

Emergency General Surgery

A Practical Approach

Carlos V. R. Brown

Kenji Inaba

Matthew J. Martin

Ali Salim

Editors

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Preface

The field of emergency general surgery encompasses a wide array of surgical diseases, ranging from the simple to the complex. Emergency general surgeons are tasked with caring for patients with emergent surgical diseases emanating from the emergency department or inpatient consultations. These diseases range from inflammatory, infectious, and hemorrhagic diseases spanning the entire gastrointestinal tract, complications of abdominal wall hernias, compartment syndromes, skin and soft tissue infections, and surgical diseases significantly complicated in special populations including elderly, obese, pregnant, immunocompromised, and cirrhotic patients.

The *Emergency General Surgery* textbook is a real-time and at-the-fingertip resource for surgeons and surgery residents, providing a practical and evidence-based approach to diagnosing and managing the wide array of surgical diseases encountered on emergency general surgery call. The chapters in this new and cutting-edge textbook are written by leading experts in the field and are filled with pearls of wisdom from surgeons with decades of experience taking emergency general surgery call. This compilation of thorough and cutting-edge content also serves as an excellent review for residency in-service exams, qualifying and certifying board exams, as well as up-to-date information for continuous certification in general surgery.

We wish to thank the professional editorial efforts of Springer and to acknowledge our peers, coworkers, friends, and family for their support throughout this project. Without the help of so many, this project could not have been brought to fruition.

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Definition of Emergency General Surgery (EGS) and Its Burden on the Society

1

Stephen C. Gale, Kevin M. Schuster,
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Defining Emergency General Surgery (EGS)

The American Association for the Surgery of Trauma (AAST) was the first to develop a formal definition of emergency general surgery (EGS) in 2013 [49]. The EGS patient was conceptually defined as “any patient (inpatient or emergency department) requiring an emergency surgical evaluation (operative or non-operative) for diseases within the realm of general surgery as defined by the American Board of Surgery” [49]. To define the actual scope of EGS practice, data were obtained from seven acute care surgeons in academic practice. Using a Delphi process, a consensus was generated over a list of International Classification of Diseases (ICD 9) diagnostic codes that encompassed EGS

(Table 1.1). The list included several major disease categories including resuscitation, general abdominal conditions, upper gastrointestinal tract, hepatic-pancreatic-biliary, colorectal, hernias, soft tissue, vascular, cardiothoracic, and others. It should be noted that these surgeons practiced exclusively in relatively urban academic medical centers where the distribution of cases may be different than more rural or private practice settings. Despite this limitation, this ICD-9 code-based definition has spurred research in EGS, including early outcomes research measuring morbidity, mortality, and costs associated with EGS patients. All large-scale data analytics of EGS as a specialty must be interpreted within the context of how it is defined by ICD-9/10 codes.

At the present time, every acute care hospital with an emergency room and a general surgeon on staff cares for EGS patients. However, it is likely that the scope of EGS practice varies from center to center and from surgeon to surgeon within a center, depending upon local resources and expertise. Not all institutions will have adequate resources for addressing every EGS disease and severity. Hence, we believe that individual hospitals should define their scope of EGS practice, based upon local capabilities and ability to transfer patients to another center for a higher level of care.

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Table 1.1 Common emergency general surgery diseases

Surgical area	Clinical conditions
Resuscitation	Acute respiratory failure, shock
General abdominal conditions	Abdominal pain, abdominal mass, peritonitis, hemoperitoneum, retroperitoneal abscesses
Intestinal obstruction	Adhesions, incarcerated hernias, cancers, volvulus, intussusceptions
Upper gastrointestinal tract	Upper gastrointestinal bleed, peptic ulcer disease, fistulae, gastrostomy, small intestinal cancers, ileus, Meckel's diverticulum, bowel perforations, appendix
Hepatic-pancreatic-biliary	Gallstones and related diseases, pancreatitis, hepatic abscesses
Colorectal	Lower gastrointestinal bleed, diverticular disease, inflammatory bowel disease, colorectal cancers, colitis, colonic perforations, megacolon, regional enteritis, colostomy/ileostomy, hemorrhoids, perianal and perirectal fistulas and infections, anorectal stenosis, rectal prolapse
Hernias	Inguinal, femoral, umbilical, incisional, ventral, diaphragmatic
Soft tissue	Cellulitis, abscesses, fasciitis, wound care, pressure ulcers, compartment syndrome
Vascular	Ruptured aneurysms, acute intestinal ischemia, acute peripheral ischemia, phlebitis
Cardiothoracic	Cardiac tamponade, empyema, pneumothorax, esophageal perforation
Others	Tracheostomy, foreign bodies, bladder rupture

Source: Shafi et al. [49]

Defining the Anatomic Severity of EGS Disease

EGS patient outcomes are related to the severity of illness, based upon preexisting medical conditions, anatomic severity of disease, and physiologic derangements [39, 41]. However, until recently, there was no unified mechanism for measuring anatomic severity of EGS diseases. Hence, AAST developed a new grading system using a defined framework based upon a combination of clinical, radiographic, endoscopic, operative, and pathologic findings (Table 1.2) [11, 48, 58]. Sixteen disease

Table 1.2 American Association for the Surgery of Trauma anatomic grading system for measuring severity of emergency general surgery diseases

Grade	Description
Grade I	Local disease confined to the organ with minimal abnormality
Grade II	Local disease confined to the organ with severe abnormality
Grade III	Local extension beyond the organ
Grade IV	Regional extension beyond the organ
Grade V	Widespread extension beyond the organ

