# Surgical rescue: The next pillar of acute care surgery

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**BACKGROUND:** The evolving field of acute care surgery (ACS) traditionally includes trauma, emergency general surgery, and critical care. However, the critical role of ACS in the rescue of patients with a surgical complication has not been explored. We here describe the role of "surgical rescue" in the practice of ACS.

**METHODS:** A prospective, electronic medical record-based ACS registry spanning January 2013 to May 2014 at a large urban academic medical center was screened by ICD-9 codes for acute surgical complications of an operative or interventional procedure. Long-term outcomes were derived from the Social Security Death Index.

**RESULTS:** Of 2,410 ACS patients, 320 (13%) required "surgical rescue": most commonly, from wound complications (32%), uncontrolled sepsis (19%), and acute obstruction (15%). The majority of complications (85%) were related to an operation; 15% were related to interventional procedures. The most common rescue interventions required were bowel resection (23%), wound debridement (18%), and source control of infection (17%); 63% of patients required operative intervention, and 22% required surgical critical care. Thirty-six percent of complications occurred in ACS primary patients ("local"), whereas 38% were referred from another surgical service ("institutional") and 26% referred from another institution ("regional"). Hospital length of stay was longer, and in-hospital and 1-year mortalities were higher in rescue patients compared with those without a complication. Outcomes were equivalent between "local" and "institutional" patients, but hospital length of stay and discharge to home were significantly worse in "institutional" referrals.

**CONCLUSION:** We here describe the distinct role of the acute care surgeon in the surgical management of complications; this is an additional pillar of ACS. In this vital role, the acute care surgeon provides crucial support to other providers as well as direct patient care in the "surgical rescue" of surgical and procedural complications. (*J Trauma Acute Care Surg.* 2017;82: 280–286. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

**LEVEL OF EVIDENCE:** Epidemiological study, level III; therapeutic/care management study, level IV.

**KEY WORDS:** Failure to rescue; complication; acute care surgery.

In many urban centers in the developed world, the field of "general surgery" is rapidly dying. As the existing practitioners of classic general surgery age,[1] medical student and resident recruits to the field are often shunted to surgical specialties, leading to increasingly organ-specific and procedure-specific scopes of practice.[2,3] To address this crisis in the supply of broadly trained general surgeons committed to caring for injured and acutely ill surgical patients, the field of acute care surgery (ACS) was created. Developed under the auspices of the American Association for the Surgery of Trauma beginning in 2005,[4] there now exist 19 American Association for the Surgery of Trauma–accredited ACS fellowships with the goal of providing the newest generation of surgeons with the skills to care for a broad range of surgical patients requiring immediate evaluation and management, often at times of the day or in clinical settings in which a specialist is not immediately available.[5,6] The field of ACS was initially conceived as a merging of the three "pillars" of trauma, emergency general surgery, and surgical critical care.[4] As the anatomic and technical principles of management in acute surgical emergencies parallel those of related elective operations, elective general surgery is considered a fourth "pillar" in the eyes of many practitioners. In this sense, the value added of the acute care surgeon is the expertise in all aspects of managing "time-sensitive surgical disease."[7] Several studies of the implementation of an ACS-type model of surgical care have shown improved efficiency, reduced delay to operation, and shorter hospital length of stay for patients with such typical ACS presentations as appendicitis[8–11] and cholecystitis.[8,12–15]

However, practitioners of ACS also possess additional unique skill in the management of the patient with a procedural complication. According to Centers for Disease Control and Prevention figures, of more than 36 million inpatient hospital discharges across the United States in 2006, more than 900,000 were related to a complication of medical or surgical care: this is a more common discharge diagnosis than bowel obstruction, appendicitis, and cholelithiasis combined.[16] Several recent large studies demonstrate that the incidence of complications across surgical specialties at high-performing versus low-performing hospitals is not significantly different, but that marked differences in mortality stem primarily from the capacity to expeditiously and appropriately "rescue" patients from the complication.[17–22] The skills of the acute care surgeon are uniquely tailored to the time-sensitive physiology of such patients and are particularly critical in maintaining institution-wide patient outcomes in centers with active interventional and surgical specialty services.[23,24]

Although the role of the acute care surgeon has been well established in the practice of trauma, emergency general surgery, critical care, and elective general surgery, the critical role of ACS surgeons in the management of procedural complications has not been systematically explored. We therefore sought to describe the incidence and importance of "surgical rescue" of the complicated surgical patient to the practice of ACS in a major urban academic medical center.

