


Pro-con debate on regionalization of emergency general surgery: controversy or common sense?

Heena Santry,¹ Lillian S Kao,² Shahid Shafi,³ Lawrence Lottenberg,⁴ Marie Crandall ⁵

¹Department of Surgery and Center for Surgical Health Assessment, Research and Policy, Ohio State University, Columbus, Ohio, USA

²Surgery, McGovern Medical School at University of Texas Health Science Center at Houston, Houston, Texas, USA

³Department of Surgery, Baylor Health Care System, Dallas, Texas, USA

⁴Department of Surgery, Charles E Schmidt College of Medicine, Florida Atlantic University, Boca Raton, Florida, USA

⁵Surgery, University of Florida College of Medicine - Jacksonville, Jacksonville, Florida, USA

Correspondence to

Dr Marie Crandall, Surgery, University of Florida College of Medicine - Jacksonville, Jacksonville FL 32209-6511, USA; marie.crandall@jax.ufl.edu

These arguments were presented as a Lunch Session for the American Association for the Surgery of Trauma annual meeting, September 2018, San Diego, California. The original recording can be accessed here.

Received 25 March 2019

Revised 23 April 2019

Accepted 25 April 2019

© Author(s) (or their employer(s)) 2019. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

To cite: Santry H, Kao LS, Shafi S, et al. *Trauma Surg Acute Care Open* 2019;4:e000319.

ABSTRACT

More than three million patients every year develop emergency general surgical (EGS) conditions and this number is rising. EGS diseases range from straightforward to potentially life-threatening, and if severe or complex may require extensive resources. Given the looming surgeon shortage and concerns about access to care, regionalization of EGS care, in a manner similar to trauma care, has been proposed. We present a unique pro-con debate highlighting the salient arguments for and against regionalization of EGS care in the USA.

INTRODUCTION

Emergency general surgery (EGS) conditions are characterized by the acute onset of diseases requiring urgent surgical evaluation and *possible* emergent surgery. The number of Americans with EGS diseases has been steadily rising from approximately 2.4 million in 2001 to 3.0 million in 2010, which is partly attributed to the aging US population experiencing more EGS diseases.¹⁻⁴ Increasing obesity and other chronic diseases may also play a role, but this has not been studied. EGS patients account for 7.1% of all hospitalizations nationally in the USA.^{1,5} These patients are suffering from a range of diseases, from the straightforward, such as cholecystitis, appendicitis, and soft tissue abscesses, to high-acuity life-threatening conditions, such as gastrointestinal perforation and necrotizing soft tissue infection (NSTI). The latter typically represent an immediate life threat, require emergent operations for source control, and constitute up to 44% of EGS patients.^{1,5-7} Given this risk of life-threatening disease, timely access to high-quality care is paramount.

Unfortunately, while all Americans are susceptible to EGS disease, they may not always have access to prompt evaluation, diagnosis, and treatment due to lack of general surgeons willing to cover EGS, lack of other resources such as intensive care units and anesthesia coverage, and emergency department (ED) closures. In the decade leading up to the 2006 seminal Institute of Medicine report declaring our nation's emergency care system at a breaking point,⁸ ED and hospital closures resulted in a net loss of 425 EDs (9%) and 198 000 ED beds.^{8,9} According to a 2010 survey of ED directors, among existing EDs, 37% reported inadequate EGS coverage.¹⁰ Inadequate EGS coverage is due to multiple factors. Of the approximately 1000 general surgery chief residents who graduate annually, less than 300 pursue general surgery careers.¹¹⁻¹⁴ The existing

general surgical workforce is also aging, with one-third of practicing general surgeons approaching retirement, and with some retiring early due to multiple factors, such as declining reimbursements and rising liability stressors.¹¹ Rural general surgeon positions are increasingly difficult to fill.¹⁵ Based on specialty choices, retirement rates, and population trends, a national shortage of 6000 general surgeons is expected by 2050.¹⁶ Although many hospitals do not or cannot offer 24/7 access to EGS care, all Americans are susceptible to EGS disease. Therefore, EGS regionalization has been proposed as a possible solution to the looming crisis in access to EGS care.¹⁷⁻²⁰

EGS regionalization: pro (HS)

Despite the universal susceptibility to EGS disease, access to EGS care is not uniformly available across the USA. With a median US county population of ~26 000, 91% of US counties with <50 000 population lack access to a hospital within the county where EGS care could be provided.²¹ US counties with <25th percentile population had 82% higher odds of lacking access to EGS care compared with those with >75th percentile population. This likely explains why rural residents transferred for EGS, including common procedures such as incarcerated inguinal hernia repairs and cholecystectomies for acute cholecystitis, travel an average of 108km, with the longest distance being > 482km.²² In addition to rural areas, socioeconomically vulnerable areas, including those with higher concentration of minorities, uninsured residents, and residents lacking college degrees, are most likely to lack access to EGS care nearby.²¹ Therefore, regionalization is an approach to provide EGS care to these millions of Americans who would have otherwise been treated in their own communities by disappearing general surgeons.

