Published in final edited form as:

Ann Thorac Surg. 2014 November ; 98(5): 1769–1775. doi:10.1016/j.athoracsur.2014.06.024.

Thirty-Day Mortality Underestimates the Risk of Early Death after Major Resections for Thoracic Malignancies

Robert R. McMillan, MD, MPH, Alexandra Berger, BS, Camelia S. Sima, MD, MS, Feiran Lou, MD, Joseph Dycoco, BA, Valerie W. Rusch, MD, Nabil P. Rizk, MD, David R. Jones, MD, and James Huang, MD

Department of Surgery, Thoracic Service, Memorial Sloan-Kettering Cancer Center, New York, New York

Abstract

Background—Operative mortality rates are of great interest to surgeons, patients, policy makers, and payers as a universal metric for quality assessment. Thirty-day mortality and discharge mortality have been presumed to capture procedure-related mortality. However, many patients die after the 30-day mark or are transferred to other facilities or to home and die there, leading to the underreporting of surgery-related deaths. We hypothesized that a longer period of observation would address these concerns and provide a more accurate measure of operative mortality.

Methods—We performed a retrospective review of prospectively maintained institutional databases of patients undergoing resection for lung cancer, esophageal cancer, and mesothelioma.

Results—From 1999 to 2012, 7646 surgical resections were performed: 6119 for lung cancer, 1258 for esophageal cancer, and 269 for mesothelioma. Among the different cancers and across operations, the additional mortality from day 31 to 90 (1.4% [95% CI, 1.2% to 1.8%]; n=111) was similar to that by day 30 (1.2% [95% CI, 1.0% to 1.5%]; n=95), resulting in overall 90-day mortality (2.7% [95% CI, 2.3% to 3.1%]; n=206) that was more than double 30-day mortality. Respiratory failure, sepsis, and cardiac events were the leading causes of death after thoracic resection.

Conclusions—Among patients who have undergone surgery for thoracic malignancies, considerable mortality attributable to surgery occurs beyond the first 30 days after surgery, as well as after hospital discharge. As cancer surgery constitutes a large portion of general thoracic surgery, we recommend national databases consider the inclusion of 90-day mortality in their data collection.

Keywords

Mortality; Outcomes; Thoracic; Lung Cancer; Esophageal Cancer; Mesothelioma

Introduction

Operative mortality rates are of interest to a variety of stakeholders, including surgeons, patients, policy makers, and payers, as they serve as a universal metric for the assessment of quality. The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database defines operative mortality as any death within 30 days of an operation [1]. The Society of Thoracic Surgeons (STS) National Database includes both 30-day mortality and discharge mortality, which includes any in-hospital deaths following a procedure during that hospitalization [2].

These measures provide surgeons a benchmark for performance, and most of the published literature considers these outcomes from the surgeon's perspective. There has been a growing interest in patient-centered outcomes, most recently championed by the Institute of Medicine in its 2013 report on cancer care [3]. From the perspective of the patient, 30-day and discharge mortality rates provide an important estimate of risk, as they weigh the purported benefits of an operation against the potential for unintended complications and death. An accurate assessment of the risk involved in a given procedure is crucial, and 30-day mortality is the most common estimate of this operative risk.

The 30-day interval has generally been presumed to be proximal enough to the procedure to capture mortality attributable to it. However, others have suggested that a period of 90 days may be more appropriate [4–6]. The fact that Medicare reimbursement for major surgical procedures includes all care during the first 90 days after the operation highlights the belief that care, and hence risk, does not end at 30 days.

Patients with thoracic malignancies tend to be older and have more comorbid illnesses, resulting in a diminished reserve to tolerate adverse events. Critically ill postoperative patients may experience protracted hospital courses only to die after the 30-day mark, whereas others may be transferred to outside facilities and die there. Other patients may be discharged after surgery only to be readmitted with complications that lead to their death. Finally, patients may be successfully discharged and then die unexpectedly at home. None of the deaths in these scenarios would be captured in either the 30-day or the discharge mortality statistics. This leads to the underreporting of deaths related to surgery. Additionally, the increased scrutiny of outcomes introduces a potential perverse incentive to prolong the life of a dying patient past the 30-day barrier or to transfer the patient to another facility before 30 days has passed.

