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Review Article

Anastomotic Leak in Colorectal Surgery: A Comprehensive Review

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Abstract

Background: In colorectal surgery, and despite the vast advances in surgical techniques and devices anastomotic leak continues to be the catastrophic complication due to the associated increased risk of morbidity, mortality, its overall impact on functional and oncologic outcome of the patient, and drainage of hospital resources. This review aims to present a comprehensive review on anastomotic leak in colorectal surgery.

Materials and methods: We electronically searched PubMed, Medline, Embase, Cancerlit and Google Scholar databases for articles published between 1950 and 2020 using the following keywords:

"Colorectal anastomotic leak", "colorectal surgery", "anastomotic leak" with a specific emphasis on risk factors, prevention strategies, and treatment strategies.

Results: Risk factors were divided into preoperative, operative and postoperative risk factors. Management scenarios were divided according to the location of anastomosis being it intraperitoneal versus extra peritoneal anastomosis and those anastomosis where a protective or diverting stoma was created in the initial surgery. Management options were then based on the clinical presentation and radiographic findings and organized into four algorithms.

Conclusion: This article is useful for management of colorectal anastomotic leak and stratifying patients according to risk factors whereby some can be modified.

Keywords: Anastomotic leak; Colorectal surgery; Complications of colorectal surgery; Management of leak

Introduction

The most dreaded complication of gastrointestinal surgery is anastomotic leak that is often associated with increased morbidity, increased mortality and prolonged hospital stay. Anastomotic leak frequency and consequences vary according to the site within the gastrointestinal tract. In colorectal surgery, and despite the vast advances in surgical techniques and devices anastomotic leak continues to be the catastrophic complication. It is the most feared and dreaded complication in colorectal surgery due to the increased risk of morbidity, mortality, its overall impact on functional and oncologic outcome of the patient, and drainage of hospital resources. Anastomotic leak can result in short term consequences including death, sepsis, need for reoperation and stoma formation and long term complications including impaired bowel function, anastomotic strictures, permanent stomas and reduced survival in patients with cancer due to increased risk of local recurrence and hence, disease free survival. Despite the heavy burden of such a complication and its consequences, few attempts have been made to bring together the available data in the medical literature in order to provide clinical guidance for surgeons and in particular for colorectal surgeons. This review aims to present a comprehensive review on anastomotic leak in colorectal surgery.

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Definition

There is no uniformly accepted definition of an anastomotic leak in the medical literature. In 1991 the United Kingdom Surgical Infection Study Group defined anastomotic leak as the "leak of luminal contents from a surgical join between two hollow viscera" [1]. Moreover, 56 different definitions of what constitutes anastomotic leak have been identified in a review of literature between 1993 and 1999 [2]. This was followed by the definition adapted in 2010 by the International Study Group of Rectal Cancer who defined anastomotic leak as a defect at the anastomotic site leading to a communication between the intraluminal and extraluminal compartments [3]. Based on this definition, in 2015, the International Multispecialty Anastomotic Leak Global Improvement Exchange (IMAGInE) defined anastomotic leak as a defect of continuity localized at the surgical site of the anastomosis, which creates a communication between intraluminal and extraluminal compartments [4]. From this definition, anastomotic leak can be classified into three grades A, B, and C. Grade A is anastomotic leak which has a clinical impact, but does not require active therapeutic action. Grade B has a clinical manifestation, therapeutic intervention is necessary such as radiologic drainage, however does not require surgical re-intervention. And grade C anastomotic leak whereby surgical intervention is mandated [5,6].

Epidemiology

The debate surrounding the definition of anastomotic leak lead to a reported incidence of anastomotic leak ranging from as low as 1 percent and reaching 30 percent in some reviews. Colorectal anastomotic leaks rates have been found to vary according to the anatomic location of the anastomosis, with distal colorectal, coloanal and ileoanal leak rates ranging from 1% to 20%, colocolonic leak rates from 0% to 2%, and ileocolonic leak rates from 0.02% to 4% [7,8]. This wide range in the incidence is mostly based on the criteria used

to diagnose anastomotic leak on one hand, and on the other hand the length of follow up, with an average of 11 percent [9]. Moreover, lower overall incidence of anastomotic leak is noted when performed by experienced surgeons [10].

Risk Factors

Identification of risk factors that increase the rate of anastomotic leak, mainly those that can be modified, is the first step towards decreasing its incidence and its associated morbidity and mortality. Having said this, we divide the risk factors for anastomotic leaks into preoperative, operative and postoperative. Preoperative alteration of risk factors associated with life style or certain type of treatment may aid in lowering the risk of anastomotic leak. However, this is not always possible especially in the emergency setting.

Preoperative Risk Factors

Alcohol

Sorensen et al concluded that alcohol abusers compared with abstainers has an increased rate of anastomotic leak with a relative risk of 7.18 (95 percent confidence interval 1.20 ± 43.01) [11]. In fact, they noted that large quantities of alcohol consumption might be a surrogate for poor nutritional status.

