ΜΕΤΑΠΤΥΧΙΑΚΟ ΠΡΟΓΡΑΜΜΑ ΣΠΟΥΔΩΝ:
‘‘ΕΛΑΧΙΣΤΑ ΕΠΕΜΒΑΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ,
ΡΟΜΠΟΤΙΚΗ ΧΕΙΡΟΥΡΓΙΚΗ ΚΑΙ ΤΗΛΕΧΕΙΡΟΥΡΓΙΚΗ’’

ΕΘΝΙΚΟ ΚΑΙ ΚΑΠΟΔΙΣΤΡΙΑΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ
ΙΑΤΡΙΚΗ ΣΧΟΛΗ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

ΘΕΜΑ:

Laparoscopic approach in diverticular disease. Review of the literature.

ΜΕΤΑΠΤΥΧΙΑΚΗ ΦΟΙΤΗΤΡΙΑ:
ΓΡΑΛΙΣΤΑ ΠΑΝΑΓΙΩΤΑ
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ΓΙΑ ΤΗΝ ΑΞΙΟΛΟΓΗΣΗ ΤΗΣ ΔΙΠΛΩΜΑΤΙΚΗΣ ΕΡΓΑΣΙΑΣ
Της Μεταπτυχιακής Φοιτήτριας Γράλιστα Παναγιώτας

Εξεταστική Επιτροπή

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Η Τριμελής Εξεταστική Επιτροπή η οποία ορίσθηκε από την ΓΣΕΣ της Ιατρικής Σχολής του Παν. Αθηνών Συνεδρίαση της.....ης ..... 20.... για την αξιολόγηση και εξέταση της υποψηφίου κας Γράλιστα Παναγιώτας, συνεδρίασε σήμερα .../.../....

Η Επιτροπή διαπίστωσε ότι η Διπλωματική Εργασία της κας Γράλιστα Παναγιώτας με τίτλο: "Laparoscopic approach in diverticular disease. Review of the literature", είναι πρωτότυπη, επιστημονικά και τεχνικά άρτια και η βιβλιογραφική πληροφορία ολοκληρωμένη και εμπεριστατωμένη.

Η εξεταστική επιτροπή αφού έλαβε υπ' όψιν το περιεχόμενο της εργασίας και τη συμβολή της στην επιστήμη, με ψήφους ..... προτείνει την απονομή του Μεταπτυχιακού Διπλώματος Ειδίκευσης (Master's Degree), στον παραπάνω Μεταπτυχιακό Φοιτητή.

Στην ψηφοφορία για την βαθμολογία ο υποψήφιος έλαβε για τον βαθμό «ΑΡΙΣΤΑ» ψήφους ....., για τον βαθμό «ΛΙΑΝ ΚΑΛΩΣ» ψήφους ....., και για τον βαθμό «ΚΑΛΩΣ» ψήφους ..... Κατά συνέπεια, απονέμεται ο βαθμός «.....».

Τα Μέλη της Εξεταστικής Επιτροπής

- Αλέξανδρος Παπαλάμπρος, **Επιβλέπων** (Υπογραφή) _____
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Contents

1. INTRODUCTION

Diverticular disease of the colon (diverticulosis) is one of the most common gastrointestinal disorders in western industrialized countries and its incidence increases with age. [1-3] The prevalence of colonic diverticulosis, the hospitalization rates and the societal impact of diverticulitis has dramatically increased in the past century in western countries. [4, 5] About 10% of patients aged <40 years [2], 30% by the age of 60 years [6] and >60% of patients aged >80 years are affected by this disorder. [2, 5, 7, 8] The high prevalence of diverticulosis is due to several factors, including an increase in detection of the disorder with the use of the CT, changes in diet, and an ageing population. [4, 9] Between 10% and 25% of individuals affected by diverticulosis will eventually develop acute diverticulitis or other complications. [1, 4-8, 10]

Most patients with diverticular disease are asymptomatic, and only 1% of patients require surgical intervention. [11] The reported rates of hospital admission for diverticulitis have increased during the past few years. Despite improvements in medical management and the changes in the indications and timing of the surgery, the need for surgery is still prevalent for patients with recurrent episodes of acute diverticulitis. Resection of the colon by an open procedure is still the "gold standard," but it is feasible to perform a laparoscopic colon resection. [7] Laparoscopic colonic resection has gained a role in the treatment of uncomplicated recurrent sigmoid diverticulitis since 1991. A minimally invasive surgical approach might encourage the elective treatment of diverticular disease, thereby enhancing its benefits. [1] The use of laparoscopy for colonic resection has evolved to become the preferred standard for uncomplicated, elective colonic resection. [6]

In comparison to conventional colectomy, several studies have shown that laparoscopic colectomy for diverticular disease results in less blood loss, decreased surgical trauma, less incidence of adhesions and incisional hernias, less postoperative pain and concomitant reduction in the need for analgesics, shorter time to first bowel movement, fewer postoperative complications, less impaired respiratory function, shorter length of hospital stay, quicker resumption of normal activities, improved cosmetic results, and improved quality of life. Also, studies have shown that recurrence rates after the laparoscopic procedures match those for open procedures. These reported benefits of laparoscopic colectomy can be offset by a prolonged operating time, the high cost of laparoscopic equipment, and the learning curve of these technically challenging procedures. Concerns have been raised that the use of laparoscopic resection for diverticulitis can be difficult and even hazardous owing to the inflammatory nature of the disease. However, given the advances in minimally invasive surgical options, there is much interest regarding the use of laparoscopy for colon resection in patients with diverticulitis. [12, 13]

For admitted patients due to acute diverticulitis, 10–20 % of patients need surgical treatment. [11] Less than 10% of patients who develop acute diverticulitis require

emergency surgery. The treatment of acute diverticulitis is based on the severity of the disease, and it includes antibiotics, computed tomography or ultrasound-guided percutaneous drainage, laparoscopic peritoneal lavage, laparoscopic or open one-stage colonic resection with direct anastomosis and sigmoidectomy with terminal colostomy (Hartmann procedure) with or without subsequent colostomy reversal. [2]

Perforated colonic diverticulitis is a severe condition that can present with intra-abdominal abscess or with purulent or fecal peritonitis. [14, 15] It is an uncommon abdominal condition, and perforation with purulent peritonitis is even more uncommon. [16] Colonic perforation is a fatal complication of acute diverticulitis, especially for immunocompromised patients. Although less than 25 % of patients will develop generalized peritonitis after colonic perforation, it is severe with high mortality. [11] The emergency treatment of perforated diverticular disease has changed over the years and is evolving. There is much debate and controversy about the various treatment strategies, making decisions in the emergency situation challenging. [17] The most commonly used procedures for these patients presenting with generalized peritonitis are laparotomy which involves resection of the inflamed and perforated colon, closure of the rectal stump and proximal end-colostomy, that is, the Hartmann procedure. [16, 18, 19] Considerable morbidity has been reported after the Hartmann procedure and many patients will never undergo secondary surgery with reversal of the stoma and restored bowel continuity. Less invasive types of surgical treatment have thus been considered. [16] An increasing number of patients are treated with sigmoidectomy and primary anastomosis or with laparoscopic lavage alone. [18]

Laparoscopic peritoneal lavage, originally proposed in 1996 by O'Sullivan et al., has emerged as a promising alternative to sigmoid resection and creation of a stoma, in order to make surgery less invasive. The procedure appears as safe and effective treatment, and it may be a promising alternative to colonic resection in the acute setting. However, the indications for this procedure have not been definitively established. [14, 15] Although Hartman's procedure is considered to be the gold standard by many, there has recently been a trend towards achieving an initial remission of the acute inflammatory episode before proceeding with the definitive surgery in nonemergency conditions. [20] Small published series have emerged showing that many patients with perforated diverticulitis may be successfully managed in the acute setting by laparoscopic lavage and drainage, permitting the resection and anastomosis to be carried out electively without the need for a stoma. [19] In cases of Hinchey IIb or III diverticulitis where either localized or free intra-abdominal pus is present, a limited laparoscopic procedure can be performed comprising of lavage and drainage of the abdominal cavity without bowel resection or formation of a stoma. This aims to converting a generalized purulent peritonitis to a localized diverticulitis which can be safely treated with antibiotic therapy. Once the acute inflammation has settled, a delayed definitive laparoscopic resection can be performed, thereby completing the totally minimally invasive management in such

patients. In addition to the avoidance of a laparotomy and stoma, such an approach is advantageous as it allows a definitive colonic resection in a nonemergency situation. [21]

Furthermore, as elective laparoscopic sigmoidectomy has several benefits compared to open surgery, acute laparoscopic resection for perforated diverticulitis might have similar benefits. [18] Thus, the proven benefit of the laparoscopic approach in the elective setting might even be more pronounced in emergency sigmoidectomy, avoiding abdominal wall complications in particular, e.g. abdominal wound dehiscence, incisional hernia, and wound infection. [22]

In this review of the literature, we aim to assess the feasibility and effectiveness of the laparoscopic approach in both elective and emergency setting of diverticular disease.