We hypothesized that 30-day mortality rates underestimate the risk of early mortality for patients undergoing surgery for thoracic malignancies. We reviewed our perioperative experience across three cancers (lung cancer, esophageal cancer, and mesothelioma) and six different procedures in terms of early mortality, readmissions, cause of death, and location of death.

Methods

We retrospectively analyzed our prospectively maintained databases of surgical resections for lung cancer, esophageal cancer, and mesothelioma performed between January 1, 1999,

and August 6, 2012, at Memorial Sloan-Kettering Cancer Center. The procedures for lung cancer included sublobar resection (wedge resection/segmentectomy), lobectomy, and pneumonectomy. Bilobectomies were included in the lobectomy group. The resections for esophageal cancer included McKeown, Ivor Lewis, and transhiatal esophagectomy. Those for mesothelioma included extrapleural pneumonectomy and pleurectomy/decortication. Patients 18 years of age or older were included in the analysis. Deaths after palliative procedures were excluded.

Data on patient mortality were obtained from the medical record—including patient charts, death certificates, and family notifications—and were cross-referenced against the Social Security Death Index. Clinical characteristics were abstracted from patient charts. The study was approved by Memorial Sloan-Kettering's institutional review board, which waived the requirement for individual consent (IRB# WA0134-13).

To mirror the Medicare global payment period of 90 days, perioperative mortality was examined separately from two periods: from postoperative day (POD) 0 to 30 and from POD 31 to 90. Total 90-day mortality was also calculated. For each interval, mortality was calculated as the proportion of deaths out of all patients alive at the beginning of the interval. The level of significance for all tests was set at $p < 0.05$, and 95% confidence intervals (CIs) were generated. STATA version 12 (StataCorp LP, College Station, TX) was used to perform all statistical analyses.

Results

During the study period, 7646 patients underwent resection for lung cancer, esophageal cancer, or mesothelioma. The median length of follow-up for the cohort was 23.3 months. The proportion lost to follow-up from POD 0 to 30 was 0.8%, and from POD 31–90 the proportion lost to follow-up was 1.5%.

Patient Characteristics

In total, 6119 patients underwent resection for lung cancer, 1258 underwent esophagectomy, and 269 underwent resection for mesothelioma. Patient characteristics are presented in Table 1. More women (58%) than men underwent lung resections; however, men represented more than 75% of the esophageal and mesothelioma resections. The mean patient age was 66 years. The median length of stay (LOS) overall, across all procedures, was 6 days. The median LOS was shorter for lung cancer operations (5 days) than for malignant pleural mesothelioma operations (7 days) or esophageal cancer operations (11 days). Across all patients, 3% (231/7646) had an LOS >30 days. The LOS exceeded 30 days in 10% of resections for esophageal cancer and 12% of resections for mesothelioma (Table 1). Almost one-third of resections included a reported complication during the index hospitalization. Comorbid cardiopulmonary disease was common, with the highest prevalence of cardiac (23%) and pulmonary (34%) disease occurring among the lung cancer cohort.

Mortality Calculations

Data on perioperative mortality for POD 0–30 and POD 31–90 are presented in Table 2. Overall, 95 deaths occurred during POD 0–30, and 111 deaths occurred during POD 31–90,

resulting in a mortality rate of 1.2% (95% CI, 1.0% to 1.5%) for POD 0–30 and 1.4% (95% CI, 1.2% to 1.8%) for POD 31–90. The overall mortality rate for POD 0–90 was 2.7% (95% CI, 2.3% to 3.1%). For nearly all types of resections, the number of additional deaths occurring during POD 31–90 was similar to the number occurring during the first 30 days. Sublobar resections had the lowest mortality rate (POD 0–30, 0.7%; POD 31–90, 0.7%); extrapleural pneumonectomy had the highest (POD 0–30, 2.6%; POD 31–90, 8.7%).

