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ORIGINAL ARTICLE

Robotic-assisted single-incision laparoscopic partial cecectomy

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Abstract

Background Single-incision laparoscopic surgery is an emerging approach in the field of minimally invasive colon and rectal surgery. This modality utilizes a 'scarless' incision concealed within the umbilicus, and results in improved cosmesis with the potential for reduced trauma, pain and length of hospital stay. However, unique technical challenges have curbed its adaptation. Robotic-assisted technique may help overcome these limitations when applied to the single-incision approach.

Methods A robotic-assisted single-incision laparoscopic partial cecectomy was performed using the da Vinci® robot and the GelPOINT™ access device. Modifications of the robotic set-up were utilized to optimize the technique. The robotic instruments were crossed below the abdominal wall to minimize internal conflict and maximize range of motion. Control of the robotic arms was reassigned on the robotic console to create a more intuitive surgical approach. The robotic camera was rotated and positioned vertically to reduce external conflict and enhance visualization.

Results Robotic-assisted single-incision laparoscopic partial cecectomy was performed in a 53 year-old male without complication or need for conversion. The procedure required 120 min with an estimated blood loss of <50 ml. Pathology revealed a sessile tubular adenoma of the cecum. The length of hospital stay was 2 days and no complications were encountered. The patient returned with a well-healed 2.5 cm incision and no postoperative complications at 6 weeks follow-up.

Conclusions With appropriate modifications, robotic-assisted single-incision laparoscopic surgery may be applicable as a minimally invasive modality for partial colectomy. Further studies are warranted to establish the safety, efficacy, benefits, and limits of this technique. Copyright © 2010 John Wiley & Sons, Ltd.

Keywords robotic surgery; da Vinci robot; single-incision; laparoscopic colectomy; minimally invasive surgery

Introduction

Minimally invasive surgery (MIS), including conventional or hand-assisted laparoscopic technique, has emerged as a valuable option for treatment of benign and malignant colorectal diseases. These approaches result in several benefits, including lower complication rate, earlier return of bowel function, reduced postoperative pain, and shorter hospitalization, as compared to open surgery (1–4). In addition, laparoscopic surgery has been shown to yield

comparable oncologic outcomes without increased risk of cancer recurrence when compared with open surgery for colorectal cancer (5–9).

Single-incision laparoscopic surgery (SLS), also known as single-port access laparoscopic surgery (SPA) or laparoendoscopic single-site surgery (LESS), may represent a bridge between MIS technique and natural orifice transluminal endoscopic surgery (NOTES). It offers many of the advantages of an MIS approach while utilizing a single umbilical incision, resulting in 'scarless' access. Recent reports have documented the safe and feasible application of single-incision technique for various colorectal procedures; however, several unique technical challenges have been noted (10–12). Robotic-assisted laparoscopic surgery (RALS) may help overcome these limitations when applied to a single-incision approach. We report our initial experience with robotic-assisted single-incision laparoscopic surgery (RA-SLS) using the da Vinci® robotic system and the GelPOINT™ access device.

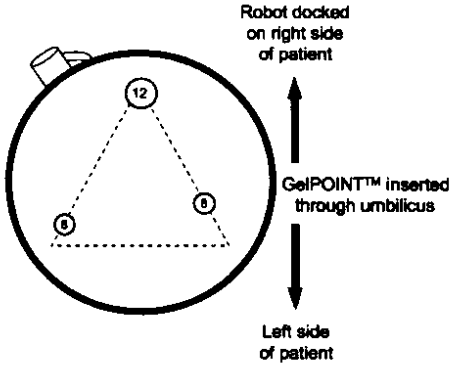

Figure 1. Configuration of ports on GelSeal® cap of GelPOINT™ device; 12, 12 mm camera port; 8, two 8 mm ports for the robotic instruments

Materials and Methods

The institutional review board approved this study. The set-up and technique for robotic-assisted single-incision laparoscopic surgery were attempted in a porcine model prior to replication in our patient.

Case history

A 53 year-old male presented following his first screening colonoscopy, in which a flat polyp was visualized in the cecum. The polyp was not amenable to complete endoscopic removal, as it did not sufficiently elevate following submucosal injection and was located at the base of the appendix. Biopsies revealed tubulovillous adenoma. The patient provided consent and was scheduled for a robotic-assisted single-incision laparoscopic resection.

