NIH-funded study to develop virtual reality simulator for 'scarless' endoscopic surgery

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New study uses virtual reality tools to accelerate development of next-generation natural orifice translumenal endoscopic surgery

Researchers at Rensselaer Polytechnic Institute have secured a $2.7 million grant to develop the first-ever virtual reality simulator for next-generation "scarless" endoscopic surgery.

The four-year study, funded by the U.S. National Institutes of Health (NIH), seeks to accelerate the development of natural orifice translumenal endoscopic surgery, or NOTES. This emerging surgical technique shows promise for operating in the human abdomen with no external incisions, no external scarring, less pain, and potentially a lower risk of post-operative infection and immobility.

In NOTES, a flexible endoscope is inserted through a natural orifice, such as the mouth, anus, or vagina. A small internal incision in the stomach, vagina, bladder, or colon then allows the endoscope access to the abdominal cavity. Potential NOTES procedures, for example, are removal of the pancreas or appendix through a patient's mouth.

While "scarless" procedures are promising, the development of tools, techniques, and platforms are currently based on extensive animal testing. Rensselaer Professor Suvranu De, who is leading this new study, said NOTES will benefit greatly from computer-based modeling and simulation - which in recent decades has redefined the way most engineering systems, from aircrafts to microprocessors, are designed. To accomplish this, De's team will develop a touch-sensitive virtual reality simulator for NOTES. The system will build from De's NIH-funded work on creating simulation technology for laparoscopic surgery.

"NOTES is a revolutionary surgical paradigm that is viewed as a natural convergence of diagnostic endoscopy and minimally invasive surgical procedures," said De, director of the Center for Modeling, Simulation and Imaging in Medicine (CeMSIM) at Rensselaer. "However, the current enthusiasm regarding NOTES should not overtake a cautioned approach to its implementation. Our new simulator will help evolve NOTES procedures, and will emerge as a platform for surgeons to learn, practice, train, and become certified in NOTES techniques before attempting them on human patients."

De is also a faculty member in the Department of Mechanical, Aerospace, and Nuclear Engineering at Rensselaer, with a joint appointment in the Department of Biomedical Engineering. Partnering with Rensselaer on this study are Beth Israel Deaconess Medical Center, Massachusetts General Hospital, Cambridge Health Alliance, Children's Hospital Boston, and Tufts University in Boston.

Endoscopic procedures, such as a colonoscopy, involve inserting a flexible endoscope into the body. Endoscopes are equipped with a light, camera, and other tools that allow surgeons and physicians to

perform a large number of operations and procedures. The progression of the endoscope through the body is guided by the surgeon via handheld controls.

In NOTES, tiny surgical instruments advance through the endoscope and enter the abdominal cavity by perforating the wall of the stomach, colon, vagina, or other viscera. After performing the surgery, the instruments are withdrawn and the visceral wound is closed. Researchers are currently using animal studies to advance and perfect this technique, but these tests often result in difficulties during the procedure as well as post-operative complications.

To move away from slow and costly animal testing, and to help discover optimal techniques for accessing different internal organs via NOTES, De and his interdisciplinary team will develop a touch-sensitive NOTES virtual reality simulator. The system will feature custom robotic interfaces and computational technology developed at CeMSIM to provide an environment that looks and feels identical to what a surgeon would experience when performing the procedure on a live patient.

The simulation's realistic computer-generated models are displayed on a monitor, and users interact with the simulation both visually and using their sense of touch. The simulator's advanced haptic touch-feedback system feels like the real thing - a physician cutting or manipulating tissue with the simulator will feel with their hands the lifelike toughness, sponginess, and resistance of virtual tissue.

De said the key challenges related to creating a NOTES simulator include developing realistic hardware interfaces, accurate computer models of multilayered hollow organs such as stomach and intestines, and realistic simulations for the interaction of flexible surgical tools with soft tissues in real time.

"The aim of this study is to overcome these preliminary challenges, and develop the first virtual reality NOTES simulator that is firmly based on physical experiments and surgical experience. The simulator must also be realistically responsive to physiological consequences of surgical complications," De said. "There's still much work to be done, and much validation, before we can think about using NOTES or our NOTES simulator in a clinical setting. But this study places us on the right path to advancing this promising, exciting new technology."