The Society of Thoracic Surgeons General Thoracic Surgery Database 2017 Update on Outcomes and Quality

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The Society of Thoracic Surgeons General Thoracic Surgery Database (STS GTSD) is a voluntary effort that provides participants with risk-adjusted semiannual performance reports that allow comparison of institutional outcomes against national benchmarks. With nearly 1,000 surgeons contributing data from more than 300 centers across North America, the STS GTSD now includes almost a half million cases. In 2016, updated risk models for lung resection and esophagectomy for cancer were reported, and composite quality measures for lobectomy and esophagectomy were developed. Ongoing efforts include upgrading the STS GTSD, establishing public reporting of lobectomy for lung cancer composite scores, creating an on-line dashboard, and strengthening international collaboration with the European Society of Thoracic Surgery Registry. With these initiatives, the STS GTSD aims to continue to improve quality of care and support research endeavors in general thoracic surgery. This article summarizes current aggregate national outcomes in general thoracic surgery and reviews related activities in the areas of quality measurement, performance improvement, and transparency from the STS GTSD during the past 12 months.

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The Society of Thoracic Surgeons General Thoracic Surgery Database (STS GTSD) is the largest clinical thoracic surgical database in the world [1]. Established in 2002, the STS GTSD is a voluntary effort that provides participants with risk-adjusted semiannual performance reports that allow comparison of institutional outcomes against national benchmarks. The overarching mission of the STS GTSD is to support quality improvement, outcomes analysis, and research in general thoracic surgery.

The STS GTSD Task Force completed multiple projects in 2016 and has undertaken new initiatives to improve the quality of thoracic surgical care, upgrade the database, and expand international collaboration. Updated risk models for lung resection and esophagectomy for cancer were reported, and composite quality measures for lobectomy and esophagectomy were developed. The STS GTSD Task Force is also in the process of upgrading the database and improving synchronization with the European Society of Thoracic Surgery (ESTS) Registry. In addition, similar to the STS Adult Cardiac Surgery Database (ACSD) and Congenital Heart Surgery Databases (CHSD), the STS GTSD has initiated public reporting of composite scores and will begin using an on-line reporting dashboard this year. This review summarizes all of the national aggregate outcome, quality measurement, and improvement initiatives from the STS GTSD during the past 12 months.

Database Participation

Similar to the STS ACSD and STS CHSD, participation in the STS GTSD has increased each year since its inception, with 306 participants submitting data for the Fall 2016 Data Analysis Report (July 2013 through June 2016). As of February 6, 2015, the STS GTSD included data from 919 physicians (892 thoracic surgeons, 1 pulmonologist, and 26 general surgeons) at 279 United States institutions in 43 states, for a total of 482,432 operations. In addition, the STS GTSD currently has nine participation agreements pending. Two international sites, the United Arab Emirates and Singapore, also currently contribute data to the STS GTSD.

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Revised Lung and Esophageal Cancer Resection Risk Models

In 2016, the STS GTSD Task Force published revised lung and esophageal cancer resection risk models [2, 3]. These models are necessary to allow accurate risk adjustment when comparing institutional outcomes across the country. The first lung resection model was created in 2008 and updated in 2010, the same year that the initial esophagectomy risk model was published [4–6]. However, the field of general thoracic surgery is evolving, and surgeons continue to expand the indications for minimally invasive approaches to lung and esophageal resection [7]. Furthermore, improved penetrance of the STS GTSD and regular data auditing has resulted in a more robust and reliable data set [8, 9].

To update the lung cancer resection risk model, all pulmonary resections for primary lung cancer captured in the STS GTSD between 2012 and 2014 were examined [2]. This included 28,473 patients from 231 institutions who underwent wedge resection, segmentectomy, lobectomy, sleeve lobectomy, bilobectomy, or pneumonectomy. Multivariable logistic regression analyses were used to create separate risk models to predict major morbidity, mortality, and composite major morbidity or mortality.