Even if a smaller or more rural hospital has a general surgeon who takes ED call and operating rooms, the inherent surgical and perioperative needs of critically ill or complex EGS patients may outstrip locally available resources. EGS patients are clinically complex compared with elective counterparts. They have more comorbidities (eg, diabetes, hypertension, chronic obstructive pulmonary disease, immunosuppression), more acute physiologic derangement (eg, respiratory failure, ascites, sepsis), and worse baseline function and cognition.^{1,23-25} Of all EGS patients, 13% to 50% require intensive care, and 12% to 14% have septic shock.^{23,26-31} Among all patients in the USA requiring intensive care for sepsis, approximately 16% are septic due to EGS disease.³² Across all EGS

diagnoses, the median length of stay (LOS) is 3 days (IQR 2–6), 29% to 34% of patients require operation, 10% experience complication(s), and 1.6% to 3% die.^{1,5,33} As with other complex surgical diseases, EGS patients should benefit from a regionalized system that enables access to the highest quality care.^{34–37}

In fact, as many as 20% of EGS patients presenting to EDs are already transferred from elsewhere for definitive care.³⁸ The need for specialized critical care resources and added risk of baseline comorbidities, along with operative availability, is theorized as the leading reason for transfers of care for EGS patients.^{17,19,20,39–43} However, these patients lack the benefit of evidence-based triage criteria and verified centers of excellence that benefit patients with trauma, acute myocardial infarction (AMI), and ischemic stroke. That Americans experiencing acute chest pain, neurologic deficits, and injury benefit from robust systems of care targeting rapid evaluation and prompt triage for prompt intervention when needed has been shown to repeatedly reduce socioeconomic and demographic disparities in access to care and outcomes (HP Santry, unpublished data).^{44–54} Investing resources to provide this kind of life-saving infrastructure and human capital at all hospitals is not feasible in the current landscape of general surgery.

There is no rational argument to treat EGS patients who need prompt diagnosis of a life threat and referral for emergency operation differently from patients with AMI or ischemic stroke who need prompt diagnosis and referral for emergent interventions. Regionalization for EGS patients to tertiary care centers that are already investing in acute care surgery (ACS) teams to provide robust 24/7 EGS coverage is an ideal pathway to ensure timely and high-quality access to EGS care.

EGS regionalization: con (LSK)

Regionalization of EGS has been proposed to be concentrated at (1) high-volume centers, (2) trauma centers, or (3) centers that have adopted the ACS model. There are arguments both for and against regionalization at each of these types of centers.

Proponents of regionalization argue that high-volume centers perform better. The relationship between operative volumes and outcomes, primarily mortality, has been described for multiple procedures and replicated by numerous investigators.^{55–57} Such a volume–outcome relationship has also been demonstrated for EGS procedures. Ogola *et al*⁵⁸ identified a significantly lower mortality of EGS patients with a predicted risk of death greater than 4% who were treated at high-volume versus low-volume EGS hospitals (7.7% vs. 10.2%, $p < 0.001$). However, there are additional issues that should be considered beyond the volume–mortality association.

First, mortality should not be considered the sole measure of surgical quality. Metrics such as minor and major complications, functional outcomes, quality of life, and other patient-reported outcomes should also be considered. Second, EGS differs from other surgical subspecialties due to the high proportion of non-operative patients, who were not accounted for in the Ogola *et al*⁵⁸ analysis. When non-operative EGS patients are included in risk-adjusted analyses, hospital rankings based on performance are significantly altered.⁵⁹ Third, the relationship between volume and mortality varies based on risk, suggesting a greater benefit for treatment of high-risk patients in a high-volume center. However, current strategies for identifying high-risk patients (ie, such as using risk calculators) may be insufficient to identify those patients who would most benefit from transfer.⁶⁰

Another argument is that standards of practice at level 1 trauma centers enhance care of EGS patients. On the one hand, level 1

trauma centers have multiple requirements which would complement EGS care, such as 24-hour, inhouse surgical coverage; existence of a robust quality assurance program; collaborative clinical services such as anesthesiology and radiology; and availability of subspecialists. On the other hand, EGS outcomes have not been shown to be better at trauma centers.^{61–63} In fact, studies have suggested increased morbidity,⁶¹ mortality,⁶³ LOS,⁶³ and mean charges at trauma centers.⁶³

As with the volume–outcome relationship, comparisons of outcomes at trauma versus non-trauma centers are more complex than they may at first appear. To start, not all surgeons have equivalent skills and outcomes. Surgeon-driven variations in care and outcomes may have a greater impact on outcome than center-driven variations.⁶⁴ Second, not all trauma centers are created equal. When stratified based on mortality among trauma patients, high-quality trauma care hospitals had lower EGS mortality rates.⁶⁵ Similarly, trauma centers with a certified ACS program have improved EGS outcomes.⁶⁶

