# Variations in outcomes of emergency general surgery patients across hospitals: A call to establish emergency general surgery quality improvement program

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**BACKGROUND:** National Surgical Quality Improvement Program and Trauma Quality Improvement Program have shown variations in risk-adjusted outcomes across hospitals. Our study hypothesis was that there would be similar variation in risk-adjusted outcomes of emergency general surgery (EGS) patients.

**METHODS:** We undertook a retrospective analysis of the National Inpatient Sample database for 2010. Patients with EGS diseases were identified using American Association for the Surgery of Trauma definitions. A hierarchical logistic regression model was used to model in-hospital mortality, accounting for patient characteristics, including age, sex, race, ethnicity, insurance type, and comorbidities. Predicted-to-expected mortality ratios with 90% confidence intervals were used to identify hospitals as low mortality (ratio significantly lower than 1), high mortality (ratio significantly higher than 1), or average mortality (ratio overlapping 1).

**RESULTS:** Nationwide, 2,640,725 patients with EGS diseases were treated at 943 hospitals in 2010. About one-sixth of the hospitals (139, 15%) were low mortality, a quarter were high mortality (221, 23%), and the rest were average mortality. Mortality ratio at low mortality hospitals was almost four times lower than that of high mortality hospitals (0.57 vs. 2.03, $p < 0.0001$). If high and average mortality hospitals performed at the same level as low mortality hospitals, we estimate 16,812 (55%) more deaths than expected.

**CONCLUSION:** There are significant variations in risk-adjusted outcomes of EGS patients across hospitals, with several thousand higher than expected number of deaths nationwide. Based on the success of National Surgical Quality Improvement Program and Trauma Quality Improvement Program, we recommend establishing EGS quality improvement program for risk-adjusted benchmarking of hospitals for EGS patients. (*J Trauma Acute Care Surg.* 2018;84: 280–286. Copyright © 2017 Wolters Kluwer Health, Inc. All rights reserved.)

**LEVEL OF EVIDENCE:** Care management, level III.
**KEY WORDS:** Emergency general surgery; quality improvement program; mortality.

Emergency general surgery (EGS) is increasingly recognized as a distinct clinical service, largely due to efforts by the American Association for the Surgery of Trauma (AAST) over the last decade. In 2014, AAST published a definition of EGS diseases using practice-based data from several large medical centers in the United States.[1] Using this definition, we have estimated the annual volume of EGS patients requiring hospitalizations at 2.6 million yearly, with a cost exceeding US $28 billion.[2] These patients are treated at over 900 hospitals across the nation.[3] However, the quality of care received by these patients remains unknown. A systems approach to quality improvement is best described by Donabedian principles, which define quality in terms of structures, process, and outcomes.[4] At the present time, there is no system to measure quality of EGS care provided at these hospitals. There are no national standards for optimal resources or clinical processes for EGS patients nor are there any national benchmarks for hospital performance.

The best known example of a systems approach to improving quality of surgical care is the National Surgical Quality Improvement Program (NSQIP).[5] Risk-adjusted benchmarking used in NSQIP has shown significant variations in outcomes across the hospitals and has led to significant improvements in patient outcomes.[6] Using the same approach, Trauma Quality Improvement Program (TQIP) has also shown wide variations in risk-adjusted outcomes at participating trauma centers, and developed processes to improve the quality of care for these patients.[7–10] Emergency general surgery is practiced at hundreds of hospitals without such benchmarking.

Our study hypothesis was that there were significant variations in risk-adjusted outcomes of EGS patients across hospitals.