Smoking

Sorensen et al. [11] did a retrospective study examining 333 patients from 1993 to 1996 and found smoking was associated with anastomotic leak on multivariate analysis. This is due to the effect of smoking on the micro vessels supplying the anastomosis, hence the leak is ischemic in nature. Add to this, Kim et al. [12] concluded that a previous smoking history (>40 pack years) is an independent risk factor for anastomotic leak. Furthermore, several studies have demonstrated current smoking to be an independent risk factor for anastomotic leak [13,14]. In fact, both current and history of smoking is associated with increased risk of anastomotic leak.

Obesity

It would be logical to think that obesity increases the risk of anastomotic leak because obesity and in particular the increased adipose tissue on the colon makes it more difficult to properly clean the colon in order to obtain the perfect anastomosis. Add to this that the mesentery in obese patients is thickened and shortened leading to undue tension over the anastomosis. Besides, the comorbid conditions associated with morbid obesity such as diabetes and its effect on the microcirculation will lead to an increased risk of anastomotic leak. Having said this, there is discrepancy in the medical literature regarding the relation between obesity and anastomotic leak. For instance, Choi et al. [15] and Vignali et al. [16] in a prospective study encompassing nearly 3,500 patients undergoing colorectal resections for malignancy, have not found obesity to be a factor that increased risk of anastomotic leak. In contrast, several other studies have shown obesity to independently increase the risk of anastomotic leak [17,18]. In fact, Rullier et al. [19] showed that the risk of leak in obese patients undergoing low anterior resection was 33 percent as compared to 15 percent leak in the nonobese patients.

Medications

In view that steroids impair wound healing one can extrapolate that steroid use will affect the healing of an anastomosis and hence, the rate of anastomotic leak. In fact, Konish et al. [20] concluded that the rate of leak was 11.8 percent in patients with steroids versus 2.4 percent in those without steroids. This was a prospective study evaluating 391 consecutive elective colon resections. Add to this the results of Golub et al. [21] and Slieker et al. [22] who concluded that prolonged use of steroid is associated with increased risk of anastomotic leak.

Bevacizumab which is a vascular endothelial growth factor inhibitor. This drug has been shown in phase III trials, in combination with several other standard chemotherapy regimens, to increase overall survival in patients with colon cancer. It should be stopped and not restarted for at least 28 days prior and after surgery as the manufacturer advice [23]. However, there's some recommendations to delay operations up to 60 days after the last dose, as the half-life of the drug is 20 days and since wound healing complication continue to occur up to 56 days after treatment which is equivalent to three half-lives [24]. The first studies examining bevacizumab reported several patients with bowel perforations [25,26]. The mechanism of this perforation is proposed to be arterial micro thromboembolic disease leading to bowel ischemia. The same mechanism can cause an anastomotic leak, as can inhibition of angiogenesis in the microvascular bed of new anastomoses.

Cyclosporine A [27] Tacrolimus [28] and Everolimus [29] there's an experimental evidence suggesting increased risk of anastomotic leak.

Nutrition and Hypoalbuminemia

Malnutrition impairs anastomotic healing by affecting collagen synthesis or fibroblast proliferation. Malnutrition defined as an unintentional weight loss of >10% in 6 months, and a serum albumin concentration of <35g/L increases the risk of anastomotic leak [30,31]. Several studies have shown a correlation between low albumin levels and an increased incidence of anastomotic leaks [32,33]. Furthermore, Makela et al. in their case control study that that malnutrition (serum albumin less than 35g/L) was a substantial risk factor for anastomotic leak after multivariate analysis. Therefore, nutritional assessment should be done in all patients being prepared for surgery, and every attempt should be made to correct malnutrition.

Bowel preparation

Traditionally, mechanical bowel preparation is used to prepare for all elective colorectal resection surgeries. Mechanical bowel preparation reduces the stool burden, and facilitate the use and insertion of stapling devices. However, if mechanical bowel preparation was not given it does not appear to increase the anastomotic leak rate in several randomized controlled trials and a systematic review [34,35]. Furthermore, Miettinen et al. [36] studied 267 patients who were randomly selected to mechanical bowel prep versus no bowel prep before colonic resection with results revealing a 2% leak rate in the unprepped patients as compared with a 4% leak rate in the prepared patients, but this difference was not significant. Add to this that Makela et al. [32] in their case-controlled study found that mechanical bowel prep did not influence the anastomotic leak rate. However, the debate of whether the presence of solid stool with bacterial collagenases contributes to suture-line breakdown and consequently anastomotic leak remain unanswered in the medical literature. From here, and given the wide range of conclusions and opinions in the literature that has examined the use of mechanical bowel preparation, we recommend mechanical bowel preparation whenever there's no contraindication in all colonic resections, although it is not pleasant to the patients.

Preoperative antibiotics and selective decontamination of

the digestive tract

Preoperative broad-spectrum intravenous antibiotics are routinely used in elective and emergency colorectal surgery, with the goal of reducing postoperative infective complications.

Furthermore, in the USA, some surgeons routinely use non-absorbable oral antibiotics such as Tobramycin and Amphotericin B. This is Known Selective Decontamination of the Digestive Tract (SDD). In fact, Roos et al. [37] did a systematic review showing that selective decontamination of the digestive tract reduces anastomotic leak rates from 7.4% to 3.3%. Add to this that Morris et al in a study of 8,000 patients with colorectal resections demonstrated lower surgical site infection and anastomotic leak rates in the treatment group [38].