1.1 Demographics

The prevalence of diverticular disease is estimated to range between 20% and 60% in the general population. Its incidence increases with age, and it is considered a disease of developed countries, related to a low-fibre diet. It is uncommon in populations under 40 years of age; it affects 5–10% of the population in the fifth decade of life, 30% at age 60, and over 60% of people over the age of 80, without sex differences. [23, 24] The risk of diverticulosis progressing to diverticulitis was traditionally reported to be as high as 10–25 %. From more recent knowledge, these historically high rates were an overestimation. More robust data suggest that only 4 per cent of patients with diverticulosis will develop an acute inflammatory episode of the affected colonic segment (diverticulitis). Diverticulitis admissions vary from 70 to 160 per 100 000 population in Western countries. Meanwhile, perforated diverticulitis has an estimated adult incidence of only 3.5 per 100 000 population. [23]

1.2 Classification

Sigmoid diverticulitis is a heterogeneous disease process ranging from mild inflammation of the sigmoid, to complicated disease including pericolic abscess, to life-threatening colonic perforation. [23, 25, 26] It can be classified into three categories: acute uncomplicated, acute complicated, and chronically recurrent diverticulitis. [27] Peritonitis caused by perforated diverticulitis is a particularly serious condition and is classified according to Hinchey into purulent or faecal. [28]

According to Ambrossetti et al., diverticulitis can be divided into two categories based on their appearance on CT: complicated and uncomplicated. Complicated diverticulitis includes abscess, extra-luminal air, and extra-luminal contrast. The American Society of Colon and Rectal Surgeons (ASCRS) consensus statement

includes obstruction and fistula in the definition of complicated diverticulitis on CT. [26]

Acute, complicated diverticulitis is divided into four stages according to the Hinchey classification (Table1), based upon preoperative findings of abscesses and intestinal perforation. In the most severe cases, abscess perforation leads to purulent peritonitis (Hinchey 3) and diverticula rupture to faecal peritonitis (Hinchey 4). [29]

Complicated diverticulitis is determined by presence of perforation, abscess, phlegmon, stricture, obstruction, fistula, or hemorrhage, and is an indication for operative management, but not always on an emergency basis. Hinchey's classification provides a means of consistent classification of severity of disease for clinical description and decision making. Perforation with operative findings of purulent peritonitis corresponds to Hinchey stage III, and feculent peritonitis to Hinchey stage IV. The most common cause for an emergency operation is advanced stage III or IV disease. Patients with stage I to II disease who fail medical management or who present with diverticular hemorrhage or obstruction may also require emergency operation illustrating the complexity of disease, and varying degrees of severity that can require emergency operation. [9]

Peritonitis secondary to diverticular perforation has been classified according to intra-abdominal pathology by Hughes et al., Hinchey et al., and Killingback. Hughes proposed a practical clinical classification based on the severity of peritoneal contamination during operation. He emphasized the necessity to definitely distinguish purulent from fecal peritonitis as they have different etiopathogenesis and prognosis. Purulent peritonitis is the consequence of pericolic abscess rupture and is therefore localized, whereas fecal peritonitis is caused by diverticular rupture that creates a “free fecal peritonitis”. Hinchey classification subdivides peritonitis, according to operative findings, into four stages that can also be identified on CT images evaluating the extension of the inflammatory–infectious process. [11]

Hinchey Classification	
Grade	Definition
1	Diverticulitis with phlegmon or paracolic abscess.
2a	Diverticulitis with pelvic or retroperitoneal abscess amenable to percutaneous drainage.
2b	Diverticulitis with pelvic or retroperitoneal abscess associated with fistula not amenable to percutaneous drainage.
3	Diverticulitis with defuse / generalized purulent peritonitis.
4	Diverticulitis with fecal peritonitis.

Table 1: Hinchey Classification. [4]

1.3 Pathogenesis and risk factors

Acquired colonic diverticula are a Western disease, thought to be brought about by industrialized processing of grain and subsequent loss of dietary fiber. [9] The underlying pathological mechanisms that cause the formation of colonic diverticula remain unclear. There are likely to be complex interactions among diet, colonic microbiota, genetic factors, colonic motility and structure that result in their formation over time. Heritability is calculated to be around 40% and there is a number of rare disorders of collagen and elastin, which are associated with complicated diverticular disease at an early age. However, as with inflammatory bowel disease, there are probably many genes involved and most cases of diverticulosis are likely to be the result of small effects from many genes. Neural degeneration with age may also contribute as several studies suggest reduction in neurons in the myenteric plexus and decreased myenteric glial cells and interstitial cells of cajal. [30]

The decrease in stool bulk promotes higher intraluminal pressure during contractile efforts to evacuate the bowel, disordered gut motility and increased colonic wall resistance. [9, 31] Mucosal herniation occurs at points where the vasa recta penetrate the bowel at the antimesenteric tenia coli. Torsion or inspissation of the diverticula results in inflammation, largely isolated to the sigmoid colon. Perforation occurs when intraluminal pressure exceeds wall tension, and is uncommon with an overall reported prevalence of 3.8 cases per 100,000. [9]

The development of inflammation in these diverticula results in acute diverticulitis. Acute diverticulitis occurs when the mouth of a diverticulum becomes blocked with inspissated faeces, resulting in localized inflammation and bacterial proliferation. It has been suggested that in the same way, obstruction by faecal material causes appendicitis, where faecal matter becomes trapped in the diverticula and as a result, low-grade inflammation develops due to abrasion of the mucosa, allowing access of faecal microbiota to the lamina propria, leading to acute inflammation of the mucosa, which usually begins at the apex of the sac. This can be associated with acute inflammation of the mesenteric and pericolic fat with the formation of a diverticular abscess. Another postulated mechanism for the development of acute diverticulitis is a micro-perforation at the fundus of the diverticulum leading to inflammation. If there is a free perforation into the peritoneal cavity, generalized peritonitis, either purulent or faecal, ensues. [30, 31]

There are few studies which present evidence of a causal relationship with preventable factors. A low-fibre diet has been suggested as a causative factor in the development of diverticulosis. Thus a diet with an increased fiber intake, particularly cellulose, is also significantly associated with a decreased risk of diverticular disease. Although the presumed correlation between incidence of sigmoid diverticulitis and the consumption of nut, corn and popcorn has not been confirmed, it had been advised against in patients with known diverticular disease. An increased risk of acute diverticulitis has been reported for in-patient alcoholic patients but this association could relate to the immunosuppressive effects of alcohol consumption. Obesity is significantly associated with an increased incidence of both diverticular bleeding and diverticulitis. A BMI of greater than 30 kg/m2 increased the relative risk of an episode of acute diverticulitis by 1.78 (95% CI, 1.08–2.94) compared to a normal BMI. Waist circumference and waist-to-hip ratio were also independently associated with this. The mechanism responsible for this increased risk is unknown, but may include the pro-inflammatory nature of adipose tissue, which secretes cytokines that may promote the inflammatory response. Correspondingly, physical activity, particularly if vigorous, is associated with decreased incidence of sigmoid diverticulitis and diverticular bleeding. Smoking was reported to be associated with a threefold increased risk of diverticular complications, including severe diverticulitis. With respect to the use of medications, the regular and consistent use of nonsteroidal antiinflammatory drugs and acetaminophen is associated with symptoms of severe diverticular disease, particularly bleeding. [25, 30]

1.4 Clinical presentation and diagnosis

The clinical severity of disease is reflected upon the presence of left lower quadrant pain, leukocytosis, and fever, which are the three most common findings in decreasing order. [9] Abdominal pain is the primary presenting symptom. Patients typically present with left lower quadrant pain, associated with a variable degree of

peritoneal irritation, which can range from none to generalized peritonitis. A redundant sigmoid colon may reach the right lower quadrant, causing suprapubic or right-sided pain and a sigmoid diverticulitis under these circumstances may mimic appendicitis [25, 30, 32]. The patient may have diffuse abdominal pain indicating complicated disease such as perforation. The pain can be constant or intermittent. Change in bowel habit can occur with both constipation and diarrhea, the latter being more common in a review of presenting symptoms in patients to the emergency department with acute diverticulitis; however, the patient may rarely present with absolute constipation due to an underlying obstruction. Nausea and vomiting are the most notable symptoms when a stricture results in an obstruction. The patient may report dysuria secondary to irritation of the bladder by the inflamed segment of colon. On examination, localized peritoneal reaction with guarding, rigidity and rebound tenderness may be noted. Severe disease associated with peritonitis may present with a rigid board-like abdomen. Rarely, a mass may be palpable in the left iliac fossa. Bowel sounds may be depressed or increased in those patients with associated obstruction with a stricture. Rectal examination may be normal or elicit tenderness in the case of a pelvic abscess. Patients may have a fever and be tachycardic. [25, 30, 32] Mild tachycardia and peritonitis (local or generalized) may accompany complicated cases as a sign of the start of the systemic inflammatory response syndrome (SIRS), which may develop into severe sepsis and a haemodynamically compromised patient with faecal peritonitis due to a large perforation. [23]

A history of recurrent urinary tract infection, dysuria with or without urgency, pneumaturia and fecaluria can suggest a colovesical fistula. When a patient reports passing stools per vagina, insertion of a vaginal speculum can reveal a fistulous opening at the vaginal apex, thus confirming a colovaginal fistula. A previous history of hysterectomy is a valuable clinical clue to the correct diagnosis as colovaginal and colovesical fistulas are rare in females with their uterus in place, as the uterus becomes a screen interposed between the inflamed colon and the bladder and vagina. Less commonly, sigmoid diverticulitis can involve other surrounding structures and cause coloenteric, colouterine or colocutaneous fistulas. [25]