Finally, there is the argument that EGS care should be provided at centers with an ACS model. In general, the ACS model, first proposed in 2005, combines trauma, EGS, and critical care in a centralized unit.⁶⁷ Since then, multiple studies have demonstrated that the ACS model is associated with reduced morbidity and mortality.⁶⁸ However, the devil is in the details. There is no consensus regarding the essential components of the ACS model, and there are wide variations in the processes of care for EGS patients among hospitals with and without an ACS model.^{68,69}

Despite the proposed benefits, adoption of the ACS model across the USA has been slow. In a national survey, only 272 hospitals out of 1690 (16%) had adopted an ACS model as of 2015.⁷⁰ Qualitative studies reveal multiple surgeon concerns.⁷¹ One such concern is that the ACS model may be surgeon-centered rather than patient-centered. The ACS model is intended to benefit surgeons in revitalizing trauma surgery, which is becoming increasingly non-operative; this may punish patients by worsening continuity of care. A second concern was voiced that the ACS model may not be compatible with institutional resources, such as for a dedicated operating room for emergency cases. Lastly, some surgeons thought that the ACS model may not be financially viable.

The unintended consequences of regionalization must also be scrutinized. Proponents of EGS regionalization suggest that it would improve safety, decrease costs, and reduce resource utilization. Regionalization has been investigated for improving outcomes in other surgical subspecialties such as surgical oncology and bariatric surgery. However, opponents of regionalization have cited negative consequences such as decreased access to care for vulnerable patient populations, increased disparities in quality of care between high-volume and low-volume hospitals, increased financial and travel burden for patients, and decreased coordination of care due to multidisciplinary team members being located at multiple hospitals.⁷² Furthermore, data on whether outcomes are truly improved after regionalization, such as after establishment of centers of excellence for bariatric surgery, are conflicting.^{73–77} The concerns that regionalization might unfairly restrict access to care without improving outcomes or reducing costs hold true for EGS surgery as well.

Data regarding the potential effects of regionalization for EGS patients are limited. Studies comparing EGS patients who were transferred versus those who were directly admitted have demonstrated that transfer is an independent predictor of

increased mortality.^{78,79} Additionally, there are reports of small groups of hospitals in other countries such as Canada and Ireland where EGS care was regionalized. In Canada, regionalization of ACS to three out of six hospitals did not improve morbidity, mortality, LOS, or readmissions.⁸⁰ Furthermore, it resulted in an increase in wait times from referral hospitals and from the ED to inpatient admission. In Ireland, regionalization of complex and emergency cases to a hospital with a dedicated operating room around the clock resulted in an increase in night-time cases and an increased delay in the time to the operating room and LOS for weekday EGS cases.⁸¹

There are several alternatives to regionalization to improve EGS care. First, participation in regional quality collaboratives that use a common data registry such as the Michigan Surgical Quality Collaborative can move the needle in improving care.⁸² Such collaboratives must collect data on both operative and non-operative EGS patients.⁵⁹ Second, standardization of care, based on high-quality evidence when available, can also improve outcomes. Huddart *et al*⁸³ found that a five-component bundle reduced mortality after emergency laparotomy. Last but not least, telementoring may provide a method for more experienced surgeons to coach those who are less experienced or have less comfort with EGS care.⁸⁴

In conclusion, there is no clear evidence that regionalization of care would improve safety, decrease costs, or reduce resource utilization. Furthermore, regionalization may have unintended consequences such as reducing the timeliness, efficiency, and patient-centeredness of EGS care or increasing disparities in access to EGS care. To determine the best strategy for improving EGS care across the USA, acute care surgeons need to participate in robust data collection in a common data registry, to develop evidence-based pathways and bundles to improve outcomes, and to develop regional or virtual quality collaboratives to share best practices. Should acute care surgeons continue to strive for regionalization, more work needs to be done in terms of understanding what constitute the core components of the ACS model, why implementation of the ACS model has not been more widespread, and how to best stratify risk (for both operative and non-operative management) of EGS patients so as to identify those most likely to benefit from transfer.

In favor of regionalization: a rebuttal (SS)

Variations in risk-adjusted patient outcomes are well known. Two decades ago, data from the Veteran Affairs system demonstrated significant variations in outcomes of surgical patients, with certain hospitals achieving significantly lower mortality than others.⁸⁵ These findings formulated the basis for the National Surgical Quality Improvement Project. About a decade later, similar findings were demonstrated for trauma centers, which formulated the basis for Trauma Quality Improvement Project.⁸⁶ Similar variations in outcomes of EGS patients across various hospitals have also been shown to occur, strengthening the case to establish the EGS Quality Improvement Program.⁸⁷ Mortality ratio at high mortality hospitals was over three times higher than low mortality hospitals, indicating a significant gap in quality. It is estimated that if all patients treated at average and high mortality hospitals experienced the same low risk of death as the low mortality hospitals, then there could be 16 812 fewer deaths per years.

The relationship between volume of surgical patients and their outcomes is well known across other diseases. Similarly, a sharp drop in mortality for EGS patients has been

found as the hospital volume of EGS patients increased over 500, and became stable at a volume of about 660 EGS patients a year (figure 2 in Ogola *et al*).⁵⁸ The mortality rate in low-volume hospitals that treated less than 660 patients a year was found to be 3.7%, whereas the mortality rate in high-volume hospitals that treated 660 or more patients was 1.6%.