Common Postoperative Complications and Causes of Death

The most common causes of death, by type of disease and postoperative interval, are shown in Table 3. Isolating a single root cause of death was not always possible. In 46 cases, more than one factor contributed to death. Cause of death was able to be determined for the majority of cases (154 [75%]), representing 88% of deaths during POD 0–30 and 64% of deaths during POD 31–90.

Respiratory failure, sepsis, and cardiac events were the leading causes of death after thoracic resection. In 11 patients (5%), the cause of death was assessed to be progression of disease. Respiratory failure occurred as a result of pneumonia, acute respiratory distress syndrome, and aspiration, whereas sudden cardiac death/arrhythmia and myocardial infarction composed the cardiac etiologies.

Hospital Discharges, Readmissions, and Location of Death

The relative proportions of in-hospital deaths and postdischarge deaths are shown in Table 4. Of the 206 deaths that occurred during POD 0–90, more than half occurred after POD 30 (111, 54%). Similarly, more than half of the 206 deaths occurred after hospital discharge (110, 53%). Taken together, there were 83 (40%) postoperative deaths that would not have been counted in either the 30-day or the discharge mortality figures.

Of the postdischarge deaths, nearly half (50, 45%) occurred during the course of readmission to the hospital. An additional 10 (5%) occurred at hospice or at home. Location of death was unknown for 50 patients who died after discharge from the hospital.

Comment

The major finding in this study is that, among patients who have undergone surgery for thoracic malignancies, considerable mortality attributable to surgery occurs beyond the first 30 days after surgery, as well as after initial discharge from the hospital. Substantial mortality occurred during POD 31–90, resulting in a 2-fold increase in mortality at 90 days (2.7%), compared with mortality at 30 days (1.2%). By examining mortality during POD 31–90 and the postdischarge period, we ascertained that the majority of deaths during these periods were attributable to surgery-related complications. With 40% of deaths during POD 0–90 falling outside of the 30-day or discharge definitions of operative mortality, these measures underreport the risk of early postoperative death.

Similar to the findings in this report, two recent studies focusing on pulmonary resections and surgery for lung cancer found that mortality during POD 31–90 equaled or exceeded that during POD 0–30 [4, 5]. In a single-institution experience, older age, comorbid disease,

and longer LOS were associated with death during POD 31–90 [4]. In an analysis of population-based data from the English National Lung Cancer Audit, mortality at 90 days (5.9%) was nearly twice that at 30 days (3%). The same results were obtained when 30-day and 90-day mortality rates were compared across eight different cancer types, including lung and esophageal cancer, in a population-based analysis from the Netherlands [6]. However, none of these studies included patients with mesothelioma, which we found to have a 90-day mortality four times that at 30 days.

A potential caveat to our findings is that cancer patients are at risk of dying of their disease. In the above-mentioned study on pulmonary resections, 19 of 44 deaths between POD 31 and 90 were attributed to “natural causes,” in which disease progression was included [4]. However, in our study, the majority of patients who died early had a cause of death related to complications associated with the procedure. Only 11 patients were identified to have died of cancer, which suggests that disease progression made a limited contribution to mortality during POD 31–90. Although early death from disease progression without the presence of treatment-related complications is possible, it should remain an unexpected outcome among patients who have been properly staged and offered resection with the promise of cure.

Isolating a single root cause of death can be challenging—indeed, in 46 patients, more than one cause was identified. Nevertheless, by far the most common causes of death across all three cancers in this study were respiratory events, sepsis, and cardiac events. Respiratory failure was the leading cause, with pneumonia, aspiration, acute respiratory distress syndrome, and pneumonitis serving as the primary etiologies. Not surprisingly, in the study by Bryant and colleagues, respiratory events were the most common cause of early death among patients who underwent pulmonary resections [4]. Sepsis resulted from anastomotic leaks, line infections, pneumonia, empyemas, and abscesses. Cardiac events included arrhythmias, sudden cardiac death, and myocardial infarctions.

