Do Cancer Centers Designated by the National Cancer Institute Have Better Surgical Outcomes?

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BACKGROUND. The National Cancer Institute (NCI) designates cancer centers as regional centers of excellence in research and patient care. Although these centers often advertise their superior outcomes, their relative performance has not been examined empirically. In the current study, the authors assessed whether patients at NCI cancer centers compared with patients at control hospitals had lower mortality rates after major cancer surgery.

METHODS. Using the national Medicare database (1994–1999), the authors assessed surgical mortality and late survival rates for 63,860 elderly patients undergoing resection for lung, esophageal, gastric, pancreatic, bladder, or colon carcinoma. For assessing performance, patients treated at the 51 NCI cancer centers were compared with patients from 51 control hospitals with the highest volumes for each procedure. Mortality rates (surgical and 5-year rates) were adjusted for patient characteristics and residual differences in procedure volume.

RESULTS. NCI cancer centers had lower adjusted surgical mortality rates than control hospitals for 4 of the 6 procedures, including colectomy (5.4% vs. 6.7%; $P = 0.026$), pulmonary resection (6.3% vs. 7.9%; $P = 0.010$), gastrectomy (8.0% vs. 12.2%; $P < 0.001$), and esophagectomy (7.9% vs. 10.9%; $P = 0.027$). Nonsignificant trends toward lower adjusted operative mortality rates at NCI cancer centers were also observed for cystectomy and pancreatic resection. Among patients surviving surgery, however, there were no important differences in subsequent 5-year mortality rates between NCI cancer centers and control hospitals for any of the procedures.

CONCLUSIONS. For many cancer procedures, patients undergoing surgery at NCI-designated cancer centers had lower surgical mortality rates than those treated at comparably high-volume hospitals, but similar long-term survival rates. ***Cancer* 2005;103:435–41.** © *2004 American Cancer Society.*

KEYWORDS: National Cancer Institute, patient care, mortality rates, survival rates.

Created in 1971 as a result of the National Cancer Act, the National Cancer Institutes (NCI) cancer centers program was created to establish regional centers of excellence in research and patient care. Hospitals compete for cancer center designation and federal funding on the basis of demonstrated excellence in three different areas: research, cancer prevention, and clinical services. Hospitals selected as comprehensive cancer centers (currently 38) meet the criteria for all 3 areas. Clinical cancer centers (currently 15) are selected primarily based on their clinical programs. Generic cancer centers (currently 8) are primarily research institutions.

There are a number of reasons to believe that the NCI clinical and comprehensive cancer centers might have better outcomes of cancer surgery than other hospitals. NCI cancer centers are widely considered to be centers of excellence in cancer care because they are well

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staffed with specialists and tend to have high-procedure volumes, both factors being associated with reduced surgical and late mortality rates after cancer surgery.[1–4] Greater access to multidisciplinary consultation (e.g., tumor boards) could also translate into better treatment plans for patients at NCI cancer centers. In addition, NCI cancer centers may adopt new and beneficial therapies earlier than other hospitals and use more standard treatment protocols and clinical pathways, and thus have less variation in processes of care than other hospitals.

That NCI cancer centers have superior outcomes is reinforced frequently by hospital advertising. To date, however, the relative performance of NCI cancer centers has not been examined empirically. For this reason, we studied surgical mortality and long-term survival rates among patients undergoing six cancer-related procedures (i.e., cystectomy, colectomy, pulmonary resection, pancreatic resection, gastrectomy, and esophagectomy) based on data from the national Medicare population. To assess the independent effect of cancer center designation, we compared outcomes at 51 NCI cancer centers with the 51 other hospitals with the highest volumes for each procedure.

MATERIALS AND METHODS

Subjects and Databases

These analyses are based on data from the Medicare Provider Analysis and Review (MEDPAR) and the denominator files from the Centers for Medicare and Medicaid Services for the period 1994–1999. These files include hospital discharge abstracts for acute care hospitalizations of all Medicare recipients covered by the hospital care program (Part A). The MEDPAR file only includes patients covered by fee for service arrangements. Therefore, Medicare patients who were enrolled in risk-bearing health maintenance organizations during this period (approximately 10% of Medicare enrollees) are not included in our analysis. We excluded patients who were < 65 or > 99 years of age from our analysis.

