Geographic Variation in Use of Laparoscopic Colectomy for Colon Cancer

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ABSTRACT

Purpose

Emerging evidence supporting the use of laparoscopic colectomy in patients with cancer has led to dramatic increases in utilization. Though certain patient and hospital characteristics may be associated with the use of laparoscopy, the influence of geography is poorly understood.

Methods

We used national Medicare claims data from 2009 and 2010 to examine geographic variation in utilization of laparoscopic colectomy for patients with colon cancer. Patients were assigned to hospital referral regions (HRRs) where they were treated. Multivariable logistic regression was used to generate age, sex, and race-adjusted rates of laparoscopic colectomy for each HRR. Patient quintiles of adjusted HRR utilization were used to evaluate differences in patient and hospital characteristics across low and high-utilizing HRRs.

Results

A total of 93,786 patients underwent colon resections at 3,476 hospitals during the study period, of which 30,502 (32.5%) were performed laparoscopically. Differences in patient characteristics between the lowest and highest quintiles of HRR utilization were negligible, and there was no difference in the availability of laparoscopic technology. Yet adjusted rates of laparoscopic colectomy utilization varied from 0% to 66.8% across 306 HRRs in the United States.

Conclusion

There is wide geographic variation in the utilization of laparoscopic colectomy for Medicare patients with colon cancer, suggesting treatment location may substantially influence a patient's options for surgical approach. Future efforts to reduce variation will require increased dissemination of training techniques, novel opportunities for learning among surgeons, and enhanced educational resources for patients.

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INTRODUCTION

In 2014, nearly 100,000 people will be diagnosed with colon cancer in the United States,¹ and most will undergo colectomy. While laparoscopy has become the preferred approach to colectomy for benign conditions,² concerns regarding oncologic quality of resection and tumor-cell dissemination initially limited its use in cancer. However, in 2004 the Clinical Outcomes of Surgical Therapy (COST) trial reported that surgical safety and oncologic outcomes of laparoscopic colectomy were equivalent to open resection, and laparoscopy enabled decreased analgesic use, shorter length of stay, and faster recovery.³ Numerous subsequent international trials⁴⁻⁷ and meta-analyses⁸⁻¹⁰ have confirmed these findings. Accordingly, the utilization of laparoscopic colectomy in patients with cancer has increased substantially in the United States: from 6% to 12% of all

patients in 2004, to 40% to 50% of all patients in 2009.^{11,12}

Despite its increased use, however, it is unknown whether access to laparoscopic colectomy is distributed equally. Some studies have found use of laparoscopy to be influenced by patients' age, sex, comorbidity, or insurance, while others have reported associations with hospital teaching status and urban location.^{11,13} Yet to date, no studies have examined geographic variation in laparoscopic colectomy utilization. Previous literature on geographic variation suggests that for a variety of conditions, such as radical prostatectomy, carotid endarterectomy, and spine surgery, procedure use may depend more on where a patient receives care than on clinically-relevant characteristics of the patient or their disease.¹⁴ Recognizing that for such conditions, "geography is destiny," geographic variation in availability of laparoscopic colectomy could suggest

urgent need for training, capacity building, and policy-making around surgery for colon cancer.

In this study, we investigate geographic patterns in utilization of laparoscopic colectomy for colon cancer in Medicare beneficiaries. To do this, we used complete Medicare claims data to examine adjusted rates of utilization across US hospital referral regions (HRRs), and compared the characteristics of patients and hospitals between regions with low and high rates of laparoscopic colectomy utilization.

METHODS

Data Source and Study Population

We used a national data set from the 100% Medicare Provider Analysis and Review (MEDPAR) files for the years 2009 and 2010. The Centers for Medicare & Medicaid Services (CMS) maintains this database using claims submitted for all fee-for-service acute care hospitalizations of Medicare beneficiaries not enrolled in managed care plans. We identified patients between the ages of 65 and 99 years old who underwent a colon resection, using International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes (17.32, 17.33, 17.34, 17.35, 17.36, 45.73, 45.74, 45.75, 45.76, 45.80, 45.81, 45.82, 45.83). We restricted our patient population to those with a concurrent ICD-9-CM diagnosis code for colon cancer (153.0-154.0). We excluded patients with rectal cancer (154.1-154.8) and emergent operations.

Patient and Hospital Characteristics

We evaluated patient characteristics including age, sex, race, and coexisting conditions. Coexisting conditions were identified by the appropriate ICD-9-CM diagnosis codes and defined using the Elixhauser Method.¹⁵ The type of colon resection (right, left, transverse, or total colectomy) and operative approach (laparoscopic or open) were defined using appropriate ICD-9-CM procedure codes.

