Deployment of Stent Retrievers in a Porcine Vasculature using Robotic Magnetic Navigation

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Introduction

Endovascular treatment (EVT) of large vessel occlusion in acute ischemic stroke is the current gold standard. EVT using a magnetic steerable catheter (MSC) is a potential alternative to well-established manual guidewire-based EVTs to directly steer the MSC with a magnetic field. Robotic magnetic navigation systems (MNS) can simplify catheter navigation and allow for remote intervention. This has the potential to reduce procedure time and costs and also provide treatment in remote areas without specially trained medical staff. Here, we present first concept results and a feasibility study of MSC navigation in small vessels and thrombectomy device deployment (TD) through the MSC in an in-vivo porcine model.

Method Overview

A magnetically steerable diagnostic catheter was developed and tested in combinations with different established thrombectomy devices (TD) from Medtronic (Solitaire X), Stryker (TREVO NTX 4x28), and Microvention (ERIC 4x24). The catheter has two magnets at the tip and was actuated with an MNS and a motorized advancer unit (Figure 1 and 2). In-vivo experiments were performed on a 45 kg pig. The catheter position was tracked with a mono-plane angiography system (Philipps Allura Xper FD20, Netherlands).

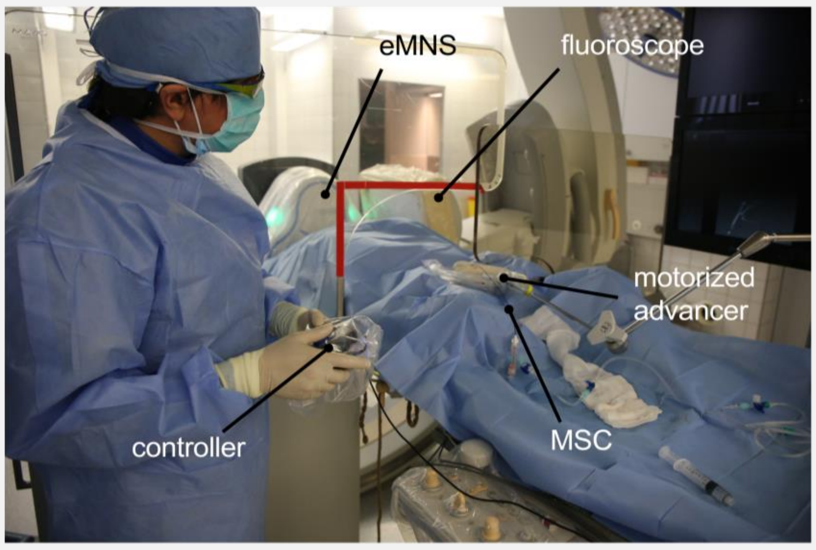

Figure 1. Remote control of the MSC with a joystick controller and fluoroscopic feedback. The catheter is navigated with the magnetic field generated by the eMNS and advanced/retracted with a motorized advancer.

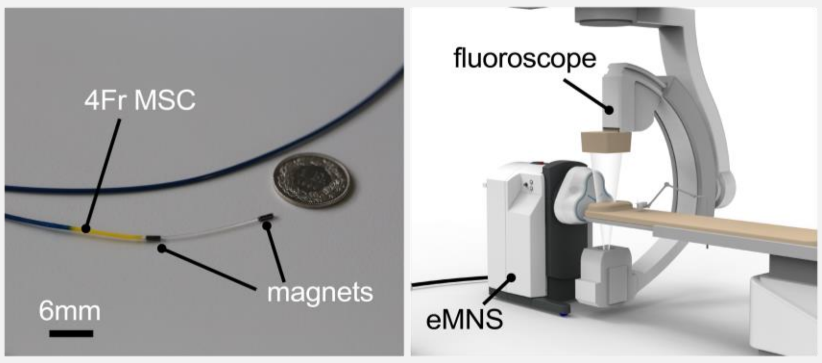

Figure 2. (left) 4Fr MSC with two permanent magnets at its tip. (right) The mobile eMNS is positioned cranially with respect to the patient bed providing patient access and control of the C-arm position and orientation.

