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Input-Output Analysis of Fluid-Structure Interaction to Optimize Stone Breakage in Lithotripsy[1] SHUNXIANG CAO, TIM COLONIUS, Caltech, COMPUTATIONAL FLOW PHYSICS GROUP TEAM — Burst-wave lithotripsy (BWL) is a non-invasive treatment of kidney stones using short pulses of focused ultrasound generated by a multi-element array medical transducer. In this work, we apply input-output analysis to optimize the design parameters of the transducer to optimize stone breakage. The frequency-domain analysis is based on a linear fluid-structure coupled system that maps the acoustic forcing from individual elements to the stress and strain in the stone. We maximize a cost function that represents the strain energy in the stone, and determine the forcing that gives rise to the maximum amplification. Specifically, the optimal forcing and the corresponding response are found through the singular value decomposition of the resolvent operator of the system. The result shows that under the same input energy, altering the amplitude and the phase of elements along the array can lead to an increase of strain energy (by 2-3 times in certain cases) compared to a uniform distribution. This indicates that the stone fragmentation could be accelerated or performed at a lower and hence safer level of energy. Results for optimizing other design parameters, including array geometry, focal distance and aperture, will also be presented.

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