Bed side investigations should include a urine analysis to exclude urinary tract infection and pregnancy in women of child-bearing age, remembering that blood and protein in the urine may reflect bladder/ureter inflammation secondary to diverticulitis. Blood tests should include a full blood count, urea and electrolytes along with a C-reactive protein and amylase or lipase (as local policy dictates). The clinical triad of left lower quadrant pain, fever and leucocytosis is often quoted in the diagnosis of acute diverticulitis; however, precise data on its accuracy are lacking. [30] Laboratory tests also include liver function enzymes, prothrombin time and partial thromboplastin time. Additionally, carcinoembryonic antigen (CEA) level should be drawn when the diagnosis of colon cancer is in question. [9]

Patients presenting with clinical features of acute diverticulitis are increasingly being investigated by computed tomography (CT), as studies have shown that the

accuracy of clinical diagnosis in diverticulitis is low. [31] CT has a high sensitivity and specificity for diverticulitis and can accurately stage disease to guide management. [23] Thus, CT associated with the use of intravenous and oral contrast and, in ideal conditions, rectal contrast is the diagnostic method of choice. CT is useful for differential diagnosis because the tissue density, vascular ingurgitation and oedema of the mesentery are associated with diverticulitis, while the presence of an intraluminal mass and lymph nodes are more associated with the diagnosis of cancer. However, misdiagnosing diverticulitis in cancer patients occurs in 5% of cases. A prospective study found a sensitivity of 97%, specificity of 98% and global accuracy of 98%. It identified localized perforation and abscesses with a sensitivity of 100% and specificity of 91%. Another prospective study showed the capacity of CT to reliably predict the possibility of failure of conservative treatment and the risk of complications. It classified diverticulitis into two groups, 'moderate' when there was a thickening of the colonic wall of more than 4 mm and signs of inflammation of the pericolonic fat, and "severe" when a pericolonic abscess, free air or extravasation of contrast were found. CT can rule out complications and has prognostic value for relapse and for response to medical therapy. It also offers the possibility of percutaneous drainage of abscesses. [24]

In the acute situation, diagnostic radiographic studies may be limited to a plain abdominal film, which can confirm pneumoperitoneum or colonic obstruction in a patient requiring an imminent laparotomy. However, a CT scan of the abdomen and pelvis with oral and IV contrast is the best diagnostic study with very high sensitivity and specificity, and a low false-positive rate. In the majority of clinical settings, it is the most appropriate imaging modality for the assessment of severity of disease, and allows for the selection of patients most likely to respond to medical therapy or percutaneous drainage of intraabdominal abscess. Increased use of this imaging modality has allowed for a comparative evaluation between surgeons and institutions on indications for operative intervention, and, subsequently, a better understanding of the relationship between the choice of operative intervention and outcome relative to the complexity of the disease. [9]

Abdominal ultrasound is an operator-dependent study that can be difficult in obese patients. The localized small-bowel ileus adjacent to the inflammatory process, the presence of gas, interposition of the distal sigmoid colon, pain and rebound tenderness can limit ultrasound evaluation. In prospective studies, it obtains a mean sensitivity and specificity of 91% and 96%. In severely ill patients, it can be used as a first option diagnostic tool as it avoids the use of intravenous and intraluminal contrast. [24] Ultrasound, however, may have a role in premenopausal women and the young to reduce radiation exposure. [30]

Magnetic resonance imaging (MRI) requires a prolonged examination time that can make cooperation of acutely ill patients difficult and is not as sensitive for the identification of free air. In a recent retrospective study MRI showed a sensitivity of

94% and a specificity of 87%. At present there is not enough evidence on the advantages of MRI in the evaluation of acute diverticulitis. [24]

A full colonoscopy should be typically avoided during an episode of acute diverticulitis because of the risk of perforation. In select cases and experienced hands, a gentle flexible sigmoidoscopy with low pressure can provide additional information and help rule out alternative diagnoses such as cancer, inflammatory bowel disease, or ischemic colitis. A recent prospective study concluded that although colonoscopy is possible it is rarely needed in the acute phase of inflammation. [24, 25]

Barium enema sensitivity varies from 29% to 93% with specificity of 50–100%, but its inability to visualize extra-luminal complications means that it is no longer used acutely. [30]

1.5 Indications for surgery

In 2000 the American Society of Colon and Rectal Surgeons with the American College of Gastroenterology and the European Association for Endoscopic Surgery, presented practice guidelines for the surgical management of diverticular disease, recommending elective sigmoid resection for patients who had had two episodes of acute diverticulitis (or a single episode in young patients) and after a single episode of complicated diverticulitis. This recommendation was based on the assumptions that after 2 attacks there was not only a very high probability of recurrent attacks of uncomplicated diverticulitis but also an increased risk of complicated diverticulitis including free perforation causing diffuse peritonitis. Recent studies have questioned this hypothesis, stating that most patients present complicated diverticulitis as the first manifestation of diverticular disease. Other studies, based on decision analysis models, have indicated that the preferred timing of elective surgery to optimize life expectancy should be after the third or fourth attack of uncomplicated diverticulitis. The most recent version of the Practice Parameters for Diverticulitis from the American Society of Colon and Rectal Surgery states that ‘the number of attacks of uncomplicated diverticulitis is not necessarily an overriding factor in defining the appropriateness of surgery’. Today the question of when to recommend elective surgery for patients with diverticular disease remains very controversial. The timing and indications for elective surgery are constantly evolving and the current trend seems to prefer a tailored approach to each patient individually, assessing the medical history, the answer to the first acute episode, and the chronic symptoms. [1, 5, 25]

It appears that elective resection should be reserved for those with ongoing symptoms, those with pelvic abscesses and those with complications such as fistulating disease, strictures or recurrent diverticular bleeding. Patients who are at high risk of perforation during future episodes of acute diverticulitis, such as those

who are immunosuppressed, or those with chronic renal failure or collagen-vascular diseases may also benefit from early elective resection. [31]

Generally, the indications for surgery include the presence of diffuse peritonitis and evidence of a pneumoperitoneum or associated sepsis that is not responding to full medical treatment. However, there is no precise definition of patients requiring surgery, as even some patients who present with generalized peritonitis may respond to a trial of conservative therapy. If a trial of conservative management is opted for, it is important to perform serial examinations in order to detect deterioration early. [31]

However, it should be noted that the advent of laparoscopic techniques for colorectal surgery in 1991 seemed to increase indications for early resection. [33]

1.6 Operative techniques

A 4-port medial-to-lateral standardized laparoscopic technique will be described. The patient is placed in a classical Lloyd-Davis position. Compression lower-leg boots are placed. The left arm is abducted and the right one along the body. The surgeon and the camera-holder stand on the right side of the patient and the assistant surgeon on the left. During the procedure, the operating table is tilted toward the right and ranged between Trendelenburg and reverse Trendelenburg positions depending on the operative steps. Pneumoperitoneum is inducted to a pressure of 12 mm Hg by the insertion of a 10-mm disposable Hasson trocar about 5 cm cranially to the umbilicus at the midline. [5] Pneumoperitoneum can also be created with a Veress needle in the left hypochondrium. [34] An accurate peritoneal inspection is carried out through a 30° camera to evaluate whether the case is suitable for laparoscopic surgery. Then 3 trocars are placed: one 10/12-mm trocar in the right flank and 2 10-mm trocars in the right lower quadrant and in the left flank, respectively. [5] Alternatively, second and third trocars are placed under direct vision respectively at the left hypochondrial and right lumber regions, and a fourth trocar is placed 4cm above the pubic bone. [33] The mobilization of the colonic splenic flexure, to ensure a tension free anastomosis, starts by opening the gastrocolic ligament with access to the lesser sac. The transverse mesocolon is dissected from right to left, exposing and preserving the capsule of the pancreatic tail. The left colonic angle is thus freed from splenic adhesions by the section of the splenocolic ligament. A lateral dissection completes the liberation of the splenic flexure. An upward traction of the left colon is then performed, which enables a medial to lateral approach. The sacral promontory is identified and the peritoneum is opened at that level. The peritoneum is dissected in a caudal to cranial direction, and, after identifying both the inferior mesenteric artery (IMA) and vein, the white line of Toldt is separated from the Gerota fascia under the arch of Treitz, with right identification of the left ureter and gonadal vessels. IMA and inferior mesenteric vein are isolated and dissected by 10-mm clips, respecting both

the inferior mesenteric and the hypogastric plexus. The left sigmoid colon is laterally freed through the dissection of the left parietocolic ligament along the line of Monk. The intestine is distally resected at the level of the upper rectus by an endoscopic linear stapler with blue-load. [5] A minilaparotomy is performed, enlarging the incision of the fourth trocar opening (Pfannenstiel incision). A wound protector is placed and the left colon sigma is exteriorized with subsequent sigmoidectomy. A 29-head circular stapler (anvil) is inserted in the colonic stump and tied with a 2.0 polypropylene purse-string suture. The colonic stump is returned to the peritoneal cavity and the incision is sutured in layers. The pneumoperitoneum is recreated, and a circular stapler is advanced via the anus. The pin of the stapler is pushed directly above the center of the stapler line at the upper third of the rectum, and a double-stapled anastomosis is obtained. Saline lavage through the anus is performed to test the efficacy of the anastomosis. [33] The omentum is then relocated whenever possible to cover the anastomosis and finally both the port sites and minilaparotomy are sutured. Drains are not used routinely. All patients are mobilized early with removal of the urinary catheter, with the exception of those preoperatively suffering from colovesical fistula, in which the catheter is maintained for 7 days. The nasogastric tube is removed after the first flatus. [5]

