Discover Medicine

Case Report

Case report: a safe laparoscopic technique for complicated appendicitis

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Abstract
A case of *complicated appendicitis* is presented to illustrate a safe laparoscopic appendectomy technique. What makes extirpation so difficult in *complicated appendicitis*? Infection and tissue injury initiate the release of cytokines, which attract the omentum and cause contiguous loops of bowel to adhere, effectively isolating the inflammatory locus. Surgical dissection must reverse this process. Visualization is excellent in laparoscopy; however, operators lack tactile sensation; and when organs are fused together, touch is a valuable aid to accurate dissection. Injury to the adjacent organs (small bowel, colon, fallopian tubes, or ureter) may occur and require repair or resection (cecectomy or hemicolectomy). What is needed is an operative technique that is safe and effective in these challenging situations, especially when the appendix is adherent to adjacent structures and encased in a cocoon of (highly vascularized) fibrous tissue, a *phlegmon*. The technique presented is derived from *open surgery*. It is utilized to avoid injuring vulnerable structures in the pelvis, when performing a proctectomy for ulcerative colitis or Hirschsprung's Disease. This goal is accomplished by maintaining a plane of dissection that abuts the rectal wall. The same technique is applied in complicated appendicitis to avoid injuring adjacent organs. This procedure is contrasted with an alternate (simpler) technique applicable to uncomplicated appendicitis.

Keywords Appendicitis (complicated and uncomplicated) · Appendicitis and phlegmon · Laparoscopic appendectomy: surgical technique · Ruptured appendix

1 Introduction

Laparoscopy changed *how* surgery was performed, not what was done (the procedure) nor why (the indications). Appendicitis is a notable exception. Remarkably, changing operative access altered how disease was treated—surely an unforeseen consequence.

The initial change was to downgrade the classification of appendicitis from *emergent* to *urgent*. No longer were appendectomies done in the middle of the night; they were scheduled next day, *first available*. Studies were done to verify that this change had no detrimental effect upon patient outcome.

But this change applied only to patients with *uncomplicated appendicitis*. Patients with *complicated appendicitis* were treated non-operatively with parenteral antibiotics, frequently necessitating long-term venous access. *Source control* was

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delegated to Interventional Radiology, and surgery was delayed 6–8 weeks to permit quiescence of a presumably *hostile abdomen* [1]. Some physicians even questioned whether (interval) appendectomy was necessary [2].

Why were sicker patients treated less aggressively? The answer is that only basic laparoscopy skills are required for *uncomplicated appendicitis*, whereas greater technical prowess is required for *complicated appendicitis* [2].

The laparoscopy learning curve is steep; but finally, it appears that we have come full circle, as more recent studies conclude that substantial benefit accrues from Same Admission Appendectomy (SAA)—the *modus operandi* prior to laparoscopy [4–9].

This report contrasts what are really two different operations: laparoscopic appendectomy for *simple* versus *complicated* appendicitis; and a technique is presented that is useful in instances where inflammation obscures the anatomy, especially the demarcation between the appendix and adjacent structures. Our hope is that surgeons who have not yet embraced SAA will do so with confidence.

1.1 Case presentation

A 17-year-old young lady complained of worsening abdominal pain of several days' duration. Her pain was initially periumbilical but gradually migrated to the right lower quadrant. It was exacerbated by movements, especially extension of her right hip; and it was associated with anorexia but no nausea or vomiting. She was otherwise healthy. Her menses were regular, and she was mid-cycle.

Appendicitis Scoring (A score of 4 or more is significant.)

Clinical Variable	Response	Value
Anorexia	Yes	1
Nausea or Vomiting	No	0
Migration of Pain	Yes	1
Fever > 100.4F/38C	No	0
Pain with Cough/Percussion	Yes	1
RLQ Tenderness	Yes	1
Leukocytosis	Yes	1

Her vital signs were normal. Blood work included a basic metabolic panel and a complete blood count. Abnormal values were a leukocytosis of 13,300/cm and an elevation of C-reactive protein 1.6 (normal < 1). Physical examination was unremarkable, except that her abdomen was mildly distended and tympanitic. Bowel sounds were diminished, and she was tender in the right lower quadrant with guarding. Psoas sign was positive on the right side. No hernia or organomegaly was appreciated.

