Use of Adjuvant Radiotherapy at Hospitals With and Without On-site Radiation Services

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BACKGROUND. In many areas of health care, whether patients receive specific medical interventions often is influenced heavily by the local availability of resources for delivering those services. However, relations between resource availability and utilization are relatively unexplored in cancer care, including perioperative adjuvant therapy.

METHODS. The authors studied associations between the on-site availability of radiation services and the use of adjuvant radiotherapy using the national, linked Surveillance, Epidemiology, and End Results-Medicare database (from 1992 to 2002). They examined 1 cancer for which the effectiveness of adjuvant radiotherapy was well established in randomized clinical trials (rectal cancer) and another cancer for which it was not (pancreatic cancer) (N = 10,198). The availability of on-site radiation services at the hospital where surgery was performed was assessed by using data from the American Hospital Association. In comparing rates of adjuvant radiotherapy, analyses were adjusted for both patient characteristics and other hospital attributes.

RESULTS. For rectal cancer, the use of adjuvant radiotherapy was similar in patients who underwent surgery at centers with and without on-site radiation services (29% vs 29%, respectively). Among patients with pancreatic cancer, however, those who underwent surgery at hospitals with on-site radiation services were twice as likely to receive radiotherapy than patients who underwent surgery at hospitals without such services (43% vs 26%, respectively; adjusted odds ratio, 2.1; 95% confidence interval, 1.4–3.2). Adjusting for other factors, the groups had similar survival rates for each cancer.

CONCLUSIONS. The availability of on-site radiation services significantly increased the likelihood that patients would receive radiotherapy, at least for cancers for which the effectiveness of such therapy was not well established. ***Cancer* 2007;109:796–801.** © *2007 American Cancer Society.*

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For some clinical conditions, whether patients receive a specific intervention is influenced heavily by the local supply of resources for delivering that service. For example, patients with acute coronary syndromes are more likely to undergo cardiac catheterization and revascularization if they present initially to hospitals that have cardiac catheterization facilities.[1] At the population level, the number of cardiac catheterization beds in a referral region is correlated positively with rates of invasive cardiac procedures, but not with the incidence of coronary artery disease.[2] Such supplier-induced demand seems to be more prevalent for *discretionary* clinical situations—those for which physician decisions about treatment are not tightly constrained by medical evidence and clinical consensus.[3,4]

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Although relations between supply and utilization have not been studied well in cancer treatment, it is plausible that the use of radiotherapy may be influenced by the local availability of such services. Because the maintenance of radiation therapy centers requires high up-front financial investments and specialized personnel, there are obvious incentives to ensure that these facilities are fully utilized. Hospitals with on-site radiation facilities also are staffed with radiation oncologists who may be more enthusiastic about the utility of radiotherapy, even in clinical settings in which the effectiveness of therapy has not been established definitively.

In this context, we studied the use of adjuvant radiotherapy among patients undergoing cancer surgery at hospitals with and without on-site radiation therapy services. We focused on 2 sites of cancer, the rectum and the pancreas, for which a high proportion of patients receive adjuvant radiotherapy. Although the 2 cancers are similar in this regard, the effectiveness of adjuvant radiation therapy in rectal cancer has been established clearly in numerous prospective, randomized clinical trials, whereas its role in the treatment of pancreatic cancer remains more controversial.[5–7] We hypothesized that the on-site availability of radiation services would have a greater influence on the use of adjuvant radiation therapy for pancreatic cancer than for rectal cancer.

MATERIALS AND METHODS

We used the national, linked Surveillance, Epidemiology, and End Results (SEER)-Medicare database from 1992 to 2002 for this study. SEER is a nationally representative collection of population-based registries of all incident cancers in the United States. During the study period, there were 11 SEER areas representing approximately 14% of the United States population. These registries contain information about patient demographics, cancer characteristics (including disease stage), and initial therapy. In the linked SEER-Medicare files, cancer registry data are linked to the claims data from Medicare patients who reside in SEER areas, including inpatient, outpatient, physician, home health, and hospice files. These files contain information that reflect both clinical diagnoses and the use of specific health services.