Six cancer procedures were chosen because of their relative complexity and high surgical mortality rates. We identified all discharges for these procedures using appropriate procedure codes from the International Classification of Diseases ICD-9.[5] To identify only resections for cancer, we restricted our sample to patients who had an accompanying cancer diagnosis code that was related to the procedure of interest. Relations between NCI designation status and the primary outcome measures were assessed separately for all six procedures.

Hospital Selection

NCI-designated cancer centers are listed on the NCI website (available from URL: www.nci.nih.gov). Links to each center's own website are also provided by the NCI. These links were used to determine the zip code and Medicare provider number of each NCI-designated cancer center and its affiliated hospitals. We excluded from our analysis the generic (research-focused) cancer centers, as well as eight centers that did not hold the NCI cancer center designation continuously throughout our study period. Because the NCI distinguishes between "comprehensive" and "clinical" cancer centers based on the scope of research rather than clinical activities, we combined the two types of cancer centers for the purposes of the current analysis. At NCI cancer centers where surgical care is delivered in more than one hospital, we chose the highest volume hospital and any others exceeding the 90th percentile (averaged across the six procedures) for cancer surgery volume. This process resulted in a total of 51 individual hospitals associated with 47 NCI cancer centers.

Hospitals in the control group were selected according to procedure-specific surgical volumes. As in our previous studies,[3,4] total surgical volumes were determined by dividing the observed Medicare volume for each procedure during the study period by the proportion of all patients undergoing the procedure who were covered by Medicare, based on data from the all-payer Nationwide In-Patient Sample. Non-NCI cancer center hospitals were then rank-ordered according to procedure volume and the 51 highest ranked hospitals for each procedure were designated control hospitals. Five hospitals were in the control group for all 6 procedures, 7 hospitals for 5 procedures, 10 hospitals for 4 procedures, 22 hospitals for 3 procedures, 34 hospitals for 2 procedures, and 67 hospitals for only 1 of the 6 procedures.

Analysis

The primary goal of the current analysis was to compare NCI cancer centers and control hospitals with respect to two outcome measures: surgical mortality and late survival rates. The patient was used as the unit of analysis, with cancer center designation assessed at the hospital level. As in our previous studies,[3,4] surgical mortality was defined as death before hospital discharge or death within 30 days after the index procedure. This definition was used because a large number of surgical deaths occur before discharge but > 30 days after surgery. Long-term survival was determined by following patients (using data in the Medicare denominator files) from the date of the

index surgical admission until death or the termination of the period of observation (i.e., December 31, 2001).

In assessing relations between cancer center designation and mortality, we adjusted for age (5 categories: 65–69 years, 70–74 years, 75–79 years, 80–84 years, ≥ 85 years), gender (male, female), and race (non-black, black). We also adjusted for comorbid conditions identified by ICD-9-CM code from all hospitalizations within 6 months preceding the surgical procedure[6] and then used to calculate a Charlson score, modified to exclude conditions reflecting primary indication for surgery or surgical complications.[7–10] We adjusted for two variables measured at the patient's zip code level (i.e., mean social security income and rural or urban residence).[11, 12] For pulmonary resections, procedure type (lobectomy vs. pneumonectomy) was also included in the risk-adjustment models.

Chi-square tests were used to compare patient characteristics between NCI cancer centers and control hospitals. We used multiple logistic regression to compare surgical mortality rates and proportional hazards models to compare long-term survival for each procedure between NCI cancer centers and control hospitals. For each procedure, the validity of the proportional hazards assumption was verified by visually inspecting the log-log survival plot. We used robust variance estimates in both the logistic and proportional hazards models to account for a lack of independence between observations (i.e., clustering of patients within hospitals). All analyses were performed using Stata statistical software version 8 (Stata Corporation, College Station, TX).[13]

RESULTS

Between 1994 and 1999, 27,021 patients underwent 1 of the 6 cancer procedures at an NCI cancer center and 36,839 patients received 1 of these procedures at a control hospital (Table 1). These patients represent 12.8% of the total number of Medicare patients (n = 500,705) undergoing these procedures during the study period. Compared with control hospitals, NCI cancer centers had lower volumes for colectomy but similar volumes for the other procedures (Table 1).

There were few clinically important differences in patient characteristics between NCI cancer centers and control hospitals (Table 2). Patients treated at NCI cancer centers had significantly higher Charlson comorbidity scores for four of the six procedures. Compared with NCI cancer centers, control hospitals treated significantly more patients > 85 years for colectomy and gastrectomy. NCI cancer centers treated significantly more black patients for cystectomy, colectomy, and pulmonary resection.

