Laparoscopic Oncologic Abdominoperineal Resection

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PURPOSE: Although the use of laparoscopic techniques in colorectal surgery has recently become a focus of major interest in intestinal surgery, there is no proof that an oncologic abdominoperineal resection can be accomplished using laparoscopic techniques. The hypothesis of this study is that a standardized technique for laparoscopic oncologic abdominoperineal resection according to accepted oncologic surgical principles can be developed in a cadaver model. The end points of this study were intraoperative complications, success in performance of proximal vascular ligation of the inferior mesenteric artery, complete removal of the mesorectum including all lymph nodes adjacent to the named rectal arteries, and wide clearance of pelvic side walls. METHODS: Laparoscopic abdominoperineal resection was performed in 11 fresh cadavers (1 female and 10 males). After surgery, all cadavers underwent autopsy. The number of removed and remaining mesenteric lymph nodes, length of remaining inferior mesenteric artery, and mesorectal and the pelvic side wall soft tissue were evaluated. RESULTS: No major intraoperative complications were recorded. The median number of removed lymph nodes in the mesorectum was 12 (range, 6–22) and no remaining lymph nodes were found at the base of the inferior mesenteric artery. The median length of remaining inferior mesenteric artery was 5 (range, 1–15) mm. Wide lateral clearance of pelvic side walls was noted in all patients. CONCLUSION: A laparoscopic technique of abdominoperineal resection can be performed according to oncologic principles with proximal vascular ligation of inferior mesenteric artery, wide clearance of pelvic side walls, and complete removal of mesorectum using our described technique. [Key words: Laparoscopic intestinal resection; Abdominoperineal resection; Oncologic colorectal surgery]

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Colorectal cancer is the most frequent indication for large bowel resection in the United States. With the increasing enthusiasm seen for performing laparoscopic colorectal procedures,[1–15] the intraoperative efficacy and feasibility of laparoscopic techniques applied to colorectal cancer surgery needs to be evaluated.

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The literature contains various descriptions of the use of laparoscopic colectomies in the treatment of malignant colorectal diseases.[4–6, 14, 15] These reports, however, have neither proved nor precisely described that colorectal resections were performed according to accepted oncologic principles.[16–20]

In order to verify that laparoscopic rectal resection may be performed according to oncologic principles, we developed a standardized approach for accomplishing abdominoperineal resection in a cadaver model, in which a complete abdominal autopsy after the procedure would reveal the extent of surgery in an irrefutable fashion.

The purpose of this study, therefore, was to evaluate in fresh cadavers the feasibility of a standardized laparoscopic oncologic abdominoperineal resection.

METHODS

The hypothesis of our study is that a laparoscopic abdominoperineal resection can be performed according to oncologic surgical principles. The end points of this study were intraoperative complications (vascular, intestinal, or ureteral injuries), initial proximal vascular ligation of inferior mesenteric artery (IMA) within 1.5 cm of its origin, and complete removal of the mesocolon and mesorectum including all lymph nodes (LNs) adjacent to named intestinal visceral arteries, and wide clearance of the pelvic side walls.

Cadavers

In order to test our hypothesis, 11 cadavers obtained in a fresh state (10 males and 1 female) received injection of an ethanol and glycerin solution *via* a femoral artery to reduce rigor mortis. Vigorous massage of the abdominal wall muscles was also performed to soften them prior to the establishment of pneumoperitoneum. The colon and rectum were cleansed of fecal material with

tap water enemas and the bladder was emptied by percutaneous needle aspiration.

Immediately after laparoscopic resection, a thorough abdominal autopsy with inspection of all surgical sites was performed in all cadavers.

Oncologic Resection

A suitable oncologic resection of colorectal carcinoma could be defined as follows: 1) resection of all known extent of cancer in the bowel wall and adjacent soft tissue, 2) resection of suitable margins of the normal bowel wall above and below the cancer, and 3) excision of draining regional LNs accompanying the major vascular pedicles to the involved bowel (mesocolon/rectum).

Therefore, oncologic abdominoperineal resection was defined in this study as complete *en bloc* resection of the rectosigmoid with its mesentery, proximal ligation of IMA with remaining vessel length less than 15 mm, and removal of all LNs belonging to the sigmoid mesocolon and mesorectum.

After laparoscopic oncologic abdominoperineal resection, the excised specimen was examined by an experienced pathologist and the number of excised LNs was documented.