We identified all patients ages 65 years to 99 years who underwent major resection for pancreatic and rectal cancers between 1992 and 1999. For the analysis of late survival, patients were followed through the end of 2002. Patients with these 2 cancer types were identified by using appropriate cancer codes from the SEER files. The subset of patients who underwent major surgical resections was identified from Medicare inpatient files using the corresponding procedure codes (International Classification of Diseases, version 9). Comorbidities were identified by using information from the index admission and inpatient encounters from the preceding 6 months based on the methods described by Elixhauser et al.[8] Inpatient, outpatient, and physician claims were used to identify patients who received neoadjuvant or adjuvant radiation therapy, which we defined as treatments 4 months before or after resection.[9]

Availability of On-site Radiation Services

To assess whether hospitals that performed the index cancer resections had on-site radiation services, we used data from the fiscal year 2000 American Hospital Association (AHA) survey of all United States hospitals. Medicare and AHA files were linked by using hospitals' unique Medicare identifiers. Hospitals that cited radiation therapy services at nearby, affiliated, or networked institutions in the AHA database were not counted as having on-site services.

Analysis

We used multiple logistic regression to compare adjuvant radiotherapy rates at hospitals with and without radiation services. On-site availability of radiation services, assessed at the hospital level, was our primary exposure variable. Receipt of adjuvant radiation therapy, assessed at the patient level, was the outcome measured. Our analysis was adjusted for patient and hospital characteristics to explore their potential roles as mechanisms underlying observed correlations between on-site availability of radiation services and receipt of radiation therapy. Specific patient characteristics included age group (5-year intervals), sex, race (black, nonblack), admission acuity (elective, urgent/emergent), mean Social Security income (zip code level), and medical comorbidities. We also accounted for potential clustering of radiation therapy use within hospitals in the analysis.

Although our primary focus was receipt of adjuvant radiotherapy, we also assessed whether late survival rates for rectal and pancreatic cancers differed between hospitals with and without on-site radiation services. Cox proportional hazards models were used to adjust for patient factors (described above) and hospital characteristics, including teaching status and procedure volume. Volume in particular was a strong potential confounder in our analysis, because it was systematically higher in hospitals with on-site radiation facilities and appeared to be related independently to improved late survival after surgery for pancreatic and colorectal cancer.[10] We adjusted for

the effect of clustering of mortality within hospitals by using marginal proportional hazards models. All *P* values were 2-tailed. The study protocol was approved by the Institutional Review Board of the University of Michigan.

RESULTS

Between 1992 and 1999, 10,198 Medicare patients who resided in 11 SEER regions underwent resection for rectal or pancreatic cancer. The characteristics of patients who underwent resection at hospitals with and without on-site radiation services are shown in Table 1. For pancreatic cancer, the 2 hospital groups treated patients with similar demographic characteristics, comorbidity prevalence, and tumor stage. For rectal cancer, hospitals with on-site radiation services treated a slightly higher proportion of black patients and patients from low-income regions (5.7% vs 3.9% [$P = .002$] and 4.1% vs 2.5% [$P = .002$], respectively). Tumor characteristics did not differ significantly between the 2 hospital groups for either type of cancer.

Patients who underwent pancreatic resection at hospitals with on-site radiation services were more likely to receive systemic chemotherapy (31.6% vs 21.0%; $P = .01$). The proportions of patients with rectal cancer that received chemotherapy were similar between hospital types (29% vs 29%). Hospitals with on-site radiation services were larger and were more likely to be teaching hospitals (Table 2). Hospitals with on-site radiation services also had significantly higher procedure volumes for each cancer type.

For rectal cancer, the use of adjuvant radiotherapy was similar in patients who underwent surgery at centers with and without on-site radiation services, both overall (29.4% vs 29.1%, respectively) and by stage (Table 3). Among patients with pancreatic cancer, however, those who underwent resection at hospitals with on-site radiation services were twice as likely to receive radiation than those who underwent resection at hospitals without such services (42.9% vs 26.1%, respectively; adjusted odds ratio, 2.1; 95% confidence interval, 1.4–3.2). This association was most pronounced in patients with regional disease (Table 3).