The overall 30-day mortality rate was 1.5%, the major morbidity rate was 9.1%, and the composite major morbidity or mortality rate was 9.5%. Predictors of operative death included age, male gender, forced expiratory volume in 1 second, low body mass index (BMI), cerebrovascular disease, steroids, coronary artery disease, peripheral vascular disease, renal dysfunction, Zubrod score, American Society of Anesthesiologists Physical Status Classification, thoracotomy approach, induction therapy, reoperation, tumor stage, and greater extent of pulmonary resection. Predictors of major morbidity included age, male gender, low BMI, steroids, coronary artery disease, peripheral vascular disease, reoperation, forced expiratory volume in 1 second, induction therapy, cigarette smoking, Zubrod score, American Society of Anesthesiologists classification, and thoracotomy approach. For the composite morbidity and mortality model, similar predictors were identified as in the morbidity model.

To revise the STS esophagectomy risk model, 4,142 patients who underwent esophagectomy for cancer at 164 participating centers between 2011 and 2014 were examined [3]. Ivor Lewis esophagectomy was the most common operation (32.5%), followed by transhiatal esophagectomy (21.7%) and minimally invasive Ivor Lewis esophagectomy (21.4%). The 30-day major morbidity rate was 33.1% and the mortality rate was 3.1%. Minimally invasive Ivor Lewis esophagectomy demonstrated a survival advantage over open Ivor Lewis esophagectomy (odds ratio, 0.52; 95% confidence interval, 0.30 to 0.92; $p = 0.04$) in the mortality analysis but not in the composite model. Predictors of composite major morbidity or mortality include age older than 65, congestive heart failure, Zubrod score exceeding 1, past or current smoking status, BMI exceeding 35 kg/m^2, and McKeown esophagectomy.

The 2016 revisions of the STS lung and esophageal cancer resection risk models demonstrate that rates of major morbidity and mortality are low among STS GTSD participants and provide updated predictors of adverse outcomes. Identification of these predictors will allow appropriate risk-stratification based on individual patient characteristics and will be useful in measuring institutional variation in performance.

Lobectomy and Esophagectomy Composite Performance Measures

Although the STS ACSD has developed multidimensional composite performance measures for coronary artery bypass grafting, aortic valve replacement, and coronary artery bypass grafting combined with aortic valve replacement [10–12], until this year, no general thoracic surgery composite measure had been reported. Because of its frequency in the STS GTSD, lobectomy for lung cancer was chosen as the first thoracic composite quality measure. To achieve this, 20,657 patients were examined who underwent lobectomy at 231 institutions between 2011 and 2014 [13]. Participant-specific risk-adjusted major morbidity and mortality rates were estimated using Bayesian hierarchical modeling. Covariates were based on the most recently published lung cancer resection risk model [2], and death was weighted approximately four-times greater than a major morbidity [12].

STS GTSD participants were categorized as 1-, 2-, or 3-star programs based on their lower-than-expected, expected, or a higher-than-expected composite score, respectively. To be a 1-star or 3-star program, the 95% credible interval (CrI) had to fall entirely below or above the STS average score. This categorized 4.7% (n = 8) of participants as 1-star and 7% (n = 12) as 3-star programs. When only centers performing 30 or more lobectomies during the 3-year study period were examined, the reliability of the STS lobectomy composite performance measure was 56% (95% CrI, 45% to 66%), which is similar to that of the STS aortic valve replacement plus coronary artery bypass grafting composite measure [12]. This volume threshold allows a star rating to be assigned to approximately 75% of participants, with the remainder having insufficient information to provide a meaningful rating. These data are reported to each STS GTSD participant in the semiannual institution-specific performance summary.

On the heels of the STS lobectomy composite performance measure, the STS GTSD Task Force set out to develop a STS esophagectomy composite outcome measure. To achieve this, 4,321 patients who underwent esophagectomy for esophageal cancer at 167 institutions between 2012 and 2014 were identified for analysis [14]. A two-domain quality measure using risk-adjusted mortality and any-or-none major morbidity was developed, and outcomes were compared to the National Inpatient

Sample (NIS). Bayesian hierarchical modeling methodology, similar to that used to create the lobectomy [13], aortic valve replacement [11], and mitral valve operative [15] composite measures, was applied.