At a thorough abdominal autopsy, the number of LNs remaining at the origin of IMA was noted and recorded. The length of the remaining IMA was measured in millimeters and the extent of pelvic side wall resection was evaluated.

Technique of Laparoscopic Oncologic Abdominoperineal Resection

Cadavers were placed in a modified lithotomy position with legs abducted 45 to 60° in the Trendelenburg position (15 to 20° head down). The shoulders, chest, and legs were securely strapped to the table. Pneumoperitoneum was established with a SURGINEEDLE® (U. S. Surgical Corporation, Norwalk, CT) and the first trocar inserted through an infraumbilical skin incision. The surgeon and cameraman stood on the right side of the cadaver and the assistant on the left side (Fig. 1). The nurse with her/his instrument table was placed between the legs. Two monitors were located at the right and left foot of the cadaver to allow easy visualization by the surgeon and assistant.

Different locations of SURGIPORT® (U. S. Surgical) trocars were tested and the following sites

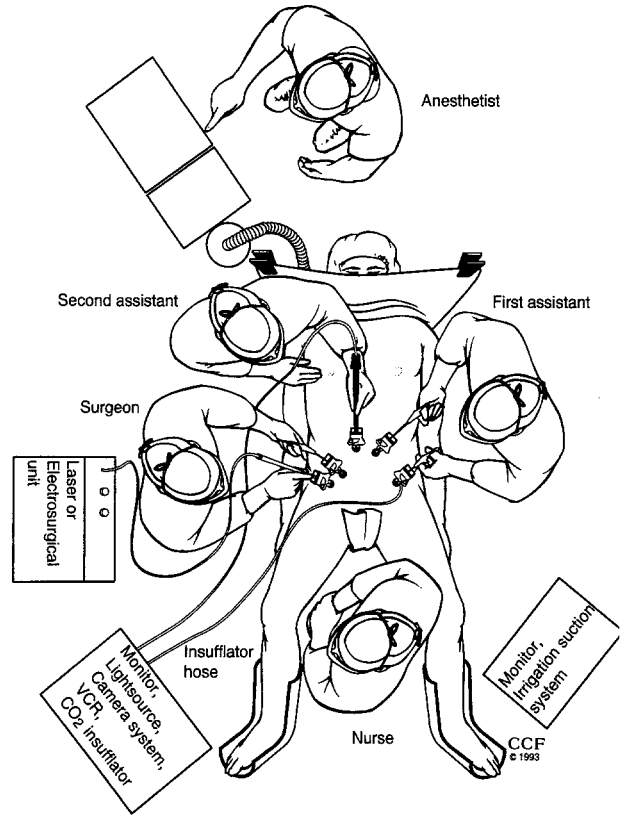

Figure 1. Location of surgeon, assistant, cameraman, nurse, and equipment for laparoscopic abdominoperineal resection.

(Fig. 2) appeared to give an optimum approach to the pelvis, sigmoid colon, and inferior mesenteric artery. The first trocar was inserted at the umbilicus with one of the trocars on the left side being placed at the colostomy site. In patients, care must be taken with this second trocar placement to avoid injury of the epigastric vessel running in the rectus sheath (Fig. 2). Two trocars were inserted in both the right and left lower quadrants. Trocars were arranged in an open half circle directed toward the pelvis. An attempt was made to keep a distance between any two trocars of greater than 8 cm to prevent "scissoring" and obstruction of movement between instruments. In general, optimum placement of the trocars in patients may depend on the configuration of the abdomen.

After placement of the first trocar, a high resolution camera was inserted (Distal Camera 360™; Baxter W. Mueller, Chicago, IL) and all additional trocars were inserted under visual control. The operating table was then tilted to the right so that the small intestine fell into the upper right quadrant. The peritoneum at the base of the mesosigmoid was incised just to the right of the midline