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## METHODS

This was a retrospective analysis of the National Inpatient Sample (NIS) data for 2010. The NIS database is part of the Health Care Utilization Project, maintained by the Agency for Healthcare Research and Quality.[11] It is a representative national sample of inpatients, and provides sampling weights that can be used to estimate nationwide incidence of hospitalizations. We identified EGS patients using AAST definitions for EGS diseases based on the primary International Classification of Diseases—9th Rev.—Clinical Modification diagnosis codes.[1] The number of patients with these diagnoses treated at each hospital was calculated using sampling discharge weights provided in the NIS database.[11] Hospital characteristics, including

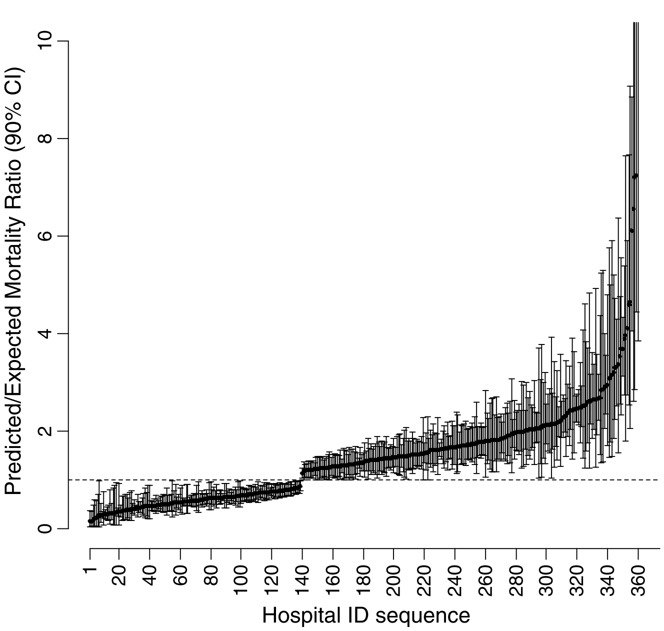


**Figure 1.** Predicted-expected mortality ratios with 90% CIs at low and high mortality hospitals (results for average mortality hospitals not shown).

 

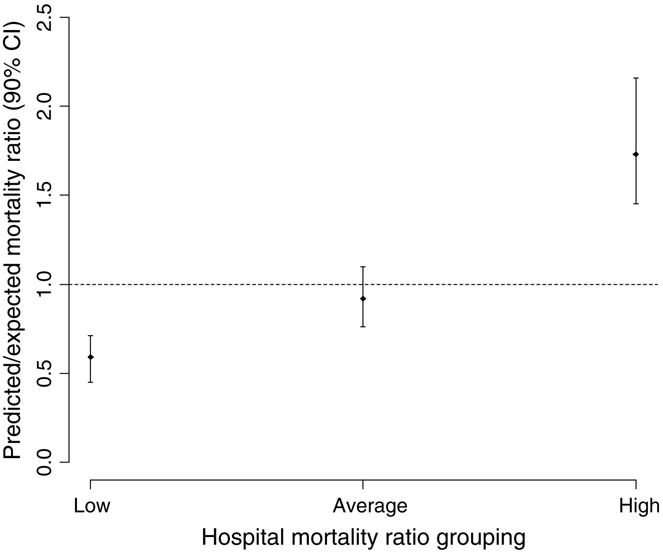


**Figure 2.** Predicted to expected mortality ratios with 90% CIs for high, average and low mortality hospitals.

geographic region (midwest, northeast, south, and west), location (rural vs. urban), teaching status (teaching vs. nonteaching), ownership (government, private investor-owned, and private not-for-profit) and bed size (large, small, and medium) were also obtained from NIS.

The primary outcome of interest was in-hospital mortality. To derive a hospital-specific metric to compare hospitals, we estimated hospital-specific standardized mortality ratio using hierarchical generalized linear model. Specifically, we modeled the logit of in-hospital mortality as a dependent variable using a hierarchical multivariable logistic regression model. Patient and clinical characteristics (including age, sex, race, ethnicity, and socio-economic status based on median household income quartile for patient's zip code, payer type (Medicare, Medicaid, private insurance, and the uninsured), indicator of major operating room procedure (none vs. major), indicator of transfer-in, and preexisting diseases (using the Charlson's Comorbidity Index.[12]) were included as fixed effect independent variables. Hospitalization facility was included in the model as a random intercept variable to account for within-hospital correlation. We used the