In 1907, Mayo et al. published the first report regarding surgical treatment for complicated diverticulitis. They described a three-stage operation. At the first operation, washout of the peritoneum and diverting colostomy were performed. Once the acute inflammatory reaction had resolved, colon resection and anastomosis were completed. Ostomy reversal was performed at a third operation. This three-stage approach was associated with a high morbidity and mortality, resulting in the application of a two-staged approach consisting of resection and colostomy initially (Hartmann's procedure), followed by stoma takedown after recovery from the first operation. This three–stage technique was performed up to the 1980s. Today, the operative management of complicated diverticulitis has progressed to include laparoscopic surgical techniques. [8, 11]

The patient is adjusted in the Davis–Lloyd position, with the hips and knees slightly flexed at 15° to facilitate intraoperative colonoscopy as needed. The patient’s arms are tucked at the sides, and shoulders are securely taped to the operating table to allow for the placement of the patient in steep Trendelenburg or right and left airplaning position to enhance the visibility by the laparoscope to the working area. Following proper preparation and draping of the abdomen and legs, the surgeon and the scope operator stand to the patient’s right side while the assistant stands to the other side. The mobile monitors are consistently adjusted to ensure good visibility for the operating team. Pneumoperitoneum is established by inserting a Veress needle in the right side flank of abdomen, and the abdominal cavity is insufflated to reach a pressure of 14 mmHg. In addition, alternate sites, such as right or left upper quadrant also can be selected in patients who have a history of prior lower abdominal surgery. Once adequate insufflation has been achieved the laparoscope is inserted into the

cavity to survey the abdominal cavity. Visualization of the abdominal cavity allows for evaluation of the entire operative field and proper placement of additional trocars to facilitate the operation accordingly. Three trocars are used (10–12 mm in the periumbilical region, 5 mm in the right hypochondrium, and 10–12 mm in the right iliac fossa). After accurate evaluation of the abdominal cavity, we eventually performed adhesiolysis in order to improve abdominal lavage. All attempts should be made to avoid excessive bleeding, which could make the working field murky for the rest of the procedures. The operation is proceeded sequentially by culturing and aspirating free purulent fluid in the peritoneal cavity and opening all the purulent cavities. The inflamed and perforated segment of the colon was localized. Blunt dissection is performed to dissect the affected colon segment form the small bowel. Intraperitoneal lavage is then performed with 6–8 L of saline solution introduced through the laparoscopic aspiration device. If an apparent colonic perforation is suturable (size <1.5 cm), we perform a primary repair of the perforation closing it with Lambert technique by using delayed absorbable suture material, such as Vicryl in one interrupted layer and we additionally put an omental patch over the suture as a reinforcement.. At the end of the procedure, two 24 French drains are placed proximal to the perforation and in the pouch of Douglas. [14, 20, 35]

2. REVIEW OF THE LITERATURE

2.1 Materials and Methods

A bibliographic search of articles, providing data on the laparoscopic approach in diverticular disease in both elective and acute setting, was performed using the electronic database MEDLINE from PubMed. The keywords “diverticular, disease, diverticulitis, sigmoid, colon, laparoscopic, approach, lavage, resection, acute, elective” were used in various combinations. Of the 465 articles retrieved with our PubMed Search, 124 were excluded as they were published before 2000. Thus, 341 articles were identified between May 2000 and January 2016.

Of 341 articles screened, 203 were excluded on the basis of either the title or abstract being irrelevant or the type of article being a case report, a letter, a video or a personal experience article. Furthermore, 73 articles were excluded as their full text was not available and 3 more because they were not available in English.

This resulted in 62 full text articles for review. The studies that considered right colon diverticulitis, elective laparoscopic sigmoid resection for complicated diverticulitis (abscess, fistulae, obstruction, bleeding) or colon resections other than sigmoid resection were not included in our final review. Articles providing data for less than twenty cases were also excluded. Articles evaluating elective laparoscopic

sigmoid resection for diverticulitis, emergency laparoscopic sigmoid resection for perforated diverticulitis and laparoscopic lavage were included. The most recent articles where preferred, as well those with the largest patient samples. Thus, 46 articles were excluded, leaving 16 articles for our final review (Figure1).

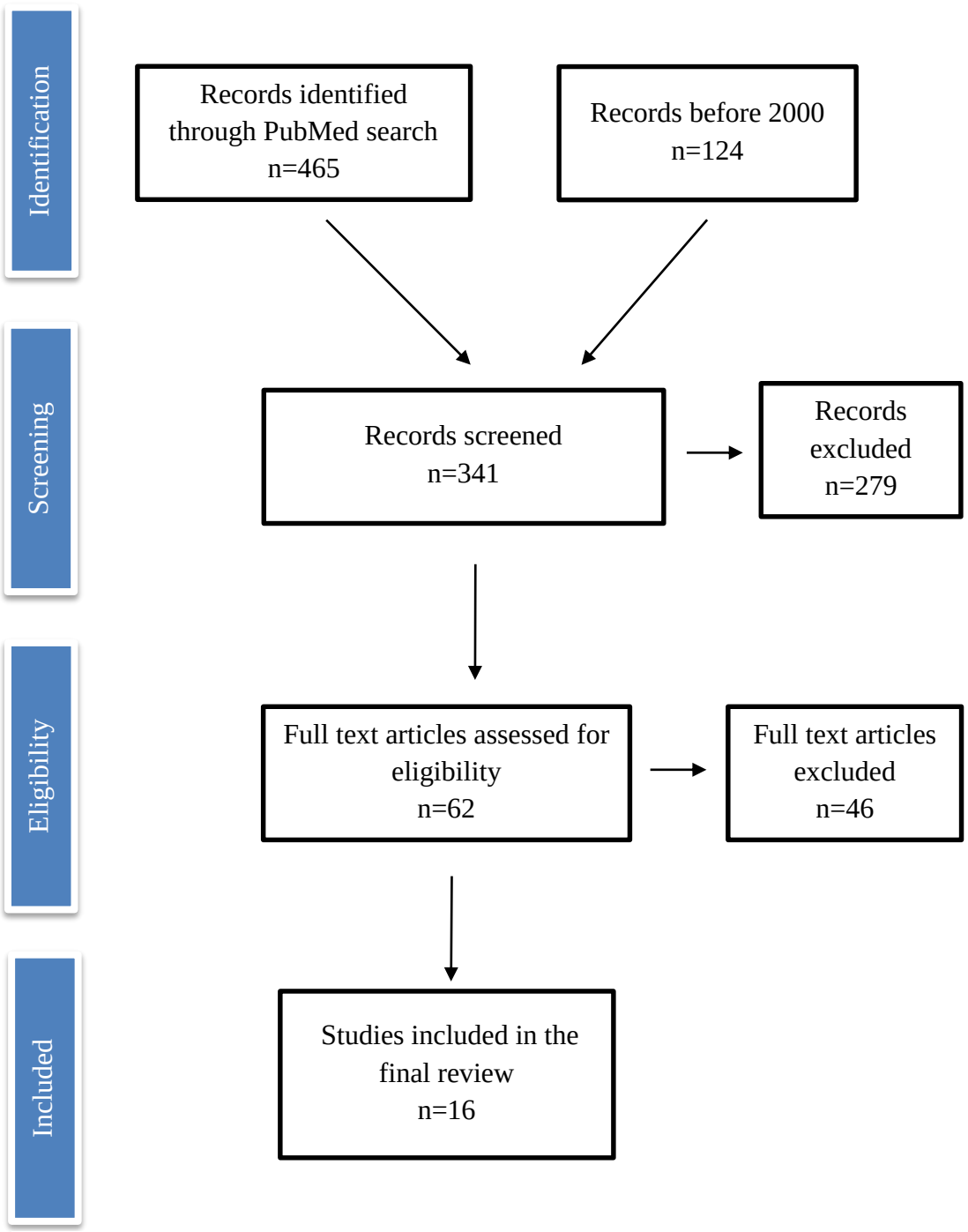

Figure 1: diagram of studies included in the review.

2.2 Results

The 16 articles included in the final review consisted of 6 retrospective studies, 5 prospective studies, 2 randomized controlled trials, 1 systematic review and metaanalysis and 2 systematic reviews. Seven articles considered elective laparoscopic sigmoid resection, seven articles evaluated laparoscopic lavage and two articles considered emergency laparoscopic sigmoid resection for perforated diverticulitis.

