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Leading Innovation

New frontiers in ultrasound-guided percutaneous interventions: combination of Smart Fusion and Smart Navigation techniques

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Introduction

Ultrasound is widely used in interventional radiology. However, this modality has its limitations, in particular with poorly echogenic patients or organs. Today, lesions that are difficult to visualize using conventional ultrasound can be rendered visible by Smart Fusion, a technique that combines imaging modalities, and accessed with the help of Smart Navigation, a needle tracking technology. The latter allows for oblique needle paths and real-time monitoring at the patient's bedside without exposing either the patient or the team of medical and ancillary staff to ionising radiation. Thus, the boundaries of conventional ultrasound can be expanded and the scope of ultrasound-guided interventional radiology is broadened. Lesions which are not visible on ultrasound but can be seen on a CT or MRI scan, either with or without contrast injection, can now be biopsied/treated using ultrasound guidance.

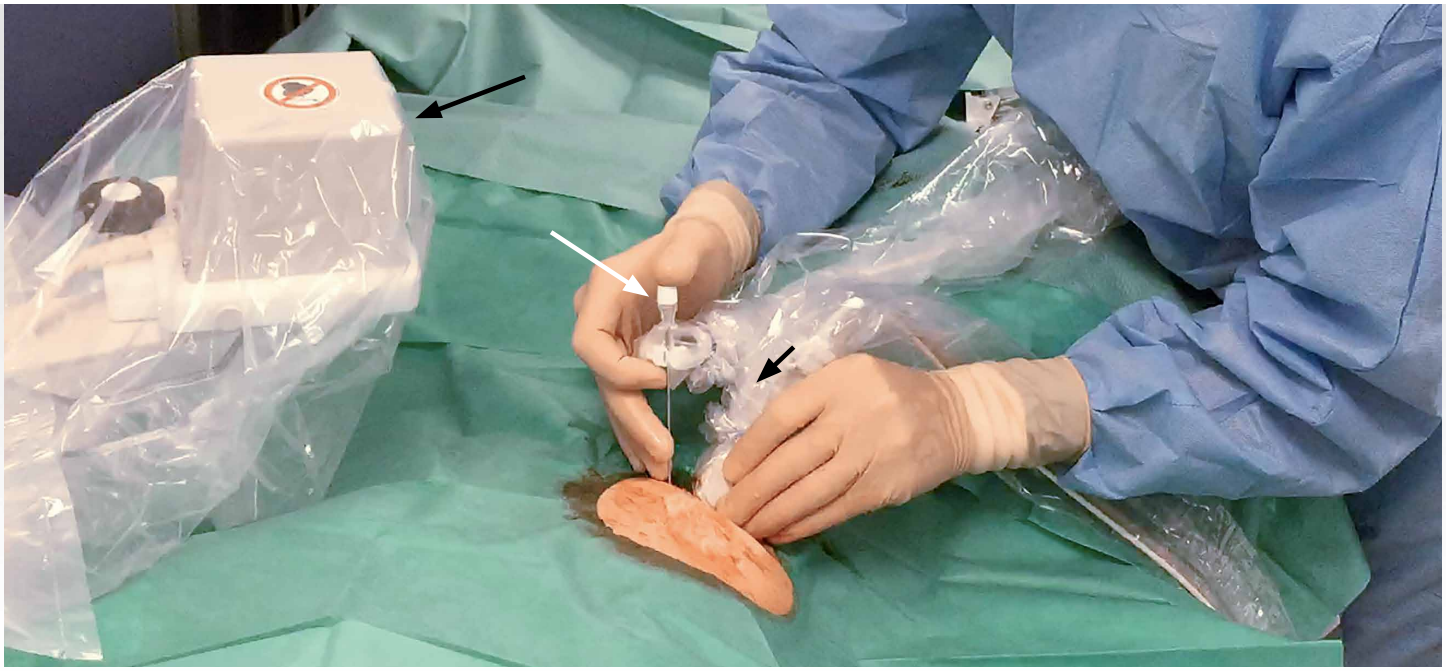
Both Smart Fusion and Smart Navigation are more accessible and less expensive than a procedure performed under CT or MRI guidance. They are contraindicated only in patients with pacemakers (because an electromagnet is used). The prerequisites are knowledge of the ultrasound features of target lesions and competence in interventional radiology.