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## MATERIALS AND METHODS

### Data Collection

Coding modifications were incorporated into the Cerner (Cerner Corporation; North Kansas City, MO) electronic medical record of the University of Pittsburgh Medical Center at Presbyterian Hospital, a large urban academic Level I trauma center. These modifications tagged prespecified data fields in any inpatient medical record with a history and physical, consult, or progress note from our established ACS service. Data were prospectively collected from January 2013 through May 2014 and extracted into an Oracle (Oracle Corporation; Redwood Shores, CA) database. The patient database was matched to social security death index records using name and date of birth to identify postdischarge all-cause mortality. This study was approved by the University of Pittsburgh Medical Center's Institutional Review Board.

### Identification of Complications and Interventions

The database of ACS patients was screened for complications of any surgical or interventional procedure not directly related to trauma using ICD-9 diagnostic codes. Candidate ICD-9 codes included 958.3, 998.1–3, 998.5, and 998.8, similar to screening criteria used in other studies of surgical complications.[25] In addition to basic ICD-9 codes, external causation "E-codes" specifying medical or procedural complications (E870-872, E874, E876, and E878-879) were also included in the screen. Patients who screened positive were then subjected to chart review to confirm and further characterize the nature of the surgical complication. Only s*urgical* complications requiring evaluation by an acute care surgeon were included; perioperative *medical* complications, such as myocardial infarction, ventilator-associated pneumonia, acute renal failure, and catheter-related urinary tract infection were not included. Complications were categorized by surgical chart reviewers into empiric clinically relevant categories, including airway emergency, hemorrhage, intestinal obstruction, perforated viscus, tube/line/device dysfunction, uncontrolled sepsis with a surgical etiology, visceral ischemia, and wound complication. Interventions were similarly categorized as airway intervention, biliary repair/reconstruction, bowel resection, hernia repair, hemorrhage control, source control of infection, surgeon-guided resuscitation, tube/line/device repair, and wound debridement.

### Statistical Analysis

All data are presented as mean ± standard deviation, median (interquartile range), or percentage; univariate comparisons were made using Student's *t* test for normally distributed data, Wilcoxon rank-sum testing for skewed data, and Fisher's exact test for proportions. An alpha of 0.05 was considered significant, with a Bonferroni correction for multiple comparisons as indicated. All data analyses were performed by the authors using Stata version 12 (StataCorp; College Station, TX).

## RESULTS

Of 2,410 patients evaluated by the ACS service during the study period, 607 patients (25%) had at least one ICD-9 code consistent with a complication. Of these, 320 (53% of screen-positive patients, 13% of overall patients population) were confirmed by chart review. The addition of ICD-9 E-codes identified significantly more confirmed complications than the use of basic ICD-9 codes alone as a screening tool (25% vs. 15%; $p < 0.001$). In terms of demographics, the 320 'rescue' patients with complications were significantly older (56 vs. 54 years; $p = 0.03$), had a higher mean body mass index (34 vs. 28; $p = 0.01$), and were more likely to be white (86% vs. 79%; $p < 0.01$), but did not differ significantly in terms of gender from the 2,090 patients without a complication (Table 1). In terms of comorbidities, rescue patients more commonly had coronary artery disease (21% vs. 14%; $p = 0.01$), but did not differ in terms of prior abdominal surgery, cancer, diabetes, liver disease, renal disease, peripheral vascular disease, pulmonary disease, or psychiatric disease (all $p > 0.05$; Table 1). More rescue patients were on antiplatelet agents (35% vs. 28%; $p < 0.01$) and psychiatric medications (54% vs. 46%; $p = 0.02$) before admission than those without complications; however, there was no difference in anticoagulant, immunosuppression, chemotherapy,