We assigned patients to an HRR using the Medicare provider identification number for the hospital in which they underwent colectomy. Hospital referral regions represent regional health care markets for tertiary care.¹⁶ Each HRR will typically include one major referral center. We obtained characteristics of hospitals from the American Hospital Association (AHA) Annual Survey. These included bed size, critical access designation, teaching status, hospital ownership, urban or rural location, cancer center designation, and level of technology.

We characterized the level of technology in each hospital in two ways. First, to determine whether laparoscopic equipment was available at a given hospital, we used a national cohort of Medicare patients undergoing cholecystectomy (ICD-9-CM codes 51.2, 51.21, 51.22, 51.23, 51.24) during 2009 and 2010 at the same hospitals included in our colectomy cohort. Laparoscopic equipment was considered available for use if a laparoscopic cholecystectomy was performed at the hospital during the 2-year study period. Second, in accordance with previous literature, a hospital was considered to have high technology if it performed cardiac surgery and/or solid organ transplantation.^{17,18}

Statistical Analysis

We generated age-, sex-, and race-adjusted rates of laparoscopic colectomy utilization for each HRR using multivariable logistic regression (indirect standardization). This method has been previously applied to similar analyses of regional variation in health care.^{19,20} We then grouped patients into quintiles, based on the adjusted rate of laparoscopic colectomy utilization in the HRR to which they were assigned. We used Cuzick's test for trend and Wilcoxon rank sum tests to compare patient and hospital characteristics across quintiles of HRR laparoscopic colectomy utilization.

To confirm our results, we performed multiple additional analyses. First, given that many previous studies of laparoscopic colectomy exclude transverse and total colectomies, we recalculated laparoscopic utilization rates for HRRs

after excluding the subset of patients undergoing these procedures. Second, to investigate the influence of age on choice of approach, we performed a similar analysis on the subset of patients between the ages of 65 and 70 years old. Third, to partially account for the possibility of selection bias due to unmeasured cancer-specific variables (such as cancer stage and tumor characteristics), we performed an instrumental variable (IV) analysis, using MEDPAR data from the years 2008 to 2010.^{21,22} This econometric technique has been previously used to balance patient characteristics (measured and unmeasured) between exposure groups.²³ Our IV was the proportion of colectomies, in a given HRR, performed on patients who live outside of that referral region, in the year before a given patient's operation. The IV varied widely across HRRs, from 2% to 67% (median 10%), and satisfied all necessary criteria for a suitable instrument. First, it is truly exogenous (ie, independent) from a particular patient because it is calculated in the year before each patient's operation. Second, it is strongly correlated with our exposure: undergoing surgery within the HRR in which a patient actually lives. Third, it is not associated with our outcome, the use of laparoscopy, except through its association with the exposure. Intuitively, some patients are more likely to receive laparoscopy based solely on which region they decide to seek care. Through IV analysis, we are able to use the variability observed in the instrument to perform a partial pseudo-random assignment of patients to better account for measured and unmeasured patient characteristics between HRR's. We used a two-stage residual inclusion method for our IV analysis, as has been previously described.²⁴ For all statistics, *P* values were two-tailed, and alpha was set at 0.05. All analyses were performed using STATA version 13 (Stata-Corp, College Station, TX).

RESULTS

During the years 2009 and 2010, 93,786 Medicare patients underwent a colectomy for colon cancer at 3,476 hospitals. Details of patient characteristics across quintiles of HRR laparoscopic colectomy utilization are shown in Table 1. The median age of all patients was 77 years and a majority were female (54.2%). African Americans accounted for 10.1% of this cohort. Right colectomy was the most frequently performed procedure (63.3%), followed by left colectomy (29.9%). Total colectomy was performed infrequently (1.9%). Of all colon resections performed during the study period, 30,502 (32.5%) were performed laparoscopically.

Patient characteristics were similar across quintiles of HRR laparoscopic colectomy utilization. Though there were statistically significant differences in chronic obstructive pulmonary disease, congestive heart failure, and neurologic disorders, the magnitude of these differences was negligible. Rates of congestive heart failure, for example, only varied from 8.1% to 9.9% between quintiles (*P* < .01).

