Title
Palliative Radiation Before Hospice: The Long and the Short of It

Journal
Journal of Pain and Symptom Management, 48(6)

ISSN
0885-3924

Authors
Yeung, Heidi N
Mitchell, William M
Roeland, Eric J
et al.

Publication Date
2014-12-01

DOI
10.1016/j.jpainsymman.2014.04.004

Peer reviewed

Original Article

Palliative Radiation Before Hospice: The Long and the Short of It

Heidi N. Yeung, MD, William M. Mitchell, MD, Eric J. Roeland, MD, Beibei Xu, PhD, Loren K. Mell, MD, Quynh-Thu Le, MD, and James D. Murphy, MD, MS

Division of Palliative Medicine (H.N.Y., W.M.M., E.J.R.), Department of Internal Medicine, and Department of Radiation Medicine and Applied Sciences (B.X., L.K.M., J.D.M.), Center for Advanced Radiotherapy Technologies, University of California, San Diego, La Jolla; and Department of Radiation Oncology (Q.T.-L.), Stanford University School of Medicine, Stanford, California, USA

Abstract

Context. Randomized data support shorter radiotherapy courses for management of cancer-related symptoms in the palliative setting.

Objectives. The purpose of this study was to evaluate the length of palliative radiotherapy before hospice enrollment among the elderly U.S. population, with a further focus on factors that influence the duration of radiation and the length of survival on hospice, including whether the duration of radiation was associated with length of survival on hospice.

Methods. A total of 6982 patients with breast, prostate, lung, or colorectal cancer who received a course of radiotherapy within 30 days before hospice enrollment were identified within the Surveillance, Epidemiology, and End Results-Medicare linked database. The primary end points included the duration of palliative radiotherapy and the time from hospice enrollment through death (hospice duration). Multivariate linear regression and multivariate Cox models evaluated factors associated with the length of radiotherapy course and hospice duration.

Results. The median length of palliative radiotherapy was 14 days, and the median hospice duration was 13 days. The course of palliative radiotherapy was longer than hospice duration in 48% of the patients. Breast and lung cancer were associated with longer courses of radiotherapy and shorter stays on hospice. Patients treated in freestanding radiation centers had longer courses of radiotherapy. For these groups, a longer radiotherapy course was not associated with longer hospice duration.

Conclusion. This study found relatively long courses of radiotherapy before short lengths of survival on hospice. Future research is needed to identify barriers to shorter radiotherapy courses. J Pain Symptom Manage 2014;48:1070–1079.

Address correspondence to: James D. Murphy, MD, MS, Department of Radiation Medicine and Applied Sciences, University of California, San Diego, 3960 Health Sciences Drive, La Jolla, CA 92093-0865, USA. E-mail: j2murphy@ucsd.edu

Accepted for publication: April 23, 2014.

0885-3924/$ - see front matter
http://dx.doi.org/10.1016/j.jpainsymman.2014.04.004

Key Words
Palliative radiation, hospice, cancer

Introduction

Palliative radiotherapy at the end of life can substantially improve quality of life. Common indications for palliative radiotherapy include painful bone metastases, symptomatic brain metastases, bleeding, nerve or spinal cord compression, and airway obstruction. The general goals of palliative radiotherapy include the relief of pain and to improve or preserve function. The primary limitation of radiotherapy in the palliative setting relates to the duration of radiation treatment, which typically involves daily treatments that can last up to several weeks. Prolonged courses of radiation can require substantial patient effort and cost, which could add significant burden particularly to those with limited life expectancy.[1]

With radiation therapy, the therapeutic window between treatment efficacy and toxicity widens when one divides a radiation course into multiple smaller treatments distributed over several days, weeks, or months.[2] This fundamental radiobiology tenet of using multiple smaller daily radiation doses, also known as fractions, plays a central role with the high doses of radiation required when treating patients with curative intent. Radiation in the palliative setting, however, requires much lower doses to achieve the desired palliative effect. In fact, numerous randomized clinical trials in palliative care patients have shown equivalency between shorter radiation regimens extending over days to a couple of weeks compared with longer radiation regimens.[3–6]

Little is known about the duration of radiation treatment before hospice enrollment.[7–10] The purpose of this population-based study was to define the duration of radiation before hospice enrollment, with a further focus on factors that influence the duration of radiation and the length of survival on hospice, including whether the duration of radiation was associated with the length of survival on hospice.