**TABLE 1.** Characteristics of Emergency General Surgery Patients by Hospital Mortality: National Inpatient Sample 2010 data

| Patient Characteristics | Low Mortality | Average Mortality | High Mortality |
|---|---|---|---|
| No. hospitals | 139 | 583 | 221 |
| No. patients | 864,064 | 1,041,140 | 735,521 |
| Age: mean ± SD, y | 58.4 ± 19.9 | 57.8 ± 19.8 | 58.5 ± 19.6 |
| Sex (female), n (%) | 465,723 (53.9) | 558,995 (53.7) | 387,746 (52.7) |
| Race (white), n (%) | 572,875 (66.3) | 647,168 (62.2) | 437,624 (59.5) |
| Ethnicity (Hispanic), n (%) | 88,246 (10.2) | 116,026 (11.1) | 80,757 (11.0) |
| Income quartile, n (%) | | | |
| $1 to $38,999 | 169,127 (19.6) | 295,567 (28.4) | 245,771 (33.4) |
| $39,000 to $47,999 | 203,114 (23.5) | 250,084 (24.0) | 189,207 (25.7) |
| $48,000 to 62,999 | 230,809 (26.7) | 242,517 (23.3) | 163,995 (22.3) |
| $63,000 or more | 246,016 (28.5) | 225,137 (21.6) | 112,244 (15.3) |
| Payor, n (%) | | | |
| Commercial | 270,928 (31.4) | 304,299 (29.2) | 197,210 (26.8) |
| Medicaid | 105,174 (12.2) | 132,261 (12.7) | 98,529 (13.4) |
| Medicare | 382,765 (44.3) | 441,520 (42.4) | 325,296 (44.2) |
| Self-pay | 63,700 (7.4) | 114,486 (11.0) | 77,648 (10.6) |
| Other | 41,498 (4.8) | 48,574 (4.7) | 36,838 (5.0) |
| Charlson's Comorbidity Index, n (%) | | | |
| 0 | 125,571 (14.5) | 158,131 (15.2) | 104,604 (14.2) |
| 1 | 100,040 (11.6) | 121,887 (11.7) | 82,182 (11.2) |
| ≥2 | 638,452 (73.9) | 761,123 (73.1) | 548,735 (74.6) |

**TABLE 2.** Hospital Characteristics by Hospital Mortality for Emergency General Surgery Patients: National Inpatient Sample 2010 data

| | Low Mortality | Average Mortality | High Mortality |
|---|---|---|---|
| No. hospitals | 139 (100.0) | 583* (100.0) | 221 (100.0) |
| Hospital bed size, n (%) | | | |
| Large | 85 (61.2) | 140 (24.0) | 90 (40.7) |
| Medium | 37 (26.6) | 136 (23.3) | 60 (27.1) |
| Small | 17 (12.2) | 297 (50.9) | 71 (32.1) |
| Hospital location - n (%) | | | |
| Rural | 19 (13.7) | 300 (51.5) | 66 (29.9) |
| Urban | 120 (86.3) | 273 (46.8) | 155 (70.1) |
| Teaching status, n (%) | | | |
| Nonteaching | 89 (64.0) | 498 (85.4) | 168 (76.0) |
| Teaching | 50 (36.0) | 75 (12.9) | 53 (24.0) |
| Hospital region - n (%) | | | |
| Midwest | 28 (20.1) | 194 (33.3) | 51 (23.1) |
| Northeast | 32 (23.0) | 54 (9.3) | 37 (16.7) |
| South | 55 (39.6) | 222 (38.1) | 88 (39.8) |
| West | 24 (17.3) | 113 (19.4) | 45 (20.4) |
| Hospital ownership, n (%) | | | |
| Government, nonfederal | 17 (12.2) | 152 (26.1) | 35 (15.8) |
| Private, investor-owned | 25 (18.0) | 93 (16.0) | 36 (16.3) |
| Private, nonprofit | 97 (69.8) | 328 (56.3) | 150 (67.9) |
| EGS volume ≥ 668 per year, n (%) | 136 (97.8) | 267 (45.8) | 187 (84.6) |

*10 hospitals with missing hospital characteristics included in this total.