Hospital characteristics, by quintile of HRR laparoscopic colectomy utilization, are arrayed in Table 2. A majority of hospitals included in this study had fewer than 200 beds, were not for profit, were located in urban areas, and were nonteaching. Greater than 98.6% of hospitals in each quintile had access to laparoscopic equipment. Hospitals located in HRRs with the highest adjusted rates of utilization had slightly higher annual colectomy volume (29, v 23 in the lowest quintile, *P* < .01), were more likely to be designated cancer centers (42.1%, v 34.3%, *P* < .01), and teaching hospitals (22.3% v 17.8%, *P* < .01), and had bed sizes greater than 200 (33.5% v 24.5%, *P* < .01), and high hospital technology (32.0% v 25.3%, *P* < .01). Low-utilization hospitals, on the other hand, were more likely to be critical-access hospitals (22.6%, v 7.7% in the highest quintile, *P* < .01).

Regional variation in adjusted utilization of laparoscopic colectomy across 306 HRRs in the United States is illustrated in Figure 1. Utilization for colon cancer varied from 0% (Yakima, WA) to 66.8%

Table 1. Patient Characteristics Stratified by HRR Quintiles of Laparoscopic Colectomy Utilization

Characteristic	HRR Quintiles Utilization of Laparoscopic Colectomy										P
	Lowest (0%-23.7%)		Low (23.8%-30.6%)		Medium (30.7%-35.7%)		High (35.8%-40.3%)		Highest (40.5%-66.8%)		
	No.	%	No.	%	No.	%	No.	%	No.	%	
Number of HRRs	98		65		46		36		61		
Number of patients	18,833		18,974		19,638		17,886		18,455		
Demographics											
Age, years											.01
Median	77		77		77		77		77		
Interquartile range	64-90		65-89		65-89		64-90		65-89		
Male	8,610	45.7	8,694	45.8	8,915	45.3	8,210	45.9	8,519	46.1	.41
African American race	1,556	8.3	1,913	10.1	2,120	10.8	1,991	11.1	1,927	10.4	< .01
Elective procedure	12,001	63.7	11,874	62.6	12,428	63.3	11,155	62.4	11,662	63.2	.26
Comorbidities											
Number of comorbidities	2		2		2		2		2		< .01
Interquartile range	0-4		0-4		0-4		0-4		0-4		
Hypertension	9,818	52.1	9,830	51.8	10,045	51.2	9,437	52.8	9,611	52.1	.48
Diabetes mellitus	3,788	20.1	3,774	19.9	3,804	19.4	3,517	19.7	3,594	19.5	.10
COPD	2,712	14.4	2,541	13.4	2,636	13.4	2,357	14.2	2,407	13.0	< .01
Congestive heart failure	1,796	9.5	1,885	9.9	1,906	9.7	1,458	8.1	1,595	8.6	< .01
Renal failure	1,057	5.6	1,007	5.3	1,095	5.6	1,000	5.6	1,051	5.7	.40
Neurologic disorder	770	4.1	722	3.8	766	3.9	664	3.7	663	3.6	.02
Operative details											
Right colectomy	11,837	62.9	11,976	63.1	12,545	63.9	11,252	62.9	11,743	63.6	.22
Left colectomy	5,751	30.5	5,620	29.6	5,762	29.3	5,470	30.6	5,481	29.7	.49
Transverse colectomy	1,459	7.7	1,551	8.2	1,506	7.7	1,311	7.3	1,336	7.2	.01
Total colectomy	360	1.9	383	2.0	373	1.9	331	1.9	308	1.7	.04
Laparoscopic approach	3,421	18.2	5,256	27.7	6,546	33.3	6,737	37.7	8,542	46.3	< .01

Abbreviations: COPD, chronic obstructive pulmonary disease; HRR, hospital referral region.

(San Luis Obispo, CA). Utilization was high in parts of New York and the four corner states (Arizona, Utah, New Mexico, and Colorado), and low in west Texas, Appalachia (West Virginia and western Virginia) and the northern border states (Montana and North Dakota). Multiple locations on the map, including the mountain region (near Wyoming and Colorado) and the mid-Atlantic region (New York and Pennsylvania) exhibited adjacent HRRs with the lowest and highest adjusted rates of utilization.

Additional analyses confirmed these results. HRR rates of laparoscopic utilization were nearly identical after excluding transverse and total colectomies (range, 0% to 68%), and patients older than 70 years old (range, 0% to 66%). Instrumental variable analysis also revealed similar results, as utilization ranged from 0% to 64%, with 95% of hospitals residing in the same quintile as the primary analysis.