Methods

Data

This study used data from the Surveillance, Epidemiology, and End Results (SEER)-Medicare linked database. The SEER Cancer Registry collects data on every cancer case in 20 distinct geographic areas across the U.S., which account for 28% of the U.S. population. Medicare provides government-funded health insurance for people older than 65 years, which includes a wide range of hospice and palliative care services for patients expected to live six months or less. The SEER-Medicare linkage contains Medicare billing claim data for each Medicare-eligible patient within the SEER database.

Study Cohort

This study focused on breast, prostate, lung, and colorectal cancer, which collectively account for 48% of cancer-related deaths in the U.S.[11] Within the SEER-Medicare database, we initially identified 688,322 subjects older than 66 years diagnosed between 2000 through 2007. Although Medicare includes patients older than 65 years, this study included only patients older than 66 years to allow for determination of pre-existing comorbidity, which requires one year of Medicare claims before diagnosis (comorbidity defined subsequently). This study focused on patients who enrolled in hospice (n = 192,677), and to reduce the number of patients in hospice for noncancer reasons, we restricted our study cohort to those with a record of a cancer-related cause of death (n = 145,842). We excluded 21,366 patients diagnosed at death or autopsy, excluded 27,085 patients with evidence of more than one primary cancer, and excluded 32,451 patients with incomplete Medicare claim data (continuous Part A, Part B, without Part C enrollment) for 12 months before diagnosis through death, leaving 64,940 patients. Finally, we included only those who received radiation therapy within 30 days before hospice admission, which yielded 8136 patients (13%). This period was chosen to further focus on those who likely received radiation with palliative intent. Because of small patient numbers, we excluded those who received radiation during hospice ($n = 249$). Finally, to reduce the number of patients treated with "definitive" intent radiotherapy, we excluded 905 patients with local or regional disease at presentation if they received radiation within six months of diagnosis, leaving 6982 patients in the final study cohort. This study was deemed exempt from the institutional review board approval.

Outcomes Analyzed

The primary outcomes in this study included duration of radiation therapy and duration of hospice enrollment. Hospice admission was identified from the hospice admission date on Medicare claims. Duration of hospice enrollment was defined from the date of hospice admission identified on Medicare claims through death. A small fraction of patients (2.0%) had multiple hospice admissions, and with these patients, our analysis focused on the last hospice admission before death.

The delivery of radiation was identified from Medicare billing claims[12] using the following Health Care Common Procedure Coding System radiation treatment codes: 61,796–61,800, 63,620–63,621, 77,371–77,373, 77,401–77,416, 77,418, 77,421–77,423, 77,470, 77,520, 77,522, 77,523, 77,525, 0197T, G0173–G0174, G0243, G0251, and G0339–G0340. The number of daily treatments per course of radiation was estimated from the number of unique days with a billing claim for radiation treatment. Patients often receive multiple separate courses of radiation throughout their cancer treatment; therefore, we assumed that any break in radiation treatment codes of more than 14 days indicated a separate course of radiation. The duration of a course of radiation was defined as the time between the first and last radiation billing claim for the individual course. With patients who received multiple courses of radiation, our analysis focused on the last course before hospice enrollment. Our inclusion criteria identified patients with a record of any radiation within 30 days before hospice enrollment. However, to accurately capture the length of treatment, our study included the entire length of this course of radiation, even when the radiation start date occurred before 30 days before hospice enrollment.