Strikingly, more than half of the deaths during POD 0–90 occurred after discharge from the initial hospitalization. More than half (60/110 [55%]) of the patients who died during this period were readmitted to the hospital and ultimately died there (n=50) or were subsequently discharged to hospice or home and died there (n=10). In some cases, patients may express a desire to die at home, which may affect discharge practices, subsequent readmission rates, and the location of death. No information about location of death was available for 50 of the patients who died after discharge. The decline in the use of autopsy further hinders our ability to distill root causes of death. Presumably, many of these patients died suddenly at home, but this lack of information highlights the challenges of obtaining detailed follow-up information without the systems infrastructure that could be provided by efforts like the NSQIP and STS databases.

That more than half of the deaths during POD 0–90 occurred after discharge, raises the question of whether anything might have been done differently, either at the time of discharge evaluation or immediately following discharge, to prevent these deaths. Bryant et al. found that, among patients who had undergone pulmonary resections, sudden death was the most common cause of death at home after discharge. Older age, prolonged LOS,

hypertension, and coronary disease were identified as predictors of postdischarge death between POD 31 and 90 [4]. Perhaps, closer monitoring after discharge, with earlier and repeated follow-up visits, better coordination with primary physicians, and regular home visits by care providers, in these high-risk patients could lead to earlier detection of problems and improved outcomes—but there is no evidence yet to support this strategy.

Implicit in the choice of 30 days as the cutoff point for postoperative outcomes is the idea that deaths occurring after this time are less likely to be related to the treatment and that the inclusion of unrelated deaths might artificially inflate the reported mortality rate. First, although it is possible that patients may die of incidental causes unrelated to the surgery during the extended period, the cumulative mortality from such events would be far lower than our observed rate of 1.4% and would thus be unlikely to meaningfully alter the reported mortality rate. Second, examination of other, nonsurgical treatment modalities provides a point of comparison. For sicker patients unfit for surgery, stereotactic body radiotherapy is an alternative to sublobar resection for localized lung cancer. Yet sublobar resection had a 90-day mortality of 1.4% in our series and 2.4% in a prospective trial (ACOSOG Z4032), whereas stereotactic body radiotherapy had a 90-day mortality of 0 in two separate studies, including a prospective trial (RTOG 0236) [7, 8].

Limitations of our study include the retrospective, single-institution analysis. Future efforts to confirm these observations in broader, population-based data sets are warranted. Other limitations are related to loss to follow-up and the difficulties previously mentioned in obtaining accurate data on cause of death. The inclusion of 90-day follow-up data in national outcomes databases would help address this knowledge gap. Our analysis was confined to operations for thoracic malignancies. It is necessary to replicate our results in nonthoracic cancer operations and major operations for benign diseases. It is possible that a 90-day observation period is relevant for only a subset of major procedures.

For payers and policy makers, changes in the interval used to define operative mortality may affect comparisons of quality and how care is compensated. Johnson and colleagues found that hospital rankings changed significantly when postoperative mortality was measured beyond 30 days [9]. From the patient's perspective, though, the fact that as many or more patients died in the second and third months after surgery as in the first month means that the oft-quoted 30-day mortality does not fully capture their risk.

Patients with thoracic malignancies accept the increased risk of mortality in the immediate period following surgery in hopes of longer-term benefit. Therefore, more-accurate accounting of postoperative mortality has important ramifications for patients—most notably in the calculation of risks versus benefits when making treatment decisions.

As cancer surgery constitutes a large portion of the practice of general thoracic surgery, we recommend that national databases such as the STS General Thoracic Surgery Database and the NSQIP database consider the inclusion of 90-day mortality in their data collection. We anticipate that doing so will provide all stakeholders, including patients, clinicians, policy makers, and payers, with a more complete assessment of the risk of early mortality after surgical resection for thoracic malignancies.