**TABLE 3.** Independent Predictors of Low Mortality Hospitals, Presented as OR and 95% CI

| Predictors | OR (95% CI) |
|---|---|
| EGS volume ≥ 668 per year | 3.89 (3.45–4.40) |
| Bed size | |
| Large vs. small | 4.46 (4.36–4.57) |
| Medium vs. small | 2.09 (2.03–2.14) |
| Location | |
| Urban vs. rural | 4.67 (4.54–4.80) |
| Teaching status | |
| Teaching vs. nonteaching | 1.63 (1.60–1.65) |
| Hospital ownership | |
| Private, investor-owned vs. government, nonfederal | 1.94 (1.89–1.99) |
| Private, nonprofit vs. government, nonfederal | 1.87 (1.85–1.93) |

coefficients from the fitted model to calculate the predicted as well as the expected number of deaths at each hospital. The predicted number of deaths in each hospital was calculated as the sum of predicted probability of death for each patient, including hospital-specific (random) effect. The expected number of deaths for each hospital was similarly calculated as the sum of predicted probability of death for each patient, ignoring the hospital-specific (random) effect.[13] We aggregated the data and calculated the predicted-to-expected (P/E) mortality ratio and its 90% confidence interval (CI) for each hospital. The P/E metric is similar to the observed-to-expected mortality ratio and has been used extensively by the Centers for Medicare and Medicaid Services to derive risk standardized mortality rates for profiling hospitals on patients' outcomes.[14–16]

We assessed within-hospital clustering effects using intraclass correlation cocoefficients, which measure the proportion of variance in outcome (mortality) explained by the grouping of patients within hospitals.[17] We obtained an intraclass correlation of 0.137 from the random intercept facility model, which indicated that approximately 13.7% of the variability in mortality was accounted for by the clustering effect of patients within hospitals in our study. We addressed the hospital clustering effect in the risk adjusted analysis by fitting a hierarchical generalized linear model as described in the previous paragraph and assuming compound symmetry covariance structure.

The area under the receiver operating characteristic curve for the risk-adjusted model had a c-statistic of 0.830 (95% CI, 0.826–0.834), which indicated good discrimination ability of our model.

Hosmer-Lemeshow goodness-of-fit to assess model calibration was statistically significant ($\chi^2 = 2821$, degrees of freedom = 8, $p < 0.0001$), suggesting poor fit of the model. However, this is a common occurrence in studies with large sample size and has little effect on the validity of the model.[18] Hence, we used calibration plot by grouping predicted probabilities into deciles and plotting the actual proportion of patients who died against predicted probability. The plotted data points were very close to the 45-degree line which indicated good model calibration (figure not shown).

We classified hospitals into "high," "average," or "low" mortality ratio based on whether 90% CI of P/E mortality ratio was greater than 1.0, included 1.0, or was less than 1.0, respectively. To determine risk factors for high mortality ratio hospital, we dichotomized hospital mortality classification and modeled the logit of high mortality ratio hospital using logistic regression model. Independent variables included hospital location, region, teaching status, bed size, ownership, and indicator of annual volume of EGS patients of 668 or more per year. This threshold was chosen based on our prior work that indicated lower mortality at hospitals with higher volumes of EGS patients.[19] The model had good discrimination ability (c-statistics = 0.722), and calibration plot showed good fit with plotted data points lying close to the 45-degree line. Results of the analysis are presented as odds ratio (OR) with 95% CI.

We estimated the number of "higher than expected" deaths at high and average mortality hospitals as the difference between the observed number of deaths and number of deaths expected using mean P/E at low mortality hospitals.

Data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC) and R[20] statistical programs.

