Clinical and laboratory evaluation of an electrosurgical laparoscopic trocar

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Abstract. Electrosurgical energy may be utilized as an adjunct to mechanical force for insertion of laparoscopic trocars. The advantage of this approach may be better operator control of insertion, with less risk of intraperitoneal and retroperitoneal injury. To assess the safety and efficacy of electrosurgical trocars, we compared them to mechanical trocars in clinical and animal trials. During 100 trocar introductions in 25 laparoscopic cholecystectomies, insertion force was measured. In contrast to mechanical trocars, which required progressively more force to insert as size increased, electrosurgical trocars required the same low insertion force regardless of size. No wound complications occurred. In animal experiments, wound healing (measured histologically and by bursting strength) was normal and equivalent for mechanical and electrosurgical insertions.

We conclude that electrosurgical trocars require less force for insertion and do not impair wound healing. Electrosurgical trocars may thus offer important safety advantages over mechanical trocars.

Key words: Laparoscopy — Trocar — Trocar Injury — Complication

Laparoscopy has a reported complication rate of approximately 0.4% and mortality rate of 0.05% [4]. Of the serious complications of laparoscopy, the most life-threatening are vascular and bowel injuries from insufflation needles and trocars. Vascular injuries, particularly to the aorta or iliac vessels, may lead to exsanguination. Bowel injuries may result in intra-abdominal sepsis, particularly because they may not be recognized at the time of the initial procedure. The true incidence of trocar injuries is uncertain. In one large study of over 5,000 laparoscopies, the incidence of bleeding was 0.46% [3]. Peterson et al. estimated the incidence of puncture injury at 0.2–0.5% [6]. In a review of 15 major vascular injuries during laparoscopy, Baadsgaard et al. concluded that this injury is probably under-reported [1]. In a study of 7,604 laparoscopic procedures, Chapron et al. reported a serious trocar injury rate of 0.28%; 52% of the injuries were bowel injuries, half of which were unrecognized at the initial procedure [2].

A major factor predisposing to intra-abdominal or retroperitoneal injury is when great mechanical force is necessary to place trocars through the abdominal wall. This situation results in a lack of operator control, such that trocars may pass across the peritoneum into underlying structures. The introduction of disposable trocars with retractable safety shields may have reduced (but not eliminated) the incidence of trocar injury; the magnitude of any such reduction has not been documented to date. Such shields reduce trocar sharpness but do not decrease the force necessary for insertion; in fact the safety shields may increase resistance and insertion force.

Trocar introduction techniques which provide more operator control of trocar introduction would be safer, potentially resulting in fewer injuries. One approach to provide better control is to utilize electrical energy as an adjunct to mechanical energy to traverse the abdominal wall. To evaluate this approach, we studied electrosurgical laparoscopic trocars. We were particularly interested in measuring the mechanical force necessary to place these trocars though the abdominal wall, hypothesizing that less force should result in better control for the surgeon. In addition, to

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Fig. 2. Comparison of mechanical insertion forces for electrosurgical and mechanical trocars. Note that mechanical trocars required significantly more insertion force. Further, insertion forces for 5- and 11-mm electrosurgical trocars were not significantly different, while insertion force increased with size for mechanical trocars.

Fig. 3. Comparison of histological features of wound healing in experimental wounds 30 d after trocar insertion. Wound healing was normal, with no difference between mechanical and electrosurgical sites.

Statistical comparisons were performed by utilizing analysis of variance (ANOVA) for multiple-group comparisons and the two-tailed unpaired t-test for single-group comparisons.

Results

Clinical trial

The forces utilized to place mechanical trocars were greater than those to place electrosurgical trocars (Fig. 2). The mean force utilized for placement of 5-mm mechanical trocars was 2.8 times greater than that utilized for 5-mm electrosurgical trocars. The force utilized for 10-mm mechanical trocars was 3.2 times greater than that utilized for 11-mm electrosurgical trocars. The insertion force for 11-mm mechanical trocars was 3.8 times greater than 11-mm electrosurgical trocars. The force necessary for 12-mm mechanical trocar insertion was 5.8 times greater than for 11-mm electrosurgical trocars. Each of these differences was highly significant.

There was no significant difference between the forces necessary to place 5- and 11-mm electrosurgical trocars, while the forces for placement of mechanical trocars increased significantly as trocar size increased ($P < 0.01$, ANOVA).

No injuries occurred in this series. However, mechanical trocars were frequently noted to pass well beyond the peritoneum during placement, while better operator control was noted with placement of electrosurgical trocars. There were no interoperator differences in insertion forces between the various resident and attending surgeons. No difference in the rate or quality of wound healing was noted between electrosurgical and mechanical trocar sites. No wound infection, wound dehiscence, or hernia was noted in any of the 100 trocar wounds.

Animal studies

Trocar wounds in animals studied 30 days after trocar introduction had histologic evidence of normal wound healing in both mechanical and electrosurgical sites. No statistically significant difference in histologic features of wound healing was noted for any of the parameters studied (Fig. 3).

Bursting strength of trocar wounds was also equal between mechanical and electrosurgical trocar sites when studied 30 days after operation. Mean wound breaking force was $15.8 \pm 2.4$ lb for electrosurgical wounds and $16.3 \pm 4.7$ lb for mechanical trocar wounds (difference not significant.)

Discussion

As the number of laparoscopic procedures increases, the numbers of complications are likely to increase as well. The introduction of trocars by mechanical force is known to have a risk of intra-abdominal and retroperitoneal injury. The risk of this complication could be decreased by techniques which decrease the mechanical insertion force and thus increase operator control of trocar introduction. Our data demonstrate that the use of electrosurgical energy significantly reduces the mechanical force necessary for trocar introduction, hence improving the surgeon's ability to control insertion.

The advantage of electrosurgical energy is evident with 5-mm trocars, where mechanical insertion force is reduced by nearly two-thirds. The advantage is even more pronounced as trocar size is increased. While little additional mechanical force is necessary to place