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Improved clinical outcome using 3D laser navigation for CT interventions

HS Na, P.Bruners, P. Isfort

From the Department of Diagnostic and Interventional Radiology, University Hospital RWTH Aachen

Figure 1. Improved placement of a RFA needle (video)

Abstract

CT-guided interventions involving complex anatomical structures or difficult access routes can be challenging and may be associated with a significant risk of harming non-target structures. A system for exact planning of the puncture trajectory and guidance of the intervention can be very helpful in order to perform swift and safe CT-guided interventions. Moreover such a system could allow a reduction of radiation exposure both of patient and interventionist. In this case series we describe the use of the SimpliCT laser Navigation system (NeoRad, Oslo, Norway) in combination with the 3D planning software (Adaptive 3D Interventional Suite, Siemens Healthcare, Forchheim, Germany).

Figure 2. Adaptive 3D Interventional Suite

Figure 3. SimpliCT laser navigation system

Introduction

When performing CT-guided interventions involving complex anatomical structures like the upper abdomen, puncture planning and execution can be rather difficult and can be associated with a significant risk of harming non-target structures (e.g. bowel or pleura). Punctures often have to be performed in an out-of-plane trajectory (angulation in z-axis) in order to finish the procedure safely. Moreover in some cases vulnerable structures (e.g. bowel) conceal an otherwise easily accessible structure leaving only a very narrow puncture corridor.

The SimpliCT System (NeoRad, Oslo, Norway) is a simple-to-use laser guiding system that allows precise in-plane and out-of-plane punctures using predefined puncture angles in x-, y- and z-plane. It uses a calibrated laser, which is either ceiling-mounted or attached to a mobile arm. After calibration of the system a laser is adjusted using the pre-defined angles with the laser beam pointing at the desired skin entry point. Thereafter the puncture can be performed easily with the needle aligned with the laser beam. For puncture planning a dedicated software tool (Adaptive 3D Interventional Suite, Siemens Healthcare, Germany) is used that allows in- and out-of-plane puncture planning. With the software the desired entry-point as well as the target can be marked. The puncture trajectory is visualized in MPR-fashion and x-, y- and z-angles are displayed. In this case series we present three cases of complex CT-guided interventions (e.g. CT-guided microwave ablation or oblique drainage placement)

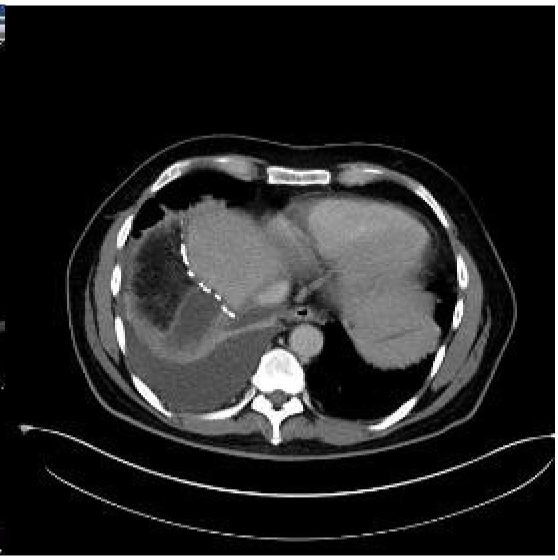
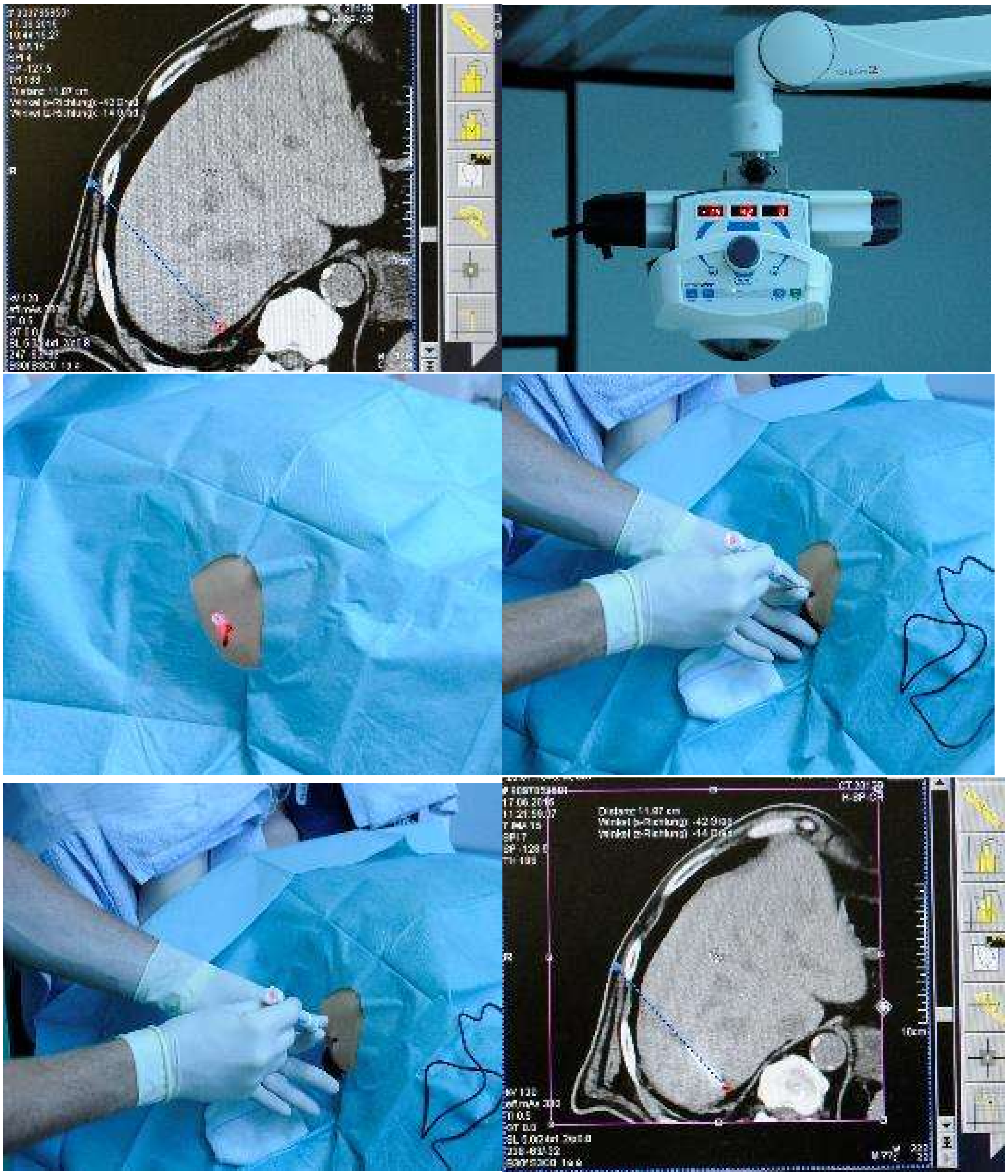


Figure 4. MPR planning liver absess *Figure 5. Axial planning*

Challenge

The combination of the Adaptive 3D Interventional Suite and the SimpliCT-system is supposed to facilitate complex out-of-plane CT-guided interventions.



