Percutaneous transgastric access for irreversible electroporation of pancreatic tumors using stereotactic image-guidance – an animal case

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Introduction

Pancreatic cancer has one of the highest mortality rates, with a 5-year survival rate of less than 5%. The only curative treatment option is surgical resection. However, only about 10% of all patients with pancreatic cancer are amenable for this procedure.
Local ablation is an alternative for advanced and nonresectable pancreatic cancer. Because advanced pancreatic tumors have usually grown around the blood vessels and the pancreatic duct a non-thermal ablation technique must be used in order to preserve the vessel structures. One such non-thermal ablation method is irreversible electroporation (IRE), which induces apoptosis of cells by applying an electric field. This method does not the affect the connective tissue of vessels. However, it relies on the placement of multiple needles in parallel in a well-defined geometric distribution. This treatment is mostly performed using an open surgical access, due to the technical challenges and the proximity of the pancreas to critical structures. This comes with the disadvantages of open surgery such as high complication rates and long hospital stays.
The percutaneous access represents a minimally invasive approach for IRE treatment in the pancreas. However, this is a very challenging procedure, because of the proximity of large blood vessels like the aorta, vena cava or portal vein. The shortest path from the anterior abdominal wall to the pancreas is through the stomach. The stomach is usually filled with air, which … the possibility of using real-time ultrasound guidance. Needle guidance based on CT would expose the patient and the interventionalist to a high radiation dose. Furthermore, inserting a needle through multiple air-tissue interfaces, may introduce significant risk of needle bending. Stereotactic image-guidance could help to overcome these issues, making this percutaneous approach safer and more efficient.
In this study, we present an initial animal case of an image-guided percutaneous transgastric IRE needle placement for pancreatic tumors in an animal trial.

Methods

For planning and placement of the IRE needles (Nanoknife, Angiodynamics) a commercially available navigation system for interventional radiology (CAS-One IR, CAScination AG) was used. The animal was under general anesthesia during the whole procedure. Initially, the navigation system was used to place an artificial tumor consisting of Arginate into the head of the pancreas. For planning of the needle trajectories, a contrast enhanced CT (CECT) was acquired and loaded onto the navigation system. Three needles were planned around the tumor using the shortest path through the stomach. With a tracked aiming device of the navigation system, each needle was placed through the skin and the stomach under real-time guidance 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. To minimize errors due to breathing motion, the animal was put on apnea with 30 mm/Hg pressure during all CT acquisitions and during the needle placement.

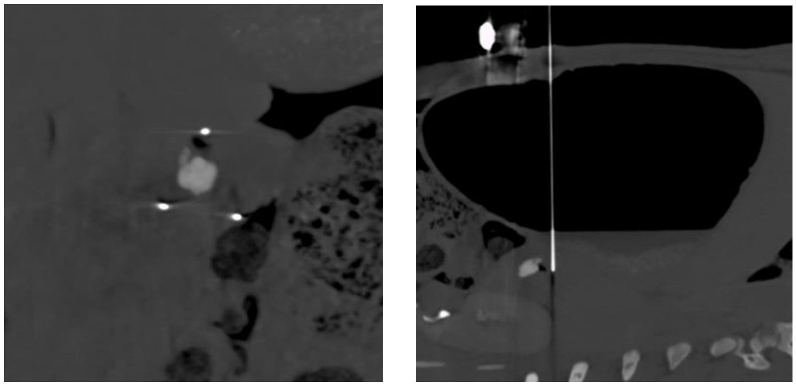

Figure 1: A top view and lateral view of the needle with respect to the tumor

Result

All three IRE needles could be safely placed through the stomach (Figure 1) with lateral distances of *0.2, 7.1, and 4.5 mm* to the tumor. The needles were intentionally placed shorter than indicated by the navigation system, due to the vicinity of the tumor to the portal vein. The longitudinal distance to the tumor was *6.1, 4.5, and 1.0 mm*, and was adjusted after the direction was verified on the control scan. One of the needles was heavily bent (lateral error of *7.1 mm*) which can be seen on the volume rendering (Figure 2).

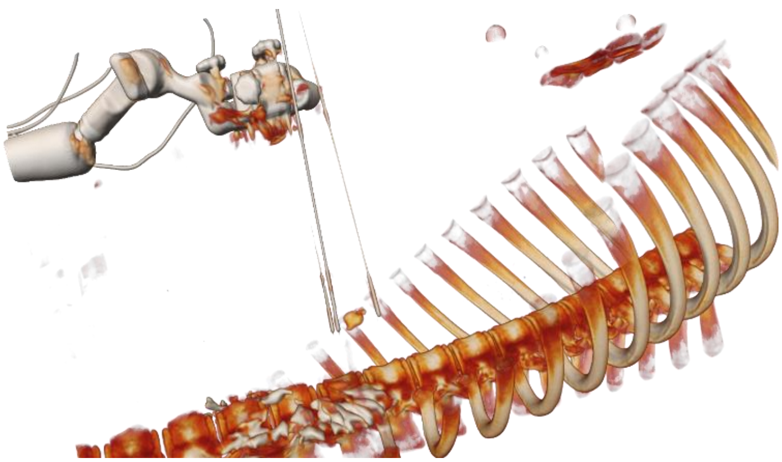

Figure 2: Volume rendering of the IRE needles places around the artificial tumor

Discussion & Conclusion

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.