Techniques

Smart Fusion Imaging

Smart Fusion involves an independent device with its control unit integrated in the ultrasound system, allowing synchronization of ultrasound with slice-based imaging (CT or MRI) in real time. It is compatible with 4 types of ultrasound probes (convex, micro-convex, linear and intracavitary), so it can be used in various anatomical regions. During Smart Fusion a recent CT scan, a 3D isotropic data set or a 2D MRI sequence in DICOM format is superimposed on the ultrasound image during the procedure. Data can be called-up directly from the hospital's archiving system or from CD, when the investigation was carried out at another centre.

The positioning of the ultrasound apparatus and of the patient is straightforward and conventional. The only addition is the electromagnet in proximity to the target lesion. The fusion must be effected with

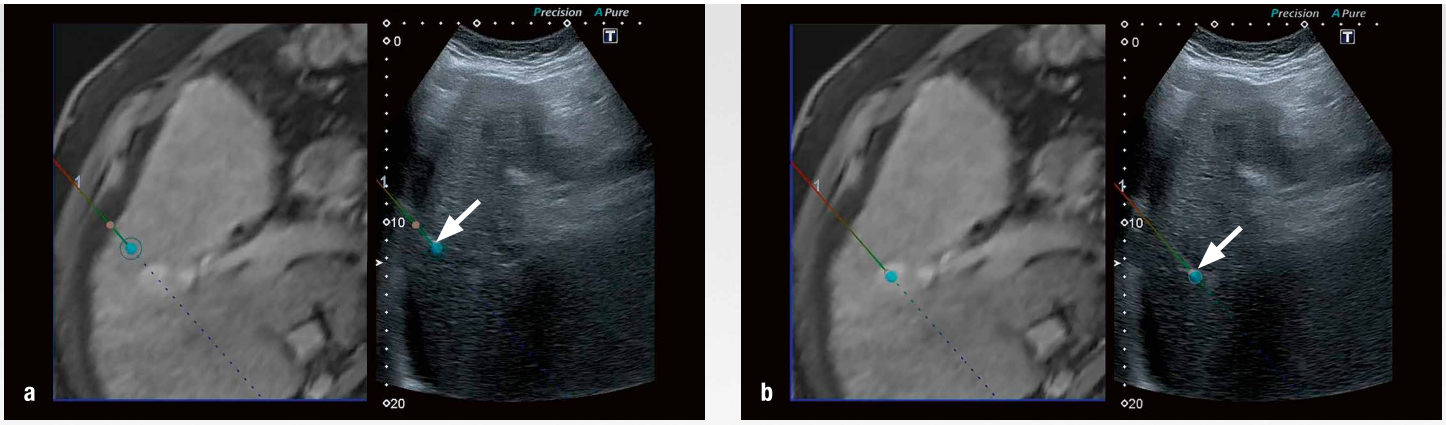


Introduction of equipment: magnet (black arrow), smart navigation (white arrow) and smart fusion (short arrow), with sterile precautions.

