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OPINION REVIEW

Diverticulitis is a population health problem: Lessons and gaps in strategies to implement and improve contemporary care

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Abstract

The disease burden of diverticulitis is high across inpatient and outpatient settings, and the prevalence of diverticulitis has increased. Historically, patients with acute diverticulitis were admitted routinely for intravenous antibiotics and many had urgent surgery with colostomy or elective surgery after only a few episodes. Several recent studies have challenged the standards of how acute and recurrent diverticulitis are managed, and many clinical practice guidelines (CPGs) have pivoted to recommend outpatient management and individualized decisions about surgery. Yet the rates of diverticulitis hospitalizations and operations are increasing in the United States, suggesting there is a disconnect from or delay in adoption of CPGs across the spectrum of diverticular disease. In this review, we propose approaching diverticulitis care from a population level to understand the gaps between contemporary studies and real-world practice and suggest strategies to implement and improve future care.

Key Words: Diverticulitis; Hospitalization; Elective; Emergent surgery; Clinical guidelines; Diverticular disease

Core Tip: Diverticulitis-associated hospitalization and colectomy are costly and have increased over the past decade, despite professional society guidelines advocating for outpatient management and individualized decisions about surgery. These trends raise flags about how to best measure guideline-concordant clinical practice in the modern era. Strategies to improve guideline-concordant care may consist of improved population-level data in diverticulitis care, regionalization of care, and system wide quality improvement initiatives for guideline implementation.

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INTRODUCTION

Diverticular disease is the most common benign pathology of the colon and exhibits an unpredictable, relapsing-remitting course[1]. The rate of symptomatic diverticulitis is estimated to range from < 5% to 25%, though its precise incidence is controversial. Of patients with symptomatic disease, 15% will develop acute or chronic complications such as abscess, fistula, obstruction, bleeding, or perforation[2-4]. Advanced age, obesity, smoking, non-steroidal anti-inflammatory drug use, sedentary lifestyle, and Western diets are all risk factors for diverticulitis[1,5-9]. It is unsurprising, therefore, that diverticular disease is pervasive in Western countries and its prevalence has increased in the recent past[1-3,10-12]. Indeed, diverticulitis is one of the top five gastrointestinal admission diagnoses in the United States, accounting for nearly 980000 hospital days, approximately 208000 admissions, and over $5.5 billion in combined inpatient and emergency department costs in 2018[3,12].

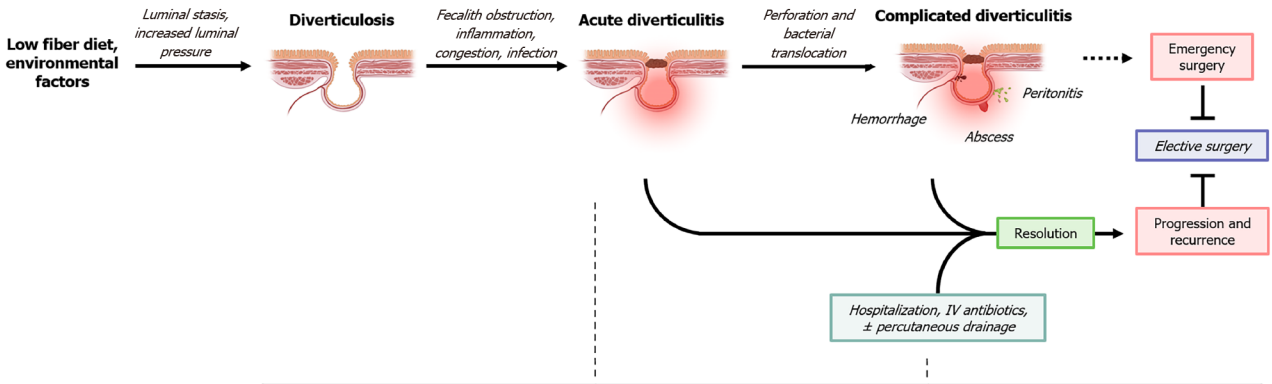
To curb this healthcare burden, several recent studies have challenged the standards of how acute and chronic diverticulitis are managed. The admission rate after selective outpatient management of uncomplicated diverticulitis is low and confers significant healthcare savings, ranging from 42%-82% compared to inpatient care[10,13]. Similarly, recent studies showed no significant difference in the rate of emergency surgery or recurrence after prophylactic colectomy for uncomplicated disease[10,14]. These data prompted many professional societies' clinical practice guidelines (CPGs) to shift toward outpatient management and individualized decisions about surgery[15-19].