## RESULTS

In 2010, a total of 2,640,725 patients with EGS diseases were treated at 943 hospitals nationwide. Of these, 139 (14.7%) hospitals were low mortality, 221 (23.4%) were high mortality, and the rest (583 hospitals) were average mortality (Fig. 1). The average P/E mortality ratio at low mortality hospitals was over three times lower than that of high mortality hospitals ($0.57 \pm 0.17$ vs. $2.03 \pm 1.14$, $p < 0.0001$) (Fig. 2).

Tables 1 and 2 summarize patient and hospital characteristics across hospital mortality class. Age, sex, and ethnicity were similar. In terms of patient characteristics, compared to the high mortality hospitals, low mortality hospitals had a higher proportion of patients who were white, were in the highest income quartile, and had commercial insurance. Multivariable modeling showed higher odds of low mortality hospital was associated with high volume of EGS patients, large bed size, urban location, northeast region of country, teaching status, and private ownership (Table 3).

There were 30,580 patients who died at average and high mortality hospitals. However, if these hospitals had performed at the same level as low mortality hospitals (i.e., P/E ratio of 0.59), then we would expect 13,768 deaths. Hence, the difference between the two numbers, i.e., 16,812 deaths (55% of total deaths) at average and high mortality hospitals was considered more deaths than expected.

## DISCUSSION

There are two important findings in this study. One, it clearly demonstrates large variations in risk-adjusted mortality rates of EGS patients across several hundred hospitals nationwide. Second, it identifies a wide gap in mortality between high and low mortality hospitals, with several thousand more deaths than expected. These findings suggest significant room for improvement in the quality of EGS care.

Variations in risk-adjusted outcomes of EGS patients are consistent with prior experience with NSQIP and TQIP.[7–10] Conceptually, a patient's outcome depends on two components: those attributable to the patient and those attributable to the quality of care received. Patient attributes that can influence their outcome include age, comorbidities, and severity of diseases. We have attempted to account for patient attributes through a robust risk-adjustment methodology. Hence, differences in patient outcomes across hospitals are likely related to differences in processes and quality of care at these hospitals.

Currently, there are no specific requirements for hospitals to provide EGS care. In fact, every acute care hospital with a general surgeon on staff is expected to be able to care for all EGS patients. This situation is very similar to trauma surgery until the 1970s, when every hospital with an emergency room was expected to be able to care for patients with major injuries. Experience with trauma over the last four decades has shown that injured patients are more likely to survive at designated trauma centers than at non-trauma hospitals.[21] An essential part of this evolution was the development of optimal resources document by the American College of Surgeons.[22] This document clearly states the resources that a hospital should have to provide optimal care for injured patients. Our findings show that over half of the deaths that occurred at high and average mortality hospitals could be considered more than expected if these patients were treated at low mortality hospitals. We need to identify the tools used at low mortality hospitals, so they may be replicated at high replicated hospitals. In other words, there is a need to develop a document that provides a comprehensive list of resources that hospitals must have to provide optimal care to EGS patients.

This evolution to dedicated EGS service lines is already occurring at many hospitals. Our findings show that low mortality hospitals were more likely to be large, urban, academic medical centers, with a high volume of EGS patients. This may be related to the fact that over the last decade, EGS has been organized as a distinct clinical service line at large academic medical centers. Such hospitals may have dedicated resources specifically for EGS patients. These resources may include distinct teams of surgeons and other clinical providers, 24/7 availability of operating rooms and personnel, data registry, performance improvement process, and clinical practice guidelines. An important consideration is availability of trained surgical manpower. A long-standing trend toward subspecialization has left a void of true "general surgeons" who may be able to handle most EGS. Acute Care Surgery Fellowships have been started recently to fill this gap. An EGS data registry that captures patient demographics, clinical information, and outcomes is absolutely essential for quality improvement. Although we do not have specific data, we believe that such organization exists at a small minority of hospitals. We also believe that there is a need for a document that outlines optimal resources for the care of EGS patients. Such a document may form the basis for a verification process in the future, as well as a regional system of EGS care, similar to Trauma.

