Stereotactic image-guidance for percutaneous transgastric irreversible electroporation of pancreatic tumors – an animal case

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Abstract

Pancreatic cancer has one of the highest mortality rates with a 5-year survival of less than 5%. Only about 10% of pancreatic cancers are curatively treatable with surgery. Irreversible-electroporation (IRE) represents a treatment method for advanced and unresectable pancreatic tumors. Due to the complex anatomy around the pancreas, this procedure is mostly performed in open surgery under intra-operative ultrasound guidance. Image-guidance could potentially allow the safe treatment in a percutaneous approach, which would lead to lower complication rates and shorter hospital stays.

Keywords: Pancreas, minimally-invasive surgery, stereotactic image-guidance

1 Introduction

Only about 10% of patients with pancreatic cancer are treatable with resection, which is considered the only curative treatment option. Local ablation is an alternative for advanced and nonresectable pancreatic cancer. These tumors have usually grown around the pancreatic duct and other blood vessels and therefore a non-thermal ablation technique must be used to preserve these vessel structures. Irreversible electroporation (IRE) is such a non-thermal ablation method, which induces apoptosis of cells by applying an electric field but does not the affect the connective tissue of vessels [1]. Due to the proximity of the pancreas to critical structures, this treatment is mostly performed using an open surgical access, which comes with high complication rates and long hospital stays.

The percutaneous access represents a minimally invasive approach for IRE treatment in the pancreas. However, due to the proximity of large blood vessels (aorta, vena cava, portal vein) it is a very challenging and risky procedure. Due to the location of the pancreas, a transgastric trajectory would be the shortest if targeted from them the anterior abdominal wall [2, 3]. As the stomach is usually filled with air it is not possible to use real-time ultrasound imaging for needle guidance. Relying on pure CT guidance exposes the patient and the interventionalist to a large amount of radiation. Additionally, as the needle must pass through multiple air-tissue interfaces, the needles are prone to bending. Therefore, stereotactic image-guidance might help to overcome these technical challenges and therefore making the percutaneous approach safer and more efficient. This would come with the advantages of percutaneous over open surgery such as less complications and faster recovery.

In this study, we present an initial animal case of a percutaneous transgastric IRE needle placement for pancreatic tumors in an animal trial.

2 Material and Methods

For planning and placement of the IRE needles (Nanoknife, Angiodynamics) a navigation system for interventional radiology (CAS-One IR, CAScination AG) was used. The animal was under general anesthesia during the whole treatment. First, an artificial tumor consisting of Arginate was percutaneously injected into the head of the pancreas using the navigation system. Then, a contrast enhanced CT (CECT) was acquired for planning of the needle trajectories. Each needle was placed through the skin and the stomach using the tracked aiming device of the navigation system. After all needles were placed, a control CT scan was acquired to validate the accurate needle positioning with respect to the plan. During all CT acquisitions and during the needle placement, the animal was put on apnea with 30 mm/Hg pressure.

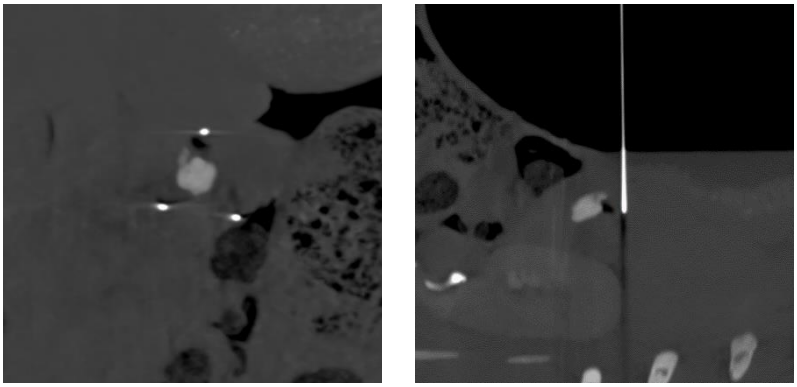

Figure 1: A top view and lateral view of the needle with respect to the tumor

3 Results

All three IRE needles could be safely placed around the tumor through the stomach (Figure 1) with lateral errors of *0.2, 7.1, and 4.5 mm*. Due to the vicinity of the needles to the portal vein, they were placed shorter than indicated by the navigation system, with a longitudinal distance to the tumor of *6.1, 4.5, and 1.0 mm*, and adjusted after the control scan. In the volume rendering (Figure 2), one can see that one needle was heavily bent, which led to a lateral error of 7.1 mm.

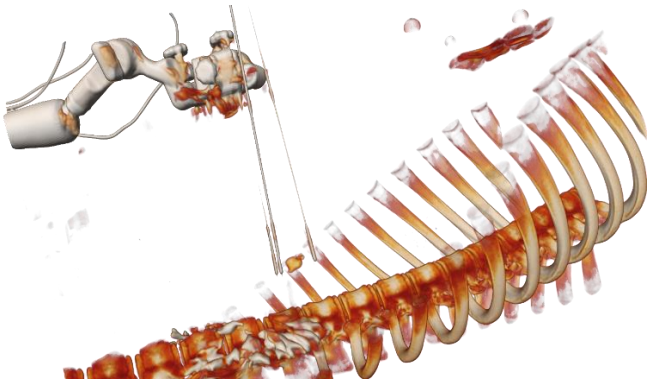

Figure 2: Volume rendering

4 Discussion

In this study, an IRE needle placement for a pancreatic tumor was successfully performed using stereotactic CT based image-guidance. The CT based planning was especially useful to plan safe trajectories with a sufficient distance to critical anatomical structures like the portal vein or the aorta, while meeting the technical constraints of the IRE system (needle spacing and parallelism).

To conclude, this image-guided approach might represent a safe and efficient approach for percutaneous IRE treatment of unresectable pancreatic cancer as an alternative to the open surgical approach.

References

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