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Evaluation of Renal Calculi Passage While Riding a Roller Coaster

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To the Editor

I applaud the ingenuity of Drs Mitchell and Wartinger in their article, “Validation of a Functional Pyelocalyceal Renal Model for the Evaluation of Renal Calculi Passage While Riding a Roller Coaster.”¹ I am amazed at the extensive attention the article received in the press, and I look forward to their future work.

I have 2 comments. First, the authors quoted 300,000 kidney stone–related emergency department visits annually in the United States, but other literature has reported 1,300,000.²

Second, Wartinger and Mitchell demonstrated that kidney stones can be shaken out of a kidney model, and at the University of Washington, we developed a system whereby kidney stones are non-invasively pushed out of the kidneys of human participants.³ Using ultrasonography, with the probe in contact with the skin, images are made of the kidney and ureter. Then the ultrasound waves are focused on the kidney stone. The energy of the wave imparts momentum to the stone, which makes the stone hop.

Fifteen conscious participants were asked to hold their breath to aid alignment. In 2 cases, ultrasonography was used during the operation to remove the kidney stones to investigate improving surgical access to large stones. Stones were repositioned in 14 of 15 participants. No adverse events or pain was observed. After the surgery, 4 of 6 participants passed residual fragments after the stone-pushing treatment. In 6 participants, what appeared to be a single large stone on clinical imaging turned out to be a collection of small passable stones. One participant had pain and a large stone in the ureteropelvic junction and felt immediate relief of that pain once it had passed.

Our work is funded by the National Institute of Diabetes and Digestive and Kidney Diseases and the National Aeronautics and Space Administration (NASA) through the National Space Biomedical Research Institute and is part of a larger effort to improve ultrasonography of kidney stones and, within the same system, test a new method to break stones called *burst wave lithotripsy*.^{4–7} Kidney stones are of particular concern for astronauts and members of the military. Bone demineralization, stasis, dehydration, and changes in urine chemistry increase the risk of kidney stones in space. Kidney stones have been documented in

astronauts after their return to Earth and in 1 cosmonaut during flight.⁸ Environmental factors associated with deployment and training increase the risk of kidney stones in military personnel, thus decreasing military operational effectiveness. The rates of incident diagnoses of urinary stones increased in the active component of the US Armed Forces during 2001–2010.⁹ On average, more than 8000 diagnoses were made, and 60 service members were medically evacuated from combat zones each year during the decade.⁹

Clinical trials continue at the University of Washington in collaboration among the Department of Urology, the Department of Emergency Medicine, and the Applied Physics Laboratory. Each year, the whole system is made available for hands-on testing at the exhibit hall of the American Urological Association. Improved kidney stone imaging and stone pushing have been added to NASA's Flexible Ultrasound System, which is the current system designed for use on the international space station and exploration missions.

Overall, our applications are similar to the clinical objectives of Mitchell and Wartinger and may be more simply and controllably achieved. As with their study, our system tested in humans can expel small stones or fragments from the kidney. This treatment would allow people to return to work or regular activities without the threat of an acute condition. In addition, we could conceivably treat a patient in the emergency department, when riding a roller coaster would not be possible.

With regard to the magnitude of forces between a roller coaster and ultrasonography, roller coasters generate a g-force as much as 6 times the acceleration of gravity, essentially 6 times the weight of a kidney stone. The acoustic power to generate a radiation force equivalent to the normal gravity weight of a 1-cm stone in urine is 7 W, which, distributed across the stone's cross-section, is approximately 7 W/cm². Our maximum approved ultrasound intensity is 200 W/cm², approximately 30 times higher. So, in a hand-waving way, the forces of the roller coaster are similar to, but a little weaker than, those of the ultrasound and are also random, whereas the ultrasound is directed to steer the stone. (doi:10.7556/jaoa.2017.069)

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