Articles evaluating elective laparoscopic resection

	Roscio 2015 [5]	Kakarla 2012 [7]	Cirocchi 2012 [1]	Masoomi 2011 [12]	Klarenbeek 2011 [36]	Alves 2005 [37]
Type of study	Prospective study	Retrospective study	Systematic review	Retrospective study	Randomized controlled trial	Prospective study
Number of patients treated laparoscopically	94	3759	570	14562	52	163
Mean age (years)	61,3 ± 11,0	55,72		55		58
Mean BMI	26,2 ± 3,7	28,51				26
Mean operative time (min)	213,5 ± 60,8	176,64				204
Estimated blood loss (ml)	67,2 ± 94,3					170
Conversion (%)	3,2				19,2	15,3
Visceral injuries (%)			6,2	0,63		4,3
Blood transfusion (%)	6,3					1,8
Primary anastomosis (%)				97,9		

Protective stoma (%)					3,8	2,5
Use of drainage (%)	29,7					65
Reoperation (%)	2,1					1,8
Incisional hernia (%)	3,19				1,9	
Wound infection (%)	8,5	9,12	3	1,03		3,7
Prolonged postoperative ileus (%)			2	12,1		1,8
Anastomotic leak (%)			2	2,3		
Intraabdominal abscess (%)			1,3	2,3	1,9	1,8
Postoperative small bowel obstruction (%)			2,8	1,65	1,9	
Length of hospital stay (days)	8,1 ± 1,9	4,77		5,06		10
Morbidity (%)		11,16	16,84		10	16
Short term mortality (%)	1,06	0,29	0,4	0,13	0	0

Table 2: Articles evaluating elective laparoscopic resection.

According to the systematic review and metaanalysis by Siddiqui et al. laparoscopic resection takes longer to perform but is associated with significantly less blood loss and with reduction in hospital stay compared with the open resection. Furthermore, analgesia requirements appear to be less in the laparoscopic group. There was no significant difference, however, in recurrence rates between the two groups. Patients who underwent laparoscopic resection had an earlier return to liquid diet and were fed earlier than patients who underwent open resection. Passage of stool also occurred quicker in the laparoscopic group. There was a significant reduction in morbidity rates in the laparoscopic group but there appeared to be no difference in

minor and major complication rates. Finally, there was no significant difference in mortality rates between the laparoscopic and open group. [38]

Articles evaluating laparoscopic lavage

	Angenete 2016 [16]	Sorrentino 2015 [14]	Radé 2014 [39]	Swank 2013 [15]	Liang 2012 [35]	Myers 2008 [40]	Franklin 2008 [20]
Type of study	Randomized controlled trial	Retrospective study	Prospective study	Retrospective study	Prospective study	Prospective study	Retrospective study
Number of patients treated with laparoscopic lavage	39	63	71	38	47	100	40
Mean age (years)	62	57	58	59	62,6 ± 16,6	62,5	60
Mean BMI	25,6		26		31,4 ± 6,7		
Mean operating time (min)	68	87,3	61	68	99,7 ± 39,8		62
Conversion (%)			0	2,6	2,1	8	0
Use of drainage (%)	94,9			91,7			
Mean number of days with drainage	3						6
Blood transfusion (%)	10,3						0

Blood loss (ml)					34,4 ± 21,2		30,3
Suture repair of perforation (%)		28,6	14	5,3			
Intraoperative complications (%)				0	0		0
Intensive care unit admission (%)	12,8			15,8			
Early reoperation (%)	13,2	9,5	15	13,2	6,4	1	0
Mean postoperative hospital stay (days)	6	7	12	10	6,6 ± 2,4	8	8
Intraabdominal abscess (%)		1,6	12,7	10,5		2	
Colocutaneous or enterocutaneous fistula (%)			5,6	7,9			
Median time to oral feeding (days)			4			2	2
Wound infection (%)				5,3	0	0	

Short term mortality (%)	7,7	1,6	6	10,5	0	3	0
Overall morbidity (%)		14,3	28	44,7		4	
Delayed elective colon resection (%)		6,3	77,5	5,3	44,7	0	> 50
Colonoscopy after surgery (%)			59,2	44,7		88	
Malignancy (%)			0	0		1	

Table 3: Articles evaluating laparoscopic lavage

Articles evaluating emergency laparoscopic resection

Vennix et al. included in a systematic review a total of 104 patients (range 7-41) who underwent acute laparoscopic sigmoidectomy for diverticulitis from 5 different studies. The mean age varied from 49-69 years in the included studies (range 23-95). Most patients were categorized as ASA classification II or III. The type of resection varied between studies with a majority of Hartmann procedures (84) over sigmoidectomy with primary anastomosis without ileostomy (20). The mean operating time varied between 115 and 200 min with ranges between 55 and 250 min. The conversion rate varied from 0 to 19%. Intraoperative complications were reported in 5 patients (4.8%). Other frequent reasons for conversion were difficult exposure in 5, synchronous cancer in 2, and anastomotic difficulty in 2. Postoperative complications were reported in 22 (21.2%) patients. Three patients died during the postoperative period (mortality rate 2.9%), one due to postoperative myocardial infarction, one uncontrolled sepsis and one from cerebral oedema from metastasized lung carcinoma after recovering from the sepsis. Two (1.9%) patients required surgical re-intervention for stoma revision and a surgical abscess drainage. In all 20 patients with primary anastomosis without ileostomy, no anastomotic leakage occurred. The mean length of hospital stay was between 6 and 16 days with a range of 5-28 days. Data on stoma reversal were reported in 79 of 84 patients who underwent a

Hartmann procedure; continuity was restored in 60 out of these 79 evaluable patients (75.9%). The available data did not allow for a meaningful comparison between primary anastomosis and Hartmann procedure with regard to postoperative outcomes. [18]

In the retrospective study by Vennix et al. 39 patients were treated with emergency laparoscopic sigmoidectomy for perforated diverticulitis. Mean age was 56.2 years, mean BMI was 25.3 and the majority of patients were categorized as ASA II. Mean duration of surgery was 127 minutes. Sigmoidectomy was performed as Hartmann's procedure in 66.7 % of patients and primary anastomosis in 33.3 %. Ileostomy rate was 61.5%. The postoperative Intensive Care Unit admission rate was 36.7%, in-hospital mortality 2.6%, in-hospital overall morbidity 43.6% with severe morbidity 12.8%, reinterventions 12.8% (surgical 5.1%, percutaneous 7.7%) and wound infection 3%. Anastomotic leakage occurred in one patient and was treated by relaparotomy and loop ileostomy. The mean postoperative hospital stay was 7 days. The stoma reversal rate after Hartmann's procedure was 88% at 12 months. After primary anastomosis, the probability of reversal was 100 %. [22]

3. DISCUSSION

Given the increased prevalence of colonic diverticular disease in the last decades, the surgical treatment of patients with diverticulitis in both elective and emergency situations has become an important topic of discussion. However, despite a considerable number of papers, the indications, choice of technique, and timing for surgery are still subject to debate. Laparoscopic surgery has revolutionized the treatment of many diseases of surgical interest. The minimally invasive treatment of diverticular disease has proved feasible and effective. Laparoscopy minimizes postoperative pain and respiratory distress, reducing the length of hospital stay and improving the return to an active life. Furthermore, the only meta-analysis available today, by Siddiqui et al, showed a statistically better outcome for laparoscopic surgery compared with open surgery in terms of time of canalization, hospital stay, and morbidity rate. [5]

The indications for elective surgical treatment of sigmoid diverticular disease are still under discussion and a case-by-case decision, based on the patient's preoperative condition and disease, is gaining support. The benefits of elective surgical management in preventing further complications of diverticular disease, improving the quality of life of patients with recurrent disease and reducing the use of Hartmann's procedure, are the crucial key points. These targets can be achieved and enhanced through a minimally invasive approach. [1, 6]

The Sigma trial, a randomized, controlled study comparing elective laparoscopic vs. open colectomy for colonic diverticulosis, concluded that the laparoscopic procedure is associated with lower complication rates; however, upon further analysis only the major complications are significantly lower in the laparoscopic group. Siddiqui et al., in their meta-analysis also showed that there is significant difference in overall morbidity with low rates in laparoscopic group, but this finding was not consistent when they divided the complications into different categories. In both studies, despite the difference in morbidity, there was no significant difference in mortality rates. Contrary to the above, Masoomi et al., in their National Inpatient Sample database study, showed that the in-hospital mortality rates are four times higher with open resection after risk-adjusted analysis. In their study, morbidity also is significantly high with open resection compared with laparoscopic resection. However, in their study, even though they had a large patient sample (125,734 patients), 88.3% of them underwent open resection. Conversely, in the study by Kakarla et al. there was almost equal distribution of laparoscopic and open resection and the study collected 30-day mortality rate, not the in-patient mortality rate. In that study, before risk adjustment, it was noticed that there is significantly high incidence of 30-day mortality, morbidity, and wound complications in the open group. But after logistic regression analysis for risk adjustment, it was noticed that the type of procedure is not associated with high 30-day mortality, but it is associated with high incidence of 30-day overall morbidity and also serious morbidity by almost twofold in the open group. That study also showed that open resection is associated with significantly high rates of wound complications within the 30-day period. From that study, it is clearly evident that laparoscopic resection, at least, may have advantages during the early postoperative period because of the low incidence of complications. [7]