Covariates

Patient demographic, tumor, and treatment data were obtained from SEER and Medicare. Covariates captured in SEER included age at diagnosis, race, marital status, registry location, socioeconomic status, and year of diagnosis (2000–2007). Individual SEER cancer registries were grouped into East (Connecticut and New Jersey), Midwest (Detroit and Iowa), South (Atlanta, Rural Georgia, Kentucky, and Louisiana), and West (San Francisco, Hawaii, New Mexico, Seattle, Utah, San Jose, Los Angeles, and Greater California). Socioeconomic status was estimated by median household income divided into quintiles. Median household income was obtained from the U.S. census, using census track data before zip code data and secondarily using race- and age-adjusted data before unadjusted data. Patients without household income data (<1%) were grouped into the bottom quintile. Comorbidity was captured from Medicare claims during the 12 months before diagnosis using the Charlson Comorbidity Index,[13] with the Deyo adaptation.[14] SEER provided information on tumor site and tumor stage at diagnosis (local, regional, or distant). Radiation delivery in a hospital-associated outpatient clinic vs. a freestanding clinic was determined from the source of billing claims, as used by Smith et al.[15] Treatment at a teaching hospital was defined as any indirect medical education payment during a hospitalization after a patient's diagnosis.

International Classification of Diseases, Ninth Revision (*ICD-9*), diagnosis codes from radiation billing claims were used to identify patients treated with bone or brain metastases. *ICD-9* diagnosis codes 196 through 198 refer to an array of secondary or metastatic neoplasm diagnoses. Bone metastases have a specific *ICD-9* code (198.5), whereas brain metastases are coupled with spinal cord metastases under a single *ICD-9* code (198.3). The rates of spinal cord metastases are low compared with brain metastases; therefore, we believe that the analysis with the *ICD-9* code 198.3 largely reflects brain metastases. Compared with spinal cord metastases, the more common clinical scenario of spinal cord compression from bony spine metastases would be coded as a bone metastasis.[16] It was assumed that patients were treated for bone or brain/spinal cord metastases when the corresponding *ICD-9* code was present, without the presence of another metastatic neoplasm *ICD-9* diagnosis code.

Statistical Analyses

Predictors of radiotherapy duration were assessed with a multivariate linear regression model. Given that radiation treatment times are non-negative and show a slightly skewed distribution (Fig. 1a), we conducted a sensitivity analysis by repeating this analysis with a multivariate negative binomial regression. Results from the negative binomial regression were similar to the linear regression, and for ease of interpretation, we have presented only the linear regression results. Time from hospice enrollment through death (hospice duration) was plotted with the method of Kaplan and Meier.[17] Predictors of hospice duration were analyzed with a multivariate Cox regression model, with hazard ratios >1 representing shorter hospice duration and hazard ratios <1 representing longer hospice duration. In an attempt to exclude patients treated with definitive intent, the patients in this study with local or regional disease at presentation were required to have radiation therapy more than six months after diagnosis. We conducted a sensitivity analysis where we increased this six-month cutoff to nine and then 12 months. The sensitivity analysis with these different time cutoffs decreased the number of local/regional patients but did not change the