DISCUSSION

In this first nationwide study of regional variation in utilization of laparoscopic colectomy for colon cancer, we found wide geographic variation in use of this procedure for Medicare beneficiaries. Despite minimal, if any, meaningful differences in the measured characteristics of patients, adjusted rates of laparoscopic colectomy utilization within HRRs varied from 0% to 66.8%. Moreover, although this is the first study to use rates of laparoscopic cholecystectomy as a measure of the availability of laparoscopy at study hospitals, we found that lapa-

roscopic equipment was nearly universally available (similar to prior studies²⁵), and there were only minimal differences in the proportion of high-technology hospitals. In other words, while most hospitals have the infrastructure to perform laparoscopic surgery, they may not have the personnel and expertise necessary to perform laparoscopic colectomy for colon cancer. This suggests that surgeons within hospitals, and not hospital structure itself, have the greatest influence on choice of surgical approach for colon cancer. The existence of wide geographic variation in surgeons' use of laparoscopic colectomy for cancer has important implications for patients, as the potentially improved outcomes associated with minimally invasive surgery may not be available to otherwise eligible Medicare beneficiaries living in certain regions.

Literature evaluating geographic variations in use of surgery corroborates these findings. While multiple theories have been proposed to explain regional variation in medical practice,²⁶ the underlying causes are likely multifactorial.¹⁴ Differences in disease incidence, patient comorbidity, diagnostic practices, and patient attitudes have been found to play a relatively minor role. In procedural specialties, regional variation primarily results from differences in provider beliefs regarding the indication for a procedure, and the inconsistent incorporation of patient preferences into clinical decisions.¹⁴

Highlighting this distinction, the marked geographic variation we observed in the use of laparoscopic colectomy starkly contrasts with the relative geographic homogeneity observed in overall rates of

Table 2. Hospital Characteristics Stratified by HRR Quintiles of Laparoscopic Colectomy Utilization

Characteristic	HRR Quintiles Utilization of Laparoscopic Colectomy										<i>P</i>
	Lowest (0%-23.7%)		Low (23.8%-30.6%)		Medium (30.7%-35.7%)		High (35.8%-40.3%)		Highest (40.5%-66.8%)		
	No.	%	No.	%	No.	%	No.	%	No.	%	
Number of HRRs	98		65		46		36		61		
Number of hospitals	805		756		667		630		618		
Annual colectomy volume	23		25		29		28		29		< .01
Interquartile range	1-52		1-57		1-61		1-64		1-65		
Availability of laparoscopy	795	98.8	746	98.7	663	99.4	621	98.6	612	99.0	.59
Critical-access hospital	182	22.6	151	20.0	76	11.4	75	11.9	48	7.7	< .01
Hospital size											
< 200 beds	608	75.5	557	73.7	467	70.0	424	67.3	411	66.5	< .01
200-500 beds	79	9.8	94	12.4	101	15.1	96	15.2	100	16.2	< .01
> 500 beds	118	14.7	105	13.9	98	14.9	110	17.5	107	17.3	.05
Hospital ownership											
Government	141	17.5	131	17.3	85	12.7	140	22.2	126	20.4	.03
Investor owned	145	18.0	102	13.5	88	13.2	132	21.0	133	21.5	< .01
Not for profit	519	64.5	523	69.1	494	74.1	358	56.8	359	58.1	< .01
Hospital location											
Urban	548	79.3	520	79.5	493	84.6	454	86.0	453	88.0	< .01
Rural	143	20.7	134	20.5	90	15.4	74	14.0	62	12.0	
Hospital teaching status											
Teaching	143	17.8	160	21.2	175	26.2	154	24.4	138	22.3	< .01
Nonteaching	668	82.2	604	78.8	497	73.8	476	75.6	486	77.7	
High-technology hospital	204	25.3	223	29.2	231	34.6	197	31.2	198	32.0	< .01
Cancer center	276	34.3	286	37.8	313	46.9	213	33.8	260	42.1	< .01
Abbreviation: HRR, hospital referral region.											

Abbreviation: HRR, hospital referral region.

colon cancer surgery reported in previous work.²⁷ In fact, because colectomy is strongly indicated in most cases of nonmetastatic colon cancer, it has traditionally been considered an archetype low-variation procedure.^{14,27} Choice of approach, on the other hand, is highly dependent on provider skills, resources, and preferences, and therefore, more similar to other preference-sensitive procedures.²⁸

The finding that differences between surgeons drive variation in use of laparoscopy for colon cancer is consistent with recent literature evaluating trends in adoption of laparoscopic colectomy.²⁹ In a survey of Canadian general surgeons, those not performing laparoscopic resections identified lack of formal training and inadequate operating time as the primary barriers to adoption. Surgeons who performed laparoscopic colectomy, on the other hand, were more likely to have recently entered practice, have minimally-invasive fellowship training, and be affiliated with a university.²⁹