TABLE 1
Distribution of Hospitals, Patients, and Procedure Volumes for NCI Cancer Centers Compared with Control Hospitals

Procedures	NCI cancer centers (n = 51)	Control hospitals (n = 51)
Cystectomy		
No. of Medicare patients	2977	2566
Mean no. of procedures/yr ± SD	18 ± 16	16 ± 7
Median no. of procedures/yr (range)	12 (1–82)	14 (10–42)
Colectomy		
No. of Medicare patients	9615	19624
Mean no. of procedures/yr ± SD	101 ± 68	209 ± 33
Median no. of procedures/yr (range)	92 (16–333)	197 (172–301)
Pulmonary resections		
No. of Medicare patients	8360	9652
Procedure mix (% pneumonectomy)	13.3	12.2
Mean no. of procedures/yr ± SD	55 ± 62	63 ± 14
Median no. of procedures/yr (range)	36 (2–313)	59 (48–117)
Pancreatic resection		
No. of Medicare patients	2297	1575
Mean no. of procedures/yr ± SD	18 ± 23	12 ± 5
Median no. of procedures/yr (range)	10 (1–136)	10 (7–27)
Gastrectomy		
No. of Medicare patients	2599	2608
Mean no. of procedures/yr ± SD	28 ± 26	32 ± 8
Median no. of procedures/yr (range)	21 (5–137)	30 (25–69)
Esophagectomy		
No. of Medicare patients	1173	814
Mean no. of procedures/yr ± SD	22 ± 23	17 ± 7
Median no. of procedures/yr (range)	13 (3–107)	15 (11–46)

NCI: National Cancer Institute; SD: standard deviation.

Differences in surgical mortality between NCI cancer centers and control hospitals are shown in Figure 1 and Table 3. In adjusted analyses (Fig. 1), NCI cancer centers had significantly lower operative mortality rates than control hospitals for 4 of the 6 procedures, including colectomy (5.4% vs. 6.7%; $P = 0.026$), pulmonary resections (6.3% vs. 7.9%; $P = 0.010$), gastrectomy (8.0% vs. 12.2%; $P < 0.001$), and esophagectomy (7.9% vs. 10.9%; $P = 0.027$). Nonsignificant trends toward lower adjusted surgical mortality at NCI cancer centers were also observed for cystectomy and pancreatic resection. The difference between NCI cancer centers and control hospitals was greatest for gastrectomy (adjusted odds ratio [OR] = 0.63; 95% confidence interval [95% CI], 0.50–0.79) and least with pancreatic resection (adjusted OR = 0.86; 95% CI, 0.61–1.21).

In contrast, differences in long-term survival rates between NCI cancer centers and control hospitals were considerably smaller (Fig. 2). Although differences were statistically significant for colectomy and gastrectomy (Table 3), adjusted hazard ratios of mortality rates at NCI cancer centers compared with control hospitals were generally close to 1, ranging from

TABLE 2
Medicare Cancer Surgery Patient Characteristics at NCI Cancer Centers Compared with Control Hospitals

Procedures	NCI cancer centers	Control hospitals	*P* value
Patient characteristics			
Cystectomy			
Age > 85 yrs (%)	3.8	3.1	0.164
Gender (% female)	18.2	18.9	0.528
Race (% black)	4.3	3.0	0.008
Charlson comorbidity score (% ≥ 3)	46.2	36.6	< 0.001
From urban area (%)	70.5	70.4	0.929
From low income zip code (%)	19.8	19.9	0.958
Colectomy			
Age > 85 yrs (%)	13.4	16.2	< 0.001
Gender (% female)	54.0	54.4	0.489
Race (% black)	14.1	6.1	< 0.001
Charlson comorbidity score (% ≥ 3)	49.2	46.2	< 0.001
From urban area (%)	79.8	87.4	< 0.001
From low income zip code (%)	22.2	19.1	< 0.001
Pulmonary resection			
Age > 85 yrs (%)	1.7	1.5	0.262
Gender (% female)	42.9	42.1	0.274
Race (% black)	5.9	4.7	< 0.001
Charlson comorbidity score (% ≥ 3)	43.8	36.7	< 0.001
From urban area (%)	69.8	65.1	< 0.001
From low income zip code (%)	18.3	23.3	< 0.001
Pancreatic resection			
Age > 85 yrs (%)	1.9	1.9	0.941
Gender (% female)	48.5	46.3	0.167
Race (% black)	5.7	5.2	0.579
Charlson comorbidity score (% ≥ 3)	65.0	54.5	< 0.001
From urban area (%)	71.0	73.6	0.081
From low income zip code (%)	18.6	19.9	0.335
Gastrectomy			
Age > 85 yrs (%)	7.0	10.3	< 0.001
Gender (% female)	35.5	38.7	0.018
Race (% black)	10.6	12.3	0.046
Charlson comorbidity score (% ≥ 3)	63.8	62.3	0.267
From urban area (%)	74.7	81.1	< 0.001
From low income zip code (%)	19.4	22.1	0.015
Esophagectomy			
Age > 85 yrs (%)	1.4	1.6	0.670
Gender (% female)	25.2	23.2	0.324
Race (% black)	6.2	6.1	0.870
Charlson comorbidity score (% ≥ 3)	43.4	41.0	0.295
From urban area (%)	63.9	68.1	0.052
From low income zip code (%)	17.9	20.6	0.149