The study has a few limitations that should be recognized. It is a retrospective analysis of an administrative database with all its inherent limitations. NIS consists of administrative data captured at discharge, and not clinical data. There are no data on anatomic severity of disease or physiologic status of the patient, both of which have significant impact on patient outcomes. Also, we do not have any data on other outcomes, such as readmissions, costs, reoperations, complications, resource utilization, and functional outcomes of survivors. Future EGS databases should attempt to capture these outcomes. Similarly, we have limited information on various characteristics of the hospitals. Specifically, we do not have any information on quality or timeliness of care provided to these patients. Nor do we have any information on social determinants of health, such as family support, education level, personal habits, and so on. However, our findings should spur further research into specific structures and processes of care that can impact the outcomes of EGS patients. Also, each record in the NIS database represents one hospitalization. Hence, it is possible for an EGS patient with multiple hospitalizations to be counted multiple times, for example, if the patient was transferred to another hospital, and both hospitals were sampled in NIS. Lastly, the findings are based on 2010 data, and patient outcomes at specific hospitals are likely to change over time.

## CONCLUSION

In conclusion, we have demonstrated significant variations in risk-adjusted mortality rates of EGS patients across hospitals, with several thousand more deaths than expected. Based on the success of NSQIP and TQIP, we recommend establishing EGS Quality Improvement Program by an organization led by surgeons. EGS Quality Improvement Program will provide risk-adjusted benchmarking of hospitals for EGS patients. It will spur performance improvement efforts at participating hospitals, similar to the successes of NSQIP and TQIP, perhaps leading to the development of a document outlining optimal resources required for the care of patients with EGS diseases.

### AUTHORSHIP

G.O. contributed to the literature search, study design, data collection, data analysis, data interpretation, writing, and critical revision of the article. M.C. and S.S. contributed to the study design, data interpretation, writing, and critical revision of the article.

### DISCLOSURE

The authors declare no conflicts of interest.

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## DISCUSSION

**Dr. John J. Fildes** (Las Vegas, Nevada): Drs. Davis and Burlew, members and guests, good morning to all of you. I'd like to thank the AAST for the opportunity to discuss this paper and to the authors for providing me with this powerful manuscript well in advance of the meeting.

The authors hypothesize that there is significant variation in mortality, mortality being the ultimate outcome indicator, and that EGS patients were treated unequally given risk-adjusted outcome measures.

They analyzed the National Inpatient Sample and demonstrated a significant difference between low- and high-mortality hospitals. They actually showed that there was greater than three times the mortality difference between low- and high-mortality hospitals and that there were thousands of potentially preventable deaths in that mix.

We have heard over the last few days that emergency general surgical cases represent about 14 percent of all surgical cases that are done. They are responsible for 50 percent of surgical mortality. And that of the EGS cases that are done, 80 percent of them fall into 7 procedures.

We have also heard other authors during the week talk about problems with the delivery of EGS. Now we know that the mortality is more than three times different between high- and low-performing centers.

This level of variation really resembles that that was seen in general surgery, in the cardio-thoracic surgery, and in trauma over the past decades, prior to the introduction of NSQIP, TQIP, and before the development of verifiable standards and robust performance improvement strategies.

In 1966 the National Academy of Science published *Accidental Death and Disability, A Neglected Disease of Modern Society.* This was a call to action.

This was a revolutionary way of thinking about injury care. It changed the way that we viewed and managed injury. And it served as a landmark in the development of trauma systems and EMS.

We have not had a similar call to action for emergency general surgery in this country. As a professional organization, we have devoted much time and effort to the improvement of emergency general surgery. But, yet, at the policy-making level that thought is not part of the fabric of public health. I say to you that emergency general surgery is, in fact, a neglected disease of this modern society.

For the authors: The most important question I have today is how do we use these findings to change the way that emergency general surgery is practiced in a systematic way?

Will these findings catalyze the development of systems of care that are defined by unique structures, processes, outcomes, and data?

Thank you very much for the opportunity to discuss this paper.

**Dr. Joseph P. Minei** (Dallas, Texas): Shahid, very, very nice work, as usual. You gave us a number of 668, I believe, operations was the threshold for better or worse care.