Operative procedure

The procedure was performed by a board-certified colon and rectal surgeon (E.M.H) using the da Vinci® S-type Surgical System (Intuitive Surgical Inc., Sunnyvale, CA, USA) and the GelPOINT™ Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA, USA). After induction of anesthesia, the patient was placed in a supine position and prepped and draped in a sterile fashion.

A 2.5 cm transumbilical incision was performed through the fascia and peritoneum, and the GelPOINT™ device was introduced. Three trocars, a 12 mm camera port and two 8 mm robotic ports, were introduced through the GelSeal® cap (Applied Medical) in a triangular configuration (Figure 1). The robotic cart was docked on the right side of the patient, perpendicular to the operating room table (Figures 2, 3). A 12 mm 30° robotic camera

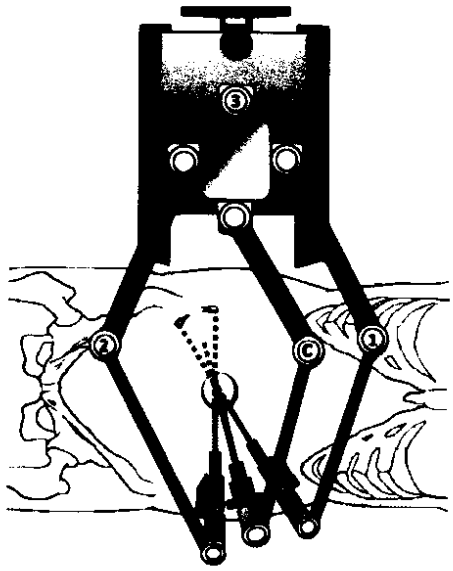

Figure 2. Diagram of robotic docking. The robot is docked on the side of the target, so the procedure is performed back toward the robotic cart; 1 and 2, robotic arms 1 and 2; C, camera arm; 3, robotic arm 3, which was not involved in the procedure. The instruments are crossed intracorporeally (dotted lines)

was placed in reverse orientation in the 'up' position, rotated 180° about its vertical axis (Figure 4). Once the robotic instruments were introduced, control of robotic arms 1 (left) and 2 (right) was reassigned on the robotic console, allowing the surgeon to operate in line with the operative field (Figure 5).

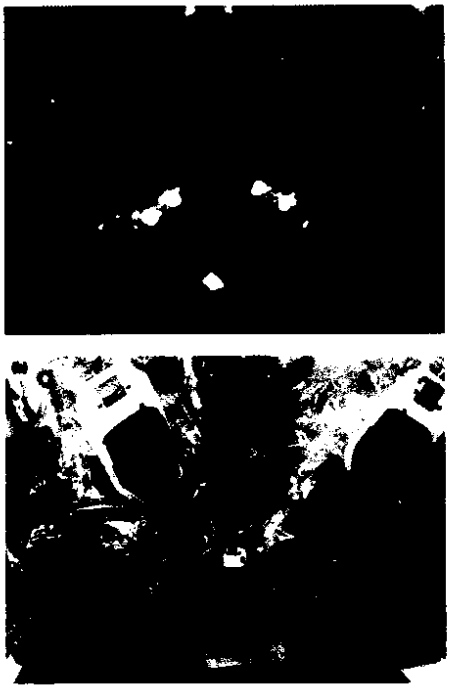

Figure 3. (a) Robotic-assisted laparoscopic partial cecectomy (during actual procedure). (b) Mock set-up for robotic-assisted laparoscopic partial cecectomy in the inanimate laboratory

The procedure commenced in a lateral-to-medial fashion with mobilization of the cecum and ileocolic attachments extending from the white line of Toldt to the hepatic flexure. Following complete mobilization, the mesoappendix was divided and a partial resection of the cecum was performed intracorporeally, using an Echelon Flex™ 60 Linear Cutter (Ethicon Endo-Surgery Inc., Cincinnati, OH, USA). To avoid undocking of the robotic arms, an additional 12 mm port was placed through the GelSeal® cap for introduction of the linear stapler. The robot was then undocked and the specimen was removed through the Alexis® wound retractor (Applied Medical, Rancho Santa Margarita, CA, USA) connected to the GelPOINT™ device.

Results

Robotic-assisted single-incision laparoscopic partial cecectomy was performed in a 53 year-old male with a body mass index (BMI) of 34.6 kg/m^2 and American Society of Anesthesiologists (ASA) score of 2. No intra-operative complications were encountered, and the procedure was completed without conversion to conventional laparoscopic or open technique. The total operative time was 120 min, with an estimated blood loss of <50 ml. Pathology revealed a 1.1 cm sessile tubular adenoma of the cecum at the origin of the appendix. The patient tolerated a clear liquid diet on the evening of surgery and was advanced to a soft diet the following day. He was discharged on postoperative day 2 after return of bowel function (i.e. passage of flatus). He presented for postoperative evaluation at 2 and 6 weeks following surgery with no complications and a well-healed umbilical incision.

