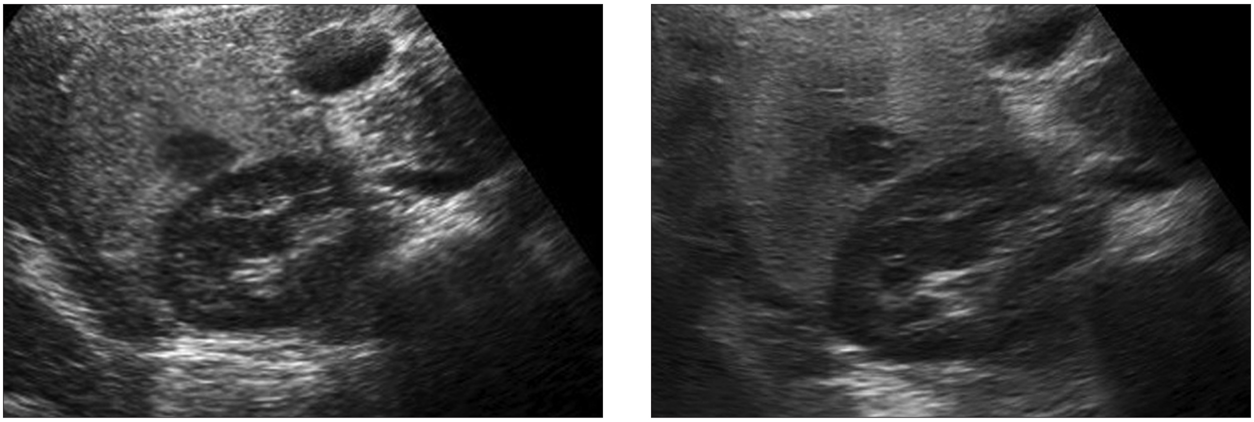


Figure 4. Images from a 35-year-old woman with Glanzmann thrombasthenia. **A**, Conventional sonography shows a hypoechoic area in the steatotic liver. **B**, The internal echo texture is more clearly differentiated on Precision Imaging. The area was thought to be focal sparing, which was confirmed by magnetic resonance imaging.

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