Development of Renal Phantoms for the Evaluation of Current and Emerging Ultrasound Technology

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The primary aim of this project was to develop novel anatomically realistic renal phantoms for the evaluation of current and emerging ultrasound techniques capable of diagnosing all grades of renal artery stenosis. Renal artery stenosis is considered the most common cause of potentially curable secondary hypertension which if left untreated can lead to renal failure. Its early detection is very important as it offers the possibility of various drug treatments, which are considerably less invasive and poses less risk to the patient.

Computer-aided modelling techniques were used to generate a range of anatomically realistic phantoms of the renal artery from medical images of a 64-slice CT scan which was acquired from a healthy volunteer with normal renal vasculature. These phantoms comprised of a normal healthy vessel and vessels with increasing stenosis (30%, 50% 70% and 85%). Using these novel phantoms a comparative study between four of the imaging techniques currently used to detect renal artery stenosis (ultrasound, magnetic resonance imaging, computed tomography and digital subtraction angiography (DSA)) was carried out. A novel kidney perfusion phantom was also developed with the ability to achieve flow velocities comparable with those found in the blood vessels of the renal macrocirculation (renal artery and renal vein) and microcirculation (kidney).

By developing an understanding of disease progression in the renal artery and kidney through experimentation, it is possible to improve the outcome of various

treatment regimes by early detection of the disease. Recent and ongoing ultrasound technological developments such as ultrasound contrast agents should render accessible the technically more challenging imaging of the renal artery and kidneys and potentially replace invasive intra-arterial DSA technique.