The covariates examined in the model were the same as those used to create the 2016 esophagectomy risk model [3], and included age, gender, race, BMI, American Society of Anesthesiologists class, Zubrod score, smoking history, hypertension, congestive heart failure, coronary artery disease, peripheral vascular disease, steroid use, diabetes mellitus, renal dysfunction, induction therapy, and clinical stage. A composite score was calculated as a weighted sum of a mortality score (1 minus the risk-adjusted mortality rate) and a major morbidity score (1 minus the risk-adjusted morbidity rate). The average STS participant composite score was 90.6, varying from 83.5 to 95.5. Participants were classified as a 1-star program if their 95% CrI fell below the STS average composite score and as a 3-star program if their 95% CrI fell above the STS average score.

Of the 164 database participants examined, only 70 (43%) contributed an average of five or more esophagectomies per year during the study period (Fig 1). An analysis of only these 70 centers yielded a composite score reliability of 58% (95% CrI, 42% to 72%), with 5 participants (7.1%) being categorized as a 3-star, 63 (90%) as a 2-star, and 2 (2.9%) as a 1-star program (Fig 2). The unadjusted STS GTSD outcomes compare favorably with data for 2,725 patients who underwent esophagectomy for esophageal cancer from the 2012 NIS, with comparable discharge mortality and shorter postoperative length of stay during a similar time period (Table 1). Using the current model, only institutions that perform an average of five or more esophagectomies per year will be eligible to receive a star rating for esophagectomy.

STS GTSD Public Reporting

As of spring of 2017, STS GTSD participants have the option of enrolling in voluntary public reporting of lobectomy for lung cancer composite measure scores on the STS Web site [16]. The STS ACSD initiated public reporting in 2010, followed by the STS CHSD in 2015. In the first stage of STS GTSD public reporting, a list of participating institutions and associated surgeons was published on the STS Web site in January 2017. These outcomes are also compared with the NIS outcomes, as demonstrated on the STS Web site (Fig 3). STS GTSD participants have demonstrated lower in-hospital mortality and hospital length of stay than that observed in the NIS [17]. By reporting the excellent outcomes of STS GTSD participants relative to the NIS, the STS GTSD Task Force hopes to encourage participation and database penetrance. The STS lobectomy composite measure facilitates accurate comparison of STS GTSD participants, encourages quality assessment, and provides meaningful comparison to national benchmarks.

The STS GTSD plans to publicly report participant-level outcomes for lobectomy compared with the STS and national outcomes in the summer of 2017. Discharge mortality, median postoperative length of stay, and a two-domain lobectomy composite measure (including risk-adjusted mortality and major complications) will be reported for consenting programs.

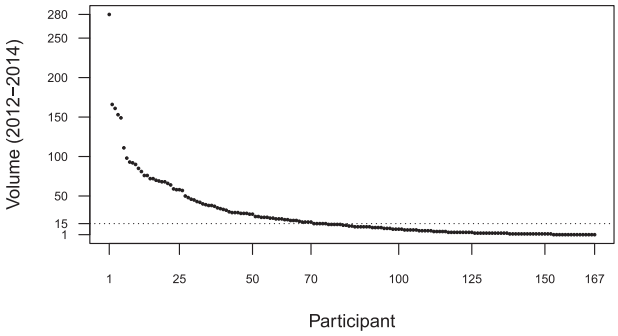

Fig 1. Esophagectomy operative volume for the 167 participants in The Society of Thoracic Surgeons General Thoracic Surgical Database (2012 to 2014). (Reprinted from Chang et al [14] with permission from The Annals of Thoracic Surgery.)