NCI: National Cancer Institute.

0.88 (colectomy) to 1.05 (esophagectomy). Five-year survival probabilities at NCI cancer centers and control hospitals differed by ≤ 4% (in absolute terms) for each of the 6 procedures.

DISCUSSION

In the current study, we found that NCI cancer centers had lower surgical mortality rates with some high-risk cancer procedures than other comparable high-volume hospitals. Although to our knowledge the current study is the first to examine surgical quality associated with cancer center designation, numerous studies to date have explored the effects of organizational characteristics and other structural variables. In addition to procedure volume,[3,14–16] hospital attributes that have been linked to lower surgical mortality rates after surgery include participation in clinical trials, intensivist staffing of intensive care units, and high nurse-to-bed ratios.[17–20] At the surgeon level, both procedure volume and subspecialty training appear to have independent effects on surgical mortality.[4,21–23]

There are at least two potential explanations for lower surgical mortality rates at NCI cancer centers. First, these centers could be treating lower-risk patients than other high-volume hospitals. Although we did not identify important differences with respect to patient age, race, and comorbidity burden, Medicare claims are limited in their ability to capture illness severity for purposes of risk adjustment.[8,24–27] We cannot rule out differences in other patient characteristics potentially related to surgical mortality. For example, patients traveling to well known centers of excellence may be more fit, affluent, or healthy in ways that are not measurable with the use of data from hospital claims.[28] However, these same factors would, presumably, confer advantages for NCI cancer centers with respect to late mortality, which we did not observe. Thus, it seems unlikely that our findings can be attributed entirely to selection bias.

Alternatively, lower surgical mortality rates at NCI cancer centers could reflect higher-quality surgical care. If so, we can only speculate on potential reasons for their better outcomes. First, patients undergoing high-risk surgery at NCI cancer centers may be selected more carefully. For example, patients at NCI cancer centers may be more likely to be considered in multidisciplinary conferences (tumor boards) or to receive consultations with nonsurgical specialists preoperatively. Patients at cancer centers may also undergo more sophisticated preoperative imaging tests. Better processes related to patient selection could identify patients better managed without surgery or help surgeons anticipate potential complications. Second, surgeons at NCI cancer centers may be more specialized than their counterparts at other high-volume hospitals. Greater experience with specific procedures could translate to better clinical decision-making or greater technical proficiency. Many of these hypotheses could be tested directly by more detailed analysis of outpatient and physician claims, but not with the inpatient files (hospital discharge abstracts) available for the current study.