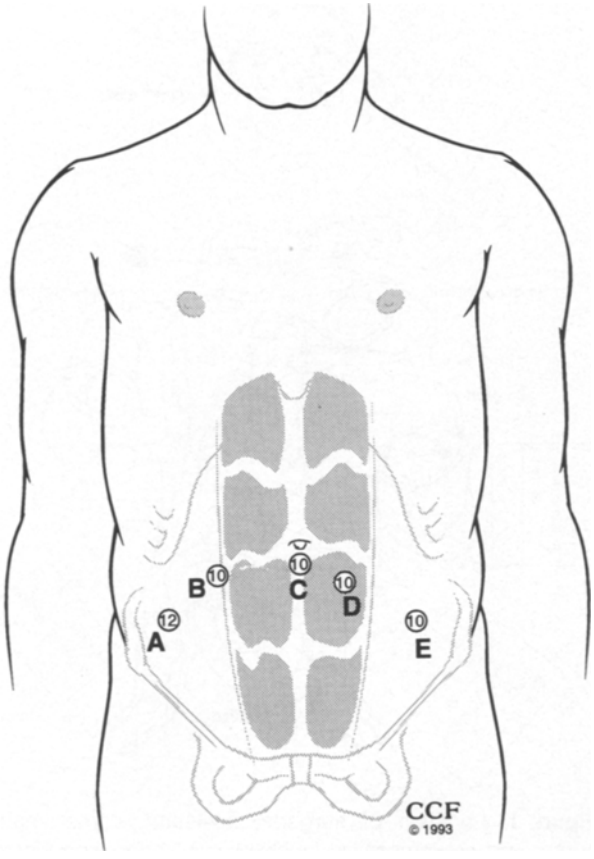

Figure 2. Location and size of trocars for laparoscopic abdominoperineal resection. Rectus muscle with epigastric vessels are highlighted.

along the IMA up to its origin at the abdominal aorta (Fig. 3). The IMA was elevated and the dissection continued posteriorly and to the left of the IMA until the ureter and gonadal vessel were identified and swept posteriorly away from the sigmoid mesentery. The IMA was then ligated above its left colic branch using an endoscopic stapler (MULTIFIRE ENDO GIA® 30-2.5 (V) stapler; U. S. Surgical) (Fig. 4). Although the IMA was dissected as close as possible to its origin, in living patients we prefer to leave the vessel 1 cm to 1.5 cm long so that, if any bleeding occurs, an additional ligation can be applied. (It is also possible to ligate the vessel with a Roederloop first and then transsect it with an endoscopic stapler.) If the IMV is close to the IMA, it can be transsected together with the IMA. If not, The IMV has to be dissected and clipped separately, which is usually the case in obese patients.

Next, the mesocolon was dissected further to the left until the inferior mesenteric vein was identified and clipped with endoscopic clips (Large ENDO CLIP® Applier; U. S. Surgical).

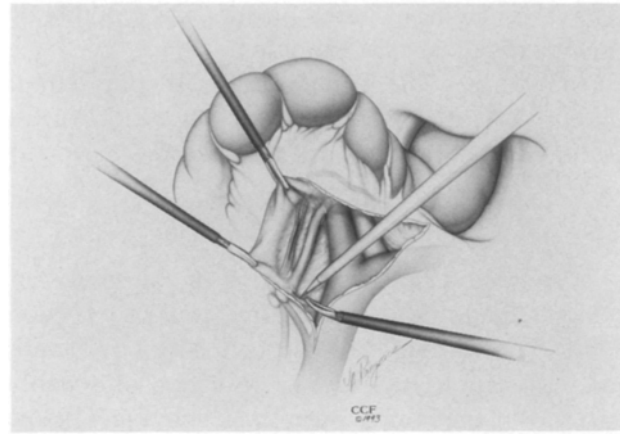

Figure 3. The operation commences with an incision in the retroperitoneum to the right of the inferior mesenteric artery.

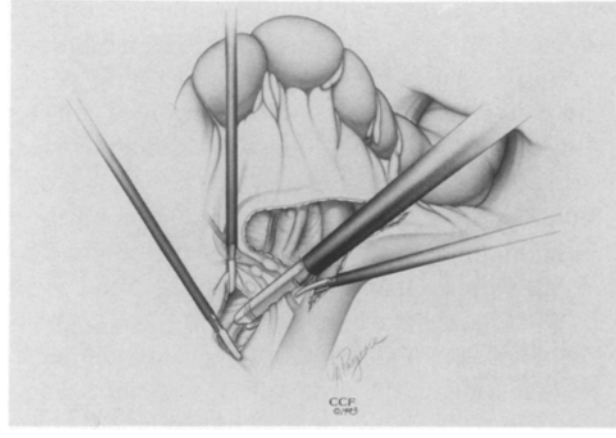

Figure 4. Endoscopic 3-cm stapler ligating and dividing the inferior mesenteric artery close to its origin. Ureter and gonadal vessel have been swept away from the mesosigmoid. The inferior mesenteric vein may be ligated simultaneously.