Based on the nonrandomized studies included in the systematic review by Cirocchi et al., the elective laparoscopic approach is safe and feasible as well as being associated with a lower overall morbidity and minor complication rate. The results from the Sigma Trial mostly agree with those of this study, with the exception of minor complications, which were higher in both groups of this RCT; however, the high overall morbidity percentage (42.3%) reported for the laparoscopic group remains a source of concern. Given the nonrandomized nature of the studies included, the results from this study have to be weighed carefully and the selection bias and the heterogeneity of the inclusion criteria in the studies should be considered. [1]

Russ et al. reported that the rate of abdominal abscess was lower in laparoscopic surgery compared to the open surgery Similarly, Alves et al found a significant decrease in overall morbidity and intraabdominal abscesses after laparoscopic compared to open surgery for diverticulitis. According to Masoomi et al., in comparison to the open operation group, patients undergoing the laparoscopic procedure demonstrated better outcomes in terms of a decreased incidence of all postoperative complications, particularly those relevant to colorectal surgery, such as

ileus, anastomotic leakage, intraabdominal abscess, wound infection, and bowel obstruction. Furthermore, patients undergoing elective laparoscopic surgery for their diverticular disease had significantly fewer perioperative complications, shorter length of hospital stay, lower hospital charges, and lower in-hospital mortality when compared with patients undergoing open surgery. [12]

According to Levack et al., the rate of anastomotic leaks in patients who underwent open colectomies was 8.2%. Patients who underwent laparoscopy had only a 2.4% rate of anastomotic leaks. Interestingly, the rates of leaks requiring reexplorations were similar between the 2 arms. [41]

A major concern regarding laparoscopic colon resection for diverticulitis is the rate of intraoperative complications related to the inflammatory process of diverticulitis. Literature comparing the rates of intraoperative complications for laparoscopic versus open colon resection for diverticulitis is limited. In the study by Massomi et al., overall intraoperative complications in the open group were almost twice that of the laparoscopic group (1.15% vs. 0.63%). The magnified view of the field of operation with better visualization could account for the decrease in intraoperative complications with the laparoscopic approach. [12]

The published short-term data of the Sigma-trial have shown a reduction in major complication rates, less pain, a shorter hospital stay, and improved quality of life at the cost of a longer operating time with the laparoscopic approach. The current data include the 6-month follow-up assessment for the laparoscopic resection and the open resection. No differences between the two groups were found in late complications such as incisional hernias, anastomotic strictures, enterocutaneous fistulas, small bowel obstruction due to adhesions, or recurrent episodes of diverticulitis. The improved quality of life 6 weeks postoperatively returned to baseline values 6 months after surgery. Consideration of total postoperative morbidity (follow-up period, 0–6 months) shows that the laparoscopic approach results in a significant 27% reduction in major complications. [36]

According to Alves et al., the main advantages of the laparoscopic approach should be an earlier recovery of intestinal transit and resumption of normal diet, less postoperative pain, and a reduction in postoperative morbidity leading to a decrease in hospital stay. In this study, both overall postoperative morbidity rates and hospital stay were significantly lower after laparoscopic colectomy than open colectomy. Although the morbidity rate was lower in the laparoscopic group in that study, it should be noted that the two groups of patients were not strictly comparable as patients in the open group were older, with a higher ASA score and a higher frequency of cardiorespiratory co-morbidity. However, the morbidity rate remained significantly higher in the open group, even when the patients were matched for age and ASA score. Multiple regression analysis revealed the operative approach of laparotomy to be the worst independent risk factor for postoperative morbidity after colectomy for diverticular disease. The remaining factors were intraperitoneal

contamination and age over 70 years. Although a propensity score correction was performed, the influence of operative approach (laparoscopy versus laparotomy) on morbidity rate remained significant, independently of the factors that might have influenced the choice of surgical approach. [37]

The laparoscopic approach has been commonly used in recent years although the inflammatory process can make it technically difficult. In a multicentre study of patients operated on for diverticulitis, the rates of complications, conversion and morbidity were acceptable. A laparoscopic approach in diverticulitis is appropriate but can be technically complex and requires experience in laparoscopic surgery; the benefits will mostly depend on low conversion and morbidity rates. After three or more episodes of acute diverticulitis the technical difficulty and the risk of conversion and postoperative complications increases. [24] In diverticular disease, 50% of converted cases were directly related to the inflammatory process itself (inflammatory mass or pseudotumor, adhesions, abscess or fistulas). The increased risk of postoperative morbidity following conversion to open colectomy has been related to an increased duration of surgery, to intraoperative complications, and, finally, to the severity of the underlying disease. [13]

Factors predictive of conversion have been evaluated by several authors. These include surgeon experience, BMI, previous abdominal surgery, presence of fistula, inflammation extending beyond the sigmoid colon, and adhesions. [8]

Obesity is a factor associated with higher likelihood of perioperative complications. The large, heavy omentum is considered by many a factor that makes the mobilization of the colon challenging during laparoscopic resection and is considered a reason to convert to an open procedure. [42]

The legitimacy of laparoscopic colectomy for diverticulitis ultimately hinges upon its effectiveness in eradication of disease, that is preventing recurrent attacks and complications. Benn et al identified complete sigmoidectomy and colorectal anastomosis as the key to adequate resection and prevention of recurrent diverticulitis. In this report, recurrence was 6.7% with a colorectal anastomosis as opposed to 12% when colocolostomy was performed. Therefore, the critical elements signifying an adequate operation for diverticulitis –complete removal of the colonic segment affected by diverticula and a totally tension free anastomosis- should be consistently reproduced by laparoscopic technique identical to those with open operation. To achieve the tension free anastomosis, it is often necessary to perform full mobilization of the colonic splenic flexure. [5, 43] Mobilization of the flexure decreases the tension on the anastomosis potentially lessening the occurrence of anastomotic leakage or stricture. [44]

Klarenbeek et al. investigated the cost effectiveness of laparoscopic versus open elective sigmoid resection for patients with symptomatic diverticular disease. The increase in total costs was determined mainly by the significantly higher operation

costs of the laparoscopic approach. Lower costs for hospitalization, blood products, paramedical services, and emergency attendance in the laparoscopic group partially compensated these increased operation costs. Total healthcare costs of laparoscopic and open elective sigmoid resections for symptomatic diverticular disease are similar. [45]

There is controversy about what constitutes the ideal treatment of perforated diverticulitis. Traditionally, patients with perforated diverticulitis and clinical evidence of peritonitis are treated with colonic resection with a primary or delayed anastomosis (primary colonic anastomosis or Hartmann's procedure, respectively). However, both of these procedures are associated with significant morbidity and mortality. Moreover, the chance of reversal of Hartmann's procedure is low. In recent decades, efforts have been made to find a less invasive approach. [14] In patients with peritonitis without gross fecal contamination, laparoscopic peritoneal lavage, inspection of the colon, and the placement of abdominal drains appear to diminish morbidity and improve outcome. Laparoscopic peritoneal lavage reduced the length of hospital stay, and a stoma could be avoided in most patients. In a second elective stage, definitive surgery can take place, although subsequent elective resection is probably unnecessary. The recent change toward conservative approach including peritoneal lavage in combination with antibiotic therapy may avoid colonic resection and a stoma. Using this approach, most patients with purulent peritonitis can avoid emergent laparotomy with the risk of colostomy, and the need for a second surgery. [26]

Since the first reported experiences, laparoscopic peritoneal lavage has emerged as a safe and effective minimally invasive procedure for the treatment of perforated colonic diverticulitis. The results of lavage with respect to the reported morbidity and mortality rates seem to compare well with those of traditional surgical resection and are very encouraging. However, no completed prospective randomized or case–control study has demonstrated the superiority of one surgical approach over the other. [14]

Critical to understanding the rationale for conservative surgery in perforated diverticulitis is appreciating that in most cases the resultant peritonitis is purulent (Hinchey III) rather than faeculent (Hinchey IV). A patent communication between the colonic lumen and the peritoneal cavity usually cannot be found as the site of the original perforation has become sealed by the inflammatory process. The observed toxaemia may be largely due to the peritoneal suppuration rather than the inflamed colon itself. The often-dramatic improvement observed in many patients within the first 24 h following lavage supports this concept. [19]

Lavage should be considered in cases of generalized peritonitis due to perforated diverticulitis. Currently, Hinchey III diverticulitis is an accepted indication for lavage, whereas treatment of Hinchey IV diverticulitis is more controversial. Cases of localized fecal peritonitis might be considered for lavage, although studies with larger

series are required to confirm this hypothesis. The safety of primary repair of perforation is still under debate, and it is not recommended by all authors. [14]

Recognizing that resectional approaches incur substantial associated morbidity, there is increasing discussion of nonresectional operations for acute diverticulitis. Laparoscopic peritoneal lavage has been proposed as a damage-control operation to contain contamination and give patients with acute perforation and purulent peritonitis a bridge to elective resection with primary anastomosis. [2, 46] Advocates of this approach report that laparoscopic peritoneal lavage and drainage combined with intravenous antibiotics can effectively treat the acute peritonitis and systemic toxicity of perforated diverticulitis such that a later sigmoid resection and primary anastomosis can be performed on an elective basis. Thus, with this approach, patients might be spared the high morbidity and requisite temporary ostomy of the classic two-stage approach. [47]