Source: Shafi et al. [48]

grading schemas were first produced for infectious or inflammatory EGS diseases, including acute appendicitis, breast infections, acute cholecystitis, acute diverticulitis, esophageal perforation, hernias, infectious colitis, small bowel obstruction due to adhesions, bowel ischemia due to arterial insufficiency, acute pancreatitis, pelvic inflammatory disease, perforated peptic ulcer, perineal abscess, pleural space infection, and surgical site infection. These grading scales were developed empirically by consensus experts but have subsequently been validated across several conditions including diverticulitis and appendicitis [20, 50]. Once validated, this anatomic grading system will be a powerful tool for research, quality improvement, and national tracking of emergency general surgical diseases. There are multiple physiologic scoring systems that have been applied to EGS patients [36]. Examples include the Sequential Organ Failure Assessment (SOFA) score, the Acute Physiology and Chronic Health Evaluation (APACHE) score, the American Society of Anesthesiologists Physical Status (ASA-PS), and various forms of the Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (POSSUM). Disease-specific scores include the Colonic Peritonitis Severity Score, Mannheim Peritonitis Index, and the Boey score for outcome prediction in perforated peptic ulcer disease [5, 7].

Burden of Disease for Emergency General Surgery

Perhaps the most remarkable aspect of EGS is the sheer volume of patients and the burden on the

society that these patients represent in terms of level of acuity, manpower needs, and costs of care. Much like the societal burden of trauma care which went unrecognized until the 1980s [46], EGS is now being recognized as one of the major underappreciated public health crises of the twenty-first century [15, 38].

EGS Volume

Using definitions created by the AAST [49], researchers have estimated EGS hospitalizations and described patient demographics, operative needs, and major outcomes [9, 15, 32,

45]. Recent examinations of the Nationwide Inpatient Sample (NIS), the country’s largest all-payer hospital database, demonstrate that EGS diseases account for nearly three million inpatient admissions annually (7% of all hospitalizations), at more than 4700 different hospitals in the United States in 2010 [34, 15]. These studies further show that EGS volumes are steadily increasing each year [15]. Nearly 30% of EGS patients required a major surgical procedure during their initial hospital stay (Fig. 1.1). Five EGS diagnostic groups accounted for more than 90% of admissions: hepatobiliary, colorectal including appendix, upper gastrointestinal, soft tissue, and intestinal

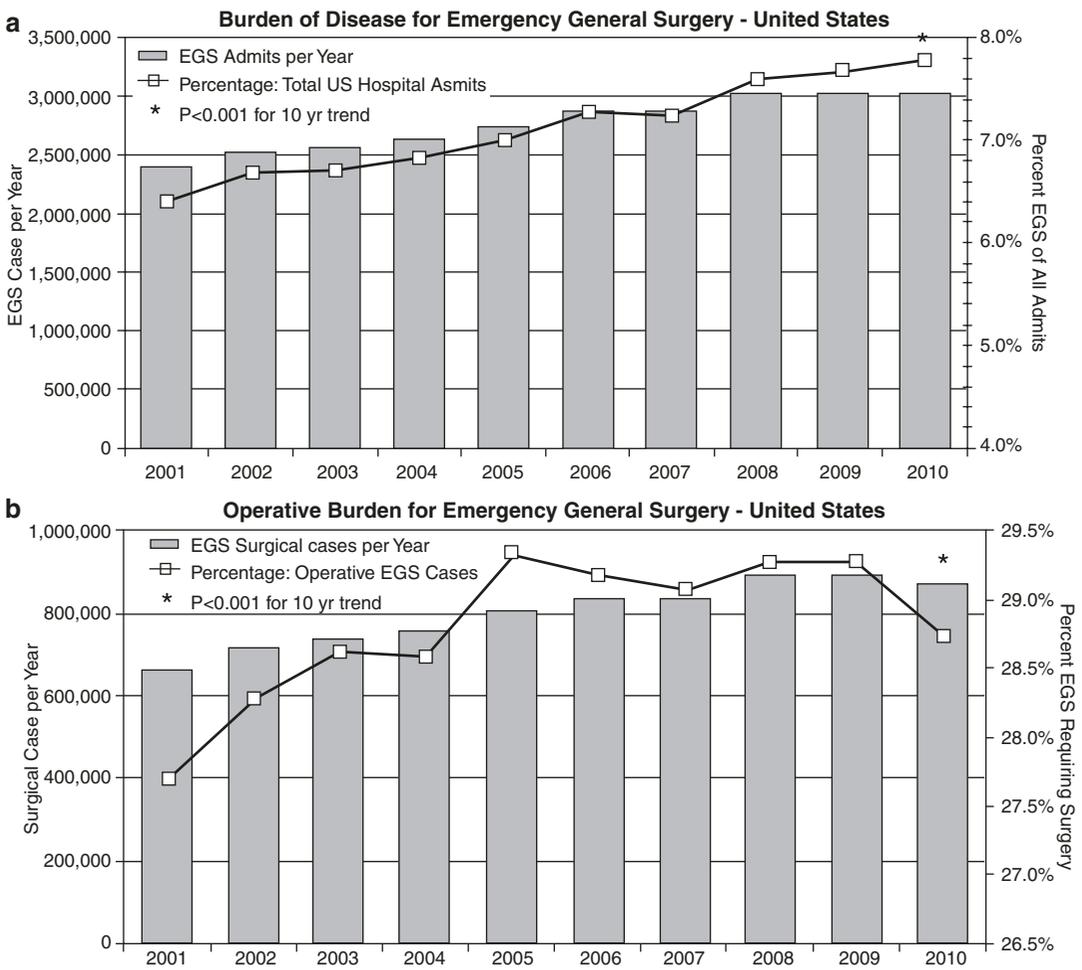


Fig. 1.1 Number of all EGS cases (a) and operative EGS cases (b) from 2001 to 2010 using National Inpatient Sample data (Source: Gale et al. [15])