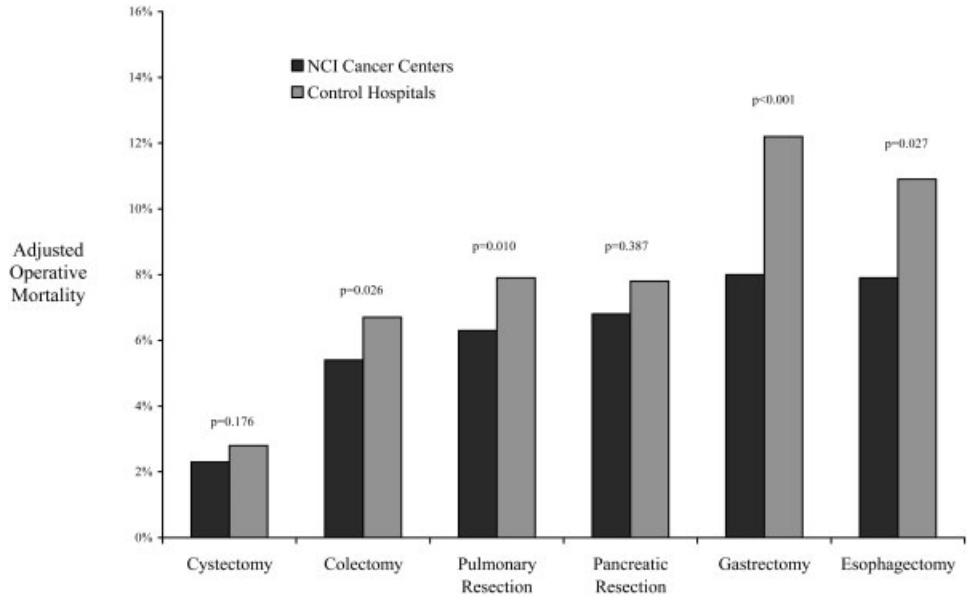

FIGURE 1. Adjusted surgical mortality rates for patients undergoing surgery at National Cancer Institute cancer centers compared with control hospitals.

TABLE 3
Observed and Adjusted Outcomes of Cancer Surgery at NCI Cancer Centers Compared with Control Hospitals

	Operative mortality rates		Odds ratio (95% CI)	
Procedures	NCI cancer centers	Control hospitals	Observed	Adjusted[a]
Cystectomy	2.7%	3.6%	0.74 (0.54–1.02)	0.80 (0.58–1.09)
Colectomy	4.7%	5.5%	0.86 (0.73–1.01)	0.80 (0.65–0.98)
Pulmonary resection	4.4%	5.6%	0.76 (0.62–0.94)	0.78 (0.64–0.94)
Pancreatic resection	4.6%	7.1%	0.64 (0.44–0.93)	0.86 (0.61–1.21)
Gastrectomy	6.5%	10.5%	0.59 (0.46–0.77)	0.63 (0.50–0.79)
Esophagectomy	7.7%	12.3%	0.59 (0.43–0.83)	0.70 (0.51–0.97)
	5-year mortality rates in surgery survivors		**Hazard ratio (95% CI)**	
Procedure	NCI cancer centers	Control hospitals	Observed	Adjusted[a]
Cystectomy	60%	61%	0.98 (0.91–1.07)	0.94 (0.85–1.03)
Colectomy	49%	50%	0.97 (0.91–1.03)	0.88 (0.81–0.96)
Pulmonary resection	57%	59%	0.95 (0.89–1.02)	0.93 (0.86–1.00)
Pancreatic resection	76%	76%	0.96 (0.87–1.06)	0.97 (0.87–1.08)
Gastrectomy	68%	71%	0.92 (0.83–1.02)	0.91 (0.83–0.99)
Esophagectomy	72%	68%	1.04 (0.91–1.19)	1.05 (0.92–1.20)

NCI: National Cancer Institute; CI: confidence interval.
[a] Adjusted for patient characteristics and residual procedure volume differences.

To our surprise, treatment at NCI cancer centers did not confer important advantages with regard to long-term survival. We had hypothesized that more specialized surgeons at cancer centers might achieve more complete surgical resections or that cancer centers would be first to implement beneficial new adjuvant therapies. We also hypothesized that patients at cancer centers would be more likely to be followed according to standardized surveillance protocols after surgery, which could detect some recurrent cancers in

