

Chapter 78

Modular Assembly Micro– Robots for Natural Orifice Transluminal Endoscopic Surgery: The Future of Minimal Invasive Surgery

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ABSTRACT

Surgical operations are progressively being performed using minimally invasive techniques. Natural Orifice Transluminal Endoscopic Surgery (NOTES) is a novel surgical technique that uses the natural orifices of the human body in order to approach the peritoneal cavity. There are two basic types of robotics for NOTES; the external robots that stay outside the patient but act inside the abdominal cavity, and the internal robots that stay and act in the abdomen. The internal robots could only be mini-robots. The development of modular assembling reconfigurable micro-robots is a revolutionary idea for the NOTES. Modular micro-robots consist of small subunits which could be assembled and construct a functional miniature robot. These surgical micro-robots may increase the possibility for true scarless tele-surgery. Although specific applications of intrabdominal surgical micro-robots are still in an early concept stage, the field is rapidly evolving. In the future, patients may be operated by specialized micro-robotic intrabdominal surgeons.

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INTRODUCTION

Natural Orifice Transluminal Endoscopic Surgery

Surgical operations are progressively being performed using minimally invasive techniques; laparoscopy is an established method for many surgical conditions. The evolution of minimally invasive surgery may well be the elimination of surgical incisions on the abdomen. Natural orifices of the human body are potential entrances to the peritoneal cavity. This approach involves the perforation of hollow viscera, which in itself presents a major complication of endoscopic surgery associated with significant morbidity and mortality (Merchea et al., 2010). However, in 2004 Antony Kalloo presented his experience in transgastric surgery, providing the basis for Natural Orifice Transluminal Endoscopic Surgery. In his study, he concluded that the peroral transgastric approach to peritoneal cavity technically is feasible and has the potential to provide an alternative to laparoscopy and laparotomy (Kalloo et al., 2004). Marescaux et al. performed in 2007 the first NOTES cholecystectomy in a human being (Marescaux et al., 2007).

This new evolutionary technique has been named by the American Society for Gastrointestinal Endoscopy (ASGE) and the Society for American Gastrointestinal Endoscopic Surgeons (SAGES), NOTES®, from the initials of the words “Natural Orifice Transluminal Endoscopic Surgery.” The same practices used for laparoscopic surgery are followed by NOTES. The difference is in the way of the approach of the peritoneal cavity and the use of flexible endoscopy instruments. In NOTES the peritoneal approach is made through the natural orifices of the human body; mouth, vagina, anus, urethra (transgastric, transvaginal, transrectal, transvesical approach), where flexible endoscopes can easily enter. After the perforation of the respective hollow viscera the pneumoperitoneum is established with the introduction of

carbon dioxide in the peritoneal cavity. The accessory channels of the endoscopes are utilized to insert tools for manipulation of the target organ. Upon completion of the surgical operation, the hollow visceral incision is repaired and the endoscope withdrawn through the natural orifice (McGee et al., 2006). These flexible endoscopes are used as all-in-one surgical instruments, thus providing light, images (video) and tools and are handled by one to three operators-surgeons (Ko & Kalloo, 2006). Current flexible endoscopes offer minimal triangulation and 2D imaging and thus impair surgical manipulation. Successful application of NOTES has been demonstrated in experimental animal and clinical human studies using either the transgastric, transvaginal, transvesical or transcolonic route (Clark et al., 2012). Various abdominal surgical procedures such as cholecystectomy, appendectomy, urological and renal procedures, organ biopsy, gastrointestinal anastomosis, oophorectomy, tubectomy and other organ resections are feasible with NOTES (Bergström et al., 2006; Decarli et al., 2009; Horgan et al., 2009; Kantsevov et al., 2005; Marescaux et al., 2007; Wagh et al., 2005, 2006; Zorron et al., 2010). However NOTES remains experimental with limited clinical applications.

The evolvement of NOTES is strictly connected to technology. In the NOTES Working Group White Paper that has been published for the first time in 2005 by the Natural Orifice Surgery Consortium for Assessment and Research™ (NOSCAR®) and updated in 2011, are described the technical difficulties for the evolution of NOTES and is emphasized the need of progress with the help of surgeons and gastroenterologists (Rattner et al., 2011). Furthermore potential barriers to clinical practice are described. Some of these barriers have not been over passed until now even in experimental models. However, the crucial point is the certain need of a new “toolbox” for the surgeon. The technological development for NOTES is different from the conventional flexible endoscopy or laparoscopy. Tissue manipulation

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