**TABLE 1.** Patient-Level Characteristics of Acute Care Surgery Patients With Procedural Complications

| Complication? | Yes (n = 320) | No (n = 2,090) | *p* |
|---|---|---|---|
| Age (years) | 56 ± 16 | 54 ± 18 | 0.03 |
| Male sex | 49% | 51% | 0.55 |
| Body mass index (kg/m$^2$) | 34 ± 10 | 28 ± 9 | 0.01 |
| White race | 86% | 79% | <0.01 |
| Abdominal surgery | 6% | 4% | 0.25 |
| Biliary disease | 3% | 2% | 0.22 |
| Bowel obstruction | 1% | 1% | 0.35 |
| Diverticulitis | 2% | 2% | 0.76 |
| Skin/soft tissue infection | 1% | 1% | 0.69 |
| Solid organ transplant | 5% | 3% | 0.29 |
| Trauma | 4% | 2% | 0.18 |
| Coronary artery disease | 21% | 14% | 0.01 |
| Cancer | 12% | 9% | 0.13 |
| Diabetes | 21% | 22% | 0.78 |
| Liver disease | 4% | 5% | 0.58 |
| Peripheral vascular disease | 1% | 1% | 0.50 |
| Renal disease | 6% | 7% | 1.00 |
| Pulmonary disease | 21% | 18% | 0.31 |
| Psychiatric disease | 11% | 11% | 0.90 |
| Antiplatelet | 35% | 28% | <0.01 |
| Oral anticoagulant | 13% | 13% | 0.93 |
| Immunosuppression | 19% | 15% | 0.10 |
| Chemotherapy | <1% | <1% | 0.61 |
| Diuretics | 28% | 26% | 0.40 |
| Antibiotics | 27% | 25% | 0.35 |
| Psychiatric medications | 54% | 46% | 0.02 |
| Lowest hemoglobin (g/dL) | 8.5 ± 2.2 | 9.8 ± 2.6 | <0.01 |
| Highest creatinine (mg/dL) | 1.1 (0.8–1.9) | 1.0 (0.8–1.7) | 0.11 |
| Highest lactate (mmol/L) | 2.0 (1.1–4.3) | 1.7 (1.0–3.3) | 0.05 |
| Highest total bilirubin (mg/dL) | 0.9 (0.4–1.8) | 0.8 (0.5–1.5) | 0.94 |
| Arrival INR | 1.3 (1.1–1.6) | 1.2 (1.1–1.5) | 0.24 |
| Arrival albumin (g/dL) | 3.3 ± 0.8 | 3.4 ± 0.8 | 0.09 |

Data are presented as mean ± standard deviation, median (interquartile range), or percentage. *p* Values calculated by Student's *t*, Mann-Whitney, or Fisher's exact testing.
INR, international normalized ratio.

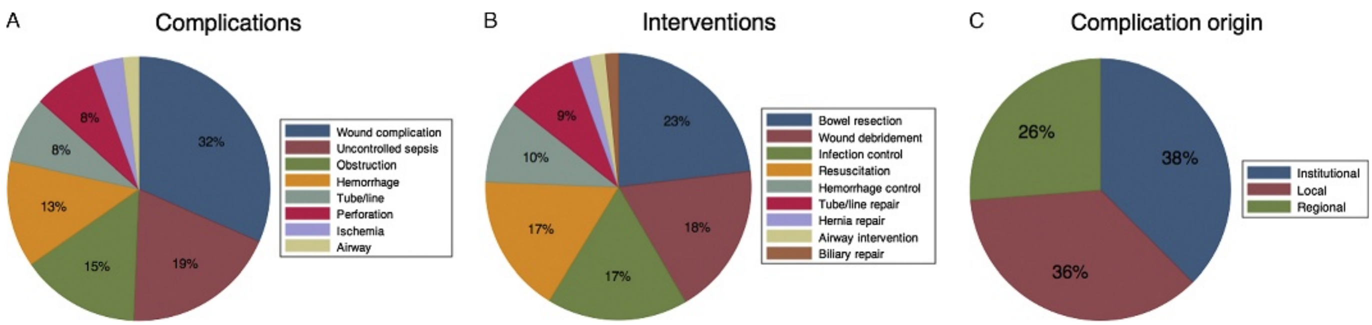


**Figure 1.** *A,* Complications. *B,* Interventions. *C,* Complication origin.

diuretic, or antibiotic use (all $p > 0.05$; Table 1). In terms of laboratory values, lowest in-hospital hemoglobin (8.5 vs. 9.8 g/dL; $p < 0.01$) and peak lactate (2.0 vs. 1.7 mmol/L; $p < 0.05$) differed significantly in rescue patients, whereas peak creatinine and bilirubin as well as arrival international normalized ratio and albumin were similar (all $p > 0.05$; Table 1).