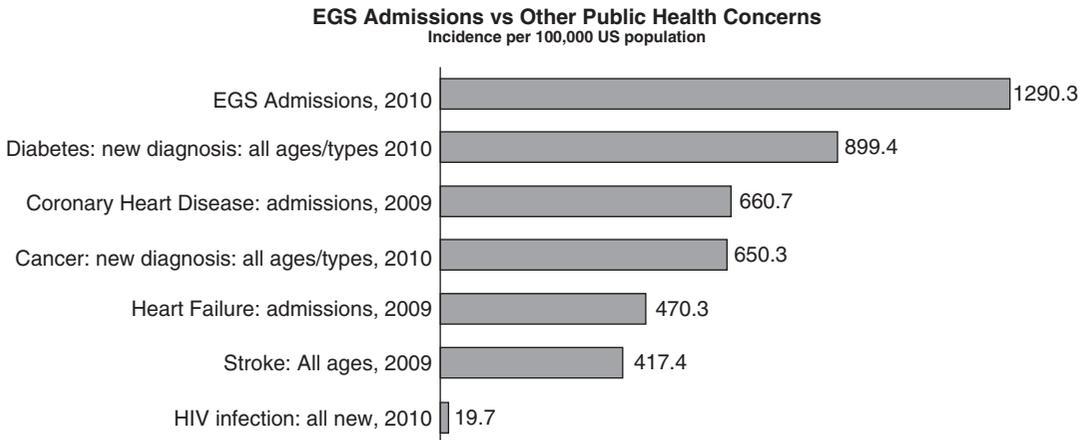


Fig. 1.2 Burden of EGS admissions compared to other common diseases (Source: Gale et al. [15])

obstruction. Cyclic seasonal variations exist in EGS hospitalizations, similar to trauma, and increase during the summer [60].

As a public health issue, the burden of EGS is very large, and population-based estimates reveal 1290 EGS admissions per 100,000 [15] – higher than many other common public health concerns including new-onset diabetes, heart disease admissions, and new cancer diagnoses, among others (Fig. 1.2).

These findings underestimate the total burden of EGS diseases, as these estimated do not include:

- Patients treated and released from the emergency room and urgent care centers (such as those with biliary colic and reducible hernias, minor soft tissue infections)
- Patients who require elective surgical procedures later in their course (such as colostomy reversal, hernia repair after reduction, delayed colectomy for diverticulitis)

- Patients who develop EGS diseases after being admitted for other conditions (such as intestinal ischemia after cardiovascular surgery, infected decubitus after prolonged mechanical ventilation, acalculous cholecystitis after prolonged parenteral nutrition)

Operative Burden

Operative rates for EGS conditions are consistent across studies at roughly one-third of admitted patients [15, 51, 52]. Further, Scott and colleagues [45] demonstrated that for patients requiring major surgery, more than 80% of procedures fall into only seven groupings: appendectomy, cholecystectomy, lysis of adhesions, colectomy, small bowel resection, hemorrhage control, and laparotomy (Fig. 1.3). These same procedures also account for more than 80% of EGS complications, deaths, and costs (Fig. 1.4) [15, 32, 35, 45].