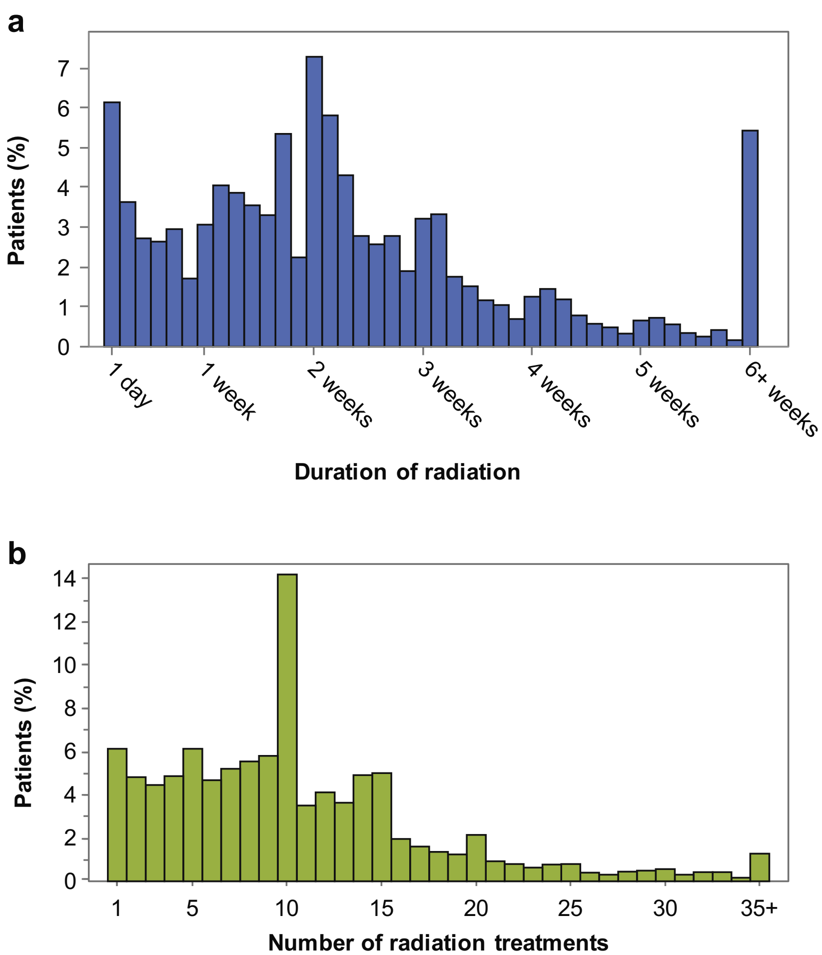

Fig. 1. Length of radiation course before hospice enrollment. a) Demonstrates the duration of palliative radiation and b) the number of daily radiation fractions/treatments for the entire study population ($n = 6982$).

results (analyses not included). All statistical analyses were conducted with SAS, version 9.3 (SAS Institute Inc., Cary, NC).

Results

Table 1 demonstrates characteristics of the 6982 patients in this study treated with radiation within 30 days before hospice enrollment. Most patients in this study had lung cancer and presented with metastatic disease. Two-thirds were treated with radiation in a hospital-associated outpatient clinic and one-third in a freestanding center. The median time from diagnosis to radiation was 5.2 months, although the study included patients treated with radiation across a wide array of time points, with 18% receiving radiation within 30 days of diagnosis and 18% receiving radiation more than one year after diagnosis.

Duration of Palliative Radiation

The median length of palliative radiotherapy was 14 days, although the distribution of treatment lengths varied greatly across the study cohort (Fig. 1). Twenty-three percent of the study cohort had radiation courses that lasted one week or less, and only 6.0% had radiation delivered in a single day. However, 40% of the study cohort received more than two weeks of radiation, and 27% had more than three weeks of radiation. As expected, the duration of radiation correlated strongly with the number of radiation treatments (Pearson $r = 0.95$, $P < 0.0001$). The median number of daily radiation treatments was 10, with 26% of the study cohort receiving five or less treatments and 22% receiving 15 or more.

Duration of Hospice Enrollment

The median time from hospice admission through death was 13 days (Fig. 2). Only 27% of the study cohort survived more than one month, and 36% died within the first week of hospice enrollment. Forty-eight percent (3373 patients) had courses of radiation equal to or longer than their hospice enrollment. There was a weak but statistically significant correlation between duration of ra-