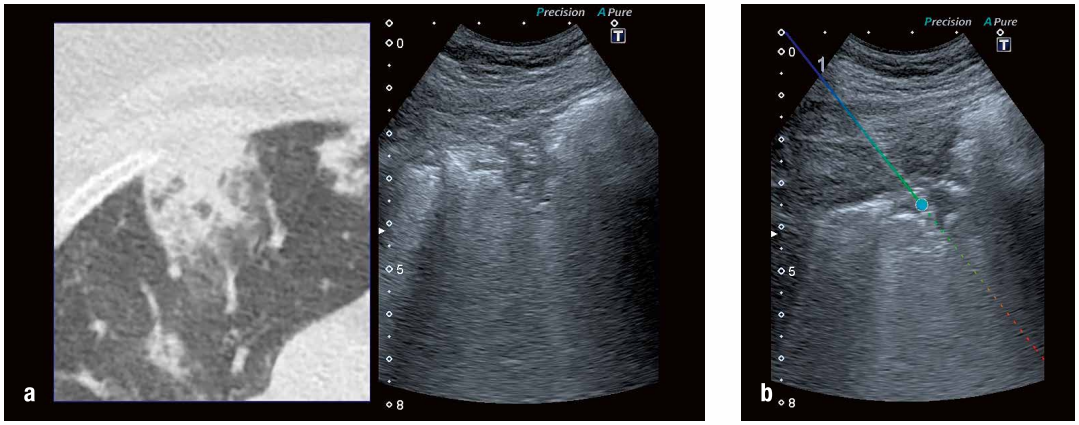
precision. The objective is to avoid any offset in the overlapping of the CT or MRI images and those obtained by ultrasound. One or more fusion points based on anatomical landmarks may be used. Smart Fusion can also be coupled with Doppler mode, contrast-enhanced ultrasound and SMI (Superb Micro-vascular Imaging). It can be disconnected at any time during the procedure and reactivated without losing the previous synchronization. Throughout the procedure, images or films can be recorded on the archiving system or on a USB flash drive.
After Smart Fusion has been carried out, a region of interest can be laid out over the area to be treated which appears both on the CT or MR scan and in the ultrasound image. It enables the pathological area to be easily identified at each stage of ultrasound scanning (after local anesthetic, between two biopsies, etc.) and is particularly helpful when the lesion is very poorly visualized. The fusion technique may be coupled with Smart Navigation used to follow the needle.

Smart Navigation/Needle tracking

The needle is visualized with the use of an electromagnetic detection device which is inserted with sterile precautions at the base of the needle. This is connected to a module installed on the ultrasound machine. As with Smart Fusion, the electromagnet must be located close to the target organ if it is to be effective.
The Smart Navigation algorithm transmits information on the position of the needle in real time, both before insertion and during insertion. Thus the tip and the path of the needle can be precisely tracked between the point of entry and the target region. Color coding and variations in cursor position indicate if and how the position of the needle needs to be corrected.
Smart Navigation is used with standard interventional radiology equipment. Before commencing the procedure the needle has to be calibrated.



Liver: 54-year-old male patient, no past history: discovery of a nodular hepatic lesion, enhancing on MRI after gadolinium injection, mildly hypoechoic on ultrasound. Smart Fusion facilitated ultrasound-guided biopsy. Smart Navigation showed passage of the needle in real time (white arrow) from image a to b. Histological findings were those of a very poorly differentiated carcinoma of unknown origin.