Despite these two paradigm shifts over the past decade, the rate of hospitalization and surgery for diverticulitis rose, which lead to an increase in costs for diverticulitis care[3,14,20-22]. The specific factors contributing to this increase in hospitalization, surgery, and costs are poorly understood. It is not clear whether increased hospitalizations and surgery are necessary, driven by patients or their providers, or reflect overuse, under use, or concordance with CPGs across the spectrum of diverticular disease. Hospitalization and surgery are major drivers of healthcare costs and understanding the factors driving their use is necessary to better risk stratify patients, improve quality of care, and control costs. In this review, we propose approaching diverticulitis care from a population level to understand gaps between CPGs and real-world practice and suggest strategies to implement and improve future care.

REFRAMING DIVERTICULITIS FROM PROGRESSIVE TO RELAPSING-REMITTING DISEASE

Diverticular disease was once considered a progressive condition arising from environmental factors, primarily a low fiber diet[1,2]. This model implicated fiber deficiency as a driver of luminal stasis and increased intraluminal pressure leading to the formation of colonic pseudodiverticula. Obstruction of these diverticula by fecaliths was thought to cause inflammation, congestion, inflammation/infection, and eventual microperforation, bacterial translocation, and abscess formation[1,2]. Predicated on this pathogenesis, aggressive care with broad-spectrum IV antibiotics, bowel rest, and hospitalization was the mainstay of diverticulitis treatment. To prevent recurrence, surgical guidelines advocated for early colectomy after two episodes of uncomplicated or a single episode of complicated diverticulitis[23,24]. Epidemiological studies addressing the natural history of diverticular disease, however, do not support this progressive disease model and have called into question the foundation of these guidelines (Figure 1)[25-30].

For example, a progressive disease model predicts more frequent/severe relapses and complications in subsequent diverticulitis episodes. While the risk of recurrence increases, the rate of complicated diverticulitis actually decreases with each subsequent episode in observational studies[3,31]. Addi-



		Diverticulosis	Uncomplicated diverticulitis	Complicated diverticulitis
Progressive disease model	*Medical*	▪ Prevention: High fiber diet ▪ Avoid nuts/seeds	▪ IV antibiotics in all patients ▪ Bowel rest ▪ IV hydration	▪ IV antibiotics in all patients ± percutaneous drainage ▪ Bowel rest ▪ IV hydration
	Inpatient Care	–	▪ Hospitalization in most patients	▪ Hospitalization in most patients
	Surgery	▪ Not indicated if asymptomatic	▪ Indicated electively after two episodes to reduce risk of recurrence[24,25]	▪ Indicated electively after one episode[24,25] ▪ Emergent surgery for peritonitis/treatment failure[24,25]
Challenges to progressive disease model	*Medical*	▪ Associated with other risk factors[38,39] • Genetic factors[36,37,40] • Colonic dysmotility[42,44] • Microbiome[38] • Chronic inflammation ▪ Nuts/seeds not associated with diverticulitis[27]	▪ Equivalent outcomes in immunocompetent patients treated with or without antibiotics in outpatient setting[46-50] ▪ Early enteral nutrition associated with lower morbidity[28,29]	▪ Four days of antibiotics after source control equivalent outcomes to extended course[26]
	Inpatient Care	–	▪ Low risk of admission after outpatient management and equal to inpatient treatment[51]	▪ High rate of recurrent abscess despite percutaneous drainage/antibiotics[30]
	Surgery	–	▪ Elective surgery did not decrease rate of emergency surgery[13] ▪ Equal rates of recurrence with or without surgery[14]	▪ Higher stoma rate, diverticulitis-associated inpatient hospital days, and cost with surgery[71]

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Figure 1 Historical understanding of diverticulitis as a progressive disease and summary of recent challenges to the progressive disease model.