Acknowledgments

Financial Support: NIH/NCI Cancer Center Support Grant P30 CA008748

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Table 1

Patient Characteristics

Characteristic	Lung Cancer			Esophageal Cancer		Mesothelioma	
	All Resections	Sublobar Resection	Lobectomy	Pneumonectomy	Esophagectomy	Extrapleural Pneumonectomy	Pleurectomy
Resections, no.	7646	1584	4221	314	1258	154	115
Female sex	3870 (51)	967 (61)	2415 (57)	151 (48)	274 (22)	39 (25)	24 (21)
Age, years, mean $\pm$ SD	66 $\pm$ 11	69 $\pm$ 10	67 $\pm$ 10	61 $\pm$ 11	63 $\pm$ 11	62 $\pm$ 11	67 $\pm$ 10
Current or former smokers	6221 (81)	1358 (86)	3552 (84)	268 (85)	868 (69)	95 (62)	78 (68)
LOS, days, median (range)	6 (0–225)	4 (1–107)	5 (1–225)	6 (2–69)	11 (0–148)	7.5 (3–60)	6 (2–89)
Proportion with LOS >30 days	231 (3%)	17 (1%)	56 (1%)	5 (2%)	121 (10%)	6 (4%)	26 (23%)
Any postoperative complication	2258 (30)	292 (18)	1273 (30)	108 (34)	500 (40)	69 (45)	16 (14)

Data are presented as no. (%) unless otherwise noted. LOS = length of stay; SD = standard deviation.

Table 2

Perioperative Mortality Following Thoracic Resection

Resection	POD 0–30		POD 31–90		POD 0–90 Total	
	Deaths	Mortality	Deaths	Mortality ^a	Deaths	Mortality
Sublobar	11	0.7 (0.3–1.2)	11	0.7 (0.3–1.3)	22	1.4 (0.9–2.1)
Lobectomy/bilobectomy	36	0.9 (0.6–1.2)	47	1.1 (0.8–1.5)	83	2.0 (1.6–2.5)
Pneumonectomy	8	2.5 (1.1–5.0)	6	2.0 (0.7–4.2)	14	4.5 (2.5–7.4)
Esophagectomy	35	2.8 (1.9–3.8)	32	2.6 (1.8–3.7)	67	5.3 (4.2–6.7)
Extrapleural pneumonectomy	4	2.6 (0.7–6.5)	13	8.7 (4.7–14.4)	17	11.0 (6.6–17.1)
Pleurectomy/decortication	1	0.9 (0.02–4.7)	2	1.8 (0.2–6.2)	3	2.6 (0.5–7.4)
All	95	1.2 (1.0–1.5)	111	1.4 (1.2–1.8)	206	2.7 (2.3–3.1)

^aConditional on patients having survived through POD 0–30.

Deaths are presented as no.; mortality is presented as percentage (95% confidence interval). POD = postoperative day.

Table 3

Leading Causes of Death by Postoperative Period for All Resections

Rank	POD 0–30	POD 31–90	POD 0–90
1st	Respiratory (35 [37%])	Respiratory (34 [31%])	Respiratory (69 [33%])
2nd	Sepsis (31 [33%])	Sepsis (27 [24%])	Sepsis (58 [28%])
3rd	Cardiac (27 [28%])	Disease Progression (11 [10%])	Cardiac (33 [16%])
Total deaths	95	111	206

POD = postoperative day.

Table 4

Inpatient versus Discharge Mortality, Readmissions, and Location of Death

Variable	POD 0–30	POD 31–90	POD 0–90
Death before discharge	67 (71)	28 (25)	96 (47)
Death after discharge	28 (29)	83 (75)	110 (53)
Mortality during readmission to an acute care hospital	14 (15)	36 (32)	50 (24)
Mortality at home or hospice	4 (4)	6 (5)	10 (5)
Unknown location of death	10 (11)	41 (37)	50 (24)
Total deaths	95	111	206

Data are presented as no. (%). POD = postoperative day.