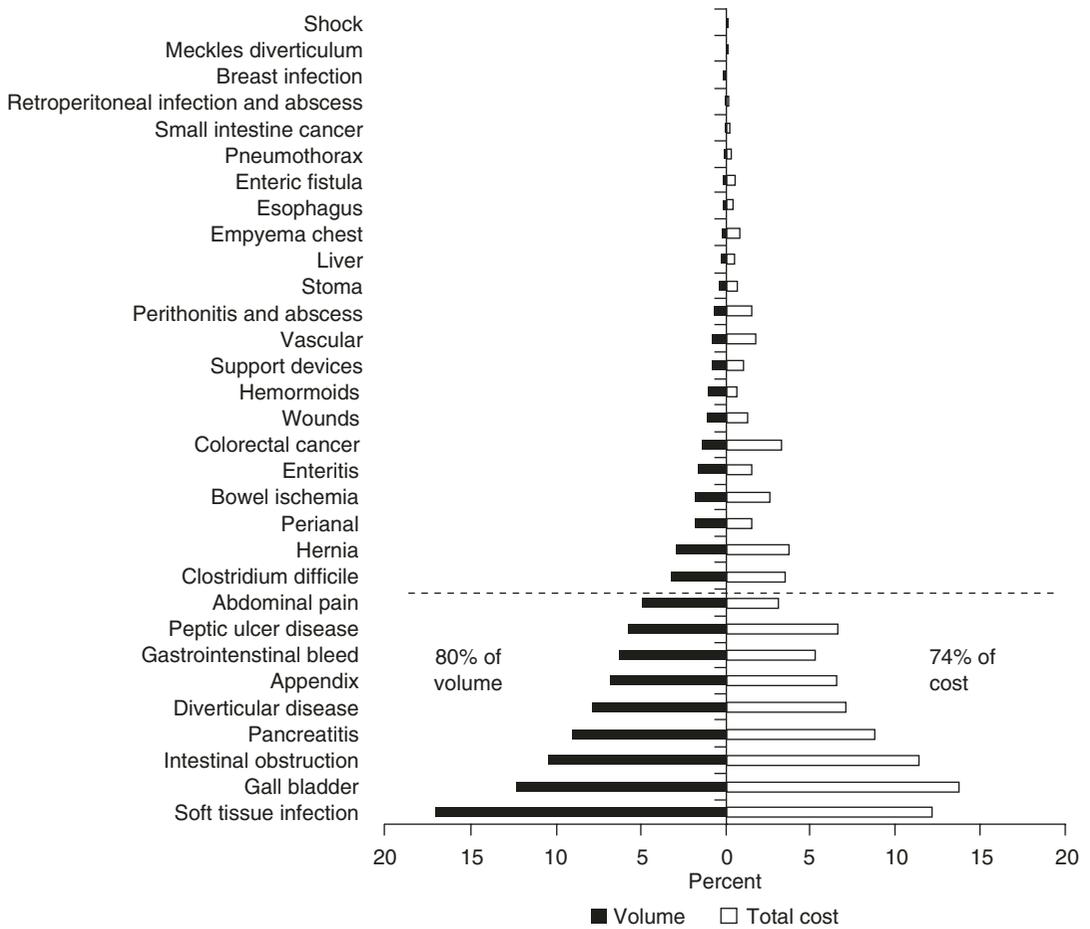
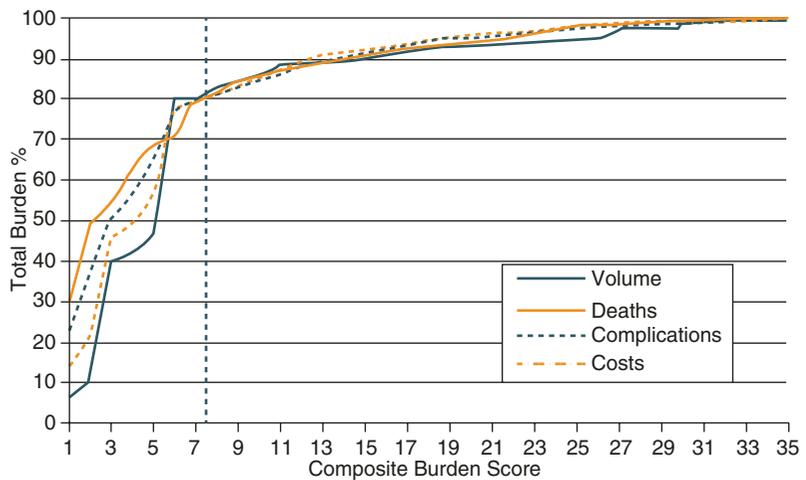


Fig. 1.3 Frequency of common EGS diseases with volume and costs (Source: Ogola and Shafi [35])

Fig. 1.4 Cumulative national burden of emergency general surgery procedures by rank. Each line represents the proportion of cumulative national burden of procedure volume, patient deaths, complications, and costs. The vertical dotted line delineates the top 7 ranked procedures, which accounted for approximately 80% of all cumulative burden. Data were obtained from the National Inpatient Sample for admissions between 2008 and 2011 (Source: Scott et al. [45])



Demographics

Most studies demonstrate a mean age near 60 years for EGS patients [15, 18, 32, 51, 52] with 10% being octogenarians or older [45, 51, 55]. There is a slight female preponderance (53%) and approximately 25% are non-White [49]. Compared to elective general surgery patients, they have higher comorbidity rates [18], and most have at least one major preexisting medical condition [15, 18, 39]. Payer mix varies between studies, but uninsured rates are reported between 8% and 12%, commercial insurers provide roughly 33% of coverage, and government insurance (Medicare or Medicaid) covers the rest – more than 50% of all EGS patients [15, 32, 35, 45, 51].

Outcomes

Patient outcomes vary between EGS conditions and are dependent on multiple factors, such as anatomic severity of diseases, physiologic derangement at presentation [20, 30, 43, 50], age [40, 51, 52, 54, 55], need for and type of surgery [45], and patient comorbidities [51, 54].

Risk Assessment

Risk assessments and outcome predictions for EGS patients are aided by validated scoring systems including Charlson age-comorbidity index (CACI) [54], frailty scores [22, 27, 37], Emergency Surgery Score (ESS) [8, 39], and the Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity (POSSUM) [21, 57]. In addition, the AAST has developed a grading system for reporting anatomic severity of multiple EGS conditions [14, 20, 43, 58, 59]. Further, the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) universal Surgical Risk Calculator is available online and through smartphone apps [4]. However, NSQIP data are limited to operative cases, and some have questioned whether the same risk stratification tools should be used for both emergent and elective procedures [8, 39]. Other risk factors

associated with poor outcomes of EGS patients include lack of insurance (associated with complex presentation [44] and mortality [51]) and treatment at rural [51] or low-volume hospitals [34] which carry higher mortality.

Morbidity and Mortality

Large cohort studies indicate that complication rates are approximately 15% for EGS patients requiring surgery [45]. Wound-related complications are most common, followed by pulmonary issues [26]. Postoperative stroke, major bleeding, and acute myocardial infarction present the highest risks for death [26]. Overall, mortality rates are relatively low, around 1.5% across multiple large studies [15, 45, 51], and have declined over time despite increasing volume [15]. Those requiring surgery have significantly higher mortality [26, 39].

Hospital length of stay has decreased over time [15] with median length of stay (LOS) of approximately four (4) days [15, 32, 51]. ICU admission rates are around 11% [32, 50, 54].