Gender and age

Male gender and increasing age (especially age over 60) may increase the risk of anastomotic leak. Anastomotic leak was reported to be more common in men probably related to surgical technical difficulties encountered in the narrow male pelvis. Bisgard et al. has shown that male gender is more prone to develop colonic anastomotic leak. On the other hand, Park et al. and Lipska et al. has shown that male gender is at higher risk of rectal anastomosis. Furthermore, in a prospective study of 196 patients with rectal cancer resections, Law et al. [39] showed on multivariate analysis that male patients with anastomoses more than 5 cm from the anal verge had a higher rate of anastomotic leak than did women. Similarly, a retrospective analysis of 541 consecutive operations with colonic and rectal anastomoses found an overall leak rate of 11% in men as compared with only 3% in women, which on multivariate analysis was significant [40].

On the other hand, the effect of chronological age is not observed consistently and is most probably accounted for by underlying comorbidities. Jung et al. [41] and Damhuis et al. [42] showed that increasing age or age >60 is associated with an increased risk of Anastomotic leak. On the contrary, Fernandes et al. [43] have failed to report this. Hence, the biological age probably is the true contributing factor towards the increased risk of anastomotic leak.

Radiotherapy

History of pelvic radiotherapy being it for prostate cancer or cervical cancer is associated with very high risk of anastomotic leak. In fact, Smith et al documented the rate of anastomotic leak to be as high as 36 percent in patients with previous radiotherapy for prostate cancer and cervical cancer.

On the other hand, neoadjuvant radiotherapy is the standard of care for locally advanced rectal cancer either T3 or N1 by preoperative radiologic staging. In fact, Chambers and Mortensen [44] found inconclusive data about whether preoperative radiotherapy leads to higher leak rates. Furthermore, several retrospective studies such as Rullier et al. [19] and Vignali et al. [16] found no differences in anastomotic leak rates between patients with low rectal anastomoses who received radiotherapy and those who did not, regardless of whether or not they also had proximal diversion. It is unclear from the existing data whether radiotherapy is a risk for anastomotic leak, however, we do recommend a protective diverting stoma in patients with low rectal anastomosis treated with neoadjuvant chemoradiation therapy until the contrary is proven.

Diabetes Mellitus

The contribution of diabetes mellitus to the rate of anastomotic leak is debatable. Whereby, one study has shown an increased rate of leak from ileocolic anastomosis in patients with diabetes [17] in addition to an increased rate of anastomotic leak in low anterior resection [45]. On the contrary, McArdle et al. [46] has demonstrated no change in anastomotic leak rate but higher mortality in those who do sustain a leak.

Tumor factors

Distance of the tumor from the anal verge and hence, the distance of the subsequent anastomosis from the anal verge is a substantial risk factor contributing to anastomotic breakdown and leak. In fact, Branagan and Finnis showed a substantially higher leak rate in patients with rectal or rectosigmoid resections (6.7%) compared with colonic anastomoses (2.6%) was reported [47]. Furthermore, multiple studies have shown that distance from the anorectal junction is an independent predictive risk factor for anastomotic leak [13,48,49]. On the other hand, other factors that increase the rate of anastomotic leak are tumor size >3 cm [50] or >4 cm [51].

Co-morbid conditions

Increased rate of anastomotic leak was found in patients with:

- Pulmonary disease [21,22,52]
- Vascular disease [53]
- Renal transplant patients [54-56]
- ASA of greater than 2 [57], 3 [16] and 4 [58]

Operative Risk Factors

A certain subset of patients develop anastomotic leak though no preoperative risk factors have been identified, this is mainly related to intraoperative event.

Surgeon's experience and hospital size

Two important factors that may impact the risk of AL after colorectal surgery are the experience of the surgeon performing the procedure and hospital volume. In fact, Marinello et al. [59] and García-Granero et al. [60] reported that the rate of anastomotic leak is related to the experience of the surgeon and only one related to hospital size.

Level of the anastomosis

The distance of the anastomosis from the anal verge is regarded as the most important predictive factor for leakage. Several studies have shown that the lower the anastomosis, the higher the risk of leakage [61-64]. Furthermore, Hamabe et al. [65] reported that the anastomotic leak rate was 3.4 times higher for tumors located less than 7 cm from the anal verge. On the other hand, when comparing right and left colonic resection Branagan et al. [47] in a prospectively collected data of 1,834 patients with colorectal resections, a higher anastomotic leak rate was observed in patients with rectal or rectosigmoid resections (6.7%) compared with colonic anastomoses (2.6%).

Duration of surgery

Prolonged operations may reflect intraoperative difficulties especially in critical patients. Konishi et al. [20] in their prospectively collected data of 391 colorectal resection showed that a higher rate of anastomotic leak was seen in operations that lasted more than 4 hours. Furthermore, one retrospective review of 1,014 patients noted that in patients where an anastomotic leak occurred after rectal resection, there was a significantly longer mean and median duration of operation (220 minutes *versus* 186 minutes) [16]. Other authors

have shown that prolonged operative time can be associated with leakage, with a reported threshold varying from 220 to 300 minutes [63,66,67].

