TP001

HAPTIC FEEDBACK SYSTEM FOR ROBOTIC SURGERY, Erik P Dutson MD, Roy Hwang,Ali Douraghy,John Zhang,Arthi Vijayaraghavan,Carlos Gracia MD,Warren Grundfest MD, 1UCLA Interdepartmental Biomedical Engineering Department2UCLA Section of Minimally Invasive and Bariatric Surgery, 3UCLA Center for Advanced Surgical and Interventional Technology (CASIT)

OBJECTIVE

Currently available surgical robotic systems do not provide the surgeon with classic tissue-level haptic feedback. This presentation will outline a plan for introduction of the tactile component in a force sensing robotic grasper based on technologies developed in our Institute.

DESCRIPTION OF THE TECHNOLOGY

The proposed instrument design will relate forces sensed by a surgical grasper directly to the surgeon. The actuation of measured forces is done through a unique finger glove design which related forces using micro-actuating balloons. The actuation balloons comprise a non-linear surface array which will allow feedback information directly to the surgeon?s hands. The design incorporates finger glove actuation controls onto a Da Vinci surgical robotic system. The device transmits force information from the surgical field to the surgeon using MEMS actuation, via micro-balloons originally used for the delta wing aircraft. Balloon actuation is the deformed shape of the silicone rubber, activated by pressurizing and decompressing via a miniature solenoid valve. The balloon actuators can deflect up to 2-mm, with a step response under 50 Hz for a force of greater than 100 mN, and have a pressure range from 0 to 20 psi. The balloons do experience deformation at high pressure and the pressure deflection relationship can be easily characterized. The final concept is a force sensor on the instrumentation that transmits information to a processing circuit and the micro-balloon actuator, which will then provide tactile feedback information to the operating surgeon.

CONCLUSIONS/FUTURE DIRECTIONS

There is an overwhelming body of evidence suggesting minimally invasive surgery is a superior method of surgery with proper patient selection based on cost, complications, short term quality of life, and return to normal functioning. The profound alteration in tactile feedback has contributed to the long learning curves of laparoscopic procedures. Robotic surgery offers some potential benefits in the transition to minimally invasive techniques for the learner, however, lack of tactile feedback is a major drawback that currently undermines its true potential. Reintroduction of tactile feedback may reduce the training time needed, and may also allow for more precise control during delicate laparoscopic and robotic surgical procedures.

TP002

ENDOSCOPIC INTRALUMINAL SUTURING IN POSTOPERATIVE ROUX-EN-Y GASTRIC BYPASS PATIENTS, Michael A Schweitzer MD, The Johns Hopkins University School of Medicine

Objective: Endoscopic intraluminal suturing devices are currently being used to treat gastroesophageal reflux disease. These suture devices now afford us the opportunity to operate on the stomach pouch of post-operative gastric bypass patients.
Methods: Five postoperative gastric bypass patients underwent endoscopic intraluminal surgery from November 2002 to October 2003 using a flexible endoscopic suturing device with a standard 11mm endoscope. Four patients with a dilated gastrojejunostomy (GJ) anastomosis and weight regain had their stoma's reduced in size. One patient had a leak after undergoing a conversion from a vertical banded gastroplasty to a gastric bypass. A gastric pouch false diverticulum remained after the drain had finally been removed. The false diverticulum was closed with 3 sutures after injection of fibrin glue.
Results: Successful stoma plication was performed on all four patients to narrow their dilated stomas that were measured at over 2cm preoperatively too less than 15mm postoperatively. Two patients had their gastric pouch plicated near the stoma. The one patient who had a gastric pouch false diverticulum closed with fibrin glue into the tract and suture closure of the opening has been asymptomatic.
Conclusion: Upper endoscopic intraluminal suturing is an exciting new field of emerging technology that will, in time, find its role in gastric surgery. The gastric pouch and stoma of postoperative gastric bypass patients is within reach for endoscopic intraluminal therapy. The current devices available were designed for gastroesophageal reflux disease. They will need further refinement to allow more flexibility so as to gain easier access to the rest of the stomach and not just the gastroesophageal junction

TP003

ENDOSENSE: THE FUTURE OF FORCE FEEDBACK, Kathryn Done' MS, Timothy N Judkins MS,Allison DiMartino MS,Dmitry Oleynikov MD, Human Centered Designs, University of Nebraska Medical Center

OBJECTIVE: The EndoSense, patent-pending, was designed primarily to provide the laparoscopic surgeon with ever more information about the surgical area. This is a laparoscopic grasper tool which provides force feedback from the grasper tip to the fingertips controlling the force. The EndoSense is also a more comfortable and functional tool, using ergonomic concepts to design a tool which better fits the user.
DESCRIPTION: The EndoSense is specifically designed to provide the user with an intuitive, comfortable, and functional surgical tool. The force feedback felt at the fingertips, which provides the user with information about the magnitude of force being exerted on what he/she is grasping, is one of the major functional advantages of this tool. When the surgeon has more information about what is happening inside the patient, this will make for a safer and less stressful procedure. (Laparoscopic surgery is an artificial interaction, but this helps make it feel more real.) The unique features of this tool include the following:
-Force feedback of grasping tissue via a novel spring-motor system
-Ergonomic handle that decreases discomfort during lengthy use
-Two finger paddles that have an intuitive movement imitating the movement of the graspers
-Use of the thumb and index finger to reduce fatigue on the hand.