Discussion

Single-incision laparoscopic technique has been employed for a multitude of surgical procedures (13,14), allowing performance of 'scarless' surgery through a single 'hidden' umbilical incision. Nevertheless, its application to colorectal surgery has only recently emerged in the published literature. Cosmesis has been the most evident advantage of the approach; however, other benefits, such as reduced incisional pain, lower morbidity and early hospital discharge, have been considered (15). Despite its promise, single-incision technique is associated with a distinct set of challenges. Collinearity of camera and instruments reduces visualization and impairs depth perception (16). Coaxial configuration and close proximity of instruments through a single incision restricts maneuverability and dexterity, resulting in frequent instrument clashing and limiting principles of triangulation and retraction (17). Furthermore, ergonomic positioning of the surgeon and assistant are less than ideal with strained and repetitive contortions.

Robotic-assisted laparoscopic surgery was developed in part to overcome several of the inherent limitations of conventional laparoscopic surgery (18,19). The modality affords important visual and operative advantages (20), including three-dimensional visualization, 10-fold magnification, a stable camera platform, and computerized instrumentation offering tremor reduction and motion scaling. The endo-wristed instrument tips provide two additional degrees of freedom as compared with conventional laparoscopic instruments, and the surgeon operates while seated at an ergonomically designed console. Merging robotic-assisted technique with the single-incision approach may overcome the limitations of SLS and result in a more efficacious approach. This case represented our initial experience and the first robotic-assisted single-incision laparoscopic colorectal procedure performed using the da Vinci® robot and the GelPOINT™ device.

Robotic technology affords the ability to make essential modifications crucial in overcoming the restrictions of collinear dissection and limited field of view typically encountered in a single-incision procedure. A critical adjustment is the use of an intracorporeal saltire (cross) configuration with command reassignment of the

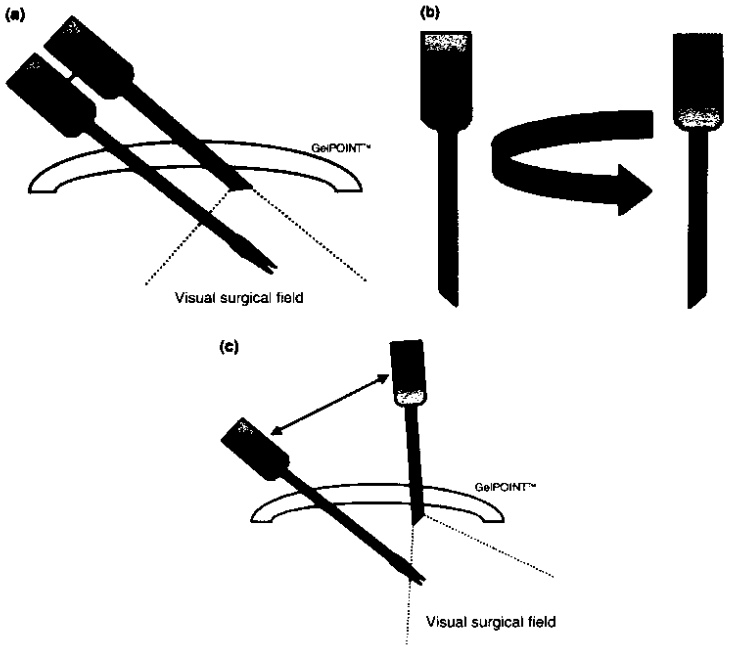

Figure 4. Positioning of the robotic camera for RA-SLS. (a) Normal coaxial configuration of the instruments and camera increases collisions and reduces the visual field. (b) The camera is rotated 180° about its vertical axis to enhance the visual field. (c) The camera is positioned vertically and aimed back toward the target and robotic cart, optimizing the field of view while eliminating external collisions between the robotic operative arms and the camera arm

robotic arms. This supplies the surgeon with a direct surgical approach; each hand at the robotic console corresponds to the robotic instrument in the ipsilateral field of view (Figure 5). Maintaining the cross-orientation maximizes separation between instruments, reducing internal and external collision while increasing range of motion – all accomplished with single-incision entry into the abdominal cavity. Similar modification has been described by Joseph *et al.* (21) as the 'chopstick' technique, and was successfully utilized by Ostrowitz *et al.* (22) in a series of three robotic single-incision right hemicolectomies in 2009. Another important component of our technique involves use of a 30° robotic camera rotated 180° about its vertical axis and positioned upright with respect to the operative robotic arms (Figure 4). This further minimizes external conflict with the robotic arms and enhances the visual field.