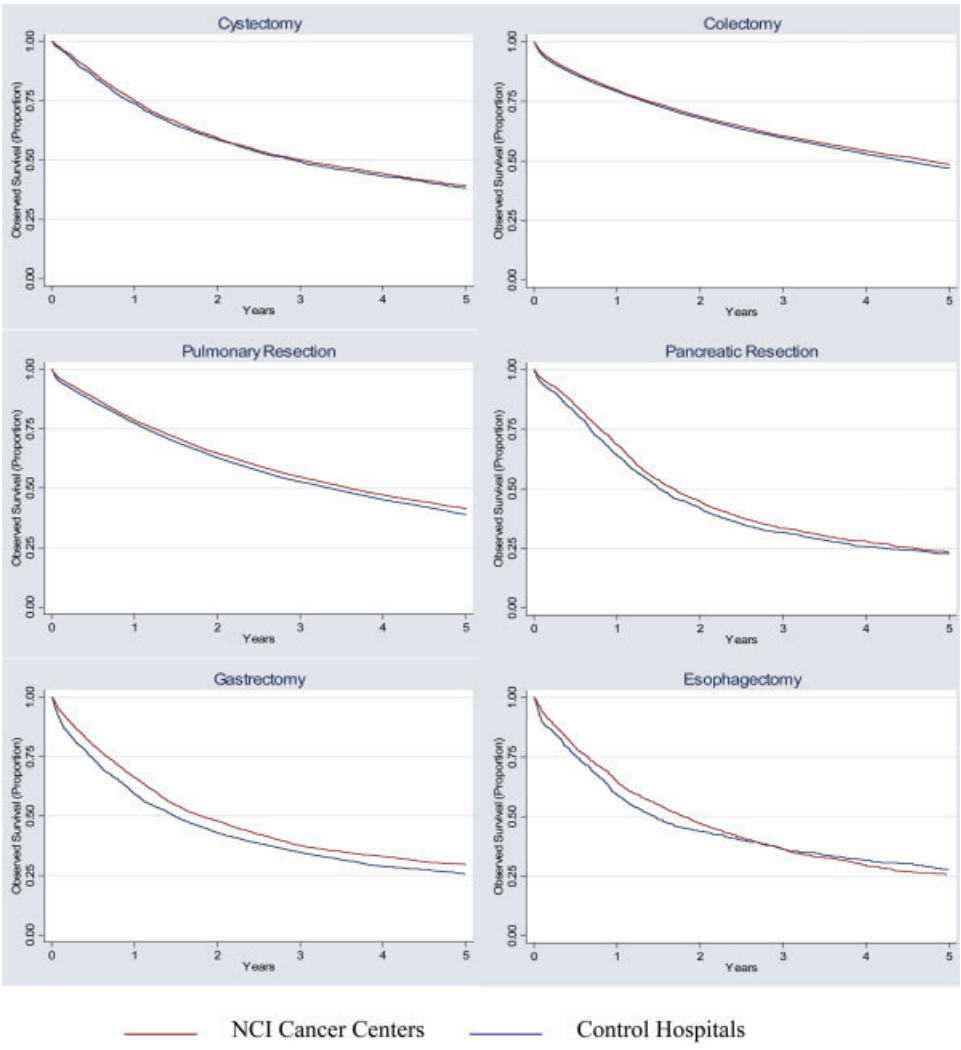

FIGURE 2. Long-term survival for patients undergoing surgery at National Cancer Institute cancer centers compared with control hospitals.

the early stages when treatment can lead to disease remission. Although our null findings related to late survival do not support these hypotheses, our results should be interpreted carefully. With the inpatient hospital data available for these analyses, we could not determine whether patients continued to receive follow-up care at the same center at which the surgery was performed or at community hospitals closer to home. Thus, our study provides stronger inferences regarding the quality of the surgical experience than the quality of subsequent surveillance or adjuvant therapy.

Our study has other limitations. Because our analysis was restricted to Medicare patients age $>$ 65 years, our findings may not be generalizable to younger patients. However, it is worth noting that Medicare patients account for greater than one-half of patients undergoing major cancer resections in the U.S. and an even greater majority of patients who die after surgery.[29] In addition, Medicare data are not perfect for identifying the presence or absence of cancer. However, we focused exclusively on cancers involving major, inpatient procedures, for which claims data tend to be more highly reliable.[30] Nonetheless, our surgical cohort no doubt included some patients without cancer and excluded some patients with cancer. To the extent that this error is random, the misclassification of patients with cancer would bias our results toward the null hypothesis (i.e., no difference between the NCI cancer centers and other hospitals).

The results of the current study suggest that NCI cancer center designation should be weighted less heavily than other factors in a patient's deciding where to undergo major cancer surgery. Although these facilities have moderately lower surgical mortality rates with several procedures, their long-term survival rates are comparable to those of other high-volume hospitals. These findings may be reassuring

for many patients residing outside the Northeast, Midwest, and Southern California, where the majority of NCI cancer centers are located. The best evidence to date suggests a number of other factors to consider when deciding where to undergo major cancer surgery and by whom the surgery should be performed. Patients will optimize their odds after cancer surgery by selecting high-volume hospitals. They will also fare better with high-volume surgeons with subspecialty training. Although patients can generally expect such providers at NCI cancer centers, most patients also should be able to find them at high-volume centers closer to home.

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