Published in final edited form as:

J Trauma Acute Care Surg. 2017 February ; 82(2): 280–286. doi:10.1097/TA.0000000000001312.

Surgical rescue: The next pillar of acute care surgery

Matthew E. Kutcher, MD*, Jason L. Sperry, MD, MPH*, Matthew R. Rosengart, MD, MPH*, Deepika Mohan, MD, MPH*, Marcus K. Hoffman, MD*, Matthew D. Neal, MD*, Louis H. Alarcon, MD*, Gregory A. Watson, MD*, Juan Carlos Puyana, MD*, Graciela M. Bauzá, MD*, Vaishali D. Schuchert, MD*, Anisleidy Fombona*, Tianhua Zhou*, Samuel Zolin*, Robert D. Becher, MD#, Timothy R. Billiar, MD*, Raquel M. Forsythe, MD*, Brian S. Zuckerbraun, MD*, Andrew B. Peitzman, MD*

Matthew E. Kutcher: kutcherme@upmc.edu; Jason L. Sperry: sperryjl@upmc.edu; Matthew R. Rosengart: rosengartmr@upmc.edu; Deepika Mohan: mohand@upmc.edu; Marcus K. Hoffman: hoffmanmk@upmc.edu; Matthew D. Neal: nealmd@upmc.edu; Louis H. Alarcon: alarconl@upmc.edu; Gregory A. Watson: watsonga@upmc.edu; Juan Carlos Puyana: puyanajc@upmc.edu; Graciela M. Bauzá: bauzagr@upmc.edu; Vaishali D. Schuchert: schuchertv@upmc.edu; Anisleidy Fombona: fombonaa@upmc.edu; Tianhua Zhou: zhout2@upmc.edu; Samuel Zolin: zolins@upmc.edu; Robert D. Becher: robert.becher@yale.edu; Timothy R. Billiar: billiartr@upmc.edu; Raquel M. Forsythe: forsytherm@upmc.edu; Brian S. Zuckerbraun: zuckerbraunbs@upmc.edu; Andrew B. Peitzman: peitzmanab@upmc.edu

*Division of Trauma and General Surgery, Department of Surgery, University of Pittsburgh Medical Center, Pittsburgh, PA

#Section of General Surgery, Trauma, and Surgical Critical Care, Yale School of Medicine, New Haven, CT

Abstract

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 Acute Care Surgery (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

Corresponding author: Andrew B. Peitzman, MD, Mark M. Ravitch Professor and Vice Chairman, Department of Surgery, University of Pittsburgh School of Medicine, Suite F1281, UPMC-Presbyterian, 200 Lothrop Street, Pittsburgh, PA 15213, peitzmanab@upmc.edu, (o) 412-647-0635, (f) 412-647-3247.

Conflicts of interest: None

This study was presented at the 29th annual meeting of the Eastern Association for the Surgery of Trauma, January 12–16, 2016, in San Antonio, Texas.

AUTHOR CONTRIBUTIONS

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.Z. contributed to data collection.

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'), while 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 mortality were higher in rescue patients compared to 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.

Conclusions—We here describe the distinct role of the acute care surgeon in the surgical management of complications; this is an additional pillar of Acute Care Surgery. 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.

Level of evidence—Level III, epidemiological study

Keywords

Failure to rescue; complication; acute care surgery

BACKGROUND

In many urban centers in the developed world, the field of 'general surgery' is rapidly dying. As the existing practitioners of classical general surgery age,¹ medical student and resident recruits to the field are often shunted to surgical specialties, leading to increasingly organ- and procedure-specific scopes of practice.^{2,3} In order 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 (AAST) beginning in 2005,⁴ there now exist 19 AAST-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 acute care surgery 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}

While 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.

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 acute care surgery 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 post-discharge 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 acute care surgery 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 *surgical* 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 $\pm$ standard deviation, median (inter-quartile range [IQR]), 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 analysis was performed by the authors using Stata version 12 (StataCorp; College Station, TX).