Blood supply to the anastomosis

Poor vascularity at the anastomosis will impact negatively on anastomotic healing and is likely to result in anastomotic leak, hence, intraoperative assessment of perfusion at the site of anastomosis is important. As a rule of thumb, prior to any anastomosis, inspection of the proximal lumen of the bowel is a must. If the mucosa is pink then the blood supply is adequate. Relying on merely looking at the serosal surface is inadequate, as the serosa might be viable but the mucosa is not.

Blood loss

Leichtle et al. [68] concluded that increased blood loss during colectomy should raise suspicion for potential postoperative anastomotic leakage.

Hypoxia

Schietroma et al. [69] proved that hypoxia increase the rate of anastomotic leak and concluded that supplemental 80% FiO2 during and for 6 h after major rectal cancer surgery, reduce postoperative anastomotic dehiscence, and should be considered part of ongoing quality improvement.

The use of vasopressors

The use of vasopressors appears to increase anastomotic leaks threefold, independent of clinical/surgical status or hypotension. In fact, Zakrison et al. [70] concluded the use of vasopressors is associated with a threefold increase in anastomotic leak.

Anastomotic technique: stapled versus hand sewn anastomosis

The tremendous advancements in technology in colorectal surgery gave birth to the question "Are leak rates comparable between the traditional hand sewn anastomosis and the staplers?"

Docherty et al. [71] showed in their multicenter, randomized, prospective trial comparing hand sewn to stapled anastomosis in elective and emergent colorectal operations showed that there's strong evidence that anastomotic rates are equal. Furthermore, similar results were found in a prospective study done by Choi et al. [15] that enrolled 1,417 patients with colon resections above the peritoneal reflection and found that there was no difference in leak rates between stapled and hand sewn anastomoses.

Use of drains

The routine use of drains after colorectal resections is a matter of debate. With conflicting reports in the medical literature regarding the pros and cons of its use. In fact, routine prophylactic drainage after colorectal anastomoses is debatable with low evidence to support its use [72]. On the other hand, draining the pelvis after pelvic colorectal resection may prevent seromas and hematomas, and hence, decreasing the risk of collection, and abscess formation which in turn can cause dehiscence of the anastomosis. Moreover, pelvic drain may help control leaks if they do take place, leading to a less severe clinical course [73]. Moreover, Yeh noted that only 5% of patients with pelvic leaks had pus or enteric contents in the preexisting drains [74]. Highlighting the fact that drains do not adequately identify a patient population with early leaks.

Aforementioned, Qu et al. [75] in their RCT of 469 patients who underwent rectal resection with infraperitoneal anastomosis. There was no significant difference in terms of pelvic sepsis between drained and non-drained patients. Furthermore, Merad et al. [76] performed a controlled, multicenter study encompassing 317 patients that proved intraabdominal drains were not beneficial.

On the contrary, two retrospective studies found that pelvic drainage is associated with lower rates of anastomotic leak after low anterior resection, though without reaching statistical significance. Furthermore, Kawada et al. [66] reported anastomotic leak rate in 10.8% of drained patients versus 20.8% of non-drained patients.

Intraoperative testing of the integrity of the anastomosis

There are two main tests used intraoperatively to document the integrity of the anastomosis. The airtight test and betadine test. In either case repair of the anastomotic defect should be attempted if the test was positive and the anastomosis then retested. Irrespective of the quality of scientific evidence these tests should be done as at least a technical leak can be ruled out.

Protective stoma: The controversy regarding a protective stoma involves whether or not the stoma prevents a leak and reduces the corresponding clinical consequences. Studies have shown that proximal fecal diversion by a protective stoma significantly reduces the overall risk of a reoperation following an anastomotic leak [77]. Furthermore, a meta-analysis of four randomized trials including 358 patients undergoing a low anterior resection for rectal cancer found that patients with a protective stoma had significantly fewer anastomotic leaks compared with patients who had no protective stoma (9.6 *versus* 22.8 percent) [78]. On the contrary, a prospective multicenter study of 2729 patients undergoing a low anterior resection, the overall anastomotic leak rate was similar in patients with and without a stoma (14.5 *versus* 14.2 percent) [79].

Postoperative Risk Factors

Postoperative NSAID use

NSAIDs: There is growing evidence that NSAIDs should be used with caution in the postoperative period. In fact, Bhangu et al. [80] in their meta-analysis showed that non-selective NSAIDs were associated with an increased risk of anastomotic leak.

Post-operative hypoalbuminemia

Monitoring of the post-operative nutritional status is a good way to identify patients with high risk of anastomotic leak. In fact, Shimura et al. [81] in a retrospective series of 200 patients undergoing laparoscopic curative surgery for colorectal cancer, the average serum albumin levels on postoperative day 1 and postoperative day 3 were significantly lower in the anastomotic leak group as compared to the non-leakage group.

More Risk Factors

Matrix Metalloproteinase (MMP) and collagenases

Emerging data continue to evolve regarding the role of local microbiome as a critical factor in the development of anastomotic leak [82]. Matrix Metalloproteinases (MMPs) and collagenases are part of the body's normal response to injury. However, these proteins have been implicated as important mediators of anastomotic leak [83]. Animal studies have suggested that certain bacterial strains that produce these collagenolytic proteins (*Enterococcus, Pseudomonas, or Serratia* species) may contribute to the development of anastomotic leak [83,84].