Most (85%) complications were related to an operation, whereas 15% were related to an interventional procedure performed outside of an operating room. To provide a clinically relevant description, complications were categorized by a surgeon-reviewer as airway emergency, hemorrhage, intestinal obstruction, perforated viscus, tube/line/device dysfunction, uncontrolled sepsis with a surgical etiology, visceral ischemia, and wound complication. The most common surgical complications were wound complications (32%), uncontrolled sepsis (19%), and intestinal obstruction (15%; Fig. 1*A*). Of rescue patients, 201 (63%) required operative intervention, and 70 (22%) required surgical critical care directly related to management of their complication. Rescue interventions were categorized as airway intervention, biliary repair/reconstruction, bowel resection, hernia repair, hemorrhage control, source control of infection, surgeon-guided resuscitation, tube/line/device repair, and wound debridement; the most common being bowel resection (23%), wound debridement (18%), and source control of infection (17%; Fig. 1*B*). In terms of outcomes, rescue patients more commonly required critical care (49% vs. 37%; $p < 0.01$) and mechanical ventilation (37% vs. 26%; $p < 0.01$), had longer hospital length of stay (10 vs. 5 days, $p < 0.01$), and were less likely to be discharged to home (56% vs. 62%; $p < 0.05$; Table 2) than patients without a complication. Both in-hospital (10% vs. 7%; $p = 0.04$) as well as 1-year all-cause mortalities (25% vs. 19%, $p < 0.01$; Table 2) were higher in rescue patients.

To explore the epidemiology of rescue patients more thoroughly, we categorized the surgical service of origin for each index complication: 36% of complications occurred in ACS primary service patients ('local'), 38% occurred in patients of another interventional or surgical service at the same institution ('institutional'), and 26% in patients referred from another institution specifically for management of the index complication ('regional'; Fig. 1*C*). In terms of critical care interventions, institutional rescue patients more commonly required intensive care unit (ICU) admission (66%) and tracheostomy (18%) than either local or regional patients, and more mechanical ventilation (52%) than local rescue patients (all $p < 0.01$; Table 3). In terms of rescue interventions, regional rescue patients most commonly required operative intervention (74%), local rescue patients more commonly required interventional radiology procedures (17%), and institutional rescue patients more commonly required surgeon-guided resuscitation (all $p < 0.01$; Table 3). Hospital and ICU length of stay, discharge to home, and in-hospital and long-term mortalities were similar between local and regional rescue patients; however, hospital length of stay (median, 14 days) and discharge to home (43%) were significantly worse in institutional rescue compared with either local or regional

**TABLE 2.** Outcomes of Acute Care Surgery Patients With Procedural Complications

| Complication? | Yes (n = 320) | No (n = 2,090) | p |
|---|---|---|---|
| Critical care | 49% | 37% | <0.01 |
| Mechanical ventilation | 37% | 26% | <0.01 |
| Tracheostomy | 9% | 7% | 0.21 |
| Hospital length of stay (days) | 10 (4–20) | 5 (3–13) | <0.01 |
| ICU length of stay (days) | 5 (2–10) | 4 (2–11) | 0.99 |
| Discharge to home | 56% | 62% | 0.05 |
| In-hospital mortality | 10% | 7% | 0.04 |
| 30-day mortality | 13% | 10% | 0.08 |
| 1-year mortality | 25% | 19% | 0.01 |

Data are presented as median (interquartile range) or percentage. *p* Values calculated by Mann-Whitney or Fisher's exact testing.