RESULTS

Of 2,410 patients evaluated by the acute care surgery 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 old, $p=0.03$), 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%, $p=0.02$) prior to admission than those without complications; however, there was no difference in anticoagulant, immunosuppression, chemotherapy, 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, while peak creatinine and bilirubin as well as arrival INR and albumin were similar (all $p>0.05$; Table 1).

Most (85%) complications were related to an operation, while 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%; Figure 1a). 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%; Figure 1b). 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 mortality (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'; Figure 1c). In terms of critical care interventions, institutional rescue patients more commonly required 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 mortality 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 to either local or regional rescue patients (Table 4). In-hospital and long-term mortality 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 acute care surgery (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. While 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, while 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%).

While the original charter of acute care surgery (ACS) was to merge and re-brand 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 (RVU) 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, as analysis of large inpatient data sets began to demonstrate that, while 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 to 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 While 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 outcome³² 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 while these procedures accounted for only 14% of the emergency operations contained in NSQIP, they were responsible for 56% of the complications.³⁵ Importantly, large datasets such as NSQIP in which enrollment is triggered by readmission or reoperation alone may underestimate the true incidence of ‘surgical rescue’, as these datasets 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 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.³⁴ A systematic review further highlighted the fact that

delay in the escalation of care occurred in 20–50% of patients with a complication, and was significantly associated with mortality.³⁶ As 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 this 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 (Figure 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.

Acknowledgments

Funding: Supported by NIH NIGMS K23GM093032 (to JLS).

References

1. Fischer JE. The impending disappearance of the general surgeon. *JAMA*. 2007; 298(18):2191–3. [PubMed: 18000204]
2. Borman KR, Vick LR, Biester TW, Mitchell ME. Changing demographics of residents choosing fellowships: longterm data from the American Board of Surgery. *J Am Coll Surg*. 2008; 206(5): 782–8. [PubMed: 18471695]
3. Stitzenberg KB, Sheldon GF. Progressive specialization within general surgery: adding to the complexity of workforce planning. *J Am Coll Surg*. 2005; 201(6):925–32. [PubMed: 16310697]
4. Committee to Develop the Reorganized Specialty of Trauma SCC and Emergency Surgery. Acute care surgery: trauma, critical care, and emergency surgery. *J Trauma*. 2005; 58(3):614–6. [PubMed: 15761359]
5. Davis KA, Dente CJ, Burlew CC, Jurkovich GJ, Reilly PM, Toschlog EA, Cioffi WG. Refining the operative curriculum of the acute care surgery fellowship. *J Trauma Acute Care Surg*. 2015; 78(1): 192–6. [PubMed: 25539221]
6. Dente CJ, Duane TM, Jurkovich GJ, Britt LD, Meredith JW, Fildes JJ. How much and what type: analysis of the first year of the acute care surgery operative case log. *J Trauma Acute Care Surg*. 2014; 76(2):329–38. [PubMed: 24458041]
7. Santry HP, Pringle PL, Collins CE, Kiefe CI. A qualitative analysis of acute care surgery in the United States: it’s more than just “a competent surgeon with a sharp knife and a willing attitude”. *Surgery*. 2014; 155(5):809–25. [PubMed: 24787108]