Clinical Presentation

In general, anastomotic leak is diagnosed within the first 2 weeks after surgery [85,86]. The majority of leaks being diagnosed between the 7th and 12th postoperative days, while up to 42% of patients are diagnosed after the patient has been discharged, and up to 12% occur even beyond postoperative day 30 [85,87]. Early anastomotic leak is defined as anastomotic leak which is diagnosed within postoperative day 6 and late anastomotic leak as leak diagnosed after postoperative day 6 [88,89].

Early and late anastomotic leak have different pathophysiology. For early anastomotic leaks, technical failure of the anastomosis resulting in immediate anastomotic dehiscence is the reason. On the contrary, late anastomotic leak, patient related factors plays the major role, which will dictate poor healing process at the anastomotic site.

Early diagnosis of anastomotic leak is essential for effective management. Delay in diagnosis and consequently delay in the management is associated with worse outcome [90]. The clinical signs include: Pain, fever, tachycardia, peritonitis, feculent drainage, purulent drainage.

However, anastomotic leak often presents with a wide array of cardiovascular and pulmonary symptoms that are also seen in patients without anastomotic leak.

From here, surgeons should be alert to early signs of leak including nonspecific signs of tachycardia and cardiac arrhythmia [91,92]. In fact, failure of clinical improvement or any departure from the normal postoperative recovery course should raise the suspicion of anastomotic leak.

The radiographic signs include: Fluid collections, gas containing collections.

The intraoperative findings include: Gross enteric spillage, anastomotic disruption.

On the other hand, white cell count appears to be less reliable as a marker of anastomotic leak [53]. CRP has been the most extensively studied biomarker, shown to have a negative predictive value of 89% to 97% for anastomotic leak [93]. CRP values below specific cutoffs between postoperative days 3 and 5 are negative predictive of anastomotic leaks [92,93]. Thus, higher levels of postoperative CRP require further investigation to confirm any presence of a leak [92,93]. Procalcitonin (PCT) is the prohormone of calcitonin with physiologic serum concentrations below 0.5 ng/mL. A recent meta-analysis demonstrated that low PCT levels on POD 3 and 5 had high negative predictive values, similar to CRP, and reliably excluded AL [94].

Diagnosis

When the anastomotic leak is clinically evident and when the patient is unwell there's no need for a diagnostic imaging. Imaging under these circumstances may give rise to unnecessary delay in management. The diagnostic accuracy of CT for suspected leakage from the distal colon may be improved with the addition of rectal and intravenous contrast [95].

Management

Early recognition with no delay in the management is the key.

Once an anastomotic leak is diagnosed patients should receive intravenous fluid resuscitation and broad-spectrum antibiotics.

Early resuscitation to avoid septic shock is the key to avoiding multisystem organ failure and even death following anastomotic leak.

Further management is dictated by the clinical scenario, the patient's stability and the availability of radiologic investigation and radiologic intervention to localize the leak, determine its severity and dictate further management.

A wide range of management strategies is available. These include observation, bowel rest, percutaneous drainage, colonic stenting, surgical revision, diversion, or drainage [96].

For management purposes, anastomotic leaks can be divided broadly into 2 categories:

- Intraperitoneal leak
- Extraperitoneal leak

Intraperitoneal leak

With generalized peritonitis and sepsis: Algorithm 1: Resuscitation and surgical intervention. The type of surgical intervention differs according to intraoperative finding.

Intraoperative findings can be either phlegmon or anastomotic defect which in turn can be either a major defect or a minor defect. Minor defects can be further classified according to the quality of tissues at the site of defect.

If the surgeon is faced by phlegmon which deems surgical progression impossible or poses a risk on the patient then a drain should be placed in the abscess cavity and peri-anastomotic space and proximal diversion done.