The key is determining which EGS patients would benefit the most from transfer to a high-volume center. Figure 3 in Ogola *et al* shows observed versus expected mortality rates at high-volume versus low-volume hospitals.⁸⁷ Mortality rates are similar at high-volume and low-volume hospitals when the risk of death is low. However, when the risk of death approached 4% and higher, the observed mortality rates start diverging, with lower mortality rates at high-volume hospitals, suggesting that high-volume hospitals achieved better outcomes for high-risk EGS patients. As expected, high-risk patients include those presenting with NSTIs, bowel perforation, bowel ischemia, vascular emergencies, gastrointestinal hemorrhage, and any emergent conditions associated with shock. These high-risk patients constituted less than 10% of all EGS patients but are most likely to benefit from transfer to high-volume centers. The remaining less severely ill EGS patients at low risk of death can be, and should be, treated locally. However, without a plan for regionalization in place, similar to regionalization of care for trauma patients, depending on severity of injury and institutional resources to provide adequate care, high-risk EGS patients will continue to suffer preventable morbidity and mortality. High-risk EGS patients should be treated at hospitals that care for a high volume of EGS patients, and this can only be done with a regionalized system of care, with transfer agreements and evidence-based triage guidelines.

Against regionalization: a rebuttal (LL)

ACS has been proposed as the model of care to serve as the hub in a hub-and-spoke regionalized model of EGS care. There are numerous aspects of an ACS service at tertiary centers that have established trauma programs, with robust trauma and acute care surgeons directing all aspects of injured and critically ill patients that might benefit EGS patients. Many of these centers serve as regional referral centers for hospitals that do not have the ability to perform complex surgical procedures or advanced surgical critical care. Data are abundant that such ACS services improve time to treatment, reduce LOS, and improve outcomes for EGS patients as previously noted. However, this model may not have the promise that has been lauded by the highly resourced single centers that also publish their successful outcomes.

In 2016 the American College of Surgeons Governors conducted a survey examining how the ACS paradigm might change the surgical landscape.⁸⁸ Most survey respondents (69%) worked in a facility with an ACS service, and about half were in academic institutions. Of the survey respondents 26% reported a decrease in the number of surgical cases done by general surgeons who were not involved in the ACS program. Although overall, 70% of survey respondents could foresee no significant change in their income if their hospital developed an ACS program, 65% of the responders preferred not to develop such a program. When analyzed by type of surgeon, a substantial majority—73% of general surgeons and 54% of other surgeons—are opposed to the development of an ACS program. If the main operators within a system of care are opposed to adopting it, how then will patient outcomes be improved by regionalizing care with such

a system, namely a hospital with an ACS service, at the core? Among the deterrents to high-quality care cited by respondents were fragmented care/poor continuity of care, operating room access barriers, and inexperience among those working as acute care surgeons.⁸⁸

Overly prescriptive regionalization plans may also have the unintended consequence of reducing access to EGS care. Kreindler and colleagues,⁸⁰ who examined the effect on EGS patients overall in a regionalized system within Canada of a hospital with ACS and six surrounding hospitals, found that wait times increased primarily for patients presenting at non-referral hospitals who were likely to require transfer to a referral hospital. They surmised from their data that those who presented to a non-system hospital had increased wait times due to those from the insystem hospitals being given priority when previously they may have been able to get adequate care at the originating hospital.

Finally, as with any practice model, the consequences for the practitioners historically providing such care must be considered. Unfortunately, the emergence of ACS has been viewed by some, including the Governors of the American College of Surgeons, as negatively impacting the profession of general surgery with overspecialized care.⁸⁸ All surgeons trained in general surgery are capable of providing EGS care, and with ACS and regionalization there may be a number of deleterious effects, including an untenable call schedule; conflicts/controversy between acute care surgeons and community surgeons; and devaluation of the general surgeon. Financially, general surgeons are also possibly hurt by ACS models of care. Miller and colleagues⁸⁹ found that despite elective case load increase by 23% after implementation of an ACS model of care, the work relative value units (wRVUs) decreased by 8% among those now in a primarily elective practice. Meanwhile, wRVUs increased by 140% among acute care surgeons.

For these reasons, ranging from fragmented care to the loss of general surgery as a profession, regionalization should be approached cautiously, if at all.

CONCLUSION

Although there is generalized agreement that there is a crisis in access to high-quality EGS care and that there is not a “one size fits all” model of ACS, embracing a system-wide, policy-driven approach to EGS care remains controversial. Stakeholders on both sides of the argument have varying interpretations of the literature and opposing stances on how to ensure access to high-quality surgical care to EGS patients. Common among both sides of the argument is the focus on the patient with unexpected need for EGS care. Debates such as these can inform institutional and policy approaches to implementing structures and processes, including a thoughtful approach to regionalized care, that ultimately ensure access to high-quality EGS care when and where it is needed.