In light of the excellent results obtained using laparoscopic peritoneal lavage to date in the management of perforated diverticulitis, traditional mandatory indications for colon resection may be reconsidered. There seems to be an international trend toward not resecting the sigmoid colon even after multiple attacks of diverticulitis, due to a limited risk of perforation after recurrence. Because both Hartmann's procedure and primary colonic anastomosis are associated with significant morbidity and mortality rates, these procedures could be avoided in many patients if lavage is used, preventing unnecessary resections. Perforation is often the clinical onset of diverticular disease and many patients remain asymptomatic after treatment with lavage. However, when peritonitis is present, it has until now been the routine to perform Hartmann's procedure. However, further studies directly comparing the two approaches are still needed to confirm these preliminary results and support the safety of laparoscopic lavage. [14, 16]

In all of these studies, the question arises as to how many of the patients "successfully" managed with lavage actually needed surgical intervention and how many would have settled with conservative management. Most patients with localized peritonitis or a small abscess, without an overt perforation, are likely to settle with conservative management and, therefore, subjecting those patients to a surgical intervention is difficult to justify. Conversely, those with an overt perforation are clearly likely to have or to develop faecal peritonitis and will undoubtedly require a resection. [31, 46]

The primary colonic anastomosis parameters set by the Standards Committee of the American Society of Colon and Rectal Surgeons suggest that the decision to recommend elective sigmoid colectomy after recovery from acute diverticulitis successfully managed with medical treatment should be made on a case-by-case basis. This approach could potentially be adopted even in cases of acute diverticulitis treated with laparoscopic lavage. In the study by Sorrentino et al., of 57 patients treated with lavage, only four patients underwent an elective colon resection because of recurrent

diverticulitis. These observations are strengthened by the long-term follow-up. [14] Supporting this hypothesis, recent data suggest that an episode of severe diverticulitis may result in a buttressing effect around the affected portion of the colon, providing protection from subsequent attacks. [14, 40] There is accumulating evidence that laparoscopic lavage and drainage is not only a safe and efficient method of treating non-feculent complicated diverticulitis but does not always necessitate a future elective colonic resection. [48]

Selection of patients who would benefit from laparoscopic lavage is probably of utmost importance, with faeculent peritonitis and the presence of overt perforation being absolute contraindications to lavage. Unsuccessful treatment is associated with higher ASA grade and co-morbidities. Patients with stage III disease who have multiple co-morbidities, immunosuppression, a high C reactive protein level and/or a high Mannheim Peritonitis Index are at high risk of failure and a Hartmann procedure as a first step could be the best option in these patients. [15, 32]

Many studies have analyzed patients with both Hinchey II and Hinchey III, and have considered Hinchey II patients as candidates for lavage treatment, without discrimination within this group of patients based on the presence of free abdominal air. This might make the results appear considerably better because Hinchey II diverticulitis is known to be associated with fewer complications than true perforated diverticulitis. Swank et al. included patients with purulent peritonitis and/or distant free air only. Laparoscopic treatment does not seem to be appropriate for patients with Hinchey II diverticulitis without free air. These patients can be treated either conservatively or by percutaneous drainage of the pelvic abscess. Laparoscopic lavage is considered to be unsafe for faeculent peritonitis or when an overt perforation is present. [15]

Mortality and morbidity were high among patients in whom the abdominal sepsis was not controlled. When no clinical improvement is observed within 48 h, (laparoscopic) reintervention is indicated for additional lavage or resection. Laparoscopic lavage might not benefit all patients with Hinchey III diverticulitis. Sigmoid resection as a first step might be the best intervention for these patients, but the mortality rate is high anyway. [15]

It seems logical that laparoscopic lavage should be reserved for abscesses not amenable to percutaneous image-guided drainage and purulent peritonitis (i.e. Hinchey II and III). However, the Hinchey classification is based on intra-operative observations. Therefore, it may be that one of the roles of laparoscopy is exploration of the peritoneal cavity to help categorize patients and improve risk stratification. [17]

The incidental cancer in the Myers et al. series also highlights the importance of vigilance in cases where the diseased colon is not resected, as there is a potential for missing malignant disease. Carcinoma could be coincidental or the primary cause of

perforation. Follow-up investigations are essential in cases where the colon is left in situ. [17]

According to Angenete et al. laparoscopic lavage for perforated diverticulitis with purulent peritonitis (Hinchey III) is feasible and safe. Compared with patients undergoing Hartmann's resection, patients treated with laparoscopic lavage were no different in regard to overall morbidity and short-term mortality. The patients also had shorter duration of surgery and shorter hospital stay after laparoscopic lavage. No differences were found in overall outcomes such as complications or mortality pointing at laparoscopic lavage as a safe alternative to Hartmann's procedure. Previous reviews have reported considerably lower mortality rates of 1.4% to 1.7% after laparoscopic lavage. However, these series may be subject to selection bias underestimating mortality rates and it is possible that the mortality rate after laparoscopic lavage of 7.7% in the study by Angenete et al, probably more closely reflect the true rate in daily clinical practice. In addition, fewer colonic perforations were reported in the laparoscopic lavage group. [16]

In the study by Rade et al. treatment was successful in the majority of patients, with acceptable mortality and morbidity rates, better than those associated with major emergency resection. Successful treatment included no stoma in most patients. Although some patients needed reintervention, this was in a semielective setting with better sepsis parameters. The alternative of resection would have necessitated a stoma and a further operation. This study confirmed the efficacy of the procedure, with a success rate of 85 per cent and no conversion to open surgery. This high rate is probably explained by the preoperative selection of patients. Nonetheless, selection of suitable patients for laparoscopic lavage can be difficult. Suspected Hinchey III peritonitis often requires laparoscopy for diagnosis. [39]

In the study by Liang et al. laparoscopic lavage not only gave superior outcomes for controlling the occurrences of intraoperative and postoperative complications, it further manifested its advantage in the long-term follow-up, which showed that only 21 patients required sigmoidectomy with primary anastomosis for the definitive management of diverticulitis, whereas the remaining 26 patients had not returned for further operation, suggesting that laparoscopic lavage has been applied as the only but sufficient surgical intervention for the management of perforated diverticulitis with Hinchey III or IV. [35]

Despite the high ASA grade of many patients in the Myers et al. series, laparoscopic management resulted in a postoperative mortality rate of only 3 per cent, and the postoperative medical complication rate of 4 per cent compares favorably with rates of 8–20 per cent for open resection. Similarly, in terms of postoperative peritonitis or abscess formation, the laparoscopic approach is comparable, with a rate of 3 per cent versus 3.9–8.6 per cent for open resection. Although some proponents of the laparoscopic approach have undertaken elective resection of the diseased portion

of bowel subsequently, only two patients in the series by Myers et al. required readmission for treatment of diverticulitis. [40]

Limitations of small series illustrating the merits of the laparoscopic approach include the lack of radiological evidence of free perforation, raising the possibility that some patients may have had severe diverticulitis without perforation and may have settled with antibiotic therapy alone. In the study by Myers et al. all patients had radiological evidence of perforation and were confirmed to have perforated diverticulitis at laparoscopy. [40]

Franklin et al. performed this procedure in patients with acute diverticulitis and peritonitis, with an average hospital stay of 3 days. There has been no conversion to open surgery and no mortality with minimum perioperative and postoperative complications. Just over 50% of the patients had a planned sigmoid colectomy, as they were indicated at the time of emergency admission. With an average follow-up of 96 months (range 1–120 months) no one required further admission or intervention for complications of diverticular disease. For the patients who had indications for resection, the proposed surgery would had been a Hartmann procedure or resection with anastomosis in a contaminated field. However, after lavage and drainage, there was a possibility of delayed second-stage colon resection, performed laparoscopically without the morbidity and mortality seen with the emergency approach. [20]

The Ladies trial, the only randomized prospective trial proposed, was interrupted due to an excessive number of postoperative conversions after laparoscopic lavage. [14] The collective, published worldwide experience is limited to fewer than 800 patients, and results from ongoing randomized trials (LapLAND, SCANDIV, DILALA, and LADIES trials) are needed to inform better decision-making. The laparoscopic lavage and drainage (LOLA) arm of the LADIES trial randomized between laparoscopic lavage and resection (with or without primary anastomosis). Recruitment was stopped early for this arm of the study, but data on the management of 38 patients treated with lavage have been published recently. Identification of patients who will have a poorer outcome following lavage is important to inform decision-making. Results from an Irish population database suggest that patients with underlying connective tissue disorders or chronic kidney disease have poorer outcomes. At present, we are aware of at least three more randomized trials, the SCANDIV study, the LapLAND study, and the DILALA study, evaluating whether laparoscopic lavage is a safe method. The trials are working toward effectiveness of minimally invasive methods for patients with perforated diverticulitis Hinchey grade III and comparing the outcomes of traditional methods of Hartmann’s procedure versus laparoscopic lavage. [23, 26]

The uptake of emergency laparoscopic surgery for acute diverticulitis has been slow. In the systematic review by Vennix et al. is indicated that in selected patients, laparoscopic sigmoidectomy is feasible in Hinchey III and IV diverticulitis. This is

reflected by an acceptable conversion rate, a low re-intervention rate, a low morbidity rate, and a low mortality rate. [18]