The appendix was not visualized by Ultrasound. A CT scan demonstrated an acutely inflamed, retrocecal appendix with fat stranding but no abscess (Figs. 1 and 2).

It is noteworthy that appendicitis with phlegmon is sometimes, but not always, apparent on CT scan [7].

Because radiographs reflect gradations in water density, an appendix with phlegmon may be more easily delineated on CT than by direct visualization.

Parenteral fluids and antibiotics, as well as an analgesic and antiemetic were given.

Consent for laparoscopic appendectomy was obtained. A retrocecal *appendicitis with phlegmon* was identified and excised, as described below. The young lady's recovery was prompt; and she was discharged the day following surgery. Analgesics, but no antibiotics, were prescribed.

The pathology report described *acute and chronic* inflammation with peri-appendicitis, which is consistent with the supposition that an extended period of time is required to create fibrous encasement of the appendix.

Fig. 1 CT Coronal and Sagittal Views. Arrows indicate a well demarcated, inflamed appendix

Fig. 2 Arrows indicate a well demarcated, inflamed appendix

1.2 Operative Procedure

The usual arrangement of the ports for laparoscopic appendectomy places the camera in the left lower quadrant, and the two working ports in the midline: one supra-pubic and the other at the umbilicus.

Because a child's abdomen is smaller than an adult's, the ports are arranged differently: the camera is placed at the umbilicus, and the working ports are situated in the left lower and right upper quadrants respectively. This creates an equilateral triangle, which facilitates dissection and tying intracorporeal knots.

If the appendix is retrocecal, the inferior and lateral peritoneal attachments of the cecum are divided to facilitate its medial rotation. In this case, the appendix was adherent to the posterolateral aspect of the cecum, buried in a trough and covered by a thick veil of fibrovascular tissue (Fig. 3).

Fig. 3 Phlegmonous Appendicitis

Fig. 4 Appendix with a well-defined mesentery (arrow)

Fig. 5 Ties are placed; the appendix is divided

In *simple appendicitis,* the appendix derives its blood supply from a well-defined vascular pedicle that can be divided *en mass* with a stapler or stepwise with cautery (Fig. 4). An appendix that is adherent to the cecum shares its blood supply, which consists of multiple small vessels that must be individually coagulated and divided.[1]

[1] A video is available—https://youtu.be/63yao7k0l9o

Fig. 6 Dissection proceeds proximal to distal

Fig. 7 The appendix is elevated, and dissection proceeds directly on the appendiceal wall

Excising the appendix, without injuring the cecum, is dauntingly hazardous. The appendix is least inflamed at its base, proximal to the fecalith. A space is created beneath this portion of the appendix by gentle dissection, dividing the small blood vessels as they penetrate the wall of the appendix (Fig. 5).

The appendix is doubly ligated and divided (Figs. 5 and 6). If a surgeon prefers to divide the appendix with a stapler, the encircling ties will assist in creating an adequate space for the stapler and situating it correctly.

The ports' equilateral arrangement facilitates intra-corporeal knot tying. By pulling the short end of a square knot up and the long end down, a *sliding knot* is created [10]. The distal end of the appendix is elevated away from the cecum, and nutrient blood vessels are cauterized and divided.

Dissection proceeds in an antegrade direction (towards the tip) along the appendiceal wall, dividing the overlying fibrovascular tissue and underlying blood vessels (Figs. 7 and 8).

1.3 Laparoscopy in uncomplicated appendicitis

"Follow the omentum!" An acutely inflamed appendix stands out like a *sore thumb* (Fig. 4). The vascular pedicle is a distinct structure that is readily coagulated and divided. Retrograde dissection proceeds towards the cecum; and the appendiceal base is secured by stapler or Endo-Loops and transected (Fig. 9 and 10).