For rectal cancer, there was no difference in late (5-year) survival rates between hospitals with and without on-site radiation facilities. For pancreatic cancer, observed mortality rates were lower for patients who underwent resection at hospitals with on-site radiation facilities. However, this relation between mortality and on-site radiation facilities was no longer significant after adjusting for patient and hospital characteristics, including procedure volume (Table 4). Further adjusting the analysis according to whether patients received adjuvant radiation had little effect on the results.

TABLE 1
Characteristics of Patients who Underwent Resection at Hospitals With and Without On-site Radiation Services

Cancer site	Hospitals with on-site RT services, n = 210	Hospitals without on-site RT services, n = 254	*P**
Pancreas			
Total no. of patients (%)	557 (78.0)	157 (22.0)	
Age (% aged >75 y)	196 (35.2)	66 (42.0)	.12
Sex (% male)	269 (48.3)	90 (57.3)	.05
Race (% black)	48 (8.7)	20 (12.7)	.13
Comorbid conditions (% with ≥2)	353 (63.4)	97 (61.8)	.72
Income (% low by zip code)	25 (4.7)	11 (7.6)	.16
Tumor stage: No. of patients (%)			
In situ/localized	104 (19.2)	28 (19.3)	.91
Regional	406 (75.1)	110 (75.9)	
Distant	31 (5.7)	7 (4.8)	
No. who received chemotherapy (%)	176 (31.6)	33 (21.0)	.0101
Rectum			
Total no. of patients (%)	6495 (68.5)	2989 (31.5)	
Age (% aged >75 y)	3397 (52.3)	1564 (52.3)	.98
Sex (% male)	3336 (51.4)	1599 (53.5)	.053
Race (% black)	371 (5.7)	117 (3.9)	.0002
Comorbid conditions (% with ≥2)	3457 (53.2)	1631 (54.6)	.22
Income (% low by zip code)	255 (4.1)	73 (2.5)	.0002
Tumor stage: No. of patients (%)			
Stage 0/I	2310 (36.6)	1058 (36.8)	.69
Stage II	1784 (28.3)	811 (28.2)	
Stage III	1614 (25.6)	754 (26.2)	
Stage IV	606 (9.6)	255 (8.9)	
No. who received chemotherapy (%)	1909 (29.4)	867 (29.0)	.70

RT indicates radiotherapy.
* Pearson chi square test.

DISCUSSION

For some cancers, whether patients receive adjuvant radiotherapy seems to be influenced heavily by the local availability of radiation services. In the current study, this relation was particularly apparent for pancreatic cancer, for which the role of adjuvant radiotherapy remains controversial.[11] Patients with pancreatic cancer were almost twice as likely to receive adjuvant radiation therapy if their surgery was performed at hospitals with on-site radiation facilities. Conversely, the use of adjuvant radiotherapy did not vary across hospital types among patients with rectal cancer, for which the indications for radiotherapy are relatively well established.

Greater use of adjuvant radiotherapy at hospitals with on-site radiation facilities is not explained easily

TABLE 2
Characteristics of Hospitals at Which Resections Were Performed According to On-site Availability of Radiation Services

Cancer type	Hospitals with on-site RT services, n = 210	Hospitals without on-site RT services, n = 254	*P**
Pancreas			
Teaching hospital status (% teaching)	66 (54.1)	22 (33.3)	.007
Volume by no. of patients (%)			
Lowest tercile	84 (68.9)	58 (87.9)	.012
Middle tercile	28 (23.0)	7 (10.6)	
Highest tercile	10 (8.2)	1 (1.5)	
Median no. of beds	348	197	<.0001†
Rectum			
Teaching hospital status (% teaching)	104 (49.5)	51 (20.1)	<.0001
Volume by no. of patients (%)			
Lowest tercile	137 (65.2)	234 (92.1)	<.0001
Middle tercile	47 (22.4)	15 (5.9)	
Highest tercile	26 (12.4)	5 (2.0)	
Median no. of beds	291	111	<.0001†

RT indicates radiotherapy.
* Pearson chi-square test.
† Nonparametric test.