This study has several limitations. First, because this analysis only includes Medicare beneficiaries ≥ 65 years old, it may not be generalizable to younger patients. Indeed, recent studies of laparoscopic colectomy utilization that include younger patients have reported higher rates of laparoscopy than those observed in this study,^{11,12} and have highlighted differences in the demographics and comorbid diseases of patients older than 65 years compared with younger patients.³⁰ Nevertheless, the median age of colon cancer diagnosis is 68 years old,³¹ patients ≥ 65 years old account for more than 60% of all patients with colon cancer,^{30,32} and the use of Medicare claims eliminates any confounding influence of cost and reimbursement. Moreover, although younger patients may exhibit higher rates of laparoscopic colectomy utilization, this should not influence the variation in rates observed at

a regional level, and sensitivity analysis limited to the youngest patients in this study (65-70 years old) confirmed these results. Second, while HRR assignment of patients according to hospital location—instead of patient residence—may overestimate rates of laparoscopic colectomy due to concentration, the design of HRRs to include the major referral center for each geographic region should minimize this effect.³³

Third, this study utilizes a large administrative database, which can be limited by miscoding and imprecision,³⁴⁻³⁶ and lacks granular clinical details. Although random miscoding errors should not introduce bias, this lack of information (eg, advanced presentation, cancer stage, provider density, provider specialty, and conversion to open) may limit understanding of factors influencing use of laparoscopy. Despite this limitation, we used the best-performing comorbidity index currently available to account for patient characteristics.³⁷ While we cannot fully account for bias due to unmeasured confounding given the observational nature of this study, it is unlikely that advanced disease presentations or technical challenges for laparoscopy vary significantly at the regional level, as shown by the lack of clinically significant differences reported in Table 1. Consequently, if significant differences existed in unmeasured patient characteristics between HRRs, they would likely be driven by the migration of complex patients to particular regions. However, additional analyses using migration as an instrumental variable to partially account for unmeasured cancer-specific characteristics failed to attenuate the results of the primary analysis. Moreover, it is unlikely that unmeasured confounding can fully account for the magnitude of the variation presented

Fig 1. Age, sex, and race-adjusted utilization of laparoscopic colectomy across 306 hospital referral regions (HRRs) in the United States for the years 2009 and 2010. (*) Values listed as range of adjusted percentage utilization (number of HRRs).

herein, and these results are corroborated by previous literature evaluating variations in use of surgery,¹⁴ and survey data investigating use of laparoscopic colectomy.²⁹

Fourth, while administrative data limits accurate assessment of the conversion rate (recently reported to be 9.9% at a single center³⁸), the classification of converted cases as so-called open procedures in administrative data should not impact these results, as the purpose of this analysis is to investigate geographic variation in the ability of patients to benefit from laparoscopy. And finally, although the ideal proportion of laparoscopic to open colectomy is unknown, the presence of wide variation unrelated to observed patient characteristics suggests that the benefits of laparoscopy⁴⁻¹⁰ may not be available to Medicare beneficiaries living in certain regions.

Future efforts to reduce the geographic variation observed here will likely require increased utilization of the laparoscopic approach in eligible patients.²⁵ To achieve this goal, successful interventions must target both surgeons and patients. At the provider level, though multiple strategies have been found to successfully reduce surgical variation,³⁹ no intervention will persuade surgeons to perform procedures they feel inadequately trained to perform. Thus, future efforts to increase utilization of laparoscopic colectomy must increase the dissemination of training techniques and promote novel opportunities for learning. Previous studies have proven this to be feasible. In the study by Kapiteijn et al,⁴⁰ workshops, symposia, and video instructions were used to teach participating surgeons the technique of total mesorectal excision, and supervision by experienced surgeons during the first five cases confirmed technical quality.

At the patient level, successful strategies must address patient education. A majority of currently available web-based educational

resources for patients with colorectal cancer are poor in quality, and may not be accessible to patients who are not technologically savvy.⁴¹ The findings of this study suggest that some Medicare patients with colon cancer may not have access to a surgeon offering the laparoscopic approach. As a result, otherwise-eligible patients in low-utilizing regions who are uninformed regarding available surgical options may unknowingly forego the benefits of laparoscopy. To address this issue, professional societies and other organizations focused on the care of patients with colorectal cancer must promote the development and dissemination of novel high-quality resources for patient education that are accessible in multiple formats. By aligning the goals and knowledge of patients and surgeons, these efforts can promote well-informed treatment decisions that are ideally suited to the characteristics and preferences of patients, and the skills of providers.

AUTHORS' DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

Disclosures provided by the authors are available with this article at www.jco.org.

AUTHOR CONTRIBUTIONS

Conception and design: All authors

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Administrative support: Justin B. Dimick

Provision of study materials or patients: Justin B. Dimick

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