tionally, patients with diverticulitis may develop chronic manifestations of disease that are not the direct result of a single episode (such as fistula or stricture). These chronic symptoms can range from ongoing abdominal pain in the absence of inflammation (symptomatic uncomplicated diverticular disease, incidence: 20%) to refractory symptoms with inflammation/early recurrence (smoldering diverticulitis, incidence: 10%), and cryptogenic segmental colitis associated with diverticulosis (incidence: 1%-11%)[32,33]. Furthermore, our understanding of the development of colonic diverticula, the precursor lesion to diverticulitis, has evolved. Statistical models derived from twin studies estimates that genetic factors account for 40%-50% of the risk of diverticular disease[34,35]. In patients of European ancestry, diverticulitis is almost exclusively in left-sided (> 95% sigmoid) but is mostly right-sided (80%) in patients of Asian descent[36]. Other studies implicate abnormal colonic neuromuscular function, altered microbial metabolism, and chronic inflammation as secondary factors contributing to development of diverticular disease[37-43]. Collectively, these data point to a relapsing-remitting inflammatory model of disease, rather than a progressive, infectious model (Figure 2). These data drove a shift in CPGs away from automatic hospitalization, antibiotics, and surgical intervention in the acute phase[15-19,44].

PROFESSIONAL GUIDELINES PIVOT AWAY FROM ANTIBIOTICS, HOSPITALIZATION, AND SURGERY

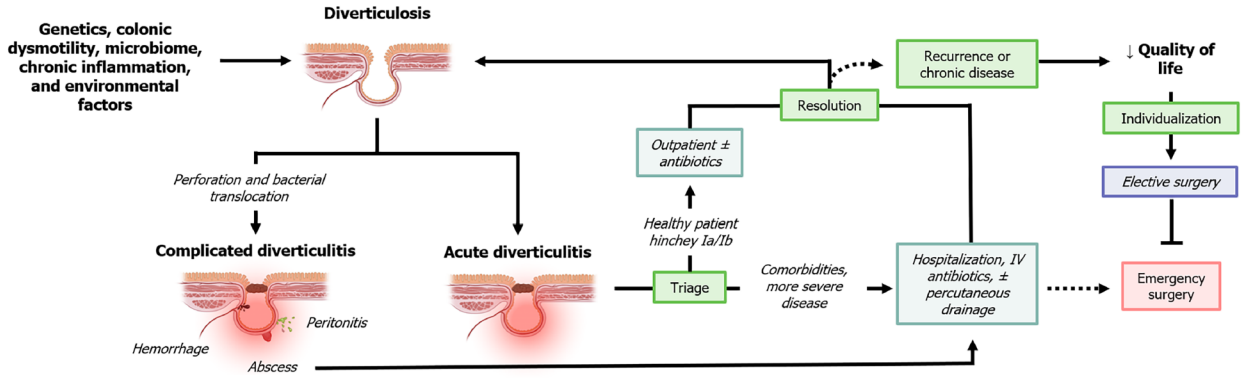
Historically, diverticulitis was considered an infectious process requiring routine antibiotics. However, multiple randomized controlled trials, as well as several metanalyses, have shown no significant difference in outcomes in patients with uncomplicated diverticulitis treated with or without antibiotics [45-49]. In response to these data, the American Gastrological Association (AGA) and American Society of Colon and Rectal Surgeons (ASCRS) now recommend selective use of antibiotics in immunocompetent patients (Table 1)[18,19]. Concurrently, the recommendation for hospitalization in uncomplicated disease was similarly challenged by clinical data showing similar outcomes in select patients receiving

Table 1 Comparison of medical and surgical professional society clinical practice guidelines for diverticular disease