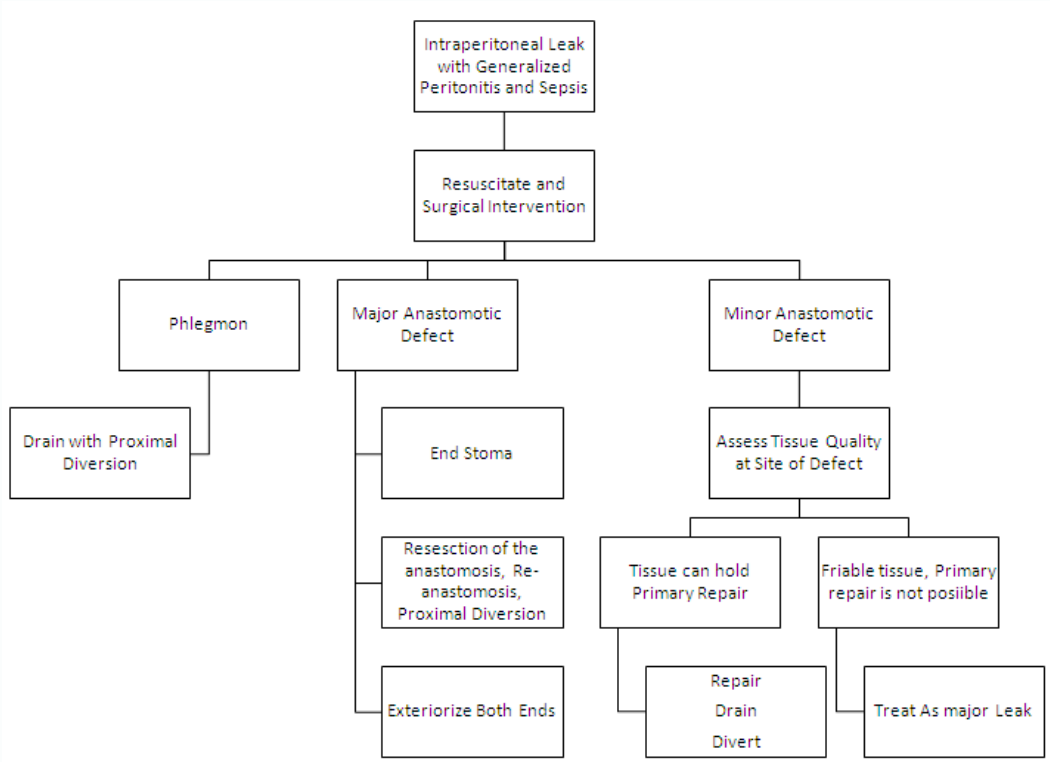
On the other hand, if progression during surgery was feasible and safe and the surgeon was able to identify the defect at the anastomosis management differs according to the size of the defect and the quality of tissues at the site of anastomosis. Although no consensus exist to classify anastomotic defect as major or minor, some experts believe that defects more than 1 cm or occupying more than 1/3 of the anastomosis is considered a major defect. Whereas, a minor defect is one that is less than one centimeter or less than 1/3 of the anastomosis. For major defects, surgical options include resection of the anastomosis with diversion, exteriorizing both ends of the anastomosis and resection of the anastomosis, re-anastomosis and proximal diversion if the patient is hemodynamically stable.

Localized peritonitis low grade sepsis or abscess: Algorithm 2: Management of patients with localized peritonitis and low grade sepsis or abscess formation starts by diagnostic imaging using CT scan abdomen pelvis with IV contrast followed by water soluble enema. If imaging reveals leak that is not contained then the patient is managed as Algorithm 1. If contained leak was diagnosed then management is dictated by the size of the abscess. For abscesses that are less than 3 cm IV antibiotics is advised, for abscesses more than 3 cm or with multiloculations Ct guided drainage is done.

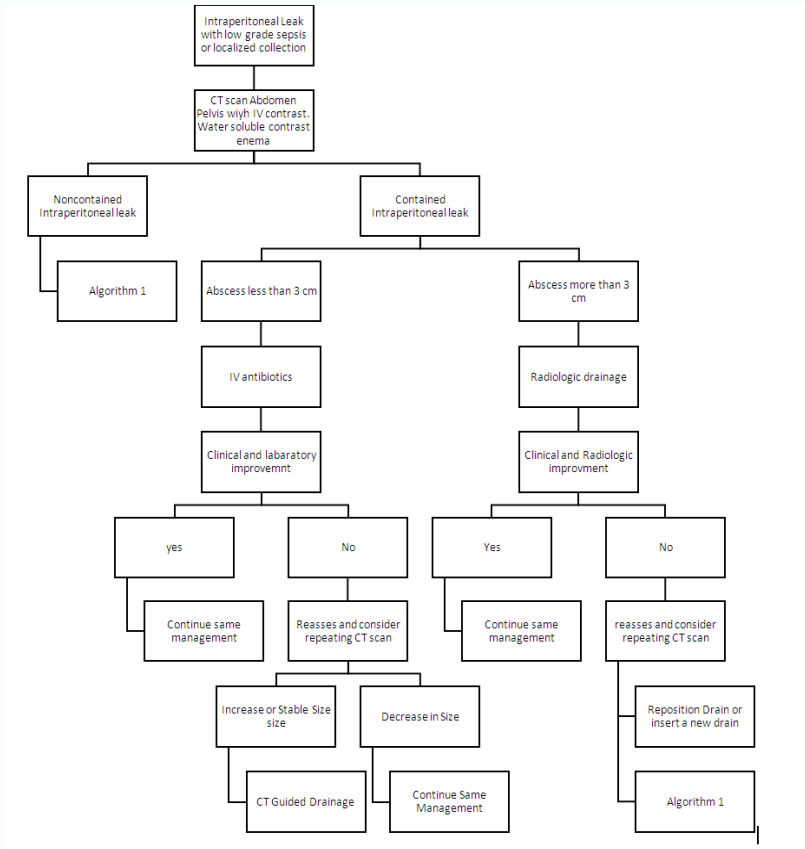
Subclinical leak: Observation only is recommended as almost all of these leaks resolve with time. If the patient develops a clinical leak, treatment will proceed according to Algorithm 1 or 2.