Contributors MC conceived of the work and edited the article. HS, LSK, SS, and LL presented their arguments at the lunch session and drafted their written arguments for the journal. HS assembled and edited the work.

Funding HS' effort is supported by a grant from the Agency for Healthcare Research and Quality (R01HS022694). The content represents the thoughts and opinions of the authors and not the funding agencies.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Commissioned; externally peer reviewed.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iD

Marie Crandall <http://orcid.org/0000-0002-6536-3123>

REFERENCES

- Gale SC, Shafi S, Dombrovskiy VY, Arumugam D, Crystal JS. The public health burden of emergency general surgery in the United States: a 10-year analysis of the Nationwide Inpatient Sample-2001 to 2010. *J Trauma Acute Care Surg* 2014;77:202–8.
- Liu JH, Etzioni DA, O'Connell JB, Maggard MA, CY K. The increasing workload of general surgery. *Arch Surg* 2004;139:423–8.
- Etzioni DA, Liu JH, Maggard MA, Ko CY. The aging population and its impact on the surgery workforce. *Ann Surg* 2003;238:170–7.
- Vilches-Moraga A, Fox J. Geriatricians and the older emergency general surgical patient: proactive assessment and patient centred interventions. *Salford-POP-GS. Aging Clin Exp Res* 2018;30:277–82.
- Shafi S, Aboutanos MB, Agarwal S, Brown CVR, Crandall M, Feliciano DV, Guillamondegui O, Haider A, Inaba K, Osler TM, et al. Emergency general surgery: definition and estimated burden of disease. *J Trauma Acute Care Surg* 2013;74:1092–7.
- Scott JW, Olufajo OA, Brat GA, Rose JA, Zogg CK, Haider AH, Salim A, Havens JM. Use of national burden to define operative emergency general surgery. *JAMA Surg* 2016;151:e160480.
- Ogola GO, Gale SC, Haider A, Shafi S. The financial burden of emergency general surgery: national estimates 2010 to 2060. *J Trauma Acute Care Surg* 2015;79:444–8.
- Future of Emergency Care: Hospital-based Emergency Care at the Breaking Point*. Washington, DC: Institute of Medicine, 2006.
- Kellermann AL. Crisis in the emergency department. *New England Journal of Medicine* 2006;355:1300–3.
- Rao MB, Lerro C, Gross CP. The shortage of on-call surgical specialist coverage: a national survey of emergency department directors. *Acad Emerg Med* 2010;17:1374–82.
- Fischer JE. The impending disappearance of the general surgeon. *JAMA* 2007;298:2191–3.
- Polk HC, Bland KI, Ellison EC, Grosfeld J, Trunkey DD, Stain SC, Townsend CM. A proposal for enhancing the general surgical workforce and access to surgical care. *Ann Surg* 2012;255:611–7.
- Sheldon GF. Access to care and the surgeon shortage: american surgical association forum. *Ann Surg* 2010;252:582–90.
- Stitzenberg KB, Sheldon GF. Progressive specialization within general surgery: adding to the complexity of workforce planning. *J Am Coll Surg* 2005;201:925–32.
- Zuckerman R, Doty B, Gold M, Bordley J, Dietz P, Jenkins P, Heneghan S. General surgery programs in small rural New York state hospitals: a pilot survey of hospital administrators. *J Rural Health* 2006;22:339–42.
- Williams TE, Ellison EC. Population analysis predicts a future critical shortage of general surgeons. *Surgery* 2008;144:548–56.
- Santry HP, Janjua S, Chang Y, Petrovick L, Velmahos GC. Interhospital transfers of acute care surgery patients: a plea for regionalization of care. *World J Surg* 2011;35:2660–7.
- Ginde AA, Rao M, Simon EL, Matthew Edwards J, Gardner A, Rogers J, Lopez E, Camargo Jr CA, Piazza G, Rosenau A, et al. Regionalization of emergency care future directions and research: workforce issues. *Acad Emerg Med* 2010;17:1286–96.
- Diaz JJ, Norris PR, Gunter OL, Collier BR, Riordan WP, Morris JA. Does regionalization of acute care surgery decrease mortality? *J Trauma* 2011;71:442–6.
- Block EFJ, Rudloff B, Noon C, Behn B. Regionalization of surgical services in central Florida: the next step in acute care surgery. *J Trauma* 2010;69:640–4.
- Khubchandani JA, Shen C, Ayturk D, Kiefe CI, Santry HP. Disparities in access to emergency general surgery care in the United States. *Surgery* 2018;163:243–50.
- Misercola B, Sihler K, Douglas M, Ranney S, Dreifus J. Transfer of acute care surgery patients in a rural state: a concerning trend. *J Surg Res* 2016;206:168–74.
- Havens JM, Peetz AB, Do WS, Cooper Z, Kelly E, Askari R, Reznor G, Salim A. The excess morbidity and mortality of emergency general surgery. *J Trauma Acute Care Surg* 2015;78:306–11.
- Becher RD, Hoth JJ, Miller PR, Mowery NT, Chang MC, Meredith JW. A critical assessment of outcomes in emergency versus nonemergency general surgery using the American College of surgeons national surgical quality improvement program database. *Am Surg* 2011;77:951–9.
- Lissauer ME, Galvagno SM, Rock P, Narayan M, Shah P, Spencer H, Hong C, Diaz JJ. Increased ICU resource needs for an academic emergency general surgery service*. *Crit Care Med* 2014;42:910–7.

