Metallic Intraspinal Catheters in MRI: a Feasibility Study

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INTRODUCTION:

In recent years, implantable infusion pumps for continuous application of drugs e.g. into the spinal cord became more and more a part of clinical neurosurgery [1]. Patients suffering from chronic pain or spasm get treated e.g. with analgetics that way. The pump is implanted subcutaneously in the abdomen. The drugs are delivered from the pump to the spinal cord via an intraspinal catheter. For better handling, stability, tolerance, and placement not only catheters and pumps made of plastics have been developed, but also metallic catheters.

However, metallic implants may turn out to be a risk for the patients' health and may detoriate the image quality in MR imaging. On the one hand concerns are related to heating at the ends of the catheter or at the pump caused by RF pulses coupling into the metallic objects [2,3,4]. Heating of the pump we used in our setup could also lead to a malfunction of the pump, as its mechanism is based on a slowly expanding gas chamber fed by an evaporating liquid. On the other hand MR signal loss near the catheter or pump due to susceptibility artifacts could make the examination useless [2,3,4].

Our aim was to perform a phantom study in order to evaluate the feasibility of MR examinations of patients with implanted metallic catheter and pump with reference to potential hazards to the patient and image quality.

MATERIAL AND METHODS:

The studies were performed on a Symphony Quantum 1.5T (Siemens, Erlangen, Germany) scanner. The measurement of the temperature was conducted with a fiberoptic thermometer (Luxtron, Santa Clara, CA, USA; four channels; accuracy 0.1°C; temporal resolution 1s). The catheter and pump (Flextip Plus 3000 and Archimedes, Codman, Walepole, MA, USA) were placed in a cubuid shaped torso phantom (90x40x20cm³) filled with 50l NaCl-solution (0.5%). To account for the extra compartment formed by the spinal cord the catheter stuck 10cm deep in a plastic tube (∅=1cm) (Fig. 1). The catheter consists of a titanium coil (∅=0.5mm) and is coated by a layer of polyurethane. The pump is made of titanium. Both are non ferromagnetic. Pump and titanium catheter are connected by a silicone connection catheter and a titanium connector. To register heating near the catheter and pump, the temperature probes were placed equally spaced along the catheter and four different points on the pump. There were also probes to monitor the temperature of the environment. The following sequences were run: T2* GE-EPI (RF power= 6.7W), diffusion weighted SE-EPI (28.1W), 3D-FLASH (17.4W), T2 TSE (116.5W), T1 SE (129.9W).

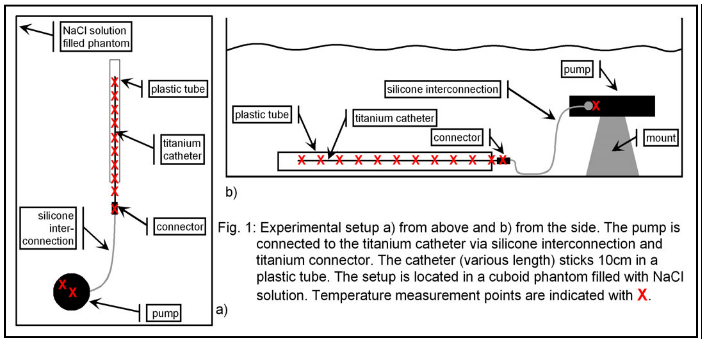

Fig. 1: Experimental setup a) from above and b) from the side. The pump is connected to the titanium catheter via silicone interconnection and titanium connector. The catheter (various length) sticks 10cm in a plastic tube. The setup is located in a cuboid phantom filled with NaCl solution. Temperature measurement points are indicated with **X**.

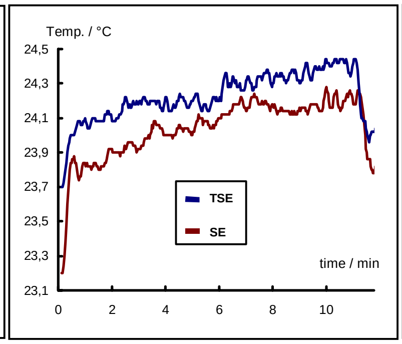

Fig. 2: Temperature at the catheter's tip for SE and TSE sequence; catheter is placed at the edge of the phantom

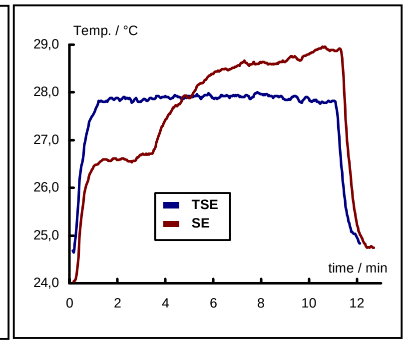

Fig. 3: Temp. at the catheter's tip for SE and TSE seq.; catheter is placed at the RF coils

RESULTS:

For the setup shown in Fig. 1 there was no heating differing from noise observable at the catheter and connector or the pump. This setup was varied in numerous measurements: We varied the length of the titanium catheter between 30cm and 70cm. There was no difference to the initial setup. The plastic tube containing the catheter was fixed at many different positions within the phantom. When it was positioned closer to the scanner's RF coils at the phantom wall heating by 0.7°C for the SE and 0.5°C for the TSE sequence was measured (Fig. 2). The position and orientation of the pump was also changed. However no heating at the pump was observable. In a "worst case scenario" the catheter was positioned outside the phantom directly at the scanner's tunnel wall, close to its RF coils. In this setup heating at the catheter's tip by 4°C for both, SE and TSE sequence was observable (Fig. 3).

Fig. 4 shows a sagital and an axial oriented T2 weighted TSE image of the catheter and the plastic tube in the phantom. The overall image quality is not influenced by the catheter. Minor deletions caused by transitions in susceptibility occur only in the immediate vicinity of the catheter. In gradient echo sequences, however, deletions were significantly larger.

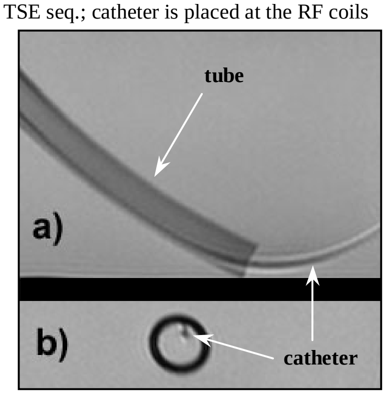

Fig. 4: T2 weighted TSE sequence; a) sagittal and b) axial orientation; the catheter is surrounded by a plastic tube

DISCUSSION:

The study shows that MR imaging of patients with implanted titanium catheters is safe in clinical routine. However, the spinal cord, where the catheter is located, may not get close to the RF coils but it has to be positioned along the z-axis of the scanner where the electrical component of the RF field is lowest. In this case hazards for the patients (due to heating of metallic implants) doesn't have to be awaited. As we didn't see temperature rise at the pump an adverse effect on the pumping mechanism can be excluded as well. For the few setups in which we observed a temperature rise the heating increased with RF power. This means that low SAR sequences should be used for the MRI examinations.

The diagnostic value seems not to be impaired by the signal deletions at the catheter, as they were limited to the immediate vicinity of the catheter. This, on the other hand, allows a reliable control of the catheter's position in the spinal cord.

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