Investigating the vesicoureteral reflux in stented ureters by means of in-silico and in-vitro modelling

Background Ureteral stents are frequently used in clinical setting to maintain the drainage of urine from kidney to bladder under obstructed conditions (e.g. kidneys/ureteral stones or tumours) and to secure ureteral patency after urological surgeries. One major side effect of indwelling stent, however, is the vesicoureteral (VUJ) reflux such that urine flows backwards from the bladder to one or both ureters. The reflux can carry bacteria back into the ureter or kidney which can lead to urinary tract/kidney infections. Ureteral stents feature side holes close to the ureterovesical junction as means of reducing the reflux, however the efficacy is still unclear. An in-silico model was developed by Cummings et al. (2004) to investigate the effects of the side holes on the reflux. At ARTORG Center an in-vitro model of urinary tract was developed (Figure) for experimental fluid dynamics investigations in the urinary tract. The proposed study therefore combines both in-silico and in-vitro methods, aiming at providing quantitative insights regarding the dynamics of reflux under different physiological conditions.

Aim In this project, the student will model the urine-flow using existing codes to study the fluid dynamics with/without indwelling stents. In-silico results will be validated with quantitative fluid dynamics investigations using the in-vitro model.

Materials and Methods The student will first study and understand the basic principles of urinary flows. Existing codes (subjected to modifications) and/or open source packages will be provided to the student to perform computational modelling of the VUJ-reflux. Quantitative measurement techniques such as particle image velocimetry or particle tracking velocimetry will be applied to validate the numerical results. Finally, novel strategies to prevent reflux should be considered and proposed.

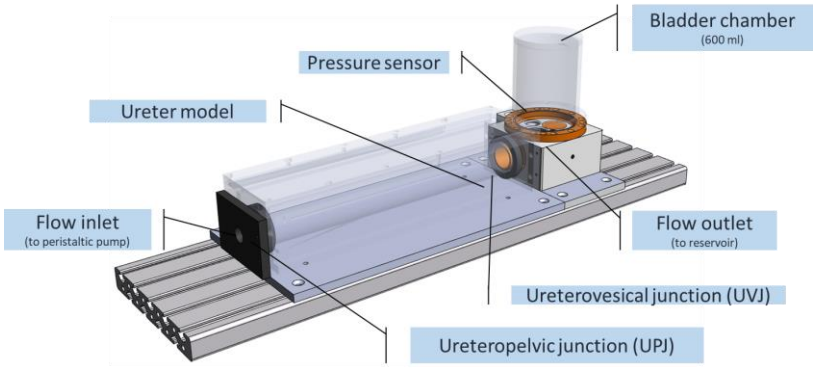

Figure 1Illustration of the in-vitro model developed at ARTORG Center.

Nature of the Thesis:
Numerical study: 60%
Experimental study: 40%

Requirements:
Good knowledge of fluid mechanics
Experiences with mathematical modelling
Strong interests in experiments

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References:
Cummings, L., et al. (2004). The effect of ureteric stents on urine flow: reflux. Journal of mathematical biology, 49(1), 56-82.
Kim, H.-H., et al. (2017). Numerical analysis of urine flow through the side holes of a double J stent in a ureteral stenosis. Technology and Health Care, 25(S1), 63-72.

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