Extra peritoneal anastomotic leak (Algorithm 3)

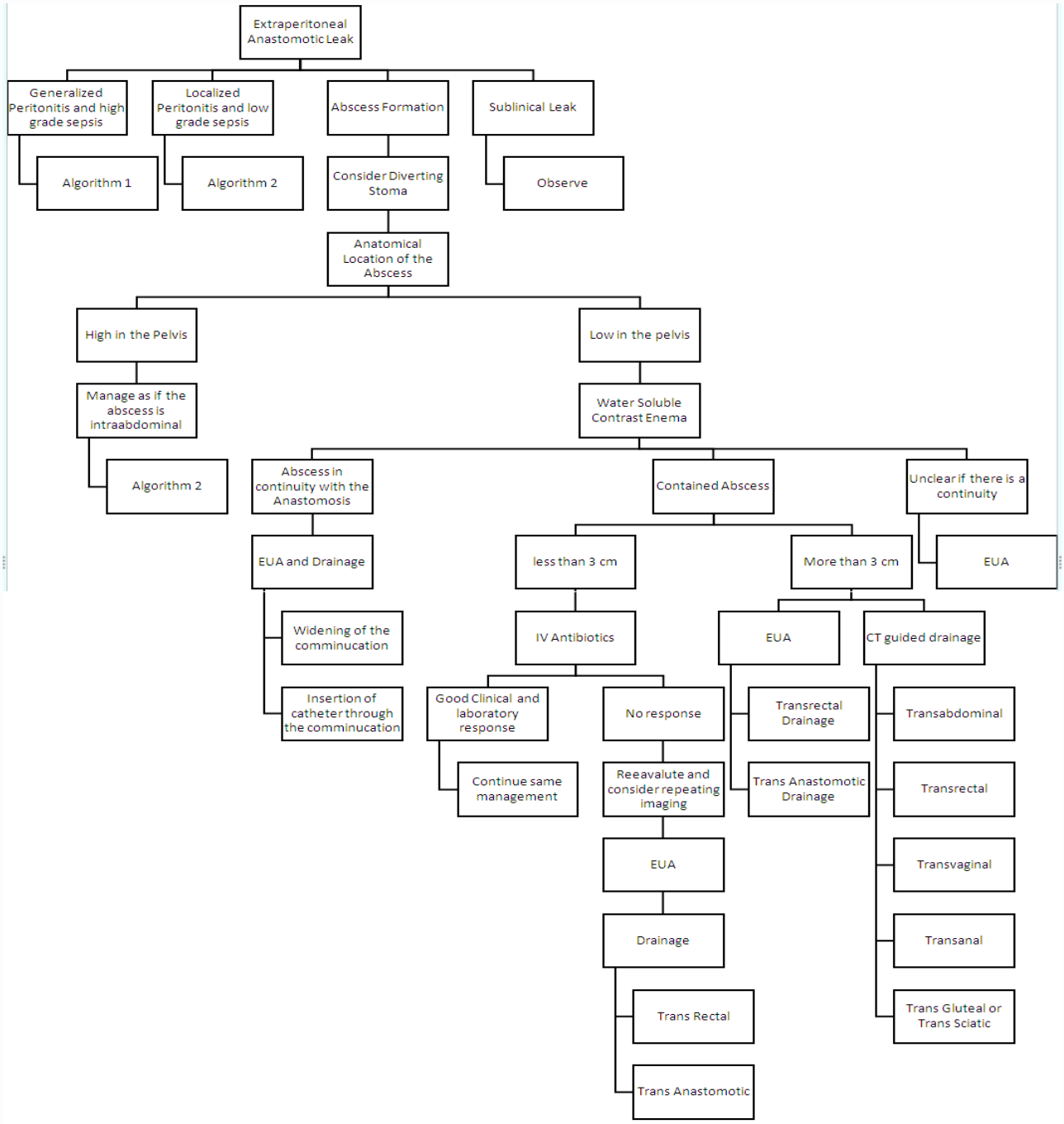
Patients with extraperitoneal anastomotic leak with generalized peritonitis or high-grade sepsis should be managed as patients with an intraperitoneal anastomotic leak (Algorithm 1) however, the resection and re-anastomosis part may not be feasible and the rectal stump if



Algorithm 1



Algorithm 2



Algorithm 3

an end colostomy is intended may be too inflamed and too short to suture or stapler necessitating the drainage of the rectal stump. On the other hand, patients with localized peritonitis and low-grade sepsis, or those who present with a subclinical leak should be managed as patients with an intraperitoneal anastomotic leak as described in Algorithm 2.

On the contrary the difference between intra and extra peritoneal leak differs only in patients who present with abscess cavity. If the patient is symptomatic consider diverting stoma. Otherwise, the anatomical position of the abscess being high or low in the pelvis guides further management.

If the anastomotic leak is situated high in the pelvis then it is managed as if the leak is situated in the lower abdomen (Algorithm 2).

For low pelvis anastomotic leaks management is dictated by whether the abscess is in continuity with the anastomosis or is it contained.

For posterior anastomotic leaks with abscess in continuity with the anastomosis Examination Under Anesthesia (EUA) and drainage is recommended. There's no international consensus on how to drain such abscess cavities. Different approaches are described among which is making a wide opening in the anastomosis with a finger or surgical instrument to allow drainage, making a small opening in the anastomosis and inserting a catheter or a drain. The optimal form for drainage is yet to be determined by further studies and research.

