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Stray Energy Injury During Robotic Versus Laparoscopic Inguinal Hernia Repair A Randomized Controlled Trial

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Background

- Utilization of surgical energy is crucial to obtaining hemostasis and greatly contributes to both the speed and safety of surgical procedures. Multiple studies have identified mechanisms by which stray surgical energy can transfer into nearby tissue, instruments or cables resulting in thermal injuries, luminal perforation, and even death [1, 2]. These phenomena and their sequelae have now been studied well in laparoscopic, endoscopic, and open surgical platforms; however, there is limited data regarding stray energy transfer in robotic platforms [3–8].
- The rapid increase in the use of robotic surgery has also been associated with an increase in the incidence of adverse events, as demonstrated by voluntary reports in the Manufacturer and User Facility Device Experience (MAUDE) database [9]. Over one-fourth of these events have been attributed to energy device failure or thermal injury; and the frequency of these type of adverse events can only be expected to increase along with the increase in robotic surgery [4–6].
- As of today, there are few studies which attempt to investigate the concepts of energy use and robotics. MendezProbst published the first data that demonstrated 0.4W of stray energy leakage in robotic instruments (DaVinci, Intuitive Surgical, Sunnyvale, CA) [10]. Our group has also confirmed stray energy transfer in both traditional and single-port robotic platforms in an ex-vivo model [7, 11]. In a similar study of stray energy transfer during endoscopy, our group demonstrated that increasing density of nearby metal cables resulted in increased energy transfer [4]. Thus, the additional metal cabling and housing associated with current robotic platforms theoretically increases the risk of stray energy transfer. However, no in-vivo evidence of stray energy transfer has been published

Purpose

- We sought to characterize stray energy injury in the form of superficial burns to the skin surrounding laparoscopic and robotic trocar sites. We hypothesize that stray energy transfer will potentially occur at all laparoscopic and robotic port sites.

Methods

- This study is a prospective, blinded, IRB approved, randomized controlled trial of patients who had undergone elective laparoscopic or robotic inguinal hernia repairs at the Denver VA Medical Center in the years of 2019–2022.
- Surgery was performed via transabdominal preperitoneal approach either laparoscopic-assisted (TAPP) or robotic-assisted (rTAPP). A monopolar scissor was used to deliver energy at 30W coagulation for all cases. At completion of the procedure, skin biopsies were taken from all the port sites. A picro-Sirius red stain was utilized to identify thermal injury by a blinded pathologist.
- Fifty-three patients were identified and offered participation in the study. Thirteen (24%) patients could not be included due to failure to grant consent, scheduling issues, or having a preference as to the modality of surgery. Our final sample included total of 40 patients randomized into two groups of 20.

Results

- Of the 40 patients randomized, 36 (90%) completed the study as planned. Nineteen patients were in the rTAPP group, and 17 patients in the TAPP group. The average age was 55 (range 28–77) and all were male. There was no difference in baseline demographics including age, gender, body mass index (BMI), Charlson Comorbidity Index (CCI), or American Anesthesiology Association (ASA) score [12-15]. There was no difference in operative time, blood loss, or other intraoperative variables. All patients were discharged home the same day of surgery. Patients were seen for follow-up 2–3 weeks after surgery as well as phone follow-up upon study completion. The mean follow-up was 36 months (range 7–48 months). There was no major morbidity (Clavien–Dindo score 2 or higher) or mortality within 30 days in either arm.
- Over half (54%, 59/108) of all samples demonstrated thermal injury to the skin at one of the port sites (Table 3). In the TAPP group, 49% (25/51) of samples showed thermal injury vs. 60% (34/57) in the rTAPP group (p=0.548). The camera port was the most frequently involved with 68% (13/19) of rTAPP samples showing injury vs. 47% (8/17) in the TAPP group (p=0.503). There was no difference in the rate of injury at the working port site (rTAPP 53%, 10/19 vs. TAPP 47%, 8/17; p=0.991) or the assistant port site (rTAPP 58%, 11/19 vs. TAPP 53%, 9/17 p=0.873).

