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## In brief



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Diverticulitis of the colon is a major cause of morbidity and mortality for patients in the United States, accounting for approximately 208,000 hospital admissions per year and 977,000 inpatient hospital days. In total, healthcare expenditures related to this disease exceed \$2 billion. Diverticulosis, the herniation of mucosa and submucosa through the colonic muscle layer, increases in prevalence as patients grow older. In total, more than one half of individuals older than 50 years have diverticulosis on colonoscopy based on prospective single institution data from 2013 to 2015. The lifetime incidence of diverticulitis among patients with diverticulosis ranges from less than 0.5%-5%. Recent studies propose that diverticulitis is primarily driven by chronic colonic inflammation and alterations in the gut microbiome, although research in this area is quite preliminary.

In total, approximately 20% of patients admitted for acute diverticulitis require emergency surgery. For the remaining patients, management is more complex. The advent of cross-sectional imaging and percutaneous drainage techniques has allowed for the minimally invasive and non-operative management of patients presenting with abscesses related to diverticulitis. In these cases, surgery may be delayed, and for some, entirely avoided. After successful non-operative management of these patients, surgeons face a difficult decision regarding which patients require elective sigmoid resection. Other difficult scenarios include the 10%-15% of patients with complicated diverticulitis who ultimately develop a fistula or obstruction. Here, we review and assess recent research on the elective surgical management of patients with uncomplicated left-sided diverticulitis, patients with complicated diverticulitis initially managed non-operatively, those with giant diverticulum or right-sided diverticulitis, and the elective surgical management of special populations such as younger patients and the immunocompromised.

For acute diverticulitis, the most common staging system is the Hinchey classification. It is important to note that this widely used classification was based on intraoperative findings from

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a single center series of 95 patients, prior to the era of advanced cross-sectional imaging. Although no classification has been rigorously demonstrated to be superior to others, a commonly accepted modification to the Hinchey classification is that proposed by Wasvary et al and subsequently Kaiser and colleagues and consists of the following stages: (0) mild clinical diverticulitis, (Ia) confined pericolic inflammation, (Ib) confined pericolic abscess, (II) pelvic or distant intra-abdominal abscess, (III) generalized purulent peritonitis, (IV) fecal peritonitis at presentation, as well as 2 other categories of fistula and obstruction.

Overall, most individuals never have a recurrence following an index episode of diverticulitis. In total, recurrence rates range from 13% to 33%, with very few of these individuals ever requiring emergent operation. For example, in long-term follow-up of 556 participants in the Antibiotics in Acute Uncomplicated Diverticulitis randomized controlled trial, 31.3% experienced a recurrent episode of diverticulitis at a median follow-up of 11 years. For the total cohort of 556 patients, only 26 (4.6%) ever went on to develop complicated diverticulitis and only 14 (2.5%) ever required an emergent surgery. After an initial episode of uncomplicated diverticulitis, elective resection can be considered but is not required.

As the management of diverticulitis has evolved toward a more conservative approach, it is important to consider the risk factors for recurrence when counseling patients. Young patients are more likely to have recurrent episodes of diverticulitis compared to older patients. A retrospective analysis of a California statewide discharge database from 1995 to 2009 found a 16.3% rate of recurrence after an initial admission for diverticulitis. Age younger than 50 years predicted recurrence overall as well as recurrence with complicated diverticulitis. Although young patients are more likely to experience recurrent episodes of diverticulitis, they are no more likely to require emergency surgery when compared to older patients.

Patients who present with complicated diverticulitis, who are successfully managed non-operatively, have higher rates of recurrent diverticulitis compared to patients with an initial episode of uncomplicated diverticulitis. Several retrospective studies have reported the recurrence rate for patients who initially present with diverticular abscess to be between 24% and 60%.