For posterior anastomotic leaks with a contained abscess formation management depends on the size of the abscess. For abscesses less than 3 cm a trial of IV antibiotics is recommended. In fact, studies have shown that small abscesses less than 3 cm may have resolution of the abscess with intravenous antibiotic therapy alone [97,98]. Abscesses more than 3 cm may be candidates for CT guided drainage of the abscess cavity *via* a transabdominal, transvaginal, transanal, or transrectal pathway [98]. These paths may be inaccessible for low pelvic locations, necessitating consideration of a transsciatic or transgluteal approach to encourage closure of the anastomotic defect.

Anterior leaks can be managed similarly to posterior leaks however; there is a greater risk of adjacent organ injury when managing anterior leaks.

If it is unclear if there's any continuity EUA is recommended.

Patients with diversion and anastomotic leak (Algorithm 4): Usually these patients present 6 to 8 weeks after the initial surgery whereby a protective stoma has been created. In the majority of cases these patients are diagnosed incidentally as a late radiologic finding while imaging is done to study the integrity of the anastomosis prior to reversal of the protective stoma. Its management depends on the anatomical location of the leak. On the other hand, in patients who present with peritonitis and abscess formation the management is similar to algorithm 1, 2 and 3.

Declaration

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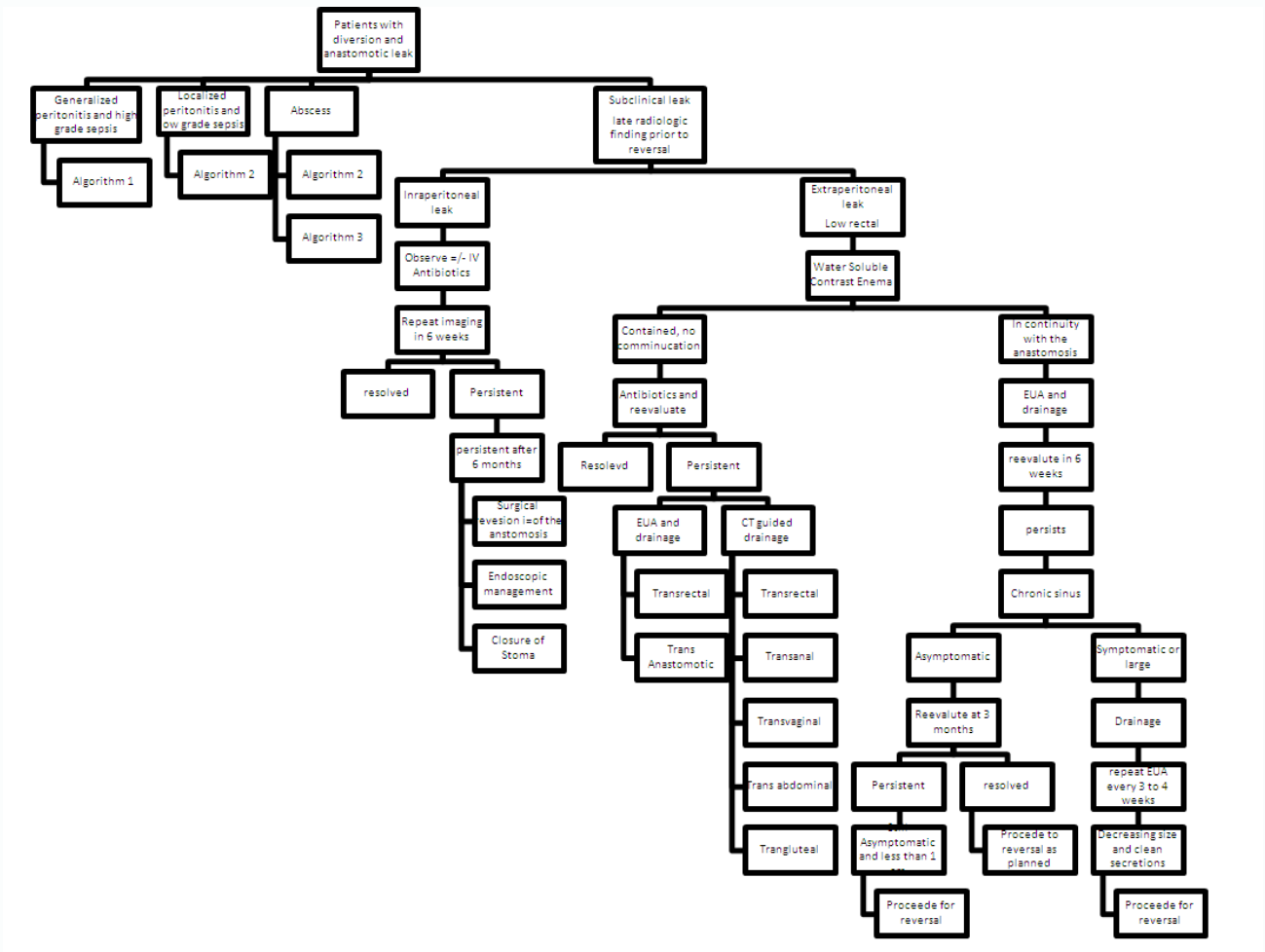

Algorithm 4

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