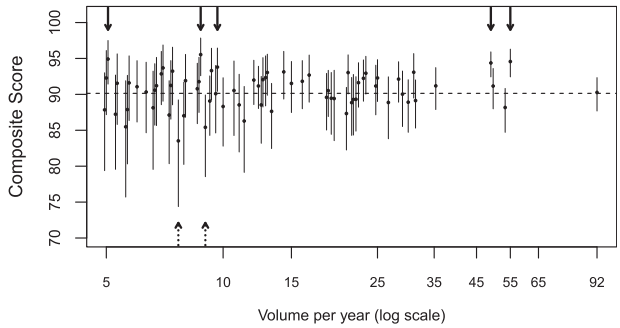

Fig 2. Distribution of The Society of Thoracic Surgeons General Thoracic Surgical Database esophagectomy composite score, sorted by increasing operative volume (2012 to 2014). The 3-star programs (n = 5; solid arrows) performed better than average, and 1-star programs (n = 2; dashed arrows) performed worse than average. Gray range bars indicate the 95% Credible Interval. (Reprinted from Chang et al [14] with permission from The Annals of Thoracic Surgery.)

Table 1. Comparison Between The Society of Thoracic Surgeons General Thoracic Surgery Database and National Inpatient Sample Unadjusted Outcomes for Esophagectomy[a]

Outcome	STS (2012–2014)	NIS (2012)
Discharge mortality, No.	4,321	2,725
Percent (No.)	2.7 (118)	3.6 (185)
95% CI, %	2.3–3.3	2.4–4.7
Postoperative length of stay, No.	4,311	2,725
Mean days (95% CI)	13.8 (13.4–14.2)	15.5 (14.3–16.2)
Median days (IQR)	10.0 (8.0–14.0)	9.9 (7.6–15.3)

[a] Reprinted from Chang et al [14] with permission from *The Annals of Thoracic Surgery*.

CI = confidence interval; IQR = interquartile range; NIS = National Inpatient Sample; STS = The Society of Thoracic Surgeons.

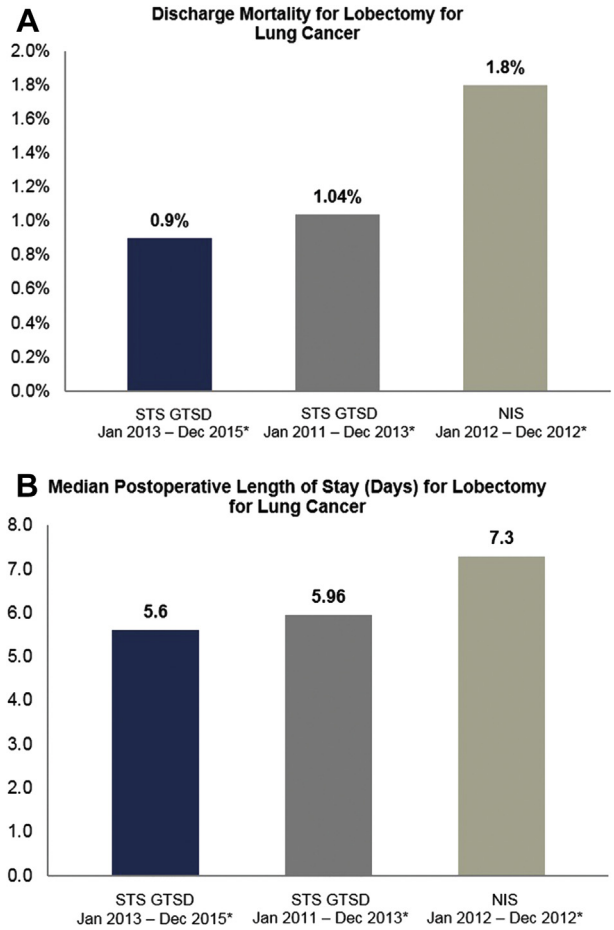

*Fig 3. (A) Discharge mortality for lobectomy for lung cancer in The Society of Thoracic Surgeons General Thoracic Surgical Database (STS GTSD) and the National Inpatient Sample (NIS), and (B) median postoperative length of stay (days) for lobectomy for lung cancer in the STS GTSD and the NIS [16]. *These NIS data are the most recent data available. There are more lobectomy for lung cancer patients in a single year of NIS data than in the STS GTSD, therefore 3 years of GTSD data were used.*

The STS GTSD Upgrade

Every 3 years, the STS GTSD Task Force updates the database fields. The objective of the upgrade is to capture additional data that will be useful for future quality improvement initiatives and eliminate less important variables. The STS GTSD Task Force met at the STS 53rd Annual Meeting in Houston, Texas, to discuss potential changes. In addition to the collection of 5-year follow-up data and the addition of histology fields, each section of the data collection form was critically examined for potential improvements.