Do we have any idea if that number, as it increases, further improves care? If you do 1,200 operations or 1,800 operations do we continue to see benefit in terms of outcome? Thank you.

**Dr. Anthony A. Meyer** (Chapel Hill, North Carolina): Tony Meyer from Chapel Hill. I expand on Dr. Fildes' comment. I think this is exceedingly important.

It's a new direction for this organization to go. And I think that one thing is that we can use the data in many ways. The key is the people that are going to drive this.

And the new generation in this room are going to have to be the ones that, like the previous generation developed the trauma registries and developed trauma systems, this is going to have to be their responsibility and their challenge to really make emergency general surgery the equivalent of trauma.

**Dr. Jeffrey G. Chipman** (Minneapolis, Minnesota): Jeff Chipman from Minneapolis. I applaud your efforts in trying to create or propose the idea of EQIP.

I would add the importance, though, of taking into account patient choice. There is a lot of parts of rural America where patients faced with these issues have the opportunity to be transferred to a higher level of care but choose not to.

For example, in Minneapolis there are people who say they have never been to the "big city" and by "big city" they mean Duluth, Minnesota.

**Dr. Garth Utter** (Sacramento, California): Utter, Sacramento. Nice work, Shahid. Do you have a sense of how the caterpillar plot might flatten if you focused only on those centers that would likely participate in an EQIP program?

As you alluded to, lots of centers don't and they are probably unlikely to participate in this program, as well, if it were started.

So, in other words, what are the proportions that would be in the "high" and "low" performing categories if you focused only on those centers that had either high volume or were large centers?

**Dr. Shahid Shafi** (Dallas, Texas): Dr. Fildes' indicated that EGS is a neglected disease of our times and what are the next steps.

 

We are fortunate to live in a time where we have learned from the experiences from NSQIP. We have learned from the experiences of TQIP. And we have over 40 years of experience from the verification process for trauma centers.

The next step is to develop an optimal resources document for EGS that outlines what it is that we expect EGS centers to be able to provide for its patients; and, in fact, there is an active movement at AAST to develop a document like that.

Another important step is to develop an EGS registry using standardized definition, standard data dictionary and fields, and a grading system. This concept is also being put in place.

There is a need to develop and implement standardized treatment protocols. Again, I'm not telling you anything that you guys don't already know. All these pieces are floating around; we just need to put them together into a service line or a service structure, just like we have done for trauma.

Do we foresee a verification system for EGS? I am not able to answer that question.

Do we need a regionalization system of EGS care, especially going to the question about patients in rural Minnesota or rural parts of Texas?

We we should not take the choice away from the patients.

But we should make sure that the hospital that they are walking into is able to provide the minimum resources required to care for those patients.

So I think every hospital that takes care of EGS patients needs to take a conscious decision to figure out what kind of patients they want to treat, what are the resources they have to treat their patients, and what are they going to do if they come across a patient that they can't treat. How will they transfer those patients to a higher level of care?

Whether we use the term "verification" or not is not important. Whether we use the term "regionalization" or not is not important. What is important is to have a process in place so that the right patient gets the right care at the right time at the right place.

And to answer the other questions, Dr. Minei, higher volume of EGS patients, exceeding 668 patients per year, at a center has been associated with reduced mortality.

But I want to qualify by saying that the number 668 was not for operative cases. Number 668 was for all EGS cases which included operative and non-operative patients.

At this conference, there was a paper presented about EGS operative volume and outcomes, which showed –different thresholds for different diseases.

And to answer Dr. Utter's question about how many centers will participate and will it flatten the caterpillar chart, and, of course, that will happen.

What is most interesting to me is that almost a decade ago, the first time when we showed variations in outcomes at trauma centers, people didn't believe us. And now here we are.

In 2017 we're talking about variations in outcomes of EGS patients and nobody questions the validity of the findings. And we are focusing on how we are going to act on it and what are we going to do next to improve patient outcomes.

This is our call to action. And I'm very proud that we have reached that stage in our evolution.

Thank you very much.