TABLE 3
Association Between Use of Radiotherapy and On-site Availability of Services for Patients Undergoing Resection for Cancer Stratified by Cancer Type and Stage

Cancer type/stage	Percentage of patients who received RT: Hospitals with on-site RT services, n = 210	Percentage of patients who received RT: Hospitals without on-site RT services, n = 254	Reference group*: OR	Reference group*: 95% CI
Pancreas				
In situ/localized	30.8	35.7	0.80	0.33–1.93
Regional	47.5	27.3	2.42	1.52–3.84
Distant	19.4	0	—	—
All patients	42.9	26.1	2.13	1.43–3.15
Rectum				
Stage 0/I	12.3	14.0	0.87	0.70–1.07
Stage II	36.0	36.6	0.98	0.82–1.16
Stage III	47.8	43.8	1.18	0.99–1.40
Stage IV	18.3	18.0	1.11	0.70–1.49
All patients	29.4	29.1	1.01	0.92–1.11

RT indicates radiotherapy; OR, odds ratio; 95% CI, 95% confidence interval.
* The reference group was hospitals without on-site RT services.

by differences in patient characteristics at those centers. Although some may argue that the SEER staging system (localized, regional, distant) is somewhat imprecise for pancreatic cancer, we detected no evidence of important differences in stage distributions between patients at hospitals with and without radiation facilities. Patients at the former hospitals may be more likely to receive postoperative radiotherapy because they are healthier and have fewer comorbidities. However, we did not detect such differences in our analysis, and the limitations of SEER-Medicare data for capturing illness severity and comorbidity are widely recognized.[12] Finally, patients at hospitals with on-site radiation facilities may be more likely to receive adjuvant therapy because they experience fewer postoperative complications that may interfere with such therapy. This hypothesis is plausible to the extent that hospitals with radiation facilities tend to be larger and have higher procedure volumes, factors that previously were linked to lower complication rates with pancreatic resection.[13,14] In the current study, we did observe that hospitals with on-site radiation services also had significantly higher procedure volumes for each cancer type. However, differences in the use of adjuvant therapy persisted after adjusting for procedure volume and seemed too large to be attributed solely to differences in postoperative complication rates. More broadly, our findings that the use of adjuvant radiotherapy did not differ between hospital types for rectal cancer make it less plausible that patient characteristics explain higher rates of adjuvant radiotherapy with pancreatic cancer.

Could our findings be explained by geography and patient preferences? In other words, some patients who undergo pancreatic resection at hospitals without radiation facilities may live too far from radiation centers and may choose not to travel for adjuvant therapy. Previous studies in breast cancer have suggested associations between increased travel distances and lower rates of breast-conservation therapy (lumpectomy and postoperative radiotherapy).[15,16] Nonetheless, this hypothesis remains an unlikely explanation for our findings. Similar relations between travel distance and use of adjuvant radiotherapy could be argued for rectal cancer, but the use of adjuvant radiotherapy did not differ between hospital types in that patient population. Given more uncertainty about its effectiveness for pancreatic cancer, travel distance may influence the use of adjuvant radiotherapy more than for rectal cancer. However, it is unlikely that such differences in use between these 2 types of cancers would be explained by patient preferences for travel. Results from a previous study suggested that most patients who underwent pancreatic resection for pancreatic

TABLE 4
Association Between On-site Availability of Radiation Services and Late Survival (5-Year Survival) in Patients Undergoing Resection for Selected Cancers

	HR for mortality: Resection at hospitals with versus hospitals without on-site RT services (95% CI)*			
Cancer type	Unadjusted	Adjusted for patient characteristics	Adjusted for patient characteristics and hospital volume (Continuous)	Adjusted for patient characteristics, hospital volume, and receipt of RT
Pancreas	1.26 (1.04–1.51)	1.20 (0.97–1.47)	1.16 (0.93–1.43)	1.11 (0.90–1.37)
Rectum	1.04 (0.99–1.10)	1.07 (1.01–1.13)	1.04 (0.98–1.10)	1.03 (0.97–1.10)

HR indicates hazard ratio; RT, radiotherapy; 95% CI, 95% confidence interval.
* Reference group is hospitals with on-site RT services.