The sigmoid mesocolon was then mobilized first from its lateral peritoneal attachments and then posteriorly in a medial to lateral fashion. The ureter and gonadal vessel were identified and further separated from the mesentery. After the line of resection was specified, the mesosigmoid was transsected using an Nd:YAG Contact Laser™ (Surgical Laser Technologies, Oaks, PA) or endoscopic scissors with monopolar electrosurgery. All mesenteric/marginal vessels were clipped, the colon was freed of all mesenteric tissue, and then transsected with an endoscopic stapler (MULTIFIRE ENDO GIA® 30; U. S. Surgical) (Fig. 5).

The dissection was continued into the pelvis by incising the peritoneum to the right and left side of the rectum. The left ureter was again identified.

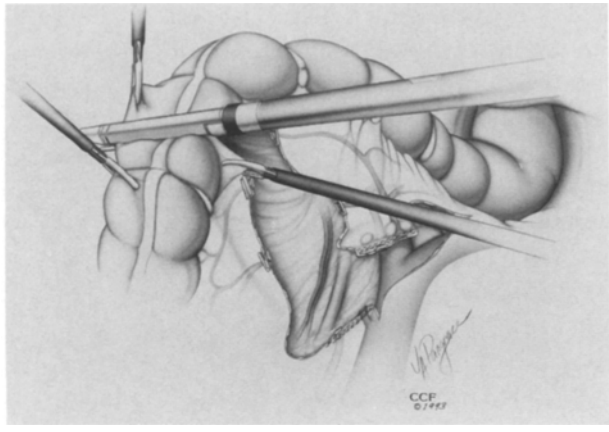

Figure 5. Transection of mesosigmoid and sigmoid colon is carried out after lateral mobilization of the sigmoidcolon.

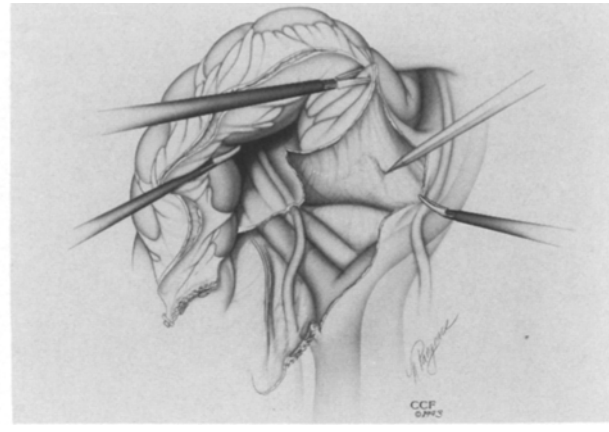

Figure 6. Mobilization of rectum posteriorly (cross-sectional view).

The rectum including mesorectum was mobilized first posteriorly (Fig. 6), then laterally on both sides, and then anteriorly (Fig. 7). Lateral ligaments were transsected and vessels coagulated or clipped. A wide lateral clearance was carried out flush with the pelvic side walls. With axial traction on the rectum, the dissection was readily continued down to the pelvic floor (Fig. 8).

The descending colon was mobilized so that it could be brought up comfortably through the stoma site, then its divided end was grasped through the trocar placed at the colostomy site. The CO_2-insufflator was shut off, the trocar removed, and the colostomy matured in a routine fashion at the conclusion of the surgery. The perineal phase of resection was then carried out in a conventional fashion and the perineal wound closed using interrupted sutures.

Although not performed in our cadaver study, in the living human situation at this point, pneumoperitoneum would be again re-established, the peritoneal cavity checked for bleeding, and the pelvis irrigated. Drains would be placed through the lower trocar incisions on both sides. All other incisions would be closed with a figure-eight, size 0 suture to the fascia and then with 4-0 absorbable polyglycolic acid sutures subcuticularly.