Fig. 8 Safe division of blood vessels and inflammatory tissue

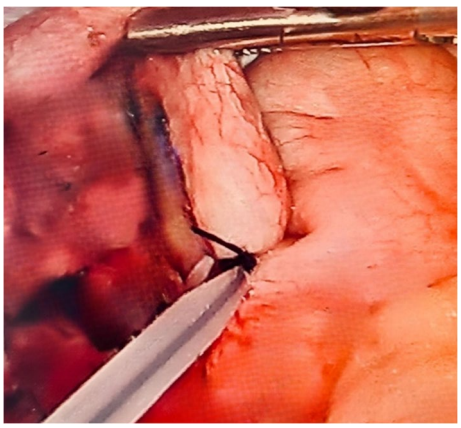

Fig. 9 Placement of Endo-Loops

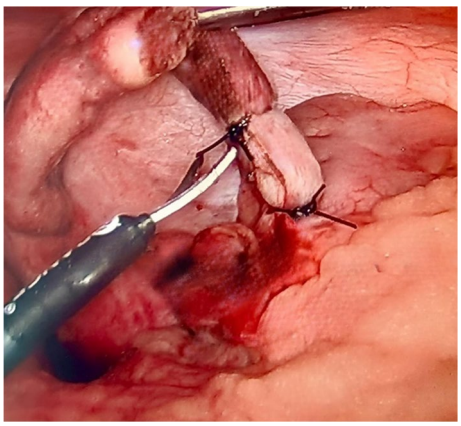

Fig. 10 Division of the appendix between ties

1.4 Discussion one size (does not) fit all!

1.4.1 Anatomy dictates the surgical technique

Searching the literature for "Appendectomy Technique" yields comparisons of open versus laparoscopic surgery outcomes or single port versus multi-port techniques. Operative technique is learned from mentors; there is scant guidance in the literature regarding how to perform a difficult appendectomy. Technical competence is assumed. After all, is not an

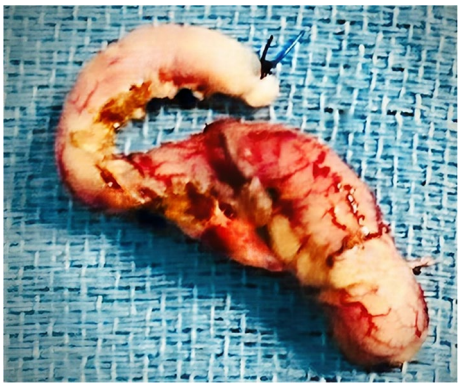

Fig. 11 The narrow portion of the appendix (read as 6 mm) may be more obvious to the radiologist; and the report cause confusion, when coupled with a description of inflammation

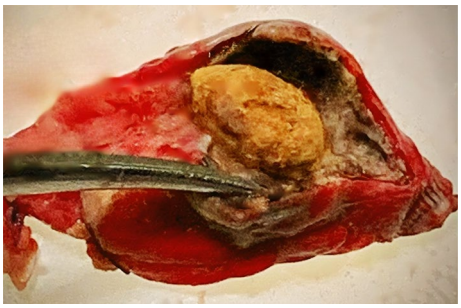

Fig. 12 Contrast the appearance of the mucosa proximal versus distal to the obstructing fecalith

appendectomy a junior resident case? Usually, two firings of the stapler are all that is required. The technique is quick and efficacious, but it has no utility when contending with phlegmonous appendicitis.

Admittedly, this report addresses a niche; however, it is an important niche, because appendicitis is encountered so frequently, and a phlegmon may not be apparent preoperatively. The technique espoused allows a surgeon to navigate obfuscated anatomy safely. It is a valuable addition to one's armamentarium.

1.4.2 Pathogenesis dictates the treatment

Diagnostic accuracy is enhanced by clinical algorithms and sophisticated imaging techniques: CT, Ultrasound, and MRI. Diagnostic criteria are:

1. Can the appendix be identified?
2. Is it dilated? If so, how much?
3. Is it compressible? Does the patient experience pain in response to this maneuver?
4. Is there inflammation of the appendiceal wall and/or contiguous tissues ("fat stranding")?
5. Is there intra-luminal obstruction, a fecalith?
6. Is there evidence of perforation/ abscess/intestinal obstruction?

A vestigial organ is deemed a relic, useful to our ancestors, but without a present function. Such a belief, however, negates the impetus to investigation; and its potential function (if any) will never be discovered. Thankfully, this conundrum, this tautology, is itself a remnant of the past.

The appendix is currently thought to have a role in the development of gastrointestinal immunity, especially extrathymically derived T and B lymphocytes [13]. *Unobstructed appendicitis* is attributed to dysfunction in the interaction of host immunity and gastrointestinal pathogens; hence, the efficacy of antibiotics in some instances.[1, 11, 12].

