Preliminary clinical experience with liver and bone biopsies guided by a robotic assistance system in a closed-bore 1.5T MR scanner

M. Moche[1], H. Busse[1], D. Zajonz[1], R. Trampel[1], and T. Kahn[1]

[1]Department of Diagnostic and Interventional Radiology, University of Leipzig, Leipzig, Germany

Introduction/Purpose

Various concepts of guiding interventions with the help of MR imaging have been realized in the past decade. Recently, a robotic assistance system has become commercially available that allows to plan and realize the trajectories of medical instruments in a closed-bore scanner. Such a device was implemented in our conventional 1.5T MRI environment and has been clinically used for about four months. The aim of this work was to report about our technical and preliminary clinical experience with percutaneous liver and bone biopsies.

Materials and Methods

The MR-compatible assistance system Innomotion (Innomedic GmbH, Herxheim, Germany) is mounted on a C-arm that fits into the standard 60-cm bore with a maximum gap of 39.8 cm to the patient table [1]. The unit can be manually moved along the C-arm and fixed in five different positions (Fig. 1, top). The main unit carries the application module (AMO, Fig. 1 below) which is equipped with four MR-visible reference markers and a sleeve holder. The system is driven by a servo pneumatic mechanism and has six degrees of freedom. Imaging was performed with a flexible loop coil (diameter 19 cm) in combination with the spine coil. In the liver, T1- and T2-weighted breathhold sequences (VIBE and HASTE) were used to plan and control the intervention. In the bone, T1-weighted turbo spin echo sequences were used for planning and VIBE sequences were used for fast control imaging. The biopsies were planned on a dedicated workstation in the MR control room by interactively setting entry and target point. The system then moved the AMO into a position near the planned insertion point. The correct 3D positioning of the device was verified by imaging the four markers attached to the AMO in two orthogonal planes. After that, the AMO is moved into its final position. In a previous phantom study, a mean deviation between actual and planned target point of less than 1 mm was determined [1]. Outside the magnet, the physician performed the feed of the needle manually. The actual needle position was then controlled by appropriate MR scans. A coaxial 16G true cut biopsy system (Invivo, Würzburg, Germany) with a length of 100 or 150 mm and a bone biopsy set (Invivo) with a 4-mm diameter were used for the liver and bone biopsies, respectively.

Results and Discussion

Before clinical application, our implementation required some technical optimization with respect to the sensitivity of the position sensors and the RF-shielding of the device. We performed four liver biopsies (one hepatocellular carcinoma, two metastases of an adenocarcinoma–Fig. 2, one focal nodular hyperplasia), one femoral biopsy (atypical Ewing sarcoma, Fig. 2), one biopsy of the thoracic spine (spondylodiscitis), and one of the sacral bone (aneurysmatic bone cyst). All lesions but the last two were not or not sufficiently visible with computed tomography. All patients were cooperative. In the case of liver biopsies, a short training and sufficient local and systemic analgesia was required to achieve the same level of inspiration during breathhold. The maximum body mass index (BMI) was 29.4 kg/m^2. For that patient, we had to take out the integrated spine coil to gain further space. The median time between first and final MR images was 1:27 h (0:58-3:25 range). All interventions could be completed successfully without any major complications. In three cases, a strong mechanical force was exerted on the AMO and the system was shutdown as devised and required a reboot. As a result, the pneumatic drive mechanism was modified and now allows a certain manual excursion of the arm and an automatic return to the original position after relief without a shutdown.

Fig. 1. Patient positioning for femoral biopsy (top); AMO above imaging coil and vacuum matress for immobilization of the leg (bottom).

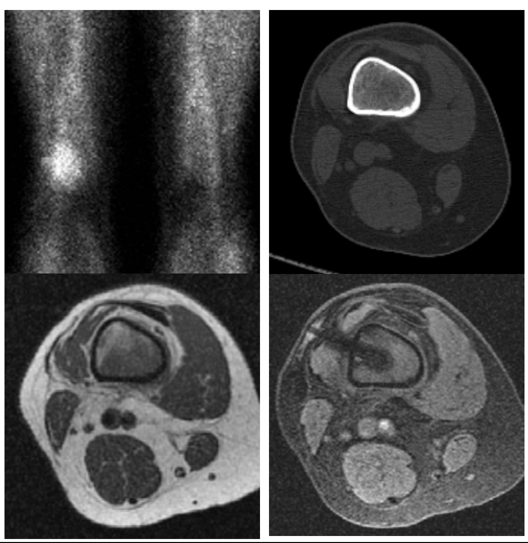

Fig. 2 Skeletal scintigraphy with high bone metabolism in right distal femur (top left); CT image with no osteolysis (top right); T1w TSE (170 s) planning image with hypointense lesion (bottom left); T1w VIBE (56 s) intraoperative control image with needle artefact (bottom right)

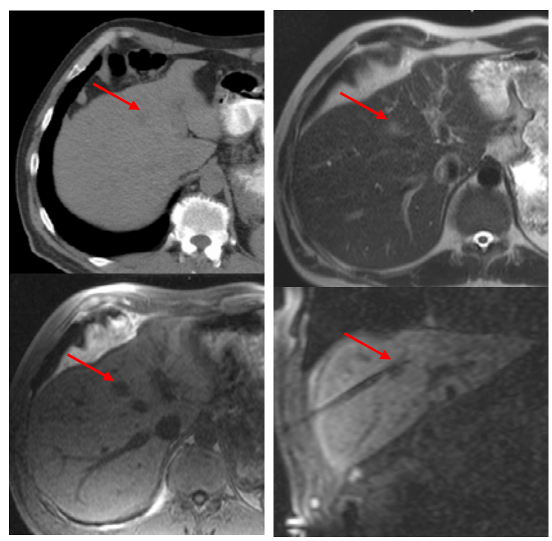

Fig. 3 Biopsy of suspicious liver lesions (arrows) of unknown primary. CT scan with inadequate visualization of the lesion (top left); T2w HASTE (21 s, top right) and T1w VIBE without CM (17 s, bottom left) with good lesion conspicuity; oblique image showing the entire needle path and the tip in the lesion (bottom right).

Conclusion

Our first clinical results suggest that biopsies can be reliably performed in a closed-bore MRI with the help of the described robotic device even in regions affected by respiration-induced motion. To achieve the same level of inspiration, however, adequate analgesia and breathhold training of the patient are essential. The patient's BMI should also not exceed 30kg/m^2 due to spatial confinement.

References

[1] Zangos S et al. Eur Radiol, 2006 Oct 10 [Epub ahead of print]