	Medical society guidelines			Surgical society guidelines		
	AGA[19], 2015	AAFP[16], 2013	ACP[17], 2022	ASCRS[18], 2020	SAGES[45], 2019	WSES[15], 2020
Diagnosis and medical management						
Triage to outpatient	-	Recommend outpatient if uncomplicated and mild (level C)	Outpatient in uncomplicated disease as outpatients in absence of SIRS (conditional, low certainty)	-	Selective outpatient in immunocompetent host with uncomplicated diverticulitis (weak, moderate-quality)	Outpatient if uncomplicated without comorbidity, re-evaluate at 7 d (weak, moderate-quality)
Antibiotics						
Use	Selective use in uncomplicated disease (conditional, low-quality)	Enteric coverage if inpatient. Use outpatient if persistent or worsening symptoms (level B)	Omit in healthy, immunocompetent outpatients with uncomplicated disease and no SIRS (conditional, low certainty)	Healthy patients with uncomplicated disease should not be treated with antibiotics (strong, high-quality). May use in non-operative strategies (strong, low-quality)	Selective use in immuno-competent patients with uncomplicated disease (weak, high-quality)	Advise against antibiotics in healthy patients with uncomplicated disease and no SIRS (strong, high-quality)
Duration	-	-	Insufficient data	-	-	-
Percutaneous drainage	-	Consider in presence of abscess. No size recommendation (level C)	Insufficient outcomes data with percutaneous drain	Recommend when abscess > 3 cm (strong, moderate-quality)	Abscess < 4 cm: Trial antibiotics, drain for failure. Abscess > 4 cm: Drain upfront (weak, low-quality)	Abscess 4-5 cm: Trial antibiotics, drain for failure (weak, low-quality). Abscess > 5 cm: Drain upfront (weak, low-quality)
Prevention	Fiber, physical activity (conditional, very low-quality)	Fiber intake, weight loss, smoking cessation	-	Tobacco cessation, limit red meat, physical activity weight loss (strong, low-quality)	-	-
Surgical management						
Emergency surgery						
Indications	-	-	-	Diffuse peritonitis, non-operative treatment failure (strong, low-quality)	Peritonitis - Hinchey class III and IV (strong, low-quality)	
Stoma or no stoma	-	-	-	Restoration of continuity preferred, when possible, based on patient/OR factors, surgeon preference (strong, moderate-quality)	Hartmann's if unstable, or immunocompromise. Sigmoid resection with primary anastomosis and proximal diversion over Hartmann's (weak, moderate-quality)	Critically-ill or major comorbidities: Hartmann's procedure (strong, low-quality). Stable without comorbidities: Primary resection ± diversion (weak, low-quality)
Laparoscopic lavage	-	-	-	Advise against in feculent peritonitis (strong, high-quality). Not preferred in purulent peritonitis (strong, high-quality)	Consider in select Hinchey III with appropriate expertise and intensive monitoring (weak, high-quality)	Reserve for highly selected patients with generalized peritonitis (weak, high-quality)
Elective surgery						
Uncomplicated	Recommends against after single episode of	-	-	Individualize, do not based on age or episodes (strong,	Resect when symptomatic disease decreases-quality of life (strong, moderate-	Recommend elective resection in high-risk patients

	acute diverticulitis, individualize (conditional, very low-quality)			moderate-quality)	quality)	(weak, very low-quality). Individualize, do not base on episodes (weak, low-quality)
Complicated	-	-	-	Consider when diverticular abscess resolved (strong, moderate-quality). Recommend for fistula, obstruction, or structure (strong, moderate-quality)	Minimum six weeks after complicated episode (weak, low-quality)	-

All professional societies agree workup should include a history and physical, laboratory studies, and imaging with contrast-enhanced abdominopelvic computed tomography (CT), if clinically indicated. Societies agree that ultrasound with regional expertise or magnetic resonance imaging are acceptable alternatives in patients in whom contrast-enhanced CT is contraindicated. Similarly, surgical societies agree that using minimally invasive surgery is preferable in emergent and elective surgery when expertise is available. AGA: American Gastroenterological Association; AAFP: American Academy of Family Physicians; ACP: American College of Physicians; ASCRS: American College of Colon and Rectal Surgeons; SAGES: Society of American Gastrointestinal and Endoscopic Surgeons; WSES: World Society of Emergency Surgery.



		Diverticulosis	Uncomplicated diverticulitis	Complicated diverticulitis
Relapsing remitting model	*Medical*	▪ Prevention • High fiber diet • Smoking cession • Weight loss	▪ Selective antibiotic use[15-19,45] ▪ PO antibiotics or early transition to PO[16] ▪ Diet as tolerated	▪ Hospitalization ▪ IV antibiotics ▪ ± percutaneous drainage
	Inpatient care	–	▪ Selective outpatient management[15-17,45]	▪ Hospitalization for many patients
	Surgery	▪ Not indicated in asymptomatic disease ▪ Does not prevent diverticulitis (re)occurrences[15,18,45]	▪ Do not base on age, number recurrences, or any single factor[18] ▪ Individualized decisions about surgery[18]	▪ Recommended selectively after complicated diverticulitis[18]
Current clinical questions	*Medical*	▪ Unknown primary etiology of diverticulosis ▪ Unknown impact of risk reduction strategies to prevent recurrence (*e.g.*, weight loss, dietary modifications)	▪ Definition and optimal management of chronic manifestations of diverticulitis poorly defined ▪ Guideline concordance unknown ▪ No consensus on "best" medical alternative to surgery	▪ Abscess size for percutaneous drainage controversial.
	Inpatient care	–	▪ Proportion and demographics of patients treated outpatient unknown	▪ Guideline concordance unknown
	Surgery	–	▪ Factors to consider in individualizing surgery are unknown ▪ Long-term improvement in quality of life after colectomy unknown[57,58] ▪ Guideline concordance unknown	▪ Is delaying/avoiding elective surgery safe in select patients with complicated disease?