Table 3 Thermal injuries from stray energy

Characteristic	Laparoscopic group $N^*=51$	Robotic group $N^*=57$	p value $p \leq 0.05$
Total percent injury (%)	49	60	0.548
Percent injury by site (%)			
Camera (a)	47	68	0.503
Assist (b)	53	58	0.873
Working (c)	47	53	0.991

More than half of all specimens demonstrated a thermal injury to the skin surrounding the trocar sites. There was a trend toward more injuries in the robotic group but this was not statistically significant

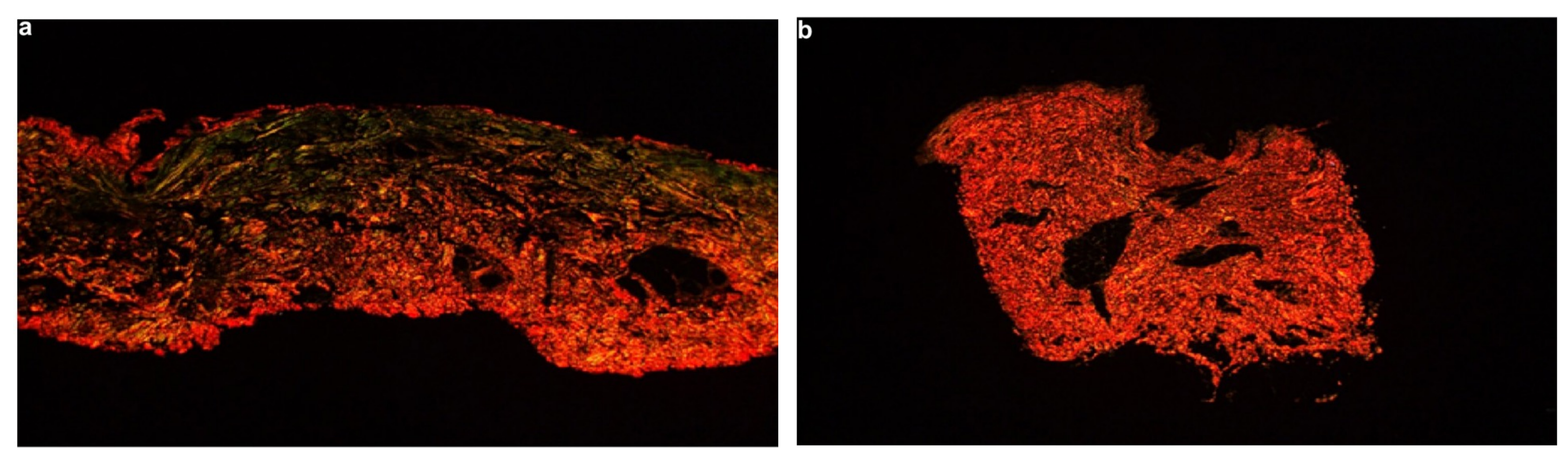

Fig. 3 Histologic thermal injury. Assessment of thermal injury via picro-Sirius staining. Injury is obviously present in a. (noted greenish-black areas representing thermal injury). No injury is reported in b (Color figure online)

- Stray energy transfer occurs during laparoscopic and robotic inguinal hernia repair with the majority (54%) of all skin samples demonstrating thermal injury. Thermal injuries occurred at all port sites, although the camera port was more commonly affected than the lateral ports. This is the first in-vivo study confirming stray energy transfer in robotic surgery, however, there were no significant complications or clinical manifestations of the thermal injuries in either group.
- Delving further into the mechanism of stray energy transfer, there are six distinct groups: direct application, residual heat, insulation failure, direct coupling, capacitive coupling, and antenna coupling [9, 16–19]. We suspect most of the stray energy transfer, aside from insulation failures, is during minimally invasive surgery which occurs via antenna and/or capacitive coupling.

Conclusion

- Despite the lack of obvious, clinical detriment as a result of stray energy transfer, there is no reason to suspect that devastating injuries do not occur. These injuries occur outside of the surgeon's view and previous authors have confirmed severe injuries, perforation, and death as a result of stray energy injury.
- Stray energy causes thermal injury to skin at all port sites during robotic and laparoscopic inguinal hernia repairs. Surgeons must educate themselves on the mechanisms of stray energy transfer during minimally invasive surgery to reduce the risk of severe, potentially life-threatening injuries.

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