Results and Discussion

The navigation of the MSC and the TD deployment were successfully tested in this in-vivo feasibility study. Figure 3 shows the successful navigation to different arterial branches of the extracranial vasculature (a-d), the acquisition of an angiogram in the ascending pharyngeal artery (d), and the deployment of a TD in a proximal cervical branch of the subclavian artery (e). Technically, the generated magnetic torque was sufficient to reliably navigate the MSC while low enough to avoid arterial damage.

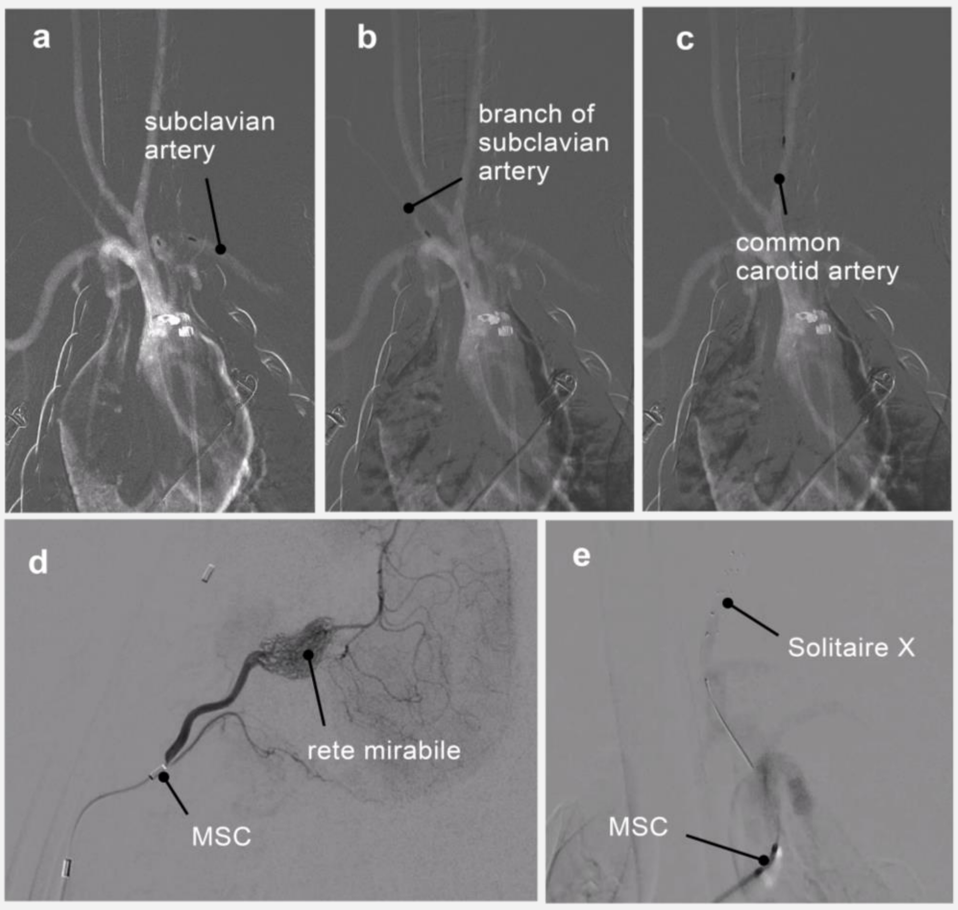

Figure 3: In-vivo feasibility study. (a) Catheterization of left subclavian artery. (b) Catheterization of a branch of the right subclavian artery. (c) Catheterization of the left common carotid artery. (d) Catheterization and angiogram of the right ascending pharyngeal artery. (e) Deployment of a Solitaire X thrombectomy device in a proximal cervical branch of the subclavian artery.

Conclusion

- This in-vivo study demonstrates the feasibility of MSC navigation in small vessels and the successful deployment of different TDs in an in-vivo model.
- Successful remote catheter navigation provides a potential platform for medical treatment in remote areas without specially trained medical staff.
- Future studies need to incorporate remote operation functionality including the remote control of the patient bed and fluoroscope to make this technology suitable for clinical use.