Fiscal Year:	FY 2015	**Task Last Updated:**	FY 04/03/2015
PI Name:	Wessells, Hunter B. M.D.		
Project Title:	First Clinical Test of Feasibility of Ultrasound to Reposition Kidney Stones		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Smart Medical Systems and Technology Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **ExMC**:Exploration Medical Capabilities		
Human Research Program Risks:	(1) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
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No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Bailey, Michael (University of Washington) Harper, Jonathan David (University of Washington) Dunmire, Barbrina (University of Washington) Coburn, Michael (Baylor College of Medicine) Lingeman, James (Indiana University School of Medicine)		
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INTRODUCTION AND OBJECTIVES: Ultrasonic propulsion is a new technology we have developed that uses focused ultrasound energy to transcutaneously reposition kidney stones. On Earth and in space, the use is to expel small stones from the kidney so they will pass naturally before requiring surgery or to prevent large stones in the kidney from obstructing and causing pain or requiring urgent surgery. On Earth, the technology could also be used to expel fragments remaining after surgery that may grow to cause recurrent symptoms. Safety and effectiveness has been demonstrated in a porcine model. We report the findings from the first use of this technology in humans.
METHODS: Studies were conducted with the approval of the University of Washington Investigational Review Board and the U.S. FDA through an Investigational Device Exemption. This was an investigator-sponsored study funded by the National Space Biomedical Research Institute (NSBRI) without commercial involvement. Thirteen awake, non-anesthetized subjects were studied without restriction of patient body habitus, stone size, or stone location. Ultrasound imaging and a pain questionnaire were completed before, during, and following propulsion. An additional two subjects underwent stone repositioning during ureteroscopy (URS). All subjects were followed weekly for three weeks.

RESULTS: Of the 15 subjects, 11 were male; average age was 56 ± 11 years; average BMI was 29 ± 3; and stone size range was dust to 13 mm. There were 6 left and 10 right kidneys treated. Two patients reported skin discomfort and sensation at depth with a few pushes.

Task Description:	Otherwise, there was no pain or adverse effects associated with the treatment. Stones were localized with the system and repositioned in all but one subject. In total, the system targeted and repositioned stones from all parts of the kidney and ureteropelvic juncture (UPJ, kidney outflow tract) including the lower pole (20 targets), midpole (10 targets), upper pole (6 targets), and renal pelvis/UPJ (7 targets). In two subjects measurable displacement was only seen after pushes as the subjects rolled over on the table. Average skin-to-stone distance was 6.5 cm, as the probe was small enough to push under the ribs with subjects on their side; although when this was not possible, such as during URS, stones were imaged and repositioned at depths greater than 11 cm. Stones were repositioned to a new location in all 6 post-lithotripsy patients, while 4 of the 6 passed over 30 stone fragments within a few days of treatment. One passed two 2 mm fragments immediately after the completion of treatment. Of the two that did not pass stones, one subject felt pain consistent with passing a stone but did not observe stone passage. De novo stones and stones as large as 8 mm were repositioned in awake patients and during URS, although movement was not as great as seen with residual fragments. In four of the 15 subjects, what was noted in clinical imaging as a single, potentially unpassable stone was shown to be several passable stones upon repositioning with ultrasound. CONCLUSIONS: Ultrasonic propulsion can safely and without pain reposition kidney stones in humans. Treatment was therapeutic in four subjects and provided diagnostic information in four. Overall, the initial clinical trial was successful and warrants continued research and development. Cost and time from concept to human demonstration were $6M and 5 years.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	More U.S. citizens have had kidney stones (nephrolithiasis) than have diabetes or heart disease. Direct and indirect costs are estimated at $5B annually. Our stone-moving technology has the potential to cuts risk, costs, and time by preventing surgeries, ER visits, and follow-on x-ray imaging procedures. The product utilizes transcutaneously delivered ultrasound waves to reposition kidney stones. Small stones can be expelled from the kidney preventing surgery and multiple follow-up x-ray exposures. Large stones can be moved deeper into the kidney to alleviate pain and obstruction and avoid emergency surgery. Fragments remaining after surgery can be expelled or repositioned for more effective treatment. With the handheld probe against the patient's skin, the user visualizes the stone and kidney on an ultrasound image, touches the stone image on the touchscreen monitor, and observes that the ultrasound simultaneously moves the stone and maintains real-time imaging. The application to move stones is novel, and our implementation is via novel software on OEM hardware. The technology is non-invasive, doesn't require the patient to be anesthetized and may be used in the urologist's office as well as in the operating room (OR) and emergency room (ER) to provide initial treatment or to supplement surgical treatment. This is the report of the NSBRI-funded, first trial of ultrasound to reposition kidney stones in human subjects.
Task Progress:	Patients presenting to the University of Washington (UW) urology clinic with a documented kidney stone on imaging were screened for this study. Those who met the study criteria and indicated initial willingness to participate to the clinical staff were approached by research staff. The research staff explained the study and obtained informed consent. During the funded year the specific aims were completed and the pilot human study enrolled all 15 approved subjects per protocol. Investigative Procedures included: a) Prior to the ultrasound study, participants completed a baseline pain questionnaire. b) Participants underwent a diagnostic ultrasound examination by a certified sonographer and Dr. Harper with the investigational device. This verified the stone was visible on ultrasound and near the location identified on the most recent diagnostic imaging. c) A video of the ultrasound exam screen was recorded. Select images of the kidney anatomy and stone were also captured. d) Participants underwent stone pushing with the investigational device. The operator began with 50-V output and increased to 90-V as necessary. Patient feedback on discomfort was recorded after each of the first 3 pushes and when noted otherwise. e) A second video of the ultrasound image from the first frame of the Push to 15 frames after the Push, and listing of the system settings, including the target location and Push power, were recorded automatically to the system hard drive. The patient position, stone position, and result of the Push burst were recorded manually. There were three potential types of motion for each push pulse, 1) no motion, 2) moved but trapped within a confined space, such as a calyx, 3) translation of the stone to a new location. A fourth option was (U) unintended Push. The IDE limited a maximum of 40 push pulses in a single session. f) Participants underwent a second diagnostic ultrasound exam to confirm the location of the stone after treatment. A video of the exam was recorded, and select images of the kidney anatomy and stone were captured. g) Participants completed a second questionnaire at the completion of the exam addressing any discomfort or pain they may have felt related to the procedure. h) Research staff contacted the patients by telephone each week for three weeks and reviewed their charts weekly for 90 days to assess for acute colic events, stone passage, and/or additional intervention. i) Subjects who might pass stones were asked to screen their urine and after 4 weeks received a clinical ultrasound exam to assess location and number of remaining stones. Otherwise in subjects scheduled to undergo surgery following the procedure, ureteroscopy video and notes were saved relating the number, location, size, and tissue attachment of stones.
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