**TABLE 3.** Interventions in Surgical Rescue Patients Based on Complication Origin

| Rescue Type? | Local (n = 116) | Institutional (n = 120) | Regional (n = 84) | p |
|---|---|---|---|---|
| Critical care interventions | | | | |
| ICU admission | 34% | 66% | 48% | <0.01 |
| Mechanical ventilation | 22% | 52%* | 38%* | <0.01 |
| Tracheostomy | 3% | 18% | 6% | <0.01 |
| Surgical interventions | | | | |
| Surgeon-guided resuscitation | 22% | 31% | 15% | <0.01 |
| Bedside procedure | 3% | 0% | 0% | |
| Endoscopy | 3% | 2% | 1% | |
| Interventional radiology | 17% | 4% | 10% | |
| Operation | 55% | 62% | 74% | |

*Statistically equivalent when corrected for multiple comparisons.
Data are presented as percentages. *p* Values are calculated by Fisher's exact testing.

**TABLE 4.** Outcomes of Surgical Rescue Patients Based on Complication Origin

| Rescue Type? | Local (n = 116) | Institutional (n = 120) | Regional (n = 84) | *p* |
|---|---|---|---|---|
| Hospital length of stay (days) | 6 (3–14) | 14 (7–29) | 10 (5–6) | <0.01 |
| ICU length of stay (days) | 5 (2–9) | 4 (2–11) | 5 (3–10) | 0.59 |
| Discharge to home | 67% | 43% | 61% | <0.01 |
| In-hospital mortality | 5% | 14% | 12% | 0.06 |
| 30-day mortality | 8% | 18% | 14% | 0.06 |
| 1-year mortality | 18% | 32% | 25% | 0.06 |

Data are presented as median (interquartile range) or percentage. *p* Values calculated by Mann-Whitney or Fisher's exact testing.

rescue patients (Table 4). In-hospital and long-term mortalities were statistically similar across all rescue groups (Table 4).

## DISCUSSION

In addition to the primary provision of trauma, emergency surgery, and critical care, we here describe the prominent role of "surgical rescue" from complications resulting from invasive procedures and operations in the daily practice of ACS. In the more than 2,000-patient census of a mature ACS service at a large urban academic medical center during the study period, 13% of the patients were being managed for a surgical complication. Although 85% of complications were related to a surgical procedure, 15% were related to endoscopic or interventional procedures performed outside of an operating room. The most common complications requiring surgical rescue were wound complications (32%), uncontrolled sepsis (19%), and intestinal obstruction (15%). The spectrum of "surgical rescue" techniques required in the care of these patients included operation (63%), surgeon-guided resuscitation (23%), critical care (22%), interventional or endoscopic procedures (10%), and bedside procedures (1%). The most common interventions included bowel resection (23%), wound debridement (18%), and source control of infection (17%). Thirty-six percent of rescue patients were primary ACS service patients, whereas 38% were referred for rescue from a specialty interventional or surgical service at the same institution, and 26% transferred from another institution. Local rescue required the most interventional radiology procedures (17%), institutional rescue required the most critical care resources (66% ICU admission), and regional rescue patients required the most operative intervention (74%).

Although the original charter of ACS was to merge and rebrand trauma, emergency general surgery, and critical care into a single formalized discipline, the development of ACS as a field was intended to broaden, not narrow, the scope of practicing trauma surgeons, general surgeons, and intensivists involved in this paradigm shift. As such, the practice of elective general surgery as an additional pillar of the ACS model has evolved naturally in parallel; in fact, some evidence suggests that the shift to an ACS model facilitates optimization of elective general surgery scheduling, allowing more work relative value unit production and added job satisfaction for both ACS and non-ACS general surgeons operating at the same institution.[26] Similarly, the care of patients with procedural and surgical complications has long been a critical, if unheralded, component of the practice of broadly trained general surgeons that now deserves further study and recognition as an additional pillar of ACS, in the hope that the skill set of "surgical rescue" can be more formally described, studied, and optimized.