8. Cubas RF, Gomez NR, Rodriguez S, Wanis M, Sivanandam A, Garberoglio CA. Outcomes in the management of appendicitis and cholecystitis in the setting of a new acute care surgery service model: impact on timing and cost. *J Am Coll Surg*. 2012; 215(5):715–21. [PubMed: 22863794]
9. Earley AS, Pryor JP, Kim PK, Hedrick JH, Kurichi JE, Minogue AC, Sonnad SS, Reilly PM, Schwab CW. An acute care surgery model improves outcomes in patients with appendicitis. *Ann Surg*. 2006; 244(4):498–504. [PubMed: 16998358]
10. Fu CY, Huang HC, Chen RJ, Tsuo HC, Tung HJ. Implementation of the acute care surgery model provides benefits in the surgical treatment of the acute appendicitis. *Am J Surg*. 2014; 208(5):794–9. [PubMed: 25441600]
11. Wright GP, Ecker AM, Hobbs DJ, Wilkes AW, Hagelberg RS, Rodriguez CH, Scholten DJ. Old dogs and new tricks: length of stay for appendicitis improves with an acute care surgery program and transition from private surgical practice to multispecialty group practice. *Am Surg*. 2014; 80(12):1250–5. [PubMed: 25513925]
12. Britt RC, Bouchard C, Weireter LJ, Britt LD. Impact of acute care surgery on biliary disease. *J Am Coll Surg*. 2010; 210(5):595–9. 599–601. [PubMed: 20421011]
13. Lau B, Difronzo LA. An acute care surgery model improves timeliness of care and reduces hospital stay for patients with acute cholecystitis. *Am Surg*. 2011; 77(10):1318–21. [PubMed: 22127078]
14. Lim DW, Ozegovic D, Khadaroo RG, Widder S. Impact of an acute care surgery model with a dedicated daytime operating room on outcomes and timeliness of care in patients with biliary tract disease. *World J Surg*. 2013; 37(10):2266–72. [PubMed: 23756774]
15. Michailidou M, Kulvatunyou N, Friesse RS, Gries L, Green DJ, Joseph B, O'Keeffe T, Tang AL, Vercruyse G, Rhee P. Time and cost analysis of gallbladder surgery under the acute care surgery model. *J Trauma Acute Care Surg*. 2014; 76(3):710–4. [PubMed: 24553538]
16. Buie VCOM, DeFrances CJ, Golosinskiy A. National Hospital Discharge Survey: 2006 Annual Summary. *Vital Health Stat*. 2010; (168)
17. Almoudaris AM, Burns EM, Mamidanna R, Bottle A, Aylin P, Vincent C, Faiz O. Value of failure to rescue as a marker of the standard of care following reoperation for complications after colorectal resection. *Br J Surg*. 2011; 98(12):1775–83. [PubMed: 22034183]
18. Ferraris VA, Bolanos M, Martin JT, Mahan A, Saha SP. Identification of patients with postoperative complications who are at risk for failure to rescue. *JAMA Surg*. 2014; 149(11):1103–8. [PubMed: 25188264]
19. Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and failure to rescue with high-risk surgery. *Med Care*. 2011; 49(12):1076–81. [PubMed: 22002649]
20. Taenzer AH, Pyke JB, McGrath SP. A review of current and emerging approaches to address failure-to-rescue. *Anesthesiology*. 2011; 115(2):421–31. [PubMed: 21587063]
21. Tamirisa NP, Parmar AD, Vargas GM, Mehta HB, Kilbane EM, Hall BL, Pitt HA, Riall TS. Relative contributions of complications and failure to rescue on mortality in older patients undergoing pancreatectomy. *Ann Surg*. 2016; 263(2):385–91. [PubMed: 25563871]
22. Wong SL, Revels SL, Yin H, Stewart AK, McVeigh A, Banerjee M, Birkmeyer JD. Variation in hospital mortality rates with inpatient cancer surgery. *Ann Surg*. 2015; 261(4):632–6. [PubMed: 24743604]
23. Peitzman AB, Leppaniemi A, Kutcher ME, Forsythe RM, Rosengart MR, Sperry JL, Zuckerbraun BS. Surgical rescue: an essential component of acute care surgery. *Scand J Surg*. 2015; 104(3):135–6. [PubMed: 26297695]
24. Peitzman AB, Sperry JL, Kutcher ME, Zuckerbraun BS, Forsythe RM, Billiar TR, Alarcon L, Rosengart MR, Mohan D, Watson G, et al. Redefining acute care surgery: Surgical rescue. *J Trauma Acute Care Surg*. 2015; 79(2):327. [PubMed: 26438902]
25. Gonzalez AA, Dimick JB, Birkmeyer JD, Ghaferi AA. Understanding the volume-outcome effect in cardiovascular surgery: the role of failure to rescue. *JAMA Surg*. 2014; 149(2):119–23. [PubMed: 24336902]
26. Barnes SL, Cooper CJ, Coughenour JP, MacIntyre AD, Kessel JW. Impact of acute care surgery to departmental productivity. *J Trauma*. 2011; 71(4):1027–32. [PubMed: 21986743]