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Figure 2 Modernized understanding of diverticular disease *via* a relapsing-remitting model and summary of ongoing controversies and gaps in the literature in diverticular disease.

outpatient treatment with or without antibiotics[50]. While the ASCRS and AGA do not make explicit recommendations regarding the appropriateness of outpatient management in any subset of diverticular disease, nearly one in five low-risk patients with uncomplicated acute diverticulitis are probably now managed in the outpatient setting[51].

Similarly, there has been insight that early surgical intervention in acute, uncomplicated diverticulitis does not prevent future complications. In their 1995 guidelines, the ASCRS recommended elective

resection after two episodes of uncomplicated diverticulitis, or one episode of diverticulitis in patients < 50 years or complicated disease at presentation[23]. However, the rate of emergency surgery in uncomplicated disease is low (1 in 2000 patient-years), and only 1.8%-7% of patients with recurrent disease will require emergency surgery[52,53]. Contemporary studies showing similar rates of emergency surgery and recurrence-related hospitalization in patients who underwent colectomy (5%-11%) compared to those who did not (4%-13%) further questioned the utility of "prophylactic" colectomy[10,14]. Complications of elective colectomy are rare, but significant, with a "rescue colostomy" rate of 1%-3% for anastomotic leak[54,55]. On the other hand, the DIRECT trial showed that patients with recurrent diverticulitis had improved quality of life (QoL) scores at six months after randomization to sigmoid colectomy. A criticism of this landmark trial is that the non-operative group had a high risk of surgery (23%) and was underpowered. This raised questions about the criteria for patients included in the study, and generalizability of 'early surgery' across a spectrum of diverticulitis presentations[56]. Collectively, these data prompted the CPGs to pivot from recommending surgery based on number of episodes toward "individualized" decisions about surgery. The ongoing Comparison of Surgery and Medicine on the Impact of Diverticulitis trial hopes to address this gap in the literature by evaluating whether elective colectomy is more effective than best medical management at improving patients' QoL in diverticular disease[57].

The management of acute complicated diverticulitis has undergone a similar evolution. While emergency colectomy remains non-controversial in feculent or purulent peritonitis, the routine use of Hartmann's procedure has been increasingly challenged in the past decade. Multiple clinical trials and meta-analyses have demonstrated the safety and efficacy of sigmoid colectomy with primary anastomosis (with or without diverting ostomy) in the short- and long-term[58-65]. In the short-term, morbidity and mortality were equivalent or decreased after resection with primary anastomosis *vs* Hartmann procedure. Despite similar recurrence rates, notable differences between the procedures were seen at follow-up[58-61,63-65]. Specifically, rates of stoma non-reversal were lower and complication rates were higher after reversal in patients who underwent Hartmann procedures, compared to primarily anastomosed patients[29,58,60,62]. The practical implication of these data is that anastomosis should be considered in most emergent cases, rather than defaulting to the traditional Hartmann's. This is particularly important, as Hartmann procedures are associated with a decrease in general QoL compared to primary anastomosis for perforated diverticulitis, and the presence of a stoma was shown to be an independent predictor of lower QoL in one study[62,66]. In the modern era, most CPGs advise against routine use of the Hartmann procedure in stable patients, favoring primary anastomosis with or without proximal diversion. However, data showing whether the practice of routine anastomosis in emergent diverticulitis has been meaningfully implemented is lacking.