The key importance of complication rate as a driver of mortality came to light in the early 1990s, because analysis of large inpatient data sets began to demonstrate that, although the incidence of surgical complications was associated principally with patient (as opposed to hospital) characteristics, the morbidity and mortality resulting from any given complication was related instead to hospital-level practices.[27] A recent study of inpatient surgery in more than 200,000 Medicare patients undergoing six major elective operations ranked hospitals based on risk-adjusted mortality rates. Surprisingly, the incidence of complications was not statistically different in high-performing compared with low-performing hospitals; the difference in mortality was the result of successful *management* of complications, with low-performing hospitals "failing to rescue" the patient with a complication.[28] Over the past decade, "failure to rescue" (FTR) has received increasing attention.[29] Although several authors have pointed out that the use of administrative data,[30] the difficulty of appropriate risk stratification in specific populations,[31] and the use of mortality as an outcome[32] make the robust assessment of FTR difficult, its use as a quality metric has rapidly caught on and is now even being reported publicly at the hospital level.[33]

Recent literature on FTR highlights the importance of a robust practice of "surgical rescue" to the component fields of ACS. An analysis of seven index emergency general surgery operations from the National Surgical Quality Improvement Project (NSQIP) showed that although these procedures accounted for only 14% of the emergency operations contained in NSQIP, they were responsible for 56% of the complications.[34] Importantly, large data sets such as NSQIP in which enrollment is triggered by readmission or reoperation alone may underestimate the true incidence of "surgical rescue," as these data sets may not capture the role of surgeons in the provision of nonoperative management, surgical critical care, and interventional and endoscopic modalities that we here identify through the use of a broad prospective database. Related to this point, a study of more than 8,000 trauma patients identified FTR in more than

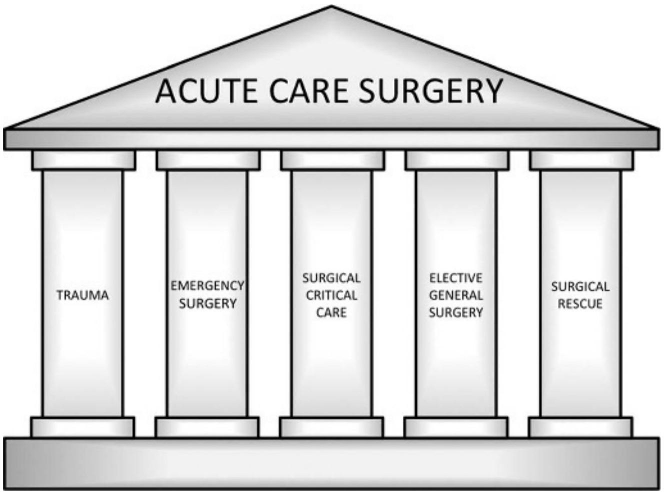


**Figure 2.** Pillars of acute care surgery.

16% of injured patients, and highlighted an 8% increase in detected complications when careful analysis of prospective data was performed beyond simple analysis of a trauma registry.[35] A systematic review further highlighted the fact that delay in the escalation of care occurred in 20% to 50% of patients with a complication and was significantly associated with mortality.[36] Because failure to deliver timely and appropriate care in the setting of trauma, emergency general surgery, and critical care constitute major contributions to FTR, as acute care surgeons, we are therefore uniquely positioned—and indeed, uniquely obligated—to investigate, develop, and articulate best practices in "surgical rescue" as a core pillar of our field.

Several limitations should be kept clearly in mind when interpreting the results of this study. Importantly, all the attendant biases of single-institution experience are applicable; in particular, significant differences in population characteristics and referral patterns at our institution may not reflect the epidemiology of "surgical rescue" at other institutions. Furthermore, as a prospectively maintained database of ACS patients only, important comparisons between the methodology and outcomes of the management of complications by other surgical services are not possible using these data. However, both of these limitations suggest the importance of further multi-institutional prospective study to more clearly define issues of efficiency, cost, and optimal care in this patient population.

Overall, we present a novel characterization of the distinct role played by the acute care surgeon in the practice of "surgical rescue," and submit that this should be considered a fifth pillar of ACS (Fig. 2). In this vital role, the acute care surgeon provides crucial support to other providers at both the institutional and regional level, as well as brings to bear a uniquely suited skill set to address the "surgical rescue" of patients with surgical complications.

## AUTHORSHIP

ME.K., J.L.S., and A.B.P. contributed to study design, data collection, data analysis, data interpretation, writing, and critical revision. M.R.R., D.M., M.K.H., M.N., L.H.A., G.A.W., J.C.P., G.M.B., V.D.S., R.D.B., T.R.B., R.M.F., and B.S.Z. contributed to study design, data interpretation, and critical revision. A.F, T.Z., and S.J.Z. contributed to data collection.

## DISCLOSURE

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