27. Silber JH, Williams SV, Krakauer H, Schwartz JS. Hospital and patient characteristics associated with death after surgery. A study of adverse occurrence and failure to rescue. *Med Care*. 1992; 30(7):615–29. [PubMed: 1614231]
28. Ghaferi AA, Birkmeyer JD, Dimick JB. Complications, failure to rescue, and mortality with major inpatient surgery in medicare patients. *Ann Surg*. 2009; 250(6):1029–34. [PubMed: 19953723]
29. Ghaferi AA, Birkmeyer JD, Dimick JB. Variation in hospital mortality associated with inpatient surgery. *N Engl J Med*. 2009; 361(14):1368–75. [PubMed: 19797283]
30. Moriarty JP, Finnie DM, Johnson MG, Huddleston JM, Naessens JM. Do pre-existing complications affect the failure to rescue quality measures? *Qual Saf Health Care*. 2010; 19(1):65–8. [PubMed: 20172886]
31. Scarborough JE, Pappas TN, Bennett KM, Lagoo-Deenadayalan S. Failure-to-pursue rescue: explaining excess mortality in elderly emergency general surgical patients with preexisting “do-not-resuscitate” orders. *Ann Surg*. 2012; 256(3):453–61. [PubMed: 22868360]
32. Wakeam E, Hyder JA, Jiang W, Lipsitz SA, Finlayson S. Risk and patterns of secondary complications in surgical inpatients. *JAMA Surg*. 2015; 150(1):65–73. [PubMed: 25472013]
33. Wakeam E, Hyder JA. Raising the bar for failure to rescue: critical appraisal of current measurement and strategies to catalyze improvement. *JAMA Surg*. 2015; 150(11):1023–4. [PubMed: 26331677]
34. Holena DN, Earl-Royal E, Delgado MK, Sims CA4, Pascual JL, Hsu JY, Carr BG, Reilly PM, Wiebe D. Failure to rescue in trauma: Coming to terms with the second term. *Injury*. 2016; 47(1):77–82. [PubMed: 26573899]
35. McCoy CC, Englum BR, Keenan JE, Vaslef SN, Shapiro ML, Scarborough JE. Impact of specific postoperative complications on the outcomes of emergency general surgery patients. *J Trauma Acute Care Surg*. 2015; 78(5):912–8. [PubMed: 25909409]
36. Johnston MJ, Arora S, King D, Bouras G, Almoudaris AM, Davis R, Darzi A. A systematic review to identify the factors that affect failure to rescue and escalation of care in surgery. *Surgery*. 2015; 157(4):752–63. [PubMed: 25794627]

Complications

Interventions

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

Figure 2.
Pillars of acute care surgery.

TABLE 1

Patient-level characteristics of acute care surgery patients with procedural complications.

Complication?	Yes (n=320)	No (n=2,090)	P-value
Age	56 ± 16	54 ± 18	0.03
Male gender	49%	51%	0.55
Body mass index	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	8.5 ± 2.2	9.8 ± 2.6	<0.01
Highest creatinine	1.1 (0.8–1.9)	1.0 (0.8–1.7)	0.11
Highest lactate	2.0 (1.1–4.3)	1.7 (1.0–3.3)	0.05
Highest total bilirubin	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	3.3 ± 0.8	3.4 ± 0.8	0.09

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

TABLE 2

Outcomes of acute care surgery patients with procedural complications.

Complication?	Yes (n=320)	No (n=2,090)	P-value
Critical care	49%	37%	<0.01
Mechanical ventilation	37%	26%	<0.01
Tracheostomy	9%	7%	0.21
Hospital length of stay	10 (4–20)	5 (3–13)	<0.01
ICU length of stay	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. ICU = intensive care unit. 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-value
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%	

Data are presented as percentages. P-values are calculated by Fisher's exact testing. Starred values are statistically equivalent when corrected for multiple comparisons.

TABLE 4

Outcomes of surgical rescue patients based on complication origin.

Rescue type?	Local (n=116)	Institutional (n=120)	Regional (n=84)	P-value
Hospital length of stay	6 (3–14)	14 (7–29)	10 (5–6)	<0.01
ICU length of stay	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. ICU = intensive care unit. P-values calculated by Mann-Whitney or Fisher's exact testing.