RESULTS

Laparoscopic abdominoperineal resection was performed in 11 fresh cadavers (1 female and 10 males) with a median age of 36 (range, 16–49) years. The median operative time was 140 (range, 100–180) minutes, and decreased with surgical experience during the study. The median number

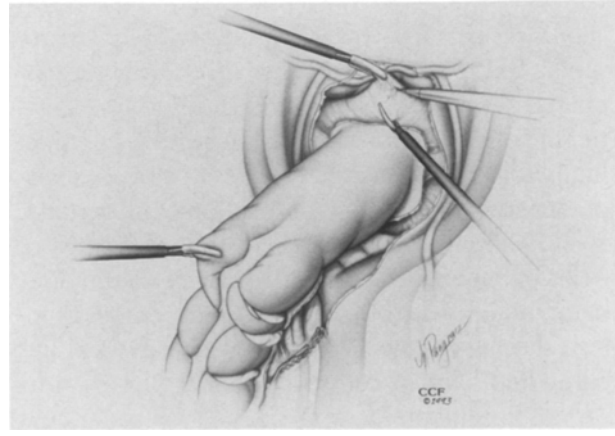

Figure 7. Mobilization of rectum anteriorly (cross-sectional view).

of removed LNs was 12 (range, 6–22) and the median length of removed specimen was 56 (range, 44–90) cm.

At the abdominal autopsy, the median length of remaining IMA was 5 (range, 1–15) mm. No remaining LNs were found at the origin of the IMA. Wide clearance of pelvic side walls was accomplished in all cadavers. There were no major vessel or ureteral injuries.

DISCUSSION

Improved laparoscopic surgical techniques have now made it possible to resect and anastomose all parts of the large intestine without a conventional incision.[1–15] Several authors have reported that possible benefits of "laparoscopic colon resection" include decreased pain, smaller incision, and earlier recovery of postoperative ileus, but these reports do not address the question as to whether adequate cancer surgery has been performed.

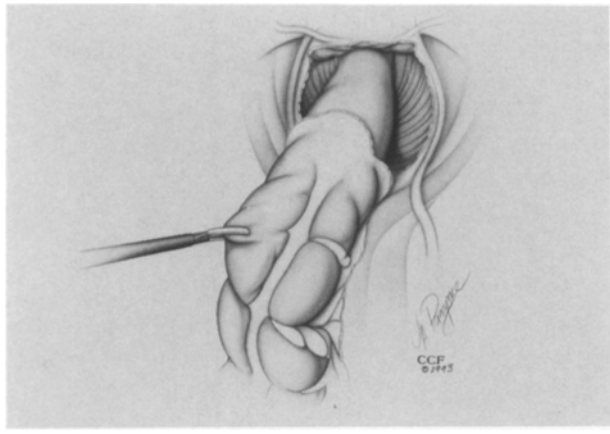

Figure 8. Complete mobilization of rectum down to pelvic floor (cross-sectional view).

Four recent articles[5, 6, 14, 15] describing laparoscopic colorectal operations listed adenocarcinoma as the most frequent indication for surgery. The first of these reports, which included 24 colectomies for colorectal cancer, contains no description of extent of resection or location of mesenteric vessel ligation.[5] This article refers to an average of 14 LNs per specimen removed, but this datum does not correlate with an adequate cancer operation. From the viewpoint of performing a new and unproven approach to colorectal cancer surgery, it is also not acceptable only to state, as these authors have, that "the extent of lymph node dissection is dependent on the skill of the operator and his or her determination to widely resect the mesentery." [5] The second article reported on 11 colectomies for colorectal cancer.[6] It does not, however, describe the authors' technique or location of ligation of the main mesenteric vessels during resection. The authors state that six of their cancer resections were performed with curative intent in which "an attempt was made to remove as much of the primary lymph node-bearing tissues as possible." [6] These articles not only do not substantiate that adequate cancer surgery was performed in this series, but they also only vaguely state their intent to accomplish curative resection for colorectal cancer.

Larach *et al.*[14] reported on four laparoscopic-assisted abdominoperineal resections for primary rectal cancer. The number of nodes identified in the specimens were one, four, six, and eight. The two patients with six and eight identified LNs each had four metastatic lymph nodes (Dukes C) and the other two patients had no positive LNs. The authors believe that their procedure was appropriate for the management of primary cancer "because the extent of bowel and mesenteric resection is similar to that obtained with open surgery and because the number of lymph nodes studied by the pathologist is similar to the number studied by an open laparotomy."[14] Since the authors neither support their statement with the number of removed LNs reported in their open laparotomy cases nor with any description of a laparoscopic oncologic resection, their statement is still questionable.