As the graspers receive resistance from the tissues within the patient, a force sensor within the tool transmits that force into resistance in the two finger paddles. This transmission of force mimics what the surgeon would feel if he/she were working with traditional open surgical tools.
CONCLUSIONS: Endoscopic surgery is one of the fastest growing surgical fields, and in need of continued improvement and innovation. Sensing the forces being exerted on tissue is one more way to equate endoscopic surgery to open surgery and thus decrease training time before surgery and errors during surgery.

TP004

ROBOT-ASSISTED 3D STRAIN IMAGING FOR MONITORING THERMAL ABLATION OF LIVER, Emad M Boctor MSc, Michelle DeOliveira MD, Gabor Fichtinger PhD,Russell H Taylor PhD,Michael Awad MD,Michael A Choti MD, Johns Hopkins University

Objective: Primary and metastatic liver cancer represents a significant source of mortality worldwide. An increasing interest has been focused on thermal ablative approaches, in which monitoring the ablation process in order to document adequacy of margins during treatment is a significant problem. Ultrasound is the most commonly used modality for target imaging and ablation monitoring. However, the appearance of ablated tumors in conventional ultrasound only reveals hyperechoic areas from microbubble and outgasing, but cannot sufficiently visualize the margin of tissue coagulation.

Materials and Methods: We capitalize on the changes of tissue elastic properties occurring during heating and protein denaturation, based on prior work of Ophir et al. They also measured elastic properties indirectly by creating mechanical disturbance such as compression and evaluating the resulting response in ultrasound, In contemporary practice, however, lack of controlled compression often results in compromised or false reading. Our approach to this problem is to apply precise mechanical compression by mechanical arm. We acquire radiofrequency ultrasound (RFUS) data from the tissue in both rested and stressed states and then estimate the induced strain distribution by tracking speckle motion. The experimental system consists of a Siemens Antares ultrasound scanner to generate RFUS measurement, a robotic arm to provide accurate compression and controlled 3D sonography, and Radionics and RITA ablators.
Experiments and Results: We performed proof-of-concept in vitro experiments on fresh bovine liver. The samples were degassed and placed in a gel-based phantom. The ablation protocol was repeated for different ablation durations (2, 3, 5, and 7 minutes) and temperature ranges (50, 75, and 100 degree Celsius). We compared the strain images, pathological examination, and conventional B-mode images of the thermally treated liver samples. The strain images were found to be consistent with the pathological margins, while the B-more images were inconclusive.
Future Directions: Currently, we are in the process of repeating the in vitro studies with a refined experimental protocol, in a more controlled manner, and on a larger number of samples, before progressing onto in-vivo animal studies. We also investigate the integration of strain based and thermal imaging. Preliminary results promise the ability of deriving accurate temperature maps based on speckle motion.

TP005

PLUG-AND-PLAY INTEROPERABILITY OF MEDICAL DEVICES IN THE OR OF THE FUTURE, Julian M Goldman MD, Susan F Whitehead BA,David W Rattner MD, Massachusetts General Hospital and CIMIT, Boston, MA, USA

INTRODUCTION: The OR is a complex and potentially dangerous environment, where clinicians rely on teamwork and a patchwork of systems to mitigate hazards instead of using automated safety systems (interlocks). Clinicians can?t easily achieve situational awareness or control devices in the OR environment. There is an absence of smart alarms and automated clinical decision support, and no technological infrastructure exists to implement the required solutions.
Proposed Future State: Widespread implementation of open-standards-based Plug-and-Play (PnP) medical device interoperability in the OR of the Future (ORF) will facilitate comprehensive data COMMUNICATION and medical device CONTROL. Adoption of ORF PnP standards will lower the barrier to the deployment of innovative networked medical device technologies.
- Benefits of COMMUNICATION interoperability:
Comprehensive population of the EMR, enhanced clinical situational awareness and decision support tools, information for QA and process improvement.
- Benefits of CONTROL interoperability: Device-device control with implementation of safety interlocks, remote user actuation of devices, ?distributed? medical devices such as distributed sensor networks, etc.
METHODS and RESULTS: The MGH/CIMIT[1] ORF PnP program was established to produce a framework for the development of safe and effective consensus medical device interoperability standardization. The program was initiated by MGH and CIMIT with a DoD-supported meeting in May 2004. Meeting goals were to identify stakeholders, define the project scope, and form working groups. Over 80 attendees included clinicians, IHDNs, >20 manufacturers, FDA , and DoD[2]. We formed multidisciplinary working groups and agreed to concentrate initial efforts on identifying high-level clinical user requirements for the proposed system. At the 2nd meeting, hosted by the US FDA in Nov 2004, and at meetings at the American Society of Anesthesiologists and the Society for Technology in Anesthesia (STA), many clinical requirements were elicited and existing connectivity standards were identified for potential adoption. The STA formed a task force to support ORF PnP. Similar meetings with surgeons and nurses are planned.
CONCLUSIONS: The “tipping point” for the standardization of medical device interoperability has clearly arrived. Clinicians and their professional societies must remain engaged to assure the clinical relevancy of the system.
1. cimit.org 2. orfpnp.org

TP006

ENDOLUMINAL REMOVAL OF INTESTINAL METAPLASIA, LOW-GRADE DYSPLASIA, AND HIGH-GRADE DYSPLASIA USING A BALLOON-BASED DILATION/ABLATION TOOL, David S Utley MD, BARRx Medical, Inc., Sunnyvale, California, USA

Objective: Esophageal intestinal metaplasia (IM) is surveyed regularly for dysplasia/adenocarcinoma. Esophagectomy or PDT is often employed for high-grade dysplasia (HGD). An endoscopic tool capable of removing IM +/- dysplasia, would serve to: 1) interrupt the metaplasia-dysplasia-carcinoma cycle, akin to the cancer risk reduction achieved with colon polypectomy, and 2) provide a less invasive alternative to surgery or PDT for HGD.
Technology Description: Such an endoscopic tool must achieve circumferential ablation of IM uniformly to the level of the muscularis mucosae (MM). To achieve this goal, the tool described herein is a balloon-based electrode array. The balloon dilates the esophagus (0.5 atm) to transiently flatten the esophageal folds and stretch the wall. While dilated, a high power, ultra-short burst of ablative energy is applied. Key features: 1) high power (300 W), 2) ultra-short energy time (<300 msec), 3) tightly spaced electrodes (<250 microns), 4) balloon dilation, 5) fixed energy density (J/cm2), 6) large surface ablated (>30 cm2).
Preliminary Results: Ganz, et al. used this ablative device in porcine and human esophagectomy patients. Dunkin, et al. reported also series of esophagectomy patients Both showed that complete removal of epithelium was possible, with maximum ablation depth MM. Overlapping did not cause deeper injury.
Two studies (AIM-I, AIM-II) have been performed in patients with IM, with no resultant strictures or buried IM. Preliminary AIM-I shows 75% of patients (10 J/cm2) as complete responders (CR, no IM on 4 quad bx). Preliminary AIM-II shows ~50% of patients are CR. Retreatment was offered to partial responders, with even further improvement in CR.
Sharma, et al. used this device in patients with IM-LGD, reporting CR 100% for LGD and 62% for IM. Additionally, there are two case reports of patients with HGD who are clear of all HGD and IM after one session, thus avoiding esophagectomy or PDT.
Conclusion: The prevalence of IM is on the rise, as is the incidence of a known risk of the disease?esophageal adenocarcinoma. While IM-HGD is treated with surgery or PDT, a much less invasive ablative therapy is desirable, as described herein. The management of IM and IM-LGD has been one of ?watchful waiting,? because we have lacked a tool to safely remove this pre-malignant tissue. The tool, as described herein, makes it possible to consider adopting a more appropriate, early intervention (removal) algorithm for these patients.

TP007

ISCHEMIA SENSING SURGICAL INSTRUMENTS, Jason M Zand MD, Gregory S Fischer MS,Eric J Hanly MD,Samuel P Shih MD,Michael R Marohn MD,Russell H Taylor PhD,Mark A Talamini MD, Department of Surgery, Johns Hopkins Medical Institutions, Baltimore-MD, USA; Johns Hopkins University ? CISST ERC, Baltimore-MD, USA

Surgical techniques rely heavily on adequate visualization of target anatomy. In laparoscopic and robotically assisted laparoscopic surgery, the operative anatomy is removed from the surgeon?s direct vision. In addition, the general view of the operative field is often obscure. As a result, peripheral anatomy is out of view. Manipulation of this peripheral anatomy may lead to ischemia, infarction, and mechanical disruption. The primary goal of the technology described is to minimize unnecessary damage to manipulated anatomy through the incorporation of biofeedback sensors into surgical instruments.