Other Outcomes: Readmissions, Reoperations, Loss of Independence, and Years of Life Lost

Havens [17] described a 5.9% readmission rate over 5 years for EGS patients – most commonly for surgical site infection – and found that Charlson Comorbidity Index score ≥ 2 , patients leaving against medical advice, and public insurance were the greatest risk factors. Muthuvel [31] described a 15.2% postoperative readmission rate using ACS-NSQIP data and proposed using the surgical Apgar score (SAS) developed by Gawande [16] as a predictor. In that study, multivariable analysis demonstrated that SAS < 6 independently predicted 30-day readmission (odds ratio 3.3, 95% C.I. 1.1–10.1, $p < 0.04$). Hospital LOS > 12 days and ASA class ≥ 3 were also predictive. Shah and colleagues [53] analyzed more than 69,000 records from ACS-NSQIP and reported a 4.0% unplanned reoperation rate for EGS conditions. Appendiceal

disorders were the most common underlying disease, and exploratory laparotomy was the most often required procedure. In that cohort, reoperation led to significant morbidity, increased mortality, and prolonged LOS.

EGS conditions pose a severe threat to independence, especially for older patients. In 2016 St. Louis and others [55] found that patients aged ≥ 80 were over four times more likely to require discharge to a facility other than home (odds ratio 4.72, 95% C.I. 1.27–17.54, $p < 0.02$). McIsaac and colleagues [27] reported on “frailty” in operative elderly EGS patients and identified 25.6% of 77,184 as frail. These patients had double the mortality rate and four times the institutional discharge rate (odds ratio 5.82, 95% C.I. 5.53–6.12; $p < 0.0001$). Berian [3] reported that of 570 elderly (aged ≥ 65) patients undergoing major EGS surgery in NSQIP database, 448 (78.6%) had some loss of independence. Many elderly and frail patients also have poor health-related quality of life (HRQOL) after EGS admission and may have indications for evaluation by palliative care clinicians [25]. The 2010 Global Burden of Disease Study [56] demonstrated a marked decline in death and disability related to EGS conditions from 1990 to 2010, and these data also indicate that 287 years

of life (YLL) and 358 disability-adjusted life years (DALY) are lost per 100,000 population indicating a massive *worldwide* burden – disproportionately borne by low- and middle-income countries with poor access to emergency surgical care.

Costs

Data on the financial burden of EGS has been limited to costs associated with inpatient admission [32, 35, 52]. Factors affecting costs of care include age [52], severity of disease [32], ICU admission [32], type of hospital [32], and need for surgery [45]. Admission costs vary by study and range from \$8246 [32] to \$13,241 per admissions [45]. In 2010 NIS data, average adjusted cost per admission for all EGS conditions was \$10,744 (95% C.I. \$10,615–\$10,874) [33]. For 2,640,725 inpatient admissions in 2010, total cost to care for EGS patients was \$28.37 billion (95% C.I. \$28.03–\$28.73 billion). Recently, Ogola used US Census Bureau’s population projections to conclude that by 2060, costs for EGS hospitalizations would increase by 45% to over \$41 billion annually – mostly related to the aging population [33] (Fig. 1.5). As mentioned before,

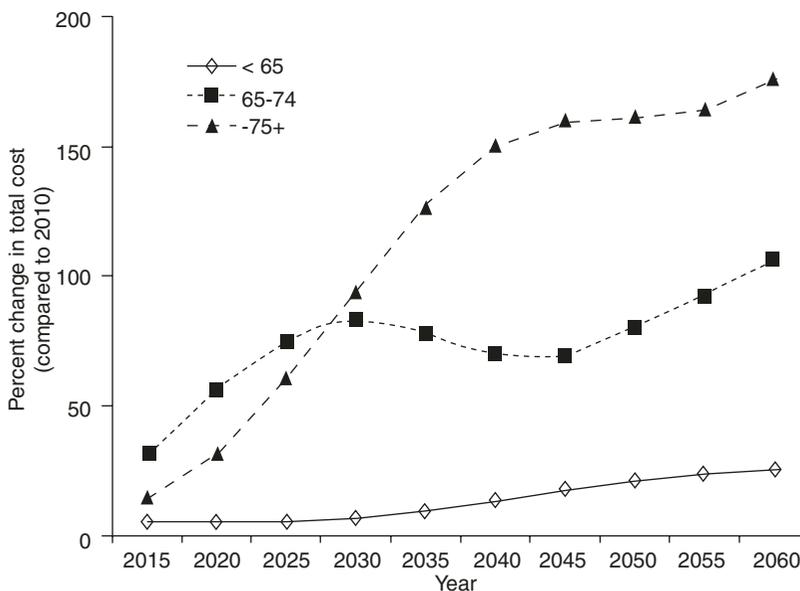


Fig. 1.5 Projected increase in cost of EGS care 2010–2060 (Source: [33])

these are underestimates due to lack of data on cost of services provided in emergency departments, urgent care centers, short-stay hospitals, post-acute care facilities (i.e., skilled nursing facilities or rehabilitation centers), physician offices, and patients' homes.