The GelPOINT™ platform was particularly beneficial in facilitating the single-incision technique. The GelSeal® cap provided a flexible fulcrum for increased range of motion, and the laterally-placed insufflation port alleviated potential loss of pneumoperitoneum during instrument exchanges, repositioning and excessive torquing. The platform's design provided a greater outer profile for port placement, reducing coaxial alignment and translating into an optimal circumferential working diameter for each instrument tip. External and internal collisions were eliminated, and principles of triangulation and retraction were maintained. Insertion of the device required a single continuous incision, avoiding the so-called 'Swiss cheese' defect and potential wound complications (e.g. increased post-operative pain and ventral herniation) considered with other SLS access platforms. The accompanying Alexis® wound retractor allowed specimen extraction without removal of the access device, which may be cumbersome in obese patients. In addition, the GelPOINT™ structure offered a solution for device dislocation, a limitation we previously reported with non-robotic SLS (23).

We chose this case for our initial robotic-assisted single-incision experience, as it involved a single operative quadrant similar to our experience in the porcine model. While the procedure was completed without complication, more advanced colorectal cases requiring multiple quadrant approaches and intracorporeal anastomoses may present new challenges requiring additional technical expertise. Another important consideration includes the use of additional robotic tools, such as an 8.5 mm camera or 5 mm flexible-tip instrumentation – neither

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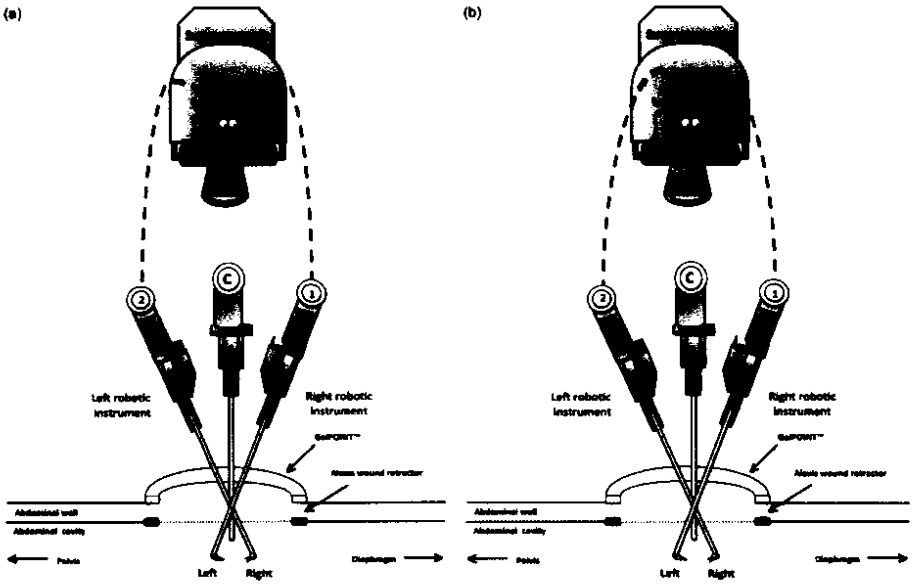

Figure 5. Control reassignment of robotic arms (sagittal plane through umbilicus). (a) Control of the robotic arms prior to reassignment. (b) Reassigning control of the robotic arms on the robotic console allows the right and left hands to control the instruments in the right (left robotic arm 1) and left (right robotic arm 2) fields of view, respectively. The surgeon's hands correspond to the instruments in the ipsilateral field of view, providing a direct surgical approach

of which were available at our institution but may prove advantageous in future models. While the da Vinci® robot provides a practical platform for completion of single-incision surgery, robotic-assisted single-incision laparoscopic technique may be optimized through innovative robotic systems offering advanced retraction, improved flexibility and augmented ergonomic design.

We report our initial experience with robotic-assisted single-incision laparoscopic surgery utilizing the da Vinci® robot and the GelPOINT™ platform. Modification of existing robotic technique facilitated completion of the procedure without complication or conversion and resulted in an expeditious recovery with quality short-term outcome. The procedure proved to be safe and feasible, warranting further study to establish its application to more complex colorectal procedures.

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