- 26 Austin MT, Diaz JJ, Feurer ID, Miller RS, May AK, Guillaumondegui OD, Pinson CW, Morris JA. Creating an emergency general surgery service enhances the productivity of trauma surgeons, general surgeons and the hospital. *J Trauma* 2005;58:906–10.
- 27 Garland AM, Riskin DJ, Brundage SI, Moritz F, Spain DA, Purtill M-A, Sherck JP. A county hospital surgical practice: a model for acute care surgery. *Am J Surg* 2007;194:758–64.
- 28 Kim PK, Dabrowski GP, Reilly PM, Auerbach S, Kauder DR, Schwab CW. Redefining the future of trauma surgery as a comprehensive trauma and emergency general surgery service 1 No competing interests declared. *J Am Coll Surg* 2004;199:96–101.
- 29 Maa J, Carter JT, Gosnell JE, Wachter R, Harris HW. The surgical hospitalist: a new model for emergency surgical care. *J Am Coll Surg* 2007;205:704–11.
- 30 Britt RC, Weireter LJ, Britt LD. Initial implementation of an acute care surgery model: implications for timeliness of care. *J Am Coll Surg* 2009;209:421–4.
- 31 Becher RD, Hoth JJ, Miller PR, Meredith JW, Chang MC. Systemic inflammation worsens outcomes in emergency surgical patients. *J Trauma Acute Care Surg* 2012;72:1140–9.
- 32 Mayr FB, Yende S, Angus DC. Epidemiology of severe sepsis. *Virulence* 2014;5:4–11.
- 33 Shah AA, Haider AH, Zogg CK, Schwartz DA, Haut ER, Zafar SN, Schneider EB, Velopoulos CG, Shafi S, Zafar H, et al. National estimates of predictors of outcomes for emergency general surgery. *J Trauma Acute Care Surg* 2015;78:482–91. discussion 490–481.
- 34 Diggs BS, Mullins RJ, Hedges JR, Arthur M, Newgard CD. Proportion of seriously injured patients admitted to hospitals in the US with a high annual injured patient volume: a metric of regionalized trauma care. *J Am Coll Surg* 2008;206:212–9.
- 35 Birkmeyer JD, Siewers AE, Marth NJ, Goodman DC. Regionalization of high-risk surgery and implications for patient travel times. *JAMA* 2003;290:2703–8.
- 36 Bilimoria KY, Bentrem DJ, Talamonti MS, Stewart AK, Winchester DP, CY K. Risk-based selective referral for cancer surgery: a potential strategy to improve perioperative outcomes. *Ann Surg* 2009;251:708–16.
- 37 Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. *N Engl J Med* 2003;349:2117–27.
- 38 Kindermann DR, Mutter RL, Cartwright-Smith L, Rosenbaum S, Pines JM. Admit or transfer? The role of insurance in high-transfer-rate medical conditions in the emergency department. *Ann Emerg Med* 2014;63:561–71.
- 39 Malangoni MA. Acute care surgery: The general surgeon's perspective. *Surgery* 2007;141:324–6.
- 40 Velmahos GC, Alam HB. Acute care surgery: the natural evolution of trauma surgery. *Scand J Surg* 2010;99:59–60.
- 41 Tang AL, Inaba K. From trauma to acute care surgery: With an eye to the future. *Scand J Surg* 2010;99:61–3.
- 42 Biffi WL, Mehler PS, Moore EE. Acute care surgery in the safety net Hospital: maintaining referrals and optimizing outcomes. *Scand J Surg* 2010;99:68–72.
- 43 Diaz JJ, Norris P, Gunter O, Collier B, Riordan W, Morris JA. Triaging to a regional acute care surgery center: distance is critical. *J Trauma* 2011;70:116–9.
- 44 Seabury S, Bogner K, Xu Y, Huber C, Commerford SR, Tayama D. Regional disparities in the quality of stroke care. *Am J Emerg Med* 2017;35:1234–9.
- 45 Aparicio HJ, Carr BG, Kasner SE, Kallan MJ, Albright KC, Kleindorfer DO, Mullen MT. Racial disparities in intravenous recombinant tissue plasminogen activator use persist at primary stroke centers. *J Am Heart Assoc* 2015;4:e001877.
- 46 Bhattacharya P, Mada F, Salowich-Palm L, Hinton S, Millis S, Watson SR, Chaturvedi S, Rajamani K. Are racial disparities in stroke care still prevalent in certified stroke centers? *J Stroke Cerebrovasc Dis* 2013;22:383–8.
- 47 O'Malley AS, Draper DA, Felland LE. Hospital emergency on-call coverage: is there a doctor in the house? *Issue Brief Cent Stud Health Syst Change* 2007;115:1–4.
- 48 Mann NC, Mullins RJ, MacKenzie EJ, Jurkovich GJ, Mock CN. Systematic review of published evidence regarding trauma system effectiveness. *J Trauma* 1999;47(3 Suppl):S25–S33.
- 49 Mullins RJ. A historical perspective of trauma system development in the United States. *J Trauma* 1999;47(3 Suppl):S8–S14.
- 50 MacKenzie EJ, Rivara FP, Jurkovich GJ, Nathens AB, Frey KP, Egleston BL, Salkever DS, Scharfstein DO. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med* 2006;354:366–78.
- 51 Celso B, Tepas J, Langland-Orban B, Pracht E, Papa L, Lottenberg L, Flint L. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma* 2006;60:371–8.
- 52 Agarwal S, Sud K, Thakkar B, Menon V, Jaber WA, Kapadia SR. Changing trends of atherosclerotic risk factors among patients with acute myocardial infarction and acute ischemic stroke. *Am J Cardiol* 2017.
- 53 Glickman SW, Granger CB, Ou F-S, O'Brien S, Lytle BL, Cairns CB, Mears G, Hoekstra JW, Garvey JL, Peterson ED, et al. Impact of a statewide ST-segment-elevation myocardial infarction regionalization program on treatment times for women, minorities, and the elderly. *Circ Cardiovasc Qual Outcomes* 2010;3:514–21.
- 54 Haider AH, Weygandt PL, Bentley JM, Monn MF, Rehman KA, Zarzaar BL, Crandall ML, Cornwell EE, Cooper LA. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. *J Trauma Acute Care Surg* 2013;74:1195–205.
- 55 Birkmeyer JD, Siewers AE, Finlayson EVA, Stukel TA, Lucas FL, Batista I, Welch HG, Wennberg DE. Hospital volume and surgical mortality in the United States. *N Engl J Med* 2002;346:1128–37.