One of the main concerns for the application of laparoscopic surgery in generalized peritonitis is the risk of damage to the distended and vulnerable small bowel. A recent systematic review reported a 64% success rate of laparoscopic treatment in 2005 patients with small bowel obstruction. About 10% of the conversions were due to iatrogenic injury and 7.6% due to inadequate exposure. Even a small bowel diameter greater than 4 centimetres was not considered to be an absolute contraindication for laparoscopy. [18, 22] Another reason why many surgeons still regard general peritonitis and especially faecal peritonitis as a contraindication for a laparoscopic approach is related to a hypothetical risk of increased bacteraemia and hypercapnia due to the pressure of the pneumoperitoneum. This theory has neither been proven nor disproven, but the experience gained with laparoscopic treatment in abdominal sepsis of various causes does not support this hypothesis. Laparoscopic lavage as a minimally invasive approach to perforated diverticulitis has been discussed extensively, in contrast to the option of laparoscopic Hartmann's or laparoscopic sigmoidectomy with primary anastomosis. Laparoscopic sigmoidectomy can be an alternative in those patients not eligible for laparoscopic lavage, such as those with faecal peritonitis or an immune deficiency, or when initial lavage has failed. [18]

The study by Turley et al. concluded that the laparoscopic Hartmann's procedure offers no clear advantages over the open technique for the management of complicated diverticulitis in the emergency setting. As the realm of minimally-invasive surgery continues to grow, it will become important to identify which procedures are truly enhanced with such techniques. Using a prospective database encompassing more than 250 participating hospitals, it was found that laparoscopic partial colectomy with end colostomy for emergency treatment of diverticulitis can be performed efficiently with similar operative times as standard open techniques. However, when compared to a propensity-matched cohort, laparoscopic Hartmann's procedure did not confer any advantages over open surgery in terms of mortality, overall morbidity, or length of hospitalization. [47]

According to the first comparative study by Vennix et al. between open and laparoscopic sigmoidectomy, laparoscopic sigmoidectomy for perforated diverticulitis is superior to open with regard to morbidity and hospital stay. Laparoscopic sigmoidectomy is safe and feasible as shown by the low conversion rate and postoperative mortality that did not differ significantly compared to open resection. The lower morbidity and hospital stay resulted in reduced costs per patient in the laparoscopic group. Stoma closure after Hartmann’s procedure occurred more often after a laparoscopic approach. Although overall postoperative morbidity was higher following open sigmoidectomy, only the difference in wound infection rate was statistically significant. However, even without the wound infections, the total number

of complications was higher following open sigmoidectomy (16 vs 73 surgical events and 23 vs 96 total events in 39 and 78 patients). [22]

The available evidence for emergency laparoscopic sigmoidectomy for the treatment of perforated diverticulitis is limited and of low quality, as it is based on small non-randomized case series without any open control group. It seems likely that these laparoscopic procedures were performed on a selected group of patients and by a dedicated laparoscopic team. Therefore, these results cannot be extrapolated unconditionally to the general population in less dedicated hospitals. The overall morbidity rate of 21% and mortality rate of 3% is low compared to the reported morbidity rates of 40-80% and mortality rates of 15-35% in high-quality studies on open surgery. These low rates may be the result of laparoscopic surgery, but is likely to be influenced by a publication and selection bias. Potential parameters of selection bias are age, Hinchey grade and ASA grade. [18]

4. CONCLUSION

The prevalence of diverticular disease is a first class healthcare problem in developed countries and causes significant morbidity and mortality. The heterogeneity of patients means that both elective and urgent treatment should be tailored on an individual basis. Further studies are needed to improve the level of evidence and grade of recommendation on different aspects of acute diverticulitis. [24]

The elective laparoscopic treatment of colonic diverticular disease is an effective and safe option that produces adequate postoperative results and ensures a satisfactory functional outcome for the patient. [5] Laparoscopic colectomy for symptomatic diverticulosis in elective setting may have several advantages over the standard open colectomy, especially in the early postoperative period, with low incidence of complications. These findings support the safety of this laparoscopic procedure that should be considered as a preferred choice depending on the availability and expertise. A large, prospective, randomized study should be conducted to confirm these findings. [7]

Laparoscopic peritoneal lavage in Hinchey III perforated diverticulitis is feasible and in the short-term as safe as Hartmann's procedure. [16] It may be considered an effective option and can be performed as a “bridge” procedure with the intent to avoid the Hartmann procedure. Widespread implementation of the technique should await long-term results from the ongoing randomized trials. [2, 16]

The indications for elective colon resection after laparoscopic lavage could be restricted to recurrent diverticulitis or related complications, with evaluation of

multiple parameters made on a case-by-case basis. Therefore, perforated diverticulitis might not be considered a mandatory indication for elective colon resection. [14]

There is limited evidence that emergency laparoscopic sigmoidectomy for the treatment of perforated diverticulitis with generalized peritonitis is feasible in selected patients and in experienced hands. High-quality prospective studies are needed to provide proof of possible benefits of acute laparoscopic sigmoidectomy compared to open sigmoidectomy for perforated diverticulitis. [18]

5. ABSTRACT

Background/Aim: Diverticular disease is a first class healthcare problem and one of the most common gastrointestinal disorders in western industrialized countries, causing significant morbidity and mortality. In this review of the literature, we aim to assess the feasibility and effectiveness of the laparoscopic approach in both elective and emergency setting of diverticular disease.

Materials and methods: A bibliographic search of articles was performed using the electronic database MEDLINE from PubMed. Of 341 articles identified, 279 were excluded, resulting in 62 full text articles for review. Our final review included 16 articles.

Results: The sixteen articles included in the final review consisted of six retrospective studies, five prospective studies, two randomized controlled trials, one systematic review and metaanalysis, and two systematic reviews. Seven articles considered elective laparoscopic sigmoid resection, seven articles evaluated laparoscopic peritoneal lavage and two articles considered emergency laparoscopic sigmoid resection for perforated diverticulitis. The elective laparoscopic approach is feasible and safe. Laparoscopic peritoneal lavage has emerged as a safe and effective minimally invasive procedure for the treatment of perforated diverticulitis. Furthermore, in selected patients, emergency laparoscopic sigmoidectomy could also be feasible for perforated diverticulitis with generalized peritonitis.

Conclusions: Laparoscopic approach can be a safe and effective option in both elective and emergency setting of diverticular disease. Large, prospective, randomized studies should be conducted to confirm these findings.

6. ΠΕΡΙΛΗΨΗ

Εισαγωγή/Σκοπός: Η εκκολπωματική νόσος αποτελεί ένα βασικό υγειονομικό πρόβλημα και μία από τις συνηθέστερες διαταραχές του γαστρεντερικού συστήματος στις αναπτυγμένες βιομηχανικά δυτικές χώρες, προκαλώντας σημαντική νοσηρότητα και θνητότητα. Σε αυτή την ανασκόπηση της βιβλιογραφίας, σκοπός μας είναι να εκτιμήσουμε την δυνατότητα και αποτελεσματικότητα της λαπαροσκοπικής προσέγγισης στην εκλεκτική καθώς και στην επείγουσα αντιμετώπιση της εκκολπωματικής νόσου.

Υλικά και μέθοδοι: Διεξήχθη βιβλιογραφική έρευνα άρθρων χρησιμοποιώντας την ηλεκτρονική βάση δεδομένων MEDLINE του PubMed. Από τα 341 άρθρα που αναγνωρίστηκαν, τα 279 αποκλείστηκαν καταλήγοντας σε 62 πλήρη άρθρα για ανασκόπηση. Η τελική μας ανασκόπηση περιέλαβε 16 άρθρα.

Αποτελέσματα: Τα δέκα έξι άρθρα που συμπεριλήφθηκαν στην τελική ανασκόπηση αποτελούνταν από έξι αναδρομικές μελέτες, πέντε προοπτικές μελέτες, δύο τυχαιοποιημένες δοκιμές, μία συστηματική ανασκόπηση και μεταανάλυση, και δύο συστηματικές ανασκοπήσεις. Επτά άρθρα μελετούσαν την εκλεκτική λαπαροσκοπική σιγμοειδεκτομή, επτά άρθρα πραγματεύονταν την λαπαροσκοπική περιτοναϊκή πλύση και δύο άρθρα την επείγουσα λαπαροσκοπική σιγμοειδεκτομή για εκκολπωματίτιδα με διάτρηση. Η εκλεκτική λαπαροσκοπική προσέγγιση είναι εφικτή και ασφαλής. Η λαπαροσκοπική περιτοναϊκή πλύση έχει αναδειχτεί ως ασφαλής και αποτελεσματική ελάχιστα επεμβατική μέθοδος για την αντιμετώπιση της εκκολπωματίτιδας με διάτρηση. Επιπλέον, σε επιλεγμένους ασθενείς, η επείγουσα λαπαροσκοπική σιγμοειδεκτομή θα μπορούσε επίσης να είναι εφικτή για εκκολπωματίτιδα με διάτρηση και γενικευμένη περιτονίτιδα.

Συμπεράσματα: Η λαπαροσκοπική προσέγγιση μπορεί να αποτελέσει μια ασφαλή και αποτελεσματική επιλογή στην εκλεκτική καθώς και στην επείγουσα αντιμετώπιση της εκκολπωματικής νόσου. Μεγάλες, προοπτικές, τυχαιοποιημένες μελέτες θα πρέπει να διεξαχθούν ώστε να επιβεβαιωθούν αυτά τα ευρήματα.

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