Subcommittees were formed to submit upgrade recommendations for each of the following sections: (1) demographics, preoperative evaluation, and comorbidities, (2) lung cancer staging, (3) esophageal cancer staging, (4) benign esophagus, (5) mediastinum, (6) diagnosis and operating room, (7) major and minor procedures, and (8) postoperative events, discharge, quality measures, and reason for readmission. Many agreed-on changes are likely to be incorporated into the updated data collection form, including updating the staging system to conform to the Eighth Edition of the American Joint Committee on Cancer staging system. Input from database managers will be sought and incorporated after the STS GTSD Task Force agrees on the proposed upgrades. Materials will be provided to vendors in the summer of 2017, and the updated database is planned to go live on January 1, 2018. In addition, the STS GTSD will transition from intermittent to continuous data harvesting on June 5, 2017. Continuous data harvesting allows participants to continuously upload data to the data warehouse as opposed to the biannual data submissions that currently occur.

Advances in Quality and Outcomes Meeting

In an ongoing effort to improve the quality of the data in the database, the STS hosts an annual Advances in Quality and Outcome meeting for database managers. The purpose of this meeting is to improve data collection and advance participant database coding skills. This year, the Advances in Quality and Outcome meeting was held in Baltimore and used a case-based learning format. STS GTSD Task Force members teamed with database managers to describe the STS GTSD audit process, the thoracic composite performance models, and the revised lung resection and esophagectomy risk models. In addition, a focus was placed on data abstraction requirements for lung and esophageal cancer, including diagnosis, staging, surgical procedures, and complications.

Understanding the Surgeon Learning Curve for Minimally Invasive Lobectomy

The STS GTSD Task Force has undertaken an initiative, led by Dr Varun Puri, to understand the learning curve and process of attainment of proficiency in minimally invasive lobectomy across participating programs. Cumulative sum analysis, a technique based on sequential monitoring of cumulative performance over a time period, resulting in real-time monitoring of performance, is being used for this purpose. Classic cumulative sum analyses evoke trainer-defined variables to measure a trainee's proficiency at an assigned task and iterate this measurement for subsequent repetitions. By incorporating risk adjustment for variables predictive of success, cumulative sum analysis becomes a powerful and valid evaluative tool. It allows programs and, potentially, individual practitioners to be evaluated in an anonymous manner. Both process measures, such as duration of operation, conversion to open, and intraoperative blood transfusion, and outcomes measures, such as major morbidity and length of stay, can be used to define success. The primary outcome will be the number of cases or time to reach proficiency in video-assisted thoracoscopic or robotic lobectomy.

Currently, STS GTSD data are being analyzed to identify an appropriate cohort of patients to study. The STS GTSD Task Force expects that the project will define a threshold at which video-assisted thoracoscopic

lobectomy programs become proficient and achieve stable and good outcomes.

Collaboration With the ESTS

During the past 5 years, collaboration between the STS GTSD Task Force and the ESTS Registry Task Force has proven to be a productive endeavor. Representatives from both Task Forces have attended each other's annual conferences for a joint meeting to discuss current tasks and to brainstorm for future projects. This relationship has resulted in multiple undertakings, with the overall goal of improving quality of care for thoracic surgical patients worldwide.

