Abstract Submitted
for the DFD19 Meeting of
The American Physical Society

Flow in a cavity: fluid mechanics of kidney stone removal JESSICA G. WILLIAMS, SARAH L. WATERS, DEREK E. MOULTON, BEN W. TURNEY, ALFONSO A. CASTREJON-PITA, University of Oxford — Flexible uretero-renoscopy provides a minimally invasive treatment for kidney stone removal. The ureteroscope is passed to the kidney through a hollow cylinder (access sheath) and has a central lumen (working channel) for surgical tools, such as laser fibres which pulverise stones. Resulting stone dust can impede the view from a miniscule camera at the scope tip; this necessitates irrigation – debris clearance by saline solution, which flows into the kidney through the working channel, and returns via the access sheath. Fast debris clearance allows for efficient ureteroscopy. We represent the renal pelvis of the kidney as a 2D rectangular cavity and investigate the effects of flow rate and cavity size on flow structure and subsequent clearance time. We model fluid flow with the steady Navier-Stokes equations, imposing a Poiseuille profile at the inlet boundary for the jet of saline, and zero-stress on the outlets, allowing for a parallel return flow. Resulting flow patterns in the cavity contain competing vortical structures. We demonstrate the existence of multiple solutions dependent on the Reynolds number of the flow and the aspect ratio of the cavity. We complement numerical predictions with PIV experiments. We model the clearance of an initial debris cloud via an advection-diffusion equation. We determine how the initial position of the debris cloud within the flow, and the Peclet number, affect clearance time, which is prolonged by entrapment of debris within closed streamlines. We discuss flow manipulation strategies to extract debris from vortices and decrease washout time.

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Date submitted: 01 Aug 2019 Electronic form version 1.4