cancer at small, low-volume hospitals resided in close proximity to high-volume centers, most of which had on-site radiation facilities.[17]

For these reasons, we believe that higher rates of adjuvant radiotherapy with pancreatic cancer at hospitals with on-site radiation facilities are more likely attributable to provider factors than to patient factors. One potential reason for this is that such facilities may have higher radiotherapy rates in part because they enroll more patients in clinical trials. Currently, however, there are not enough ongoing, multimodality, phase II or III trials for pancreatic cancer to explain differences in utilization rates of the magnitude observed in this national, population-based study.[7]

A more likely explanation is that hospitals with on-site radiation services are staffed with cancer specialists who are more enthusiastic about adjuvant therapy. The *enthusiasm hypothesis*, as suggested orig-inally by Chassin, suggests that variations in health care utilization occur primarily because physicians in different settings vary in their proclivity to recommend specific medical interventions.[18] Specialists and/or high-volume providers of specific interventions tend to be most enthusiastic in these clinical situations; and, when decisions are not constrained tightly by medical evidence or professional consensus, large variations in practice style may result. In the context of this study, hospitals with on-site radiation services have on-site radiation oncologists participating in clinical decision making (including multidisciplinary tumor boards). Like in any group of specialists, radiation therapists are likely to be more optimistic about the benefits of services they provide than physicians outside their specialty. They also may be more likely to recommend adjuvant radiotherapy when it seems more convenient (because it is available locally) or in response to pressures, implicit or explicit, to fully utilize their hospitals' resources. Similar to patterns observed for the use of radiotherapy, patients with pancreatic cancer also were much more likely to receive chemotherapy when they were treated at hospitals with on-site radiation facilities, whereas there was no apparent difference in the utilization of chemotherapy among patients with rectal cancer. The direct relation between the use of chemotherapy and hospitals with on-site radiation facilities was not examined as part of this study.

It is worth acknowledging limitations in our ability to ascertain the presence of on-site radiation facilities at individual hospitals. The presence of such facilities was based on self-reported information collected by the AHA in its annual, voluntary survey of United States hospitals. Because the response rate to this survey is incomplete, and hospitals may not complete every field, we were unable to establish the presence or absence of on-site radiation facilities in 27% of hospitals. The net effect of excluding these hospitals from our analysis, or of misclassification of facility status in hospitals that did respond, is uncertain. However, we believe that such misclassification of our main exposure variable would most likely bias our results toward the null, causing us to underestimate the effect of on-site resources and adjuvant radiotherapy use.

Among patients with stage III rectal cancer, somewhat fewer patients received radiotherapy at the hospitals without on-site radiation services (43.8% vs 47.8%), suggesting a component of underutilization in the face of strong, evidence-based medicine. Our study documents much greater variation in the rates of adjuvant radiotherapy for pancreatic cancer, but it does not answer the basic question: Which rate is right? Currently, the literature that supports the effectiveness of adjuvant therapy in this setting is mixed. Only 1 small randomized controlled trial (RCT) of 5-fluorouracil chemotherapy and radiother-

apy that was conducted by the Gastrointestinal Tumor Study Group between 1974 and 1982 demonstrated a benefit for adjuvant radiotherapy in pancreatic cancer.[19] Subsequent, larger RCTs failed to demonstrate a similar benefit, and results from the most recent trial even suggested a detrimental effect for radiotherapy.[11,20] Although our results were not as powerful as evidence from RCTs, it is worth noting that we did not detect any evidence that more frequent use of adjuvant radiotherapy was associated with improved survival after resection for pancreatic cancer in the current study.

Nonetheless, our current findings suggest that adjuvant radiotherapy for pancreatic cancer is either over-utilized at hospitals with radiation facilities or under-utilized at centers without them. The former would imply unnecessary inconvenience and potential morbidity for patients as well as unnecessary expense for payers. The latter would imply that many patients are missing opportunities for better multimodality cancer treatment. Distinguishing between these 2 scenarios will require a better understanding about how both patients and physicians make decisions about adjuvant therapy under conditions of uncertainty. Most important, it will require more definitive information from prospective trials about the effectiveness of adjuvant radiotherapy for patients with pancreatic cancer.

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