Although Monson *et al.*[15] reported the length of their removed specimens and the number of removed LNs, a description of an oncologic resection is also lacking in this article.

Since the number of resected LNs widely varies after resection of colorectal cancer,[21–24] counting the number of removed LNs is not a reliable index of an adequate oncologic resection. Scott and Grace,[24] using a meticulous mesenteric fat clearance technique, reported that in order to accurately stage 90 percent of colorectal cancers, a retrieval of at least 13 LNs from the specimen is necessary. This does not mean that a specific number of excised LNs guarantees that an oncologic resection was performed but that a specific number of LNs are necessary to stage the tumor accurately. The only number of LNs which might prove that an oncologic resection has or has not been accomplished is the number of LNs left inside the patient along the major mesenteric vessels or pelvic side walls.

We defined, for the purpose of our study, standards of adequate cancer surgery based on parameters proscribed in authorative works in colorectal cancer surgery[16–20]; namely,[1] resection of all known extent of cancer in the bowel wall and adjacent soft tissue,[2] resection of suitable margin of normal bowel wall above and below the cancer, and[3] excision of draining regional LNs accompanying the major vascular pedicles to the involved bowel (mesocolon/rectum).

There is no information available in the literature showing that a laparoscopic oncologic resection of colorectal cancer can be performed according to these surgical principles. Moreover, clinical results as to the efficacy of using laparoscopic techniques in curative colorectal cancer surgery will not become apparent for many years, except anecdotally. Therefore, we felt compelled to verify that an adequate cancer operation can be successfully performed by anatomic criteria using laparoscopic

techniques in fresh cadavers before attempting these procedures in candidates for curative abdominoperineal resection.

Laparoscopic resection in a cadaver model allowed us an excellent opportunity to test our hypothesis. We were able to perform an autopsy in every case immediately after the operation in order to assess and document adequate anatomic resection of the rectosigmoid and its adjacent mesentery and soft tissue.

This study permitted us not only to prove that a laparoscopic oncologic abdominoperineal resection is feasible but also to develop a standardized technique (illustrated here in detail) which may permit an adequate oncologic resection. In addition, by defining such a systematic approach, a radical procedure such as an oncologic abdominoperineal resection will undoubtedly be performed more safely and effectively.

An extremely high ligation of the IMA (range, 1–15 mm) was used in all cases to demonstrate that radical removal of the rectosigmoid lymphatic drainage is feasible. In a clinical case, such extreme proximal ligation may not be advisable because of the danger of bleeding.

There were no remaining LNs at the origin of the IMA in any cadaver. An oncologic resection in accordance with our definition was accomplished in all cadavers.

Since laparoscopic intestinal surgery is in its infancy, and no long-term data are available regarding results in oncologic colorectal surgery, we therefore believe this study answers several critical questions. Using the anatomic and surgical criteria we have outlined here, the IMA can be divided and ligated close to the aorta and a radical resection of the rectal and sigmoid mesentery can be performed deep in the pelvis using laparoscopic techniques. The described procedure contradicts the statement of MacFadyen *et al.*[25] that ". . . laparoscopically, . . . major blood vessels are not easily identified until the colon has been removed."

Although this study cannot address physiologic questions (*e.g.*, bleeding, anastomotic leakage) about laparoscopic intestinal surgery, which we have evaluated in animal models,[26–28] only a study such as this, using cadavers in a fresh state with postoperative autopsy, can verify anatomically that an adequate primary colorectal cancer operation can be performed using laparoscopic techniques.

Only a prospective, randomized study which compares the recurrence and long-term survival between "open" and laparoscopic surgery can answer the question as to whether a curative abdominoperineal resection of rectal cancers can be accomplished with the same outcome as in open surgery. Since reliable results of a survival study will not be available in the next five to ten years, we recommend following a standardized approach of abdominoperineal resection for cancer. Furthermore, the laparoscopic surgeon must, for the sake of optimum patient care, use video documentation in each procedure to prove that an oncologic curative resection has been performed, or abort the laparoscopic procedure and perform the surgery using a conventional approach.

CONCLUSION

This study illustrates a step by step approach for the performance of an oncologic abdominoperineal resection using laparoscopic techniques and proves that a proximal ligation of the IMA with wide clearance of the lymphatic drainage of the rectosigmoid can be accomplished laparoscopically.

ACKNOWLEDGMENTS

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