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Damage potential of single-bubble collapse in shockwave lithotripsy

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In shockwave lithotripsy, the combined effect of focused shockwaves and cavitation pulverizes kidney stones. Although cavitation is known to play an important role in stone comminution, the underlying mechanism is not fully understood. The goal of the present study is to quantify the potential damage caused by Rayleigh collapse (RC) and shock-induced collapse (SIC) of a single bubble near a stone. A high-order accurate, quasi-conservative, shock- and interface-capturing scheme [E. Johnsen and T. Colonius, J. Comput. Phys. 2006] is employed to simulate both phenomena. A high-speed re-entrant jet forms during the collapse and hits the distal side of the bubble, thereby generating a water-hammer pressure wave. A high pressure is measured along the stone surface upon the impact of this wave, thus providing potential for erosion. In SIC, this pressure may reach 1 GPa and bubbles within approximately 15 initial radii generate a pressure higher than the incoming pulse. In addition, by using the present results as time-dependent boundary conditions for an elastic wave propagation code, it is shown that a tension large enough to lead to failure may be achieved within small stones or fragments.
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