Table 1
Patient Characteristics

Characteristics	*N* (%)
Tumor site	
Breast	458 (6.6)
Colorectal	419 (6.0)
Lung	5725 (82)
Prostate	380 (5.4)
Palliative radiation target	
Bone	1643 (24)
Brain/spinal cord	1765 (25)
Other/unknown	3574 (51)
Disease stage at diagnosis	
Localized	561 (8.0)
Regional	991 (14)
Distant	5297 (76)
Unknown	133 (1.9)
Charlson Comorbidity Index	
0	3610 (52)
1	2013 (29)
2	785 (11)
≥3	574 (8.2)
Age at diagnosis (yrs)	
66–69	1604 (23)
70–74	2020 (29)
75–79	1829 (26)
80–84	1115 (16)
≥85	414 (5.9)
Sex	
Male	3546 (51)
Female	3436 (49)
Race	
White	6231 (89)
Black	448 (6.4)
Other	303 (4.3)
Marital status	
Married	3753 (54)
Other	3229 (46)
Region	
East	1483 (21)
Midwest	1268 (18)
South	1662 (24)
West	2569 (37)
Reside in a metropolitan area	5769 (83)
Year of diagnosis	
2000	874 (13)
2001	931 (13)
2002	896 (13)
2003	910 (13)
2004	901 (13)
2005	902 (13)
2006	862 (12)
2007	706 (10)
Radiation oncology clinic	
Freestanding center	2309 (33)
Hospital-associated outpatient clinic	4554 (65)
Hospital-associated outpatient clinic and freestanding center	119 (1.7)
Teaching hospital	3430 (49)
Time from diagnosis to radiation	
<1 month	1116 (16)
2 months	1405 (20)
3–6 months	1151 (16)
7–12 months	1445 (21)
>1 year	1865 (27)
Prior course of radiation	2206 (32)

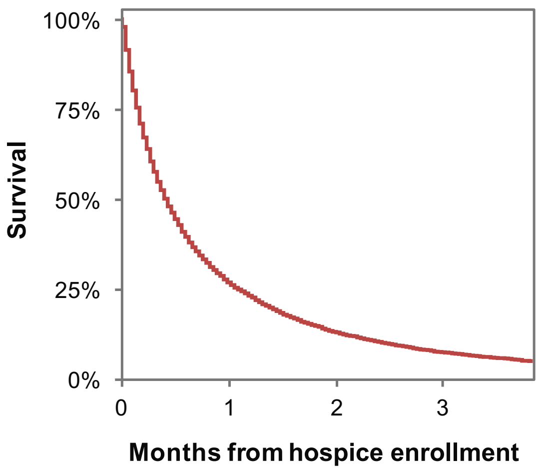

Fig. 2. Duration of hospice enrollment. This plot represents a Kaplan-Meier analysis of the time from enrollment in hospice through death.

diation and duration of hospice enrollment ($r = 0.03$, $P = 0.01$). This weak correlation translated clinically into a one-day increase in hospice enrollment for each additional week of radiation.

Predictors of Duration of Palliative Radiation and Duration of Hospice

Next, we used multivariate analyses to identify potential factors associated with length of radiation and also determined if these factors predicted for longer or shorter durations of hospice enrollment (Fig. 3). Notable findings include that patients with breast and lung cancer had slightly longer courses of radiation compared with those with prostate cancer (average 1.8 days longer and 1.5 days longer, respectively); however, they had shorter stays in hospice. Those receiving radiation for brain/spinal cord metastases had nearly identical radiation courses as those with bone metastases, although had shorter hospice duration. Patients treated in freestanding radiation centers had longer courses of radiotherapy, yet this translated into no detectable difference in hospice duration. Patients with no history of radiotherapy had longer courses of palliative radiation, but this was not associated with differences in hospice duration. Male patients had no significant difference in length of radiation course; however, they had shorter stays in hospice compared with female patients. Of note, the length of palliative radiation and length of hospice enrollment both tended to decrease over the study period.

Discussion

Multiple factors influence the decision regarding a radiation prescription dose and corresponding treatment duration. In patients with advanced cancer and limited life expectancy, the time commitment and daily transportation required for treatment can place considerable burden on patients, families, and caregivers. Additionally, the high cost of radiation limits its use in hospice,[18] which means that longer courses of palliative radiation could potentially delay a patient's enrollment into hospice. Overall, one could argue that the individual patient would benefit most from the shortest course of effective and safe radiation treatment.

The key finding in this study relates to the observation that a large number of patients receive long courses of palliative radiation before relatively short durations of hospice enrollment. The heterogeneity of conditions treated with palliative radiotherapy makes standardization of treatment difficult; however, multiple prospective randomized clinical trials evaluating different radiation doses have found equivalency between shorter and longer radