Multimodal image fusion in endovascular complex aortic aneurysm repair

CHAPTER 9

Valorization

SOCIAL AND ECONOMIC RELEVANCE OF MULTIMIMODAL FUSION FOR AORTIC ANEURYSM INTERVENTIONS AND IMAGE-GUIDED INTERVENTIONS IN GENERAL

The visualization of the human vasculature using X-ray and contrast media has led to unique diagnostic capabilities and treatment options. Minimal invasive procedures are increasingly performed in modern medicine, accompanied by a reduction of open surgical procedures. In the Netherlands and the United States, annually more than 3,200 or 63,000 aortic aneurysm repair procedures are performed today, with approximately 75% of them being endovascular repairs.

Fluoroscopy and digital subtraction angiography have become two of the most important tools for image-guided interventions. This thesis has shown that use of multimodal image fusion can decrease procedure time as well as iodinated contrast media dose in endovascular procedures. Such a reduction implies large potential benefits for patients undergoing aortic aneurysms repair for their postoperative renal outcome and morbidity. This thesis also explored the translation of fusion technology to other imaging modalities such as in MRA and use in vessel regions with smaller diameters such as peripheral arteries. Many patients who are referred for interventional procedures are at increased risk for contrast-induced kidney injury which can be as high as 30% in patients with common associated risk factors like diabetes and pre-existing renal impairment. Recommended prophylaxis with 1-1.5 ml/kg/hr saline intravenously at least six hours before and after iodinated contrast administration per case induce additional health care costs of about 56 million Euro per year in the Netherlands. In addition to prolonged hospitalization and its' associated costs, the health risk to patients with chronic heart failure due to volume overload is considerable. This thesis intends to promote the benefits of fusion imagining to endovascular surgeons, interventional radiologists and angiosuite technicians. It needs to be broadly recognized that fusion image technology can effectively reduce procedural iodinated contrast media dose or even eliminate application of contrast media when used in combination with other imaging modalities. All state of the art angiosuite systems today are capable of multimodal image co-registration and visualization of hybrid fusion roadmaps. Medical staff involved in fluoroscopy guided interventions should become familiar with multimodal fusion guidance and offer it to patients with renal impairment or other conditions that do not allow iodinated contrast media administration.

The use of X-rays is crucial for endovascular aortic repair, but also associated with certain risks. Radiation exposure to individuals from image-guided procedures has increased substantially, and by some estimates more than 8-fold since 1980. By use of fusion, the medical staff radiation exposure and associated risk of radiation induced injuries can be reduced. Multimodal image fusion might benefit most patients and medical staff if they were translated into a best clinical practice for complex endovascular procedures.

This thesis offers prospects for future research and products as already partly outlined in the discussion. Besides technology that can detect and visualize deformation of the vascular roadmap, further improvement of the workflow of multimodal fusion visualization is necessary. Ideally for any procedure, the pre-operative MDCT or MR angiography studies of a patient would be automatically displayed to the operator in a segmented, 3D fashion. No more should be needed than selecting the preoperative imaging study and loading it into a workstation connected to the hybrid operating room. Ideally, a completely automated co-registration algorithm based on the live fluoroscopic image and automated motion correction would run before and during the procedure. By these means the entire 3D information of preoperative imaging could be directly visualized and made accessible for every intervention. Since fluoroscopic imaging has been introduced in the last century, several milestone technology improvements have increased use and applicability of this technology for patient care. Interactive hybrid holographic visualization during interventions is possible and likely to happen within the next years. This thesis provides several impulses that support the evolution of fusion guidance for becoming a key technology for minimal invasive treatments.