- 56 Reames BN, Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and operative mortality in the modern era. *Ann Surg* 2014;260:244–51.
- 57 Morche J, Mathes T, Pieper D. Relationship between surgeon volume and outcomes: a systematic review of systematic reviews. *Syst Rev* 2016;5:204.
- 58 Ogola GO, Haider A, Shafi S. Hospitals with higher volumes of emergency general surgery patients achieve lower mortality rates: a case for establishing designated centers for emergency general surgery. *J Trauma Acute Care Surg* 2017;82:497–504.
- 59 Wandling MW, Ko CY, Bankey PE, Cribari C, Cryer HG, Diaz JJ, Duane TM, Hameed SM, Hutter MM, Metzler MH, et al. Expanding the scope of quality measurement in surgery to include nonoperative care: results from the American College of surgeons national surgical quality improvement program emergency general surgery pilot. *J Trauma Acute Care Surg* 2017;83:837–45.
- 60 Havens JM, Columbus AB, Seshadri AJ, Brown CVR, Tominaga GT, Mowery NT, Crandall M. Risk stratification tools in emergency general surgery. *Trauma Surg Acute Care Open* 2018;3:e000160.
- 61 Ingraham AM, Cohen ME, Raval MV, Ko CY, Nathens AB. Effect of trauma center status on 30-day outcomes after emergency general surgery. *J Am Coll Surg* 2011;212:277–86.
- 62 Ingraham AM, Haas B, Cohen ME, Ko CY, Nathens AB. Comparison of hospital performance in trauma vs emergency and elective general surgery: implications for acute care surgery quality improvement. *Arch Surg* 2012;147:591–8.
- 63 Nagarajan N, Selvarajah S, Gani F, Alshaikh HN, Giuliano K, Zogg CK, Schneider EB, Haider AH. "Halo effect" in trauma centers: does it extend to emergent colectomy? *J Surg Res* 2016;203:231–7.
- 64 Udyavar R, Cornwell EE, Havens JM, Hashmi ZG, Scott JW, Sturgeon D, Uribe-Leitz T, Lipsitz SR, Salim A, Haider AH, et al. Surgeon-driven variability in emergency general surgery outcomes: Does it matter who is on call? *Surgery* 2018;164:1109–16.
- 65 Scott JW, Tsai TC, Neiman PU, Jurkovich GJ, Utter GH, Haider AH, Salim A, Havens JM. Lower emergency general surgery (EGS) mortality among hospitals with higher-quality trauma care. *J Trauma Acute Care Surg* 2018;84:433–40.
- 66 Khalil M, Pandit V, Rhee P, Kulvatunyou N, Orouji T, Tang A, O'Keeffe T, Gries L, Verccruysee G, Friese RS, et al. Certified acute care surgery programs improve outcomes in patients undergoing emergency surgery. *J Trauma Acute Care Surg* 2015;79:60–4. discussion 64.
- 67 Committee to Develop the Reorganized Specialty of Trauma SCC, Emergency S. Acute care surgery: trauma, critical care, and emergency surgery. *J Trauma* 2005;58:614–6.
- 68 Chana P, Burns EM, Arora S, Darzi AW, Faiz OD. A systematic review of the impact of dedicated emergency surgical services on patient outcomes. *Ann Surg* 2016;263:20–7.
- 69 Santry HP, Madore JC, Collins CE, Ayturk MD, Velmahos GC, Britt LD, Kiefe CI. Variations in the implementation of acute care surgery: results from a national survey of university-affiliated hospitals. *J Trauma Acute Care Surg* 2015;78:60–7. discussion 67–68.
- 70 Daniel VT, Ingraham AM, Khubchandani JA, Ayturk D, Kiefe CI, Santry HP. Variations in the delivery of emergency general surgery care in the era of acute care surgery. *Jt Comm J Qual Patient Saf* 2019;45:14–23.
- 71 Collins CE, Pringle PL, Santry HP. Innovation or rebranding, acute care surgery diffusion will continue. *J Surg Res* 2015;197:354–62.
- 72 Lumpkin S, Stitzenberg K. Regionalization and its alternatives. *Surg Oncol Clin N Am* 2018;27:685–704.
- 73 Dimick JB, Nicholas LH, Ryan AM, Thumma JR, Birkmeyer JD. Bariatric surgery complications before vs after implementation of a national policy restricting coverage to centers of excellence. *JAMA* 2013;309:792–9.
- 74 Scally CP, Shih T, Thumma JR, Dimick JB. Impact of a national bariatric surgery center of excellence program on Medicare expenditures. *J Gastrointest Surg* 2016;20:708–14.
- 75 Livingston EH. Bariatric surgery outcomes at designated centers of excellence vs nondesignated programs. *Arch Surg* 2009;144:319–25. discussion 325.
- 76 Kwon S, Wang B, Wong E, Alfonso-Cristancho R, Sullivan SD, Flum DR. The impact of accreditation on safety and cost of bariatric surgery. *Surg Obes Relat Dis* 2013;9:617–22.
- 77 Nguyen NT, Hohmann S, Slone J, Varela E, Smith BR, Hoyt D. Improved bariatric surgery outcomes for Medicare beneficiaries after implementation of the Medicare national coverage determination. *Arch Surg* 2010;145:72–8.
- 78 DeWane MP, Davis KA, Schuster KM, Erwin SP, Maung AA, Becher RD. Transfer status: a significant risk factor for mortality in emergency general surgery patients requiring colon resection. *J Trauma Acute Care Surg* 2018;85:348–53.
- 79 Yelverton S, Rozario N, Matthews BD, Reinke CE. Interhospital transfer for emergency general surgery: an independent predictor of mortality. *Am J Surg* 2018;216:787–92.
- 80 Kreindler SA, Zhang L, Metge CJ, Nason RW, Wright B, Rudnick W, Moffatt MEK. Impact of a regional acute care surgery model on patient access and outcomes. *Can J Surg* 2013;56:318–24.
- 81 Beecher S, O'Leary DP, McLaughlin R. Increased risk environment for emergency general surgery in the context of regionalization and specialization. *Int J Surg* 2015;21:112–4.

