Fusion imaging of real-time ultrasound images with CT or MRI in hepatic interventions

The technique of fusion imaging involves the fusion of images from two different imaging modalities. One of the areas of application of such technology is in hepatic intervention, e.g., in guided biopsies or in guided radiofrequency ablation.

A group of researchers at the Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea under the leadership of Prof. MW Lee has established an impressive reputation and an extensive list of publications in this field. A brief summary of selected papers from the group is presented below.

As pointed out by Lee et al., ultrasonography (US) has in recent years been widely used for interventional procedures for the liver [1]. There are several reasons for this extensive use of US, including real-time capability, no hazard from ionizing radiation, easy accessibility, and low cost.

However, when carrying out US-guided interventional procedures, the operators need to mentally register both a reference data set (either CT or MR images) and also the working data set, which is generated from the real-time US images. In practice, this “mental” registration can be challenging if the liver cannot be scanned in orthogonal transverse, sagittal, or coronal planes, which are those most frequently used for the acquisition of CT or MR images in routine practice. In addition, as a result of breathing motion and the heartbeats of the patients, there can be deformation and displacement of the liver. Moreover, a sonographic window of the liver is sometimes limited by the rib cage, colon, or omental fat surrounding the liver.

All this can give rise to erroneous “mental” registration, which may in turn give rise to mistargeting during US-guided hepatic interventions [2]. Fusion imaging is a useful approach to address such issues.

FUSION IMAGING

This is the technique that fuses two different imaging modalities. Thanks to advances in CT and MR technology, small target lesions that previously would be difficult to detect are now being found more frequently than before. In the field of hepatic intervention, fusion imaging usually involves real-time US (the working data set) being fused with other imaging modalities such as CT, MR, and positron emission tomography (PET/CT). The resulting fused reference data sets are useful for localizing inconspicuous focal hepatic lesions on B-mode US. The technique can thus facilitate accurate interventional procedures such as Radiofrequency ablation (RFA) and biopsy even with challenging target lesions.

Fusion imaging has consequently gained considerable attention in recent years since it can help operators to conduct such interventional procedures with high confidence and accuracy for challenging target lesions [3].

• Guided percutaneous biopsy of focal hepatic lesions with poor conspicuity in conventional sonography [4].

Since pathologic confirmation is usually crucial for proper treatment of hepatic lesions, successful biopsy is of great importance. Advanced techniques are required for detection of target lesions.

However, one problem is that focal hepatic lesions are often encountered that have poor sonographic conspicuity. Although earlier studies of fusion imaging–guided biopsy had already shown promising results, they had vague inclusion criteria and lacked homogeneity of the patient population.

For this reason, the researchers from the Samsung Medical Center set up a well-organized study focusing on the advantages of fusion imaging–guided percutaneous liver biopsy [4]. The purpose of the study was to evaluate the effectiveness of fusion imaging for percutaneous sonographically guided biopsy of focal hepatic lesions with poor sonographic conspicuity. Although the number of patients was relatively limited, the results of the trial were quite conclusive [4]. The group found that fusion imaging is effective for improving lesion conspicuity and localization of target lesions during percutaneous biopsies of lesions that are invisible or poorly conspicuous on B-mode sonography. Furthermore, it was found that extensive radiologic experience was not required to carry out a biopsy accurately.

• Usefulness of image fusion with 3D ultrasonography in percutaneous ultrasonography-guided radiofrequency ablation of Hepatocellular carcinomas [5].

In a recent paper, the researchers set out to evaluate the usefulness of fusion imaging with real-time ultrasonography and three-dimensional (3D) US for the guidance of radiofrequency ablation (RFA) of hepatocellular carcinomas (HCCs) 2-5 cm in diameter.

Radiofrequency ablation (RFA) has been widely utilized as a curative treatment option for the management of hepatocellular carcinomas (HCCs) < 3 cm in diameter. Although RFA has shown promising results for very early stage HCCs < 2 cm in diameter, it is still challenging for HCCs > 2 cm due to a high rate of local tumor progression.

The Korean group of researchers carried out a study of the possibility of using image fusion with 3D US. Their findings were that, additional image fusion with 3D US to conventional fusion imaging is useful for percutaneous RFA of HCCs.
that are 2-5 cm in diameter. After electrode insertion under conventional fusion imaging guidance, RFA monitoring and controlling can be performed under image fusion with 3D US guidance. Based on the fused 3D US, ablation zones with near spherical configurations can be achieved through multiple overlapping ablations.

- Radiofrequency ablation of very-early-stage hepatocellular carcinoma inconspicuous on fusion imaging with B-mode US: value of fusion imaging with contrast-enhanced US [6].

Small HCCs are difficult to localize with B-mode US in patients with liver cirrhosis. However, these small HCCs with poor sonographic conspicuity can benefit from fusion imaging. According to previous studies fusion imaging of B-mode US and CT/MR images is useful for localizing small HCCs. However, not all small HCCs can be identified on fusion imaging. The researchers therefore set out to study the effect of the value of fusion imaging with contrast-enhanced US [6], and concluded that fusion imaging with CEUS and CT/MR images is very effective for percutaneous RFA of very-early-stage HCCs inconspicuous on fusion imaging with B-mode US and CT/MR images. Therefore, the additional use of CEUS should be considered when fusion imaging alone is not satisfactory for localizing small HCCs.

**REFERENCES**


**Advanced technical features in new ultrasound system include fusion capabilities**

The advanced technical capabilities of the new model RS80A with Prestige from Samsung are built on the well-established successes of Samsung technologies, including superior image quality, and offering additional exclusive options. Additional features such as S-Fusion, S-Tracking and S-Shearwave provide diagnostic confidence and user convenience in challenging practices.

**S-FUSION**

S-Fusion functionality is incorporated into the RS80A with Prestige ultrasound system and enables simultaneous localization of a lesion with a real-time ultrasound image supported by 3D-Data sets from other modalities. Implementations of image fusion from other companies still face challenges such as relatively long registration time and low accuracy of registration. In contrast, the fusion speed and accuracy of Samsung’s proprietary S-Fusion system is one of its main features, making the system ready for advanced clinical applications.

S-Fusion imaging takes up to 66 seconds. Positioning Auto-registration and fusion imaging only takes about 30 seconds. With the transducer placed on the epigastrium and precisely aligned, the system provides easy and fast registration. This frees up the interventionalist to focus on the actual interventional procedure.

**S-TRACKING**

S-Tracking increases the rate of accuracy during interventional procedures by providing the simulated path of the needle and the target mark in the live ultrasound image. Clear Track, one of two functions provided by S-Tracking, secures the accuracy by using a specialized needle with a sensor tip. Virtual Track uses general needles during the procedure, providing both accuracy and economic benefit.

**S-SHEARWAVE**

S-Shearwave detects the velocity of a shearwave propagated through the targeted lesion and displays the numerical measurement of stiffness expressed in kPa or m/s together with a Reliable Measurement Index (RMI). It also provides Variation Range (VR), a parameter that intuitively shows the uniformity of tissue stiffness in the Region of Interest (ROI). The wider the range, the less tissue stiffness uniformity. In the profile window, the user can easily edit each measurement value depending on its Reliable Measurement Index. S-Shearwave thus helps to reduce the number of conventional liver biopsies by providing quantitative tissue characteristic information.

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