CONTEMPORARY PRACTICE OF HOSPITALIZATION AND SURGERY DO NOT LINE UP WITH GUIDELINES

The incidence of diverticulitis has increased dramatically in the United States over the past several decades, and hospitalizations for acute diverticulitis rose by 25%-41% from 2000 to 2010[3,67]. Similarly, the rate of elective colectomy for uncomplicated disease has increased[10,14,20,22]. These increases in healthcare utilization are occurring as data and guidelines are urging a shift away from inpatient care and surgery. One explanation may be that more cases of diverticulitis are driving hospitalization and operations, outpacing the recommendations of CPGs. This argument is supported by two observations: (1) The prevalence of diverticulitis is highest in patients aged 65 years and older, a group whose numbers are predicted to increase by 48% in the United States by 2030[47]. CPGs reserve outpatient management for healthy patients, potentially excluding many older diverticulitis patients from receiving outpatient treatment[15,16,19,44]; and (2) The age-adjusted rate of diverticulitis is also increasing, particularly in adults under 50 years of age wherein the incidence of diverticulitis increased by 132% from 1980 to 2007[3]. Conceptualizing diverticulitis as a progressive disease, rather than relapsing-remitting, may prompt some surgeons to operate on younger patients more frequently; however, the magnitude of this effect on rates of surgery are unknown[22]. Studies evaluating the fundamental epidemiology of diverticular disease are dated, and updated studies are needed to better characterize changes in diverticular disease incidence and distribution. Understanding the interplay between this evolving epidemiology and how diverticulitis is treated across healthcare settings and disease severity is important to contextualizing and optimizing patient care in the modern era.

In addition, better data are needed to assess impact of CPGs on diverticulitis care. Contemporary research shows it takes 17 years to incorporate only 14% of published literature into clinical practice, highlighting the role of CPGs in synthesizing vast bodies of literature, and modernizing practice[68]. When implemented, CPGs have the potential to improve the processes of care and patient outcomes, but are infrequently followed[69-72]. For diverticulitis care, the rising rates of hospitalization and surgery may indicate a delay or disconnect in guideline concordant care. In a recent joint consensus statement by the European Association for Endoscopic Surgery (EAES) and Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), only 65% of providers offered outpatient treatment

to low risk patients with uncomplicated disease[44]. When measured about a decade ago, approximately 1 in 3 patients undergoing elective colectomy in Washington State did not meet CPG criteria for resection and it is unclear whether these data reflect regional practice or larger trends in surgical management of diverticulitis[73]. As such, larger scale studies are needed to assess national trends in diverticulitis surgery, but thus far have been limited by a lack of granularity needed to identify the indication for surgery and, therefore, appropriateness of operation and outcome. Furthermore, when emergent diverticulitis surgery is performed by general surgeons, there is a high, and increasing, rate of ostomy, despite CPG suggesting primary anastomosis is safe[18,74]. Yet, another state-level study suggests that mortality after emergency surgery for perforated diverticulitis (particularly in resection with primary anastomosis) may be higher when performed by general compared to colorectal surgeons. Jointly, these studies offer insight into disconnect with CPGs, but incompletely describe the practice patterns for diverticulitis care and are not generalizable to other clinicians or non-surgical patients. These findings may be explained also by selection bias, isolated regional trends in clinical practice, or standard of care. Indeed, diverticulitis remains a clinical challenge for physicians across specialties, including general practitioners, emergency room physicians, gastroenterologists, and surgeons. Said otherwise, there is a lacking in the definition of "guideline concordant care" for diverticulitis and measures thereof across the spectrum of clinical contexts.

One challenge is many diverticulitis CPGs offer conflicting or vague recommendations, and clinicians are less likely to implement CPGs when they are perceived as lacking clarity or sufficient evidence, offer many weak/conditional recommendations, or are too rigid[71,72,75]. For example, while several studies have indicated that outpatient management for uncomplicated disease in select patients is safe, the incorporation of these findings into modern guidelines is inconsistent (Table 1). The decision whether to operate and what operation to perform is similarly fraught with a lack of consensus, shifting guidelines, and behavioral inertia. No professional society offers discrete indications for elective resection, nor specifies which factors to incorporate into such individualized care. There are also no guidelines for managing chronic manifestations of diverticulitis, such as smoldering disease or chronic pain. The ambiguity of these recommendations likely reflects the complexity of decision-making in diverticulitis and a lack of quality population-level studies that address the fundamental epidemiology of disease. Additionally, it has been long recognized that the staging system for diverticulitis is inaccurate and poorly suited to clinical decision making. For example, the term "complicated disease" spans the spectrum of complex disease, ranging from chronic, QoL-limiting conditions requiring elective surgery (*e.g.*, fistula) and acute, life-threatening disease requiring emergency surgery (*e.g.*, feculent peritonitis). This absence of a clinically relevant classification system could contribute to ambiguous guidelines. Collectively, these factors may contribute to inappropriately heterogeneous and potentially low-value care, particularly considering the persistently high rate of elective colectomy in the United States compared to other Western countries[76].

The absence of clear guidance from professional societies may also explain regional variations in clinical practice that can be driven by patient, hospital, and market factors. For example, referral patterns to surgeons could influence the rate of colectomy *via* physician-induced demand[77]. In this phenomenon, information asymmetry leads to undue physician influence on patient decision making, thereby increasing demand for health services like surgery. Perhaps patients who might not otherwise undergo an operation choose to do so electively because surgery is offered more often than if they never saw a surgeon. Indeed, one study showed the rate of elective colectomy increased linearly with surgeon density, but the observational nature of the study precludes conclusions about causation[78]. This same study showed patients receiving diverticulitis care in large (> 500 beds) metropolitan for-profit hospitals are more likely to undergo elective colectomy compared to smaller, suburban, or rural hospitals[78]. Importantly, these studies do not differentiate the indication for surgery (*e.g.*, stricture/fistula *vs* QoL indication) and thus should be interpreted with caution. These data could reflect national referral patterns of complex patients to metropolitan centers or differences in reginal practice patterns, and whether one practice is more 'guideline concordant' or not is unknown.

PROPOSING NEW, POPULATION-LEVEL STRATEGIES

Reframing diverticulitis as a relapsing-remitting disease has the potential to inform systems-level practices to improve the quality, efficiency, and effectiveness of diverticulitis care. To start, the ubiquity of diverticulitis in the general population coupled with the complexity of medical decision-making raises the question of where patients currently do and/or should receive care. It is well established that medical and surgical outcomes are improved and less costly (*via* economies of scale) when patients with colorectal cancer and inflammatory bowel disease are treated at specialized centers[69,70]. As a result, resources and structures for treating these diseases are concentrated at a few high-volume hospitals, a process called regionalization. To date, no studies have explicitly addressed whether regionalization would produce similar outcomes in diverticulitis, though there is some suggestion that diverticulitis patients may benefit from specialized care. Two separate studies showed that patients undergoing emergent colectomy for complicated diverticulitis undergo fewer Hartmann's procedures when

operated on by fellowship-trained colorectal surgeons compared to general surgeons after controlling for comorbidities and disease severity[74,79]. In one of these studies, patients in the colorectal surgeon group also experienced fewer post-operative complications and had their ostomies reversed sooner[74]. Yet another study suggests patients undergoing a Hartmann's reversal experienced fewer complications when performed by a colorectal surgeon[80]. While it is possible regionalizing care could increase surgeon volume, expertise, and outcomes, there is no agreed upon definition of "high-volume" at the clinician or systems level. Referral patterns, hospital resources, on-call responsibilities, eligible patient population, and numerous other factors may also explain current practice for diverticulitis care. It is, therefore, critical to characterize who is currently providing care across a spectrum of disease and healthcare settings, particularly when considering potential drawbacks of regionalization such as economic cost, travel burden, and healthcare disparities[81]. Importantly, attempts to regionalize diverticulitis care would require a radical shift in the distribution of diverticular disease burden, a sharp transition that brings into question whether any individual or collection of hospital systems can function as high-volume centers. Even if these centers had sufficient capacity, economic and travel burden are significant costs, which if incurred by rural and underserved patients could significantly limit access to care. Given the lack of supporting data and potential challenges of regionalization, more studies should evaluate the distribution of diverticulitis care focusing beyond single institutions and perhaps at the health system or state level. Characterizing distribution of care allows researchers to explore the association of volume and clinical outcomes in diverticulitis. If diverticulitis care is broadly distributed across institutions, this decentralized model of care has profound implications for how diverticular disease is studied and for implementation of quality improvement initiatives. This work should consider also regional practice patterns to better characterize how diverticular disease is actually treated in the general population.

Expanding the use of telemedicine has the potential to alleviate this burden, but a need for in-person consultation, rescue, and follow-up remains a challenge. Telemedicine also offers little to alleviate the travel burden of 19-42 million Americans without reliable access to fixed broadband services, a new frontier of inequity affecting predominantly poor, racial minority, and rural populations[82-84].

If concordance with CPGs leads to improved patient outcomes across a spectrum of medical and surgical disease, then improving existing CPGs or better adherence to them may result better, more cost-effective care. The decision to "individualize" surgery may arise from a composite assessment of patient/surgeon preferences, disease-specific factors, assessments of the "built environment" (*e.g.*, transportation, social support, *etc.*), and continuity of care. Yet, CPG recommendations are made without defining what clinical and external factors should be considered before recommending surgery. The SAGES/EAES guidelines advocate for colectomy when symptomatic disease impacts QoL; however, studies evaluating QoL following elective colectomy exhibit mixed results[44,85-89]. Despite technically successful operations, many patients have recurrent or ongoing symptoms after colectomy [86,87]. These studies are often underpowered, lack standardization of QoL, and do not discuss timing of QoL evaluation[85,90]. Presumably, QoL will be lower near a diverticulitis episode, improving overtime as symptoms resolve. In one prospective study, Droullard *et al*[91] identified four distinct QoL trajectories in diverticulitis patients and found that 40% of patients with unacceptable baseline QoL improved without surgery. These data suggest that phenotyping patient QoL trajectory could aid in the selection of appropriate surgical candidates in diverticulitis, a hypothesis that warrants further study. It is important to note, however, that patients with diverticulosis and no history of diverticulitis may exhibit higher physical and mental QoL scores than patients with symptomatic uncomplicated diverticular disease and those with a history of diverticulitis. However, differences in QoL scores were small (1-3 points) and whether these findings are clinically meaningful is not established[92]. Making comparisons between studies is challenging due to a lack of standardization in assessing QoL in diverticular disease. Some studies rely on more global assessments, such as the highly-validated and global SF-12, whereas others rely on more specific, but less broadly validated, and potentially convoluted measures, such as the diverticulitis QoL scale[44,66,85,86,89-93]. To date, there is no consensus regarding when or how the impact of diverticulitis on QoL should be assessed, and whether the timing of evaluation could change a surgeons' propensity to offer surgery. These global and disease specific QoL metrics need to be validated across a spectrum of diverticular disease patients with consideration paid to clinically meaningful changes for each metric. Consolidating these data and providing an actionable tool for clinicians would likely require consensus and multidisciplinary agreement. As an example, the Pelvic Floor Consortium, a multidisciplinary organization that aims to enhance care of patients with pelvic floor disorders, recently modeled how to establish a combined, validated patient reported outcomes tool to standardize QoL assessments across subspecialties[94]. A consortium of colorectal surgeons, general surgeons, gastroenterologists, and primary care providers could offer similar guidance and allow for longitudinal evaluations of QoL in diverticular disease.

Even in the context of clearer CPGs, measuring their implementation is complex and predicated on provision of clear and actional recommendations. Most studies evaluating other programs to improve guideline concordance are often (and appropriately) narrow in scope and lack conceptual clarity, thereby limiting their general applicability. One study implemented benchmarking and a peer-to-peer messaging initiative that increased guideline concordance among surgeons participating in Washington State's Surgical Care and Outcomes Assessment Program and highlights the potential of regional

initiative to improve guideline concordance[73]. However, this was limited to those patients having surgery, and the appropriateness of 'non-operative' management was not included. Ongoing research by the Expert Recommendations for Implementation Project seeks to define and evaluate discrete generalizable and comprehensive implementation strategies to improve guideline conformity. These research efforts are ongoing and may provide discrete implementation strategies applicable to diverticulitis care[95].

CONCLUSION

Awareness of the healthcare burden of diverticulitis and its distribution of inpatient and outpatient care is critical for cost-containment and improving disease management. Population-level studies provide the best reflection of an increasingly common disease that requires complex clinical decision-making that appears discordant with contemporary CPGs. Based on our current understanding of diverticulitis, the biggest challenges include improving population-level data in diverticulitis care, an evaluation of regionalized care for diverticulitis, and development/implementation of CPG-concordance measures.

FOOTNOTES

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