A patient's risk for recurrence increases with the number of prior episodes of diverticulitis. A retrospective review of a state discharge database included 181,115 patients between 1985 and 2006 and found a rate of subsequent admission for diverticulitis to be 8.7% in those with one prior episode, 23% with 2 prior episodes, 36% with 3 prior episodes, 41% after a fourth admission, and 46% following a fifth admission. A family history of diverticulitis is associated with 2- to 4-fold greater risk of recurrence compared with patients who do not have a family history of diverticulitis, as demonstrated in 2 moderately sized retrospective studies in Canada and the United States.

Other risk factors of interest, shown to be associated with recurrence in limited studies, include computed tomography findings such as extraluminal air, retroperitoneal abscess, and colonic wall thickening. Tobacco use is a risk factor for recurrence in some studies, but further research is required. Obesity and nonsteroidal anti-inflammatory drug use have been studied, but the association with recurrence is not well established. Further research is warranted to better define the association between these risk factors and recurrent diverticulitis.

Abscesses develop in 15%–40% of all patients with acute diverticulitis. Percutaneous drainage provides a non-operative modality for achieving source control, with greatly reduced morbidity and mortality as compared to open surgical drainage. Small abscesses can be treated with antibiotics alone and those greater than 3 cm should be treated with percutaneous drainage. However, antibiotics and percutaneous drainage for diverticular abscess have never been directly compared in a randomized controlled trial. Overall, either modality is associated with a 20% rate of treatment failure. Percutaneous drainage can be associated with adverse events such as sepsis (4% risk), bleeding, cellulitis around the drain, or bowel transgression. These drains require frequent supportive management such as flushing and tracking output volume, and may require upsizing or replacement. In long-term follow-up, more than 50% of these patients undergo resection, including approximately 6% who require emergency colectomy. Further research is warranted to determine what proportion can be safely managed non-operatively. Thus far, abscess

size is the most consistently identified risk factor for failure of non-operative management. Diverticular strictures and fistulae pose significant operative challenges, but operative management is generally required to address symptoms. There is little role for medical or expectant management in patients with fistulae who are fit for surgery.

Immunocompromised patients typically include those undergoing immunosuppression for solid organ or bone marrow transplants, on systemic chemotherapy, on immunosuppressive therapies for auto-immune disease, or those on chronic steroid therapy. Over the past decade, investigators have refuted the historic belief that a single episode of diverticulitis provided an adequate indication for elective colectomy in the immunocompromised patient. This new management strategy is largely based on evidence that immunocompromised patients are no more likely to have recurrences, and particularly recurrences requiring emergency surgery, than a typical patient. Data from the National Surgical Quality Improvement Project show that these patients have significantly higher risk of complications and death after elective resection for diverticular disease.

Diverticulitis can unfortunately recur after resection. In long-term follow-up, the risk is 5%-10%, but fewer than 1% of patients require reoperation. This event is poorly studied and considered to be a result of an inadequate distal sigmoid resection and failure to create a true colorectal anastomosis at the time of sigmoid resection.

Diverticular disease has other manifestations that are less common and poorly understood. Symptomatic uncomplicated diverticular disease is defined as gastrointestinal symptoms in the setting of diverticulosis without evidence of inflammation or diverticulitis. The diagnosis of this disease entity is questionable given considerable overlap in symptomatology with irritable bowel syndrome. There is extremely limited evidence regarding the use of colectomy for management of symptomatic uncomplicated diverticular disease. Giant colonic diverticulum is a rare manifestation of diverticular disease and is defined as a diverticulum greater than 4 cm in size, with most ranging between 4 and 9 cm, and a small number being 25 cm or larger. Patients can develop perforation or obstruction and should undergo sigmoid resection even if they are asymptomatic. Right-sided diverticular disease is more common in younger patients and those of Asian descent. Diverticulitis of the right colon is diagnosed on abdominal computed tomography scan and is frequently associated with a focal diverticulum and fecalith. Treatment is similar to left-sided diverticulitis, but surgical management is far less likely to be required, with surgical resection rates reported in as few as 3% of patients. Colonic resection or diverticulectomy can be performed for this disease in the elective setting, but in an urgent setting, resection is required.