Differences in data fields and variations in definitions hindered initial attempts to compare patients in the STS GTSD with patients in the ESTS Registry. This early realization prompted the identification and harmonization of more than 60 core variables by members of the STS GTSD Task Force and the ESTS Registry Task Force [18]. Although this harmonization facilitated an intersocietal comparison of pulmonary resection practices and short-term outcomes between the STS GTSD and the ESTS Registry [7], it became clear that many definitions remained discrepant (Table 2). For example, unlike the ESTS Registry, the STS GTSD collects data on preoperative steroid use, postoperative sepsis, and various quality measures. Conversely, the ESTS Registry collects variables that are not in the STS GTSD, including Medical Research Council dyspnea scale, predicted postoperative forced expiratory volume in 1 second (%) and diffusion capacity of the lung for carbon monoxide (%), and acute postoperative heart failure. Meanwhile, the definitions of certain data points vary between databases, including preoperative chronic kidney disease and how preoperative radiotherapy is defined.

To develop future projects with clinical and educational relevance, the STS GTSD and the ESTS Registry Task Forces have agreed to improve harmonization of the ESTS Central Lung Database with the STS GTSD. This initiative will set a foundation for intersocietal collaboration, facilitate accurate data merger, and enable meaningful intercontinental studies.

Table 2. Examples of Discrepancies Between The Society of Thoracic Surgeons General Thoracic Surgery Database and the European Society of Thoracic Surgery Central Lung Registry

STS GTSD Only	ESTS Registry Only	Different Definitions
Preoperative steroid use	MRC score	Chronic kidney disease
Postoperative sepsis	ppo FEV_1, %	Preoperative radiotherapy
Smoking counseling	ppo DLCO, %	
IV antibiotics within 1 hour of incision	FVC, %	
DVT prophylaxis	Acute heart failure	

DLCO = diffusion capacity of the lung for carbon monoxide; DVT = deep venous thrombosis; ESTS = European Society of Thoracic Surgery; FEV_1 = forced expiratory volume in 1 second; FVC = forced vital capacity; IV = intravenous; MRC = Medical Research Council; ppo = predicted postoperative; STS GTSD = The Society of Thoracic Surgeons General Thoracic Surgery Database.

Initiatives for 2017

The STS GTSD has several projects scheduled for 2017. There are plans to optimize the biannual feedback reports provided to institutions with each data harvest. Attempts to shorten the report, with a focus on the most important and relevant risk-adjusted data, will allow participants to better understand and use their data. In addition, on-line dashboard reporting, similar to that piloted by the STS ACSD is planned by mid-2017.

Furthermore, multiple collaborative projects with the ESTS Registry are underway. This partnership will be facilitated by database harmonization and creation of the first intersocietal legal documents that abide by international data transfer regulations. The relationships being forged between the STS GTSD and ESTS Registry Task Forces set the stage for Delphi processes investigating intercontinental best care practices in general thoracic surgery. Working with and learning from additional international databases remains a priority of the STS GTSD. Such partnerships will make more data available for study and provide international perspectives, with the universal goal of improving the quality of care for general thoracic surgical patients.

Finally, the STS GTSD continues to work to improve database penetrance across North America. Many general surgeons and cardiac surgeons perform general thoracic surgical procedures that are not captured in the STS GTSD. This is reflected in the fact that nearly 25% of programs could not be assigned a lobectomy star rating. Similarly, because 57% of programs could not be assigned an esophagectomy star rating with the current model, further refinement would be needed before being considered as a publicly reported quality measure. Increased participation in the GTSD would permit a more valid and broadly applicable rating system [13, 14]. Public reporting of STS GTSD participants' excellent outcomes relative to the NIS may encourage improved penetrance and program participation in the future. In addition, steps to simplify data entry and focus the scope of the STS GTSD are being considered to reduce the number of procedures that require data entry and therefore, reduce the burden/cost of participation.

Conclusions

The STS GTSD Task Force had another busy year in 2016. With a growing number of participants and higher-quality audited data, revised risk models for lung resection and esophagectomy for cancer were reported, and composite quality measures for lobectomy and esophagectomy were developed. Ongoing efforts in 2017 will focus on upgrading the STS GTSD, further

establishing public reporting, the roll-out of on-line dashboard reporting, and strengthening international collaboration with the ESTS Registry. With these initiatives, the STS GTSD aims to continue to improve quality of care and support research endeavors in general thoracic surgery.

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