Policy and EGS Regionalization

In 2006, the Institute of Medicine described emergency care in the United States at a “breaking point” [23]; that same year the American College of Surgeons released “A Growing Crisis in Patient Access to Emergency Care” [13] outlining the issues surrounding the shortage of surgeons willing or able to provide EGS coverage. Reasons include declining reimbursement, uncompensated care, increased surgical specialization, aging of the surgeon workforce, and liability concerns. Further, as reimbursement models evolve from “fee for service” toward “value-based care,” there exists a concern that the greater complexity [10] of EGS patients that results in higher complication rates, readmission rates [29], and costs [19] may place surgeons and hospitals at risk for financial penalties [61] and poor performance on published quality ratings [10]. These and other issues have led some to call for regionalization of EGS care – similar to the development of the national trauma system over the previous decades [2, 6, 12, 24, 34, 42]. Proponents argue that regionalization would capitalize on and further improve expertise, consolidate and make better use of limited resources, and ultimately lead to improved outcomes [6, 12, 24, 34]. Indeed Ogola postulated that 23.5% of EGS-related deaths in low-volume hospitals may be preventable by transfer to higher-volume hospitals [34]. Obviously costs are added with transporting patients between hospitals [28], delaying definitive care, and adding providers in tertiary centers, yet significant cost savings would occur with improved outcomes [34]. Detractors warn that, much like the evolution of trauma care, regionalization could lead to sanctioned repudiation of all EGS care – independent of severity or hospital capability –

resulting in a net transfer of complex, poorly compensated care to already overburdened tertiary care centers. In the NIS database in 2010, over 80% of hospitals caring for EGS patients were “non-teaching,” and 40.8% were “rural” [34]; the logistics of large-scale EGS patient transfers need to be considered, as well. Hence, given the complex financial implications [28] and large, heterogeneous EGS patient volume, much remains unknown with regard to regionalization efforts.

Data Sources and Future Work

Data sources currently available to study EGS conditions and outcomes include local institutional registries, the NSQIP database, and various administrative discharge databases including State Inpatient Databases (SID) and the NIS. Each is limited by its scope, nonstandard format, and retrospective nature. In addition, most are not designed for collecting EGS-specific clinical data including physiologic, severity of disease, and operative details further limiting their clinical and research usefulness. To improve our understanding of EGS diseases and their treatment, allow outcomes benchmarking for hospitals and surgeons, facilitate research, and serve as a quality improvement tool, a dedicated national EGS registry, modeled on the NSQIP, is a critical next step and is currently being pursued [1, 47].

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Evaluating the Acute Abdomen

2

Sawyer Smith and Martin A. Schreiber

Introduction

Acute abdominal pain is one of the most common complaints leading to patients seeking medical care, accounting for between 5% and 7% of all US emergency department visits [1, 2]. Due to the frequency of patients presenting with abdominal pain and the vast number of causes, a thorough and directed evaluation is necessary to rule out causes that require emergent intervention from those that may be managed conservatively. A surgeon must start making their differential diagnosis from the moment they meet the patient; keying in on pertinent positives and negatives in the patient's history of presenting illness, past medical and surgical history, and the physical exam will narrow the possible diagnoses. Determining the gravity of the patient's current physiologic state through vital signs, laboratory tests, and imaging will identify the criticalness of the patient's illness and the speed at which intervention is necessary. A thorough understanding about the potential disease processes is also necessary for a surgeon to have to make sure that all

possibilities for the patient's symptoms are accounted for so that the proper diagnosis leads to the most appropriate treatment for the patient in a timely manner.

History

Taking a thorough, concise history is essential to narrowing the differential diagnosis of the patient's abdominal pain. A surgeon must ask the pertinent questions to help guide the decision-making, imaging choice, and ultimate management of the patient, while eliminating many other causes of abdominal pain. One must take into account not only the most common causes for a patient's symptoms, but rule out less frequent life-threatening causes or other diagnoses that the patient may be predisposed to due to their previous medical history or demographics. When asking questions about a patient's pain, below is a list of categories that are essential to delineate (Table 2.1):

- *Onset*: The timing of the patient's symptoms is important as typical problems present similar time cadences. The pain can either be immediate (onset in minutes), progressive (1–4 h), or indolent (4–24 h).
- *Location*: The surgeon must differentiate between localized and generalized abdominal symptoms. If the patient's pain is located in a

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specific area, this can help narrow the differential diagnosis. Localizing the symptoms to a specific quadrant will drive the next steps in evaluation and can lead to more specific lab and imaging tests. Generalized abdominal symptoms are worrisome for a more widespread process.

- *Quality/Character:* The type of pain (dull, sharp, electric, etc.) should also be elucidated. The physician should inquire about specific things that may improve or worsen the pain. Signs that point toward peritonitis include increased pain with movement, pain when hitting bumps while driving, or pain with coughing.
- *Radiation:* Certain pathology will classically have pain symptoms that radiate from one portion of the abdomen to other locations in the body. Pancreatitis typically radiates from the epigastrium to the spine. Urogenital pathology may radiate to the inguinal area or down into the scrotum of males.
- *Associated Symptoms:* Other symptoms in concert with severe abdominal pain such as nausea, emesis, diarrhea, constipation, hematemesis, or hematochezia are important to identify.

Care should be taken to not just focus on the history of the present illness, but also on the patient’s prior medical history. A careful medical history and review of systems will help identify any risk factors that the patient may have that either could be the cause of their presenting symptoms or contribute to their overall presentation. A cardiac history including any history of coronary artery disease or arrhythmias including atrial fibrillation would put the patient at risk for mesenteric ischemia from either thrombotic or embolic causes. Uncontrolled diabetes mellitus can blunt some abdominal pain symptoms due to neuropathy from chronic hyperglycemia. Prior history of malignancy or radiation would put the patient at risk for either recurrence of the primary tumor, metastatic disease, or radiation enteritis leading to their symptoms. A history of peptic ulcer disease would put the patient at risk for stomach or duodenal perforation or intraluminal hemorrhage. A thorough gynecologic history in female patients will help identify patients at risk for pelvic inflammatory disease, endometriosis, or ectopic pregnancy.