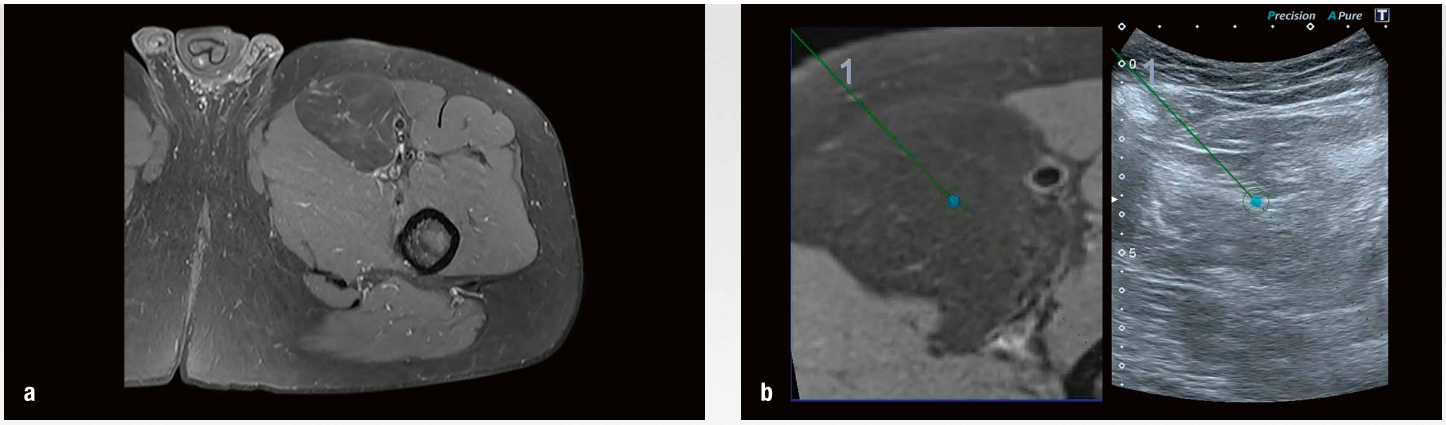


Lung: 45-year-old male patient with peripheral lung consolidation on thoracic CT scan, suggesting cryptogenic organizing pneumonia (COP). Histological confirmation was requested. The lesion was not apparent on simple ultrasound but was seen with the aid of Smart Fusion (image a). The passage of the biopsy needle was then visualized using Smart Navigation (image b). Histology confirmed the diagnosis of COP.

Thus, the system operates with needles of any length or diameter and does not require a specific needle. When the ultrasound image alone is not of adequate quality, this technique is useful to locate the precise needle position, in particular the position of its tip. This arises, for example in poorly echogenic patients; when the lesions are hyperechoic or located behind a structure casting a cone-shaped shadow; and when the path taken by the needle is long and vertical.

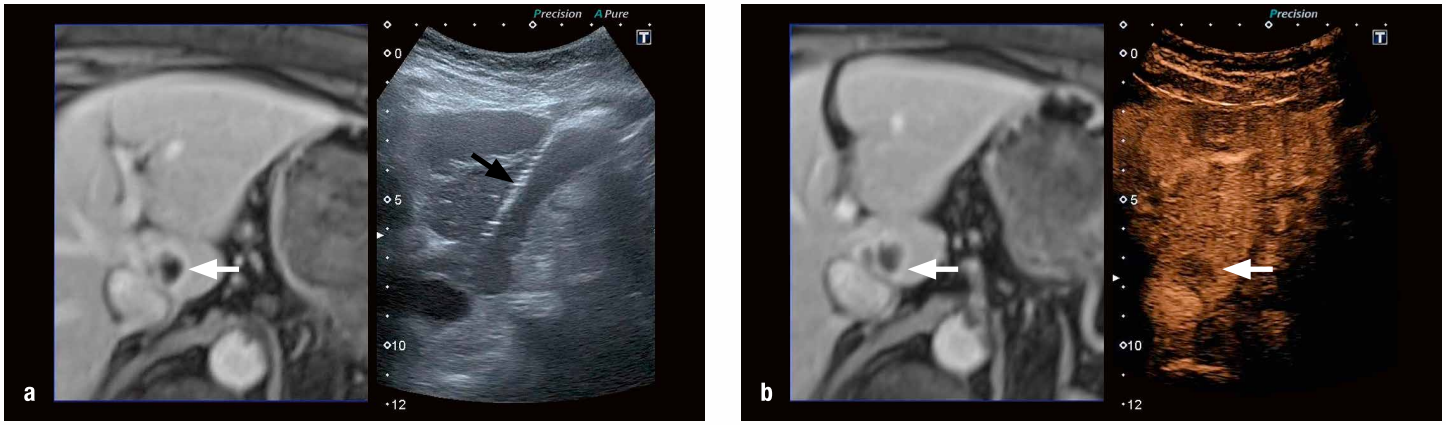
Smart Navigation can be used alone or in combination with Smart Fusion. During the procedure, it can also be disabled and reactivated without losing the calibration information. It can be used in sequence with several needles (for example, with the local anesthetic needle followed by the needle being used for the interventional procedure). For instance, fusion ultrasound compensates for poor contrast resolution, particularly in B-mode pulmonary ultrasound. Thus, lesions in contact with the pleura become accessible to ultrasound-guided procedures. This pleural contact is needed to preclude the risk of pneumothorax, which acts as a barrier to ultrasound and may change the pulmonary anatomy thus rendering erroneous the slice-based imaging used for the fusion method. The fusion technique facilitates access to small lesions, which are hard to detect, both because of the large surface area of the rib cage and poor differentiation on conventional ultrasound. The navigation technique also increases the operator's confidence by enabling the depth of the biopsy to be controlled precisely.

In addition, some peripheral bone lesions can be biopsied by virtue of the fusion ultrasound technique. Since bone cortex is hyperechoic, it casts a cone of shadow which makes it impossible to follow the needle's course. With Smart Navigation, once the cortical bone shadow has been passed, the depth of the needle is known and the procedure can thus be tracked. The goal in Smart Fusion remains to detect the target lesion.



Musculoskeletal: 37-year-old male patient: mass of fatty consistency in the left thigh, measuring 8 cm in its long axis. Septa in the lesion enhanced on MRI after gadolinium injection (image a).

This fatty mass was hyperechoic making its boundaries difficult to define on ultrasound, but fusion with the MRI made it possible to target the area to biopsy correctly. Moreover, Smart Navigation enabled precise guidance of the hyperechoic needle within this hyperechoic mass (image b). Histology showed a liposarcoma.



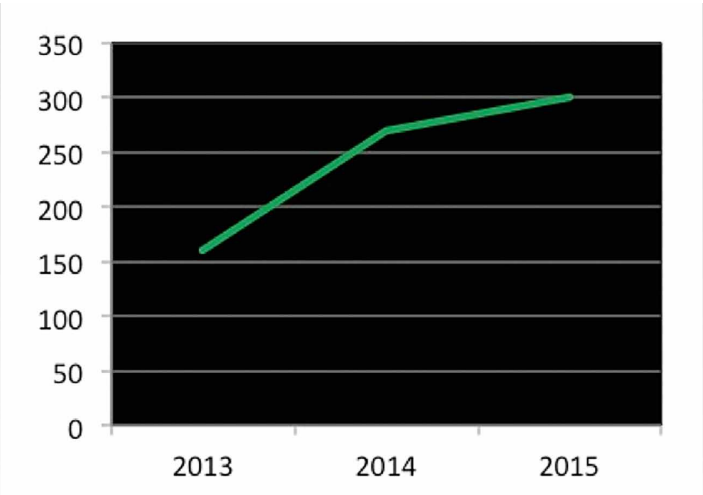
Liver 2: 63-year-old female patient, past history of breast cancer: suspicion of hepatic metastases in segment I (discovered incidentally on PET-CT performed because of sternal osteitis). The lesion had reduced signal and peripheral enhancement on T1-weighted imaging (white arrow). It was not seen on ultrasound.

Ultrasound-guided biopsy was performed using Smart Fusion (image a). Once the biopsy needle (black arrow) was in place, contrast-enhanced ultrasound (CEUS) was performed (image b): this showed a non-enhancing lesion (pink arrow) with the needle within it. Smart Navigation was not used, as the needle was very well visualized in B-mode. Histology failed to show a primary or secondary malignant lesion. This result was reliable because the correct position of the biopsy needle had been verified during the procedure.

Conclusion

The new Smart Navigation and Smart Fusion devices are easy to access, can be positioned rapidly and are radiation-free. They broaden the scope of application of ultrasound-guided interventional radiology by making visible lesions that are poorly identified on standard ultrasound imaging. Radiologists can therefore have confidence in procedures supported by this technology.

Practice has been changed, so that it is now preferable to perform certain procedures using ultrasound fusion imaging instead of CT or MRI guidance.



Graph demonstrating the increase in numbers of biopsies performed using ultrasound since the arrival of Smart Navigation and Smart Fusion in the department.

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