In patients whose appendices are obstructed and dilated, diagnosis and treatment are clear. But what about patients whose studies show inflammation, but no luminal obstruction or significant dilatation (Fig. 11)?

Antibiotics are usually begun in the emergency room based upon the radiologist's report. Should they be continued? Should the child be observed, or should an appendectomy be done? Only if the pathologist identifies mucosal inflammation is the radiologic diagnosis corroborated.

Is there a subset of appendicitis that is primarily infectious in etiology, rather than primarily obstructive and secondarily infectious? (Fig. 12) Could obstruction be caused by lymphoid hyperplasia, rather than a fecal concretion? Ambiguous cases may represent viral infections (mesenteric adenitis).

The etiology of obstructed *appendicitis* accords with the classic model. Obstruction of the appendiceal lumen (by a fecalith) increases the intra-luminal pressure through glandular secretion and bacterial overgrowth. This causes ischemia and release of cytokines that recruit leukocytes, mobilize the omentum and cause proliferation of fibro-vascular tissue, which circumscribe and isolate the septic locus. This reaction takes time, which accords with the pathology report's description of *acute and chronic inflammation*.

Whereas antibiotics may be efficacious in treating *unobstructed appendicitis*, appendectomy is generally considered necessary to resolve *obstructed appendicitis* [13]. Clinical corroboration is provided by instances of "Stump Appendicitis," wherein the anatomy is obscure, and a portion of an obstructed appendix is inadvertently left behind leading to recurrent appendicitis.

1.4.3 The over-riding question is, "What is best for the patient?"

An exhaustive study of 63,627 pediatric patients compared Same Admission Appendectomy *(*SAA) versus Non-Operative/Interval Appendectomy *(*NO/IA) and reported data that favored SAA [7, 8].

SAA patients did have longer hospitalizations, but only if the IA days were excluded in reporting NO/IA data. SAA had more initial complications: sepsis, bacteremia, pneumonia, ileus, and wound infections, but NO/IA had more unplanned hospitalizations (prior to IA), more imaging studies, and more ancillary procedures, such as lysis of adhesions and IR drainage of abscesses; and consequently, their over-all cost was greater. There was no difference in the incidence of serious complications, such as intestinal resections, anastomoses, or creation of ostomies [3, 14–17]. The authors of these studies concluded that "health-related" quality of life was better with SAA.

Patients with *appendicitis and phlegmon* recover promptly, since there is usually no contamination, only encasement of the appendix in vascularized fibrous tissue. Recovery in ruptured appendicitis is hastened by removal of the infected, necrotic organ. Parenteral antibiotics are required for an extended time- period; but generally, this is shorter than prescribed in NO/IA**.**

The rational for delay (NO/IA) is that laparoscopic appendectomy is rendered less hazardous. In our opinion, delay is unnecessary. Laparoscopic appendectomy (even if ruptured or phlegmonous) is feasible and safe during the initial hospitalization and much to be preferred.

2 Conclusion

The conclusion, SAA is better than NO/IA, is based upon clinical experience and the references cited.

"If this is true, why is NO/IA so widely practiced?" The answer and impetus for writing this report is that SAA can be extremely difficult, fraught with peril. Occasionally one hears, bantered about the operating room, that a "radical appendectomy" (appendix plus colon) was performed. Tumor may warrant such an operation, but the pejorative terminology suggests rather a technically flawed appendectomy. It is this conundrum, this niche, that we address.

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Author contributions James G. Glasser MD is the sole author. He also performed the surgery and edited the photographs and the video; in addition, he prepared and edited the manuscript.

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Data availability Physicians rightly ask themselves, "What is best for the patient?" The conclusion that 'Same Admission Appendectomy' is better than 'Non-Operative/Interval Appendectomy' is based upon the studies referenced in the text. The impetus for writing this report is, "If this claim is true, why is NO/IA still widely practiced?" The answer is that laparoscopic appendectomy (in complicated appendicitis) is difficult and hazardous; hence, surgeons shy away from it. This paper describes a technique that is safe and efficacious.

Declarations

Consent for publication Written informed consent was obtained for publication of the accompanying images for educational purposes, in conformity with the guidelines of the affiliated institution. A copy of the written consent is available for review if requested by the Editor-in-Chief.

Competing interests The authors declare no competing interests.

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