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- INTRODUCTION OF SURGICAL ROBOTICS SYSTEMS
- INTEGRATION OF ROBOTICS INTO THE CLINICAL SETTING
- VIRTUAL REALITY SIMULATION IN LAPAROSCOPIC SURGERY
- OBJECTIVE MEASUREMENT OF SURGICAL SKILL USING LAPAROSCOPIC SIMULATORS

AWARDS

International Conference of Robotics and Automation

- The Blue DRAGON – A System for Measuring the Kinematics and the Dynamics of Minimally Invasive Surgical Tools In-Vivo, Best Paper Award Finalist

Introduction of Surgical Robotics Systems

Many recent advances in surgery concentrate on minimizing the invasiveness of a procedure which improves outcome and patient satisfaction. Yet, in the conversion from traditional open surgery to minimally invasive surgery, the surgeon has lost several degrees of hand and wrist freedom as well as 3D visualization. As surgery enters the technology age, many innovations integrate computer systems to allow for enhancement of visualization, accuracy, dexterity and stability. Surgical robotic systems are an extension of this type of computer-aided surgery in combination with minimally invasive or endoscopic technique. These systems provide surgeons with the dexterity and depth perception that are lacking in standard endoscopic equipment. Moreover, maximal precision can be achieved through "motion scaling" in which large hand movements are translated and reduced into fine instrument movement. Further developments in technology will create virtual immobilization which gives the illusion of stillness to allow for beating-heart surgery. The potential clinical applications of surgical robotics are vast.

Integration of Robotics into the Clinical Setting

Surgical robotics systems are being integrated into operating rooms all over the world. With the degree of sophistication in these systems, it is no longer sufficient to simply purchase the equipment and begin clinical use without proper training. While the surgeon may receive extensive instruction through courses and proctoring, the ancillary services are often overlooked. Our goal is to create a systematic approach for the clinical intro-

duction of a surgical robotics system which involves the entire surgical team.

Surgeons require hands-on training in both a dry lab setting as well as an animal or cadaver lab. For centers that do not have animal or cadaver labs, this type of training must be sought out in established centers. Instruction should not only be focused upon robotic skills practice, but also equipment setup, system capabilities and limitations, and troubleshooting. A checklist of tasks with established goals should be outlined. The amount of time needed to achieve mastery may be highly variable. Regardless, surgeons must be able to document their training and abilities in order to obtain privileges to operate these systems.

Operating room nurses also need detailed instruction in equipment setup, instrumentation, sterilization techniques, and patient safety issues. Practice sessions in the operating room with mock patients simulate the actual procedure and allow the staff to iron out any inefficiencies. In-servicing is also mandatory for the instrument room and clinical engineering to ensure the proper care, cleansing, servicing and storage of the system. In addition, proper education of clinic nurses and patient care coordinators who often address patients' concerns is paramount to a successful robotic operation. Informational handouts should be developed specifically for patients emphasizing systems operation, surgeon presence, and patient safety.

We have successfully incorporated robotic technology into our operating room at UWMC. We have shown that the clinical introduction of this technology can succeed through the use a systematic approach to training and education which includes surgeons, nurses, support staff, and patients.

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Virtual Reality Simulation in Laparoscopic Surgery

Laparoscopic surgery has become a mainstay of the general surgery armamentarium. Its mastery, however, requires a unique set of operative skills. The psychomotor challenges inherent in laparoscopic manipulations have frustrated skilled surgeons and trainees alike. Compared with traditional open surgery, laparoscopy requires the surgeon to perform tasks using a two-dimensional videoscopic image of the operative field while viewing only the tips of the instruments. Laparoscopic instruments are longer than traditional instruments and the surgeon's hands are therefore far removed from the working ends. These instruments also provide muted tactile feedback. Finally, a "fulcrum effect" exists where directional movements of the surgeon's hand result in contrary deflections of the working end of a laparoscopic instrument, creating a disparity between visual and proprioceptive feedback. These variables impact the laparoscopic novice until he or she learns to adjust through extensive psychomotor practice.

Another unique aspect of laparoscopic surgery is the limited ability of the mentor to control the operative field for the trainee. In order for the trainee to perform a procedure, he or she must be given full control of the operating instruments leaving the mentor to instruct by verbal coaching rather than physical guidance. This experience can provoke anxiety and frustration in trainee and mentor alike. In order to overcome these limitations, a number of inanimate and animate models have been developed to help the trainee hone their laparoscopic skills. The sophistication of these training devices has varied from periscope viewing and foam rubber organs to live animal labs. The development of powerful personal computers has made virtual reality training a more recent possibility for developing laparoscopic skills. These trainers can simulate many of the steps of laparoscopic surgery such as manipulating tissue, clipping, cutting, and even suturing. The potential for greatly enhancing laparoscopic surgical training is great. Now the trainee can work independently in a life-like environment on a platform that is available 24-hours a day. Basic tasks can be rehearsed until mastered without impacting patient outcome or undue utilization of operating room time.

Many studies have demonstrated that trainees who practice laparoscopic skills in a simulated environment will improve their mastery of those skills when tested in that same environment. Fewer studies have been able to demonstrate a direct correlation between such simulation training and improved performance in the operating room. Our group is participating in a multi-center trial which will investigate whether a training curriculum involving a virtual reality laparoscopic simulator (LapSim[®], Surgical Science Ltd, Göteborg, Sweden) will help surgical residents gain mastery of the skills necessary to complete a laparoscopic cholecystectomy.



FIGURE 1: Virtual reality laparoscopic simulator

Objective Measurement of Surgical Skill Using Laparoscopic Simulators

Providing a safe and efficient training environment for our surgical residents to become the future leaders in surgery is a primary goal of any academic institution. Attaining this goal can be a challenge given new reductions in resident work hours and societal distrust of resident training. The use of surgical simulators appears to improve surgical training, but few criteria have been established to document objective assessment of technical skill.

At the University of Washington, the departments of Surgery and Engineering have constructed and validated the BlueDRAGON™ system in a live swine model, which allows objective assessment of laparoscopic surgical performance. The system acquires force/torque (kinematics) and motion (dynamic) information from the tip of an instrument during performance of surgical tasks. Our previous analysis of data reveals that surgeons of different levels of skill from novice to expert show varying patterns of states while surgeons with similar levels of skill show characteristically similar patterns. Therefore, a particular surgeon's kinematic and dynamic

data can be analyzed and objectively correlated to a degree of technical expertise.

Our goal is to develop and validate *inanimate* surgical training models for use with the BlueDRAGON™ system to objectively measure surgical skill. Residents at all levels as well as attending laparoscopic surgeons will perform surgical tasks while their performance data is collected by our novel system and then analyzed. As residents proceed through training, their improvement in technical skill can be further evaluated. This will provide safe and efficient training with objective feedback to residents as they acquire surgical expertise.

RELATED PUBLICATIONS

1. Rosen J, Brown J, Barreca M, Chang L, Sinanan M, Hannaford B. "The BlueDRAGON - A system for monitoring the Kinematics and the dynamics of endoscopic tools in Vivo in the quest for developing an objective evaluation methodology of minimally invasive surgical skills." *In Medicine Meets Virtual Reality*, Westwood et al (Eds), IOS Press, Amsterdam, 2002, pp. 412-18.
2. Chang L, Satava RM, Pellegrini CA, Sinanan MN. "Robotic Surgery: Identifying the learning curve through objective measurements of skill." *Surgical Endoscopy*, Sept 10, 2003, (electronic publication ahead of print).

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