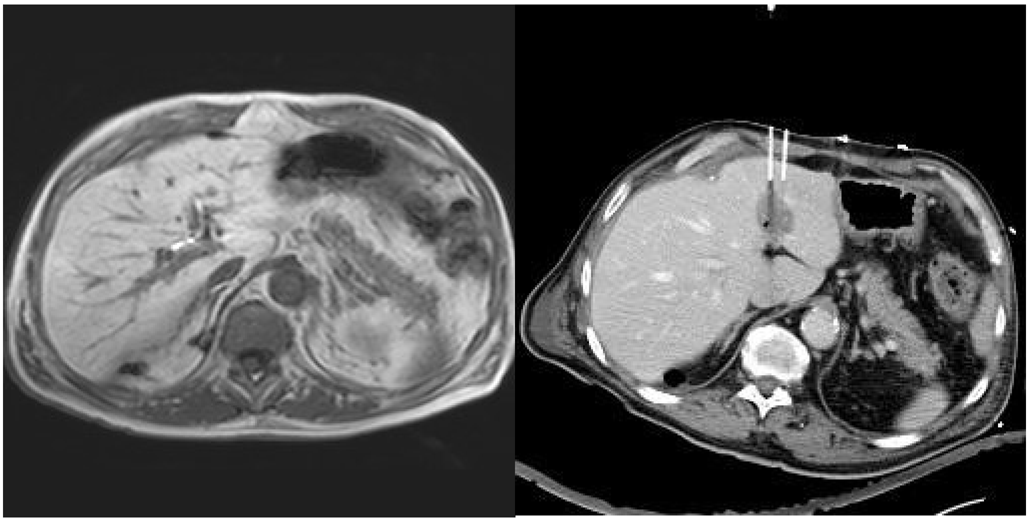
Figures 6-11. Placement of RFA needle under laser guidance

Cases:

The case of a 59-year-old patient with a 4,3 x 3,7 x 4,1 cm tumor in the liver dome (metastasis of a urinary bladder carcinoma) shows that laser navigation and 3D CT guidance can speed up the placement of the radiofrequency ablation (RFA) probe in this long-distance out-of-plane approach 15,5 cm distance between needle entry point and target) with high accuracy. For tumor ablation correct positioning of the applicator is of utmost importance to ensure complete necrosis of the tumor including a sufficient safety margin. The laser guiding system as well as the 3D-planning software was successfully used to perform exact probe placement. On average only three control scans were necessary for probe-positioning, which is significantly less than in free-handed technique considering such a long needle pathway.

Another case of a 67-year-old patient with a 4,8 x 7 x 5,6 cm subphrenic abscess post hemihepatectomy right also demonstrates the benefit of using a 3D CT guidance as the target was obscured by parts of the small bowel so that again an out-of-plane approach was necessary. In order to avoid injuries of the intestine only a narrow access route for the drainage catheter was possible. Using the 3D-planning software in combination with SimpliCT allowed to place the drainage catheter swiftly and without complications. Even in this scenario only three control scans were necessary to complete the procedure.

Using the Adaptive 3D Interventional Suite in combination with the SimpliCT system is not only useful for out-of plane interventions. In a 81-year-old patient with a 1,5 cm single metastasis of a colorectal carcinoma close to the hilum of the liver we were asked to treat the patient by minimal-invasive treatment due to severe comorbidities. The challenging aspect of this case was the immediate proximity of the tumor to central vessels and a biliary duct. We decided that IRE would be the best method to avoid the injury of vascular tissue. Performing the procedure with the Adaptive 3D Interventional Suite in combination with the SimpliCT guidance system we were able to perform the placement of 2 IRE probes successfully without corrections and with only five control scans. No major complications occurred and the patient was discharged from hospital two days after the procedure.



Figures 12-13. Placement of IRE needles under laser guidance

Solution

The Adaptive 3D Interventional Suite allows easy in- and out-of-plane puncture planning. After marking skin entry and target in the CT dataset the software displays x-, y and z-plane angles. These angles can be used to adjust the SimpliCT laser guidance system. The puncture path defined by the software is displayed in the control scans to compare the actual needle position with the planned pathway. The technique is especially useful in out-of-plane punctures especially with long puncture pathways and interventions that require precise placement of several ablation probes or needles, e.g. tumor ablation of large tumors as shown in the first case or in irreversible electroporation, a technique that requires precise parallel placement of up to 6 applicators.

Conclusion

The combination of the Adaptive 3D Interventional Suite and the SimpliCT navigation device can improve the performance of difficult out-of plane interventions in complex anatomical environments with simultaneous reduction of applied radiation dose. Furthermore the technique ensures a more standardized approach to CT-guided interventions what may be less prone to individual experience and availability of key personnel.

References

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