- 82 Vu JV, Collins SD, Seese E, Hendren S, Englesbe MJ, Campbell DA, Krapohl GL. Evidence that a regional surgical collaborative can transform care: surgical site infection prevention practices for colectomy in Michigan. *J Am Coll Surg* 2018;226:91–9.
- 83 Huddart S, Peden CJ, Swart M, McCormick B, Dickinson M, Mohammed MA, Quiney N, ELPQuiC Collaborator Group. Use of a pathway quality improvement care bundle to reduce mortality after emergency laparotomy. *Br J Surg* 2015;102:57–66.
- 84 Dawe P, Kirkpatrick A, Talbot M, Beckett A, Garraway N, Wong H, Hameed SM. Tele-mentored damage-control and emergency trauma surgery: a feasibility study using live-tissue models. *Am J Surg* 2018;215:927–9.
- 85 Khuri SF. The NSQIP: a new frontier in surgery. *Surgery* 2005;138:837–43.
- 86 Shafi S, Nathens AB, Parks J, Cryer HM, Fildes JJ, Gentilello LM. Trauma quality improvement using risk-adjusted outcomes. *J Trauma* 2008;64:599–606. discussion 604-596.
- 87 Ogola GO, Crandall ML, Shafi S. Variations in outcomes of emergency general surgery patients across hospitals: a call to establish emergency general surgery quality improvement program. *J Trauma Acute Care Surg* 2018;84:280–6.
- 88 Paramo JC, Puls MW, Welsh DJ, Andreone P. 2016 ACS governors survey: will acute care surgery change the surgical landscape? *Bull Am Coll Surg* 2017;102:28–34.
- 89 Miller PR, Wildman EA, Chang MC, Meredith JW. Acute care surgery: impact on practice and economics of elective surgeons. *J Am Coll Surg* 2012;214:531–5. discussion 536-538.