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Hand-to-hand coupling and strategies to minimize unintentional energy transfer during laparoscopic surgery

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ABSTRACT

Background: Energy-based devices are used in nearly every laparoscopic operation. Radiofrequency energy can transfer to nearby instruments via antenna and capacitive coupling without direct contact. Previous studies have described inadvertent energy transfer through bundled cords and nonelectrically active wires. The purpose of this study was to describe a new mechanism of stray energy transfer from the monopolar instrument through the operating surgeon to the laparoscopic telescope and propose practical measures to decrease the risk of injury.

Methods: Radiofrequency energy was delivered to a laparoscopic L-hook (monopolar "bovie"), an advanced bipolar device, and an ultrasonic device in a laparoscopic simulator. The tip of a 10-mm telescope was placed adjacent but not touching bovine liver in a standard four-port laparoscopic cholecystectomy setup. Temperature increase was measured as tissue temperature from baseline nearest the tip of the telescope which was never in contact with the energy-based device after a 5-s open-air activation.

Results: The monopolar L-hook increased tissue temperature adjacent to the camera/telescope tip by $47 \pm 8^\circ$C from baseline ($P < 0.001$). By having an assistant surgeon hold the camera/telescope (rather than one surgeon holding both the active electrode and the camera/telescope), temperature change was reduced to $26 \pm 7^\circ$C ($P < 0.001$). Alternative energy devices significantly reduced temperature change in comparison to the monopolar instrument ($47 \pm 8^\circ$C) for both the advanced bipolar ($1.2 \pm 0.5^\circ$C; $P < 0.001$) and ultrasonic ($0.6 \pm 0.3^\circ$C; $P < 0.001$) devices.

Conclusions: Stray energy transfers from the monopolar "bovie" instrument through the operating surgeon to standard electrically inactive laparoscopic instruments. Hand-to-hand coupling describes a new form of capacitive coupling where the surgeon's body

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acts as an electrical conductor to transmit energy. Strategies to reduce stray energy transfer include avoiding the same surgeon holding the active electrode and laparoscopic camera or using alternative energy devices.

Introduction

Energy-based devices are essential in performing laparoscopic surgery. A potential limitation of surgical energy is that stray current can transfer or "couple" to other instruments and cause significant thermal injury outside the surgical field of view. Mechanisms of this coupling phenomenon include antenna coupling[1,2] and capacitive coupling.[3,4] Prior work has defined parameters that the surgeon can modify to reduce the amount of unintentional energy transfer including lowering the power setting,[3,4] the use of cut or blend mode in preference to coagulation mode,[3-5] shortening dwell time,[3] separating the active electrode cord from other cords containing conductive material,[1,2] and using desiccation in preference to fulguration technique.[3,4] Other scenarios which may decrease unintentional energy transfer such as alternate energy devices have been postulated based on basic principles of electricity but have not been studied. Current training efforts in the surgical community include the Fundamental Use of Surgical Energy Curriculum sponsored by the Society of American Gastrointestinal and Endoscopic Surgeons.[6]

The purpose of this study was to define clinical scenarios that reduce the amount of unintentional energy transfer which are relevant to the laparoscopic surgeon. The specific aims were to describe the effects of hand-to-hand energy coupling, then quantify the effects in context of other clinically relevant strategies to reduce unintended stray energy transfer such as adding fluid to the surgical field and using alternative energy device.

Materials and methods

Regulatory exemption due to designation as nonhuman research was obtained from the Colorado Multi-Institutional Review Board (COMIRB #08-1377). The laparoscopic instruments studied were a monopolar L-hook (Karl Storz, Tuttlingen, Germany), with energy delivered from a monopolar generator (Force FX; Covidien, Boulder, CO), a 10-mm 30° laparoscopic telescope and camera (Karl Storz), an advanced bipolar device (Ligasure; Covidien), and an ultrasonic device (Harmonic; Ethicon, Blue Ash, OH). Instruments were placed though 10-mm all-plastic trocars (Ethicon) in a Szabo-Berci-Sackier Laparoscopic Trainer (Karl Storz) with orientation similar to a four-port laparoscopic cholecystectomy. Energy was delivered to 20 × 5 × 5 cm section of bovine liver tissue (room temperature, >20°) placed on top of the adhesive side of the dispersive electrode pad which rested on the floor of the box trainer. All energy-based device cords were bundled (oriented in parallel) to the camera/telescope's cord mimicking typical operating room setup. Dwell time was 5 s for all activations. All researchers wore standard surgical gloves.

Control

A control experiment was performed before completing the five aims. The tip of the nonelectrically active telescope was placed on the tissue with no energy device activation occurring. The temperature difference from baseline to immediately removing the instrument tip after 5 s was recorded.

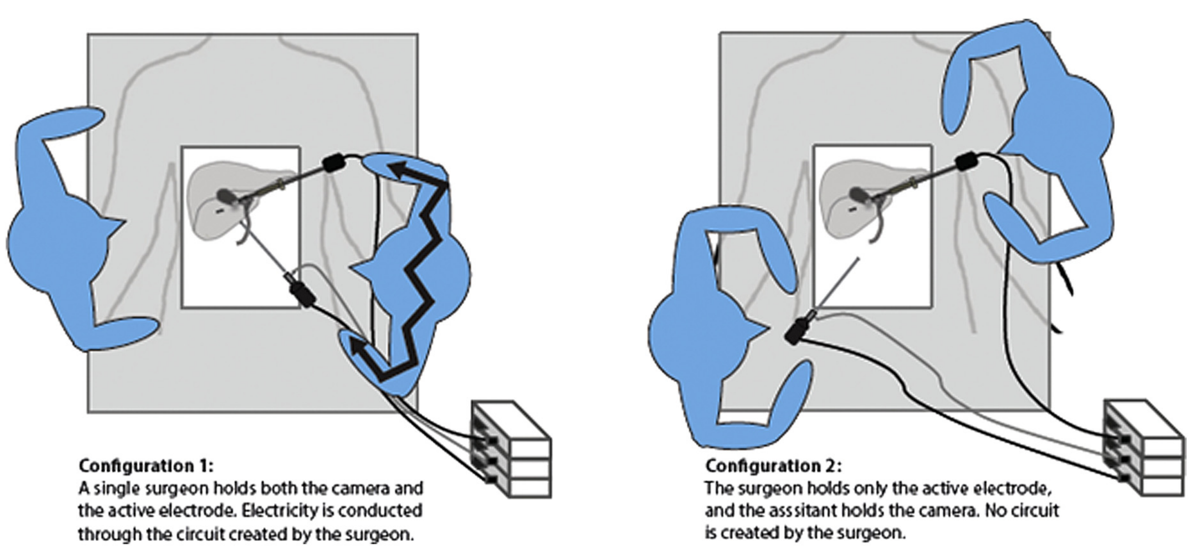

Fig. 1 – Hand-to-hand coupling. The same surgeon holding both the monopolar instrument and the camera/telescope (left graphic) creates greater unintentional energy transfer in comparison to when different surgeons hold the active electrode and the camera/telescope (right graphic). (Color version of figure is available online.)