Nonsurgical causes of abdominal pain can be misleading. Etiologies include cardiopulmonary, metabolic, toxic ingestions, hematologic, immunologic, and infectious (Table 2.2).

A thorough surgical history should be obtained from every patient that is being worked up for surgical pathology but especially in the case of an acute abdomen. Knowledge of prior surgeries will give an understanding of any altered anatomy, identify any complications the patient may be at risk for, or eliminate certain pathology from consideration. Prior surgeries, such as bariatric procedures, can alter the patient’s intestinal anatomy which can lead to many different

Table 2.1 Essential components of history taking

History of present illness
Onset
Location
Quality/character
Radiation
Associated symptoms
Past medical history
Past surgical history
Family history
Medications

Table 2.2 Medical causes for acute abdominal pain

Cardiopulmonary	Metabolic	Toxic	Hematologic	Infectious
Myocardial infarction	Addison’s crisis	Withdrawal syndromes	Sickle cell crisis	Gastroenteritis
Pericarditis	Diabetic ketoacidosis	Corrosive ingestion	Lymphadenopathy	Parasitic disease
Pneumonia	Hypercalcemia	Lead poisoning	Hemorrhage due to anticoagulants	Malaria
		Drug packing		Typhoid

pathological entities. An understanding of the patient's prior operations will also alert the surgeon to potential complications or pitfalls that will help with the planning and approach if the patient requires an operation. Lastly, prior surgeries can put patients at risk for hernias leading to incarcerated or strangulated bowel that should be added to the differential diagnosis.

Physical Exam

The physical exam of the patient presenting with acute abdominal findings begins as the surgeon walks into the room. Initial visual inspection of the patient's general appearance, position on the bed, and mannerisms will tell a great deal about their condition. Patients with peritonitis will often be ill appearing and moving minimally while patients with renal or biliary colic may be writhing in pain unable to get comfortable. Along with the initial inspection of the patient, vital signs (heart rate, blood pressure, respiratory rate, oxygen saturation, and temperature) should be noted. Severe intra-abdominal processes can push the patient into shock with inadequate tissue oxygen delivery. Patients in shock will be tachycardic and hypotensive and have decreased oxygen saturation. If shock is due to sepsis, hyperthermia or hypothermia may be present. These quick determinations of the patients overall appearance along with determining if the patient is in shock will help the surgeon determine if immediate action is needed to stabilize the patient or if there is time for further evaluation prior to determining the first treatment options.

A systematic physical exam should be performed with a focus on the heart, lungs, and abdomen. Cardiac and pulmonary exams are important not just to identify abnormalities that may lead to a nonsurgical diagnosis as the cause of the abdominal pain, but also to identify any comorbidities that may preclude or need further workup prior to the patient obtaining a general anesthetic if the patient requires surgery. Cardiac examination should identify any murmurs or arrhythmias, while the pulmonary exam should

focus on overall work of breathing, equal breath sounds, and auscultation of crackles consistent with pulmonary edema.

The abdominal exam should start with inspection looking for abdominal distention, previous incisions, asymmetry, or any obvious deformities consistent with a hernia. Auscultation of the abdomen, although classically taught in physical exam, is not as helpful with abdominal pathology as it is for aiding in the diagnosis in other regions of the body. There is low sensitivity and specificity along with auscultative findings being inconsistent from surgeon to surgeon [3, 4]. Percussion of the abdomen can help identify organ enlargement (hepatomegaly or splenomegaly) along with being able to help identify any free fluid such as ascites. Palpation of the abdomen will identify any signs of peritonitis with voluntary or involuntary guarding. Signs of peritonitis can be either localized to a certain area of the abdomen or diffuse throughout the abdomen. When palpating the abdomen, the surgeon should also be assessing for masses, fluid within the abdominal cavity, and any abdominal wall defects.

Examination of the inguinal canal should be completed in every patient with abdominal complaints looking for signs of incarcerated or strangulated hernias. Hernias that are extremely tender, unable to be reduced, or have overlying skin erythema are concerning for containing compromised intestine. Rectal examination and stool-occult blood testing can identify either gross or microscopic intestinal bleeding. All female patients with acute abdominal symptoms, particularly lower abdominal complaints, should have a pelvic exam including both bimanual examination and a speculum examination to identify gynecologic causes of acute abdominal pain such as ectopic pregnancy, ovarian torsion, or pelvic inflammatory disease.

Depending on a patient's presenting symptoms, further maneuvers may aid in determining the diagnosis. Rebound tenderness can be an indicator of peritonitis. This maneuver is positive when the patient has increased pain upon release of pressure on the abdomen as opposed to when the abdomen is palpated. Rovsing's sign is another maneuver that is positive when the patient has pain in the right

lower quadrant of the abdomen at the time of palpation in the left lower quadrant. This sign is associated with acute appendicitis. Murphy's sign is a physical exam maneuver that classically is associated with cholecystitis. This maneuver is performed by having the patient exhale completely, palpating deeply in the right upper quadrant, and then having the patient take a deep breath in. If the patient has severe increased pain and arrests inspiration, this points toward cholecystitis.

Laboratory Studies

Although the mainstay of the diagnosis of the patient who presents with an acute abdomen is the history and physical exam, laboratory tests can aid in determining the cause of the patients' symptoms. While these tests can help, they should be used as an adjunct to the information gained from the history and physical exam, not as the mode of making the diagnosis. Along with aiding in diagnosis, laboratory tests will also show any metabolic or hematologic abnormalities that may need correction prior to the patient undergoing surgery (Table 2.3).

A complete metabolic panel will identify any electrolyte disturbances such as sodium, potassium, or chloride abnormalities. These changes in electrolytes could be associated with the primary process (emesis or diarrhea) or secondary to kidney injury due to hypovolemia or sepsis. Electrolyte disturbances can have implications with anesthetics and should be addressed prior to taking the patient to the operating room.

Table 2.3 Necessary laboratory tests for patients with acute abdominal pain

Laboratory tests
Complete metabolic panel
Complete blood count
Lipase
Amylase
PT/INR
PTT
Urinalysis
Pregnancy assessment (females of child-bearing age)
Stool studies

Creatinine and blood urea nitrogen (BUN) levels will give the clinician information about the patient's renal function. Metabolic panels will also provide liver enzymes, bilirubin, alkaline phosphatase, and albumin levels. Liver enzymes and bilirubin may be elevated from hepatobiliary processes or due to ischemia from hypotension due to other causes. Lipase and amylase are elevated with pancreatic inflammation with lipase being more specific for pancreatic inflammation. Pancreatitis is most commonly due to gallstone disease in the Western population but also may be due to alcohol abuse, hypercalcemia, hypertriglyceridemia, or autoimmune disease.

Complete blood counts and coagulation panels can also aid in the diagnosis but are essential for any patient prior to surgery. The white blood cell count can be elevated or depressed from normal values due to sepsis from an intra-abdominal infection. Hemoglobin and hematocrit levels can be depressed if hemorrhage is present but also in the setting of chronic illness. The platelet count, prothrombin time/international normalized ratio (PT/INR), and the partial thromboplastin time (PTT) are the classic indicators used to evaluate coagulopathy. Thrombelastography (TEG) is also used at some institutions giving the surgeon generalized functional coagulation information. These coagulation parameters are imperative for both the surgical and anesthesia team to evaluate prior to any operation to help minimize blood loss and correct any underlying abnormalities.

Urinalysis is another important lab to obtain for any patient with abdominal pain. Identification of a urinary tract infection that could account for the patient's symptoms should be done prior to more in-depth and expensive tests. Stool studies such as occult blood tests, fecal leukocytes, and ova and parasite examination can be helpful with patients who have symptoms of hematochezia, melena, or diarrhea and concern for gastrointestinal infection.

Imaging Studies

As medicine has evolved, there are multitudes of imaging studies that are available, many of which have various roles in evaluating patients with

acute abdominal pain. Again, imaging studies should be used to assist in the diagnosis or for surgical planning. The specific imaging studies to obtain should be determined after a thorough history and physical exam have been done. After the history and physical exam, a physician should be able to narrow the differential diagnosis which can then direct the necessary imaging studies to be obtained. Reducing unnecessary tests will reduce radiation exposure, false-positive/false-negative studies, and overall cost to the patient and the healthcare system [5].

Standard X-rays, or plain films, of the abdomen provide limited anatomical information but can be very useful in the right situation. These images can readily identify obstructive or nonobstructive intestinal gas patterns. Patients with small intestinal obstruction will typically have multiple dilated loops of small bowel in the central abdomen with air/fluid levels. Plain films should be obtained with the patient in the upright or lateral decubitus position to utilize gravity to allow for visualization of air/fluid levels, which will be less apparent or not visualized on a supine radiograph. Upright and lateral decubitus images will also allow for identification of free intraperitoneal air which can be present if perforated viscus is the cause of the patient's presentation (Fig. 2.1).

Giving patients contrast, either by mouth or by rectum, can be used to identify specific problems within the gastrointestinal tract (GI tract). Upper gastrointestinal series (UGI) is used to image the esophagus, stomach, and small intestine. This can help identify perforations within these portions of the GI tract, hiatal hernias, or bowel obstructions. Barium or water-soluble contrast (i.e., gastrografin) are generally the intraluminal contrast that the patient will drink for the study. If the patient is at risk for aspiration, water-soluble contrast should not be used as it can cause intense pulmonary edema as the osmotic pressure draws fluid into the alveoli. If there is a risk for perforation, then barium should not be used as leakage into the peritoneal cavity can cause an inflammatory response and barium can persist in the peritoneal cavity making future studies more difficult to interpret.



Fig. 2.1 Upright plain film of the abdomen with free intraperitoneal air that can be seen under the diaphragm

Ultrasound is another imaging modality that can be utilized to gain more information on a patient with an acute abdomen. Ultrasound is readily available, does not use radiation, and is inexpensive. The graded-compression technique is used when evaluating the abdomen with ultrasound, where the operator gradually increases the pressure to move the underlying fat and intestine out of the way. This technique can be used to identify free fluid, abscesses, or occasionally free intraperitoneal air which is represented by gas echoes that act as an obstacle to deeper imaging. Ultrasound is also the imaging modality of choice when patients present with acute right upper quadrant abdominal pain concerning for biliary pathology (Fig. 2.2). Although ultrasound has its benefits and is without radiation, it is operator dependent, and the reliability of the imaging is reliant upon the experience of the operator. Obese patients are also more difficult to image with ultrasound as the sound waves are less likely to penetrate the deeper, more dependent areas of the abdomen that are of interest.

Computed tomography (CT) is the mainstay for imaging of the acute abdomen as it shows the greatest anatomic and pathologic detail while being relatively quick to obtain. CT obtains axial slices of variable thickness, most commonly 5–7 mm, of the entire abdomen and pelvis. These images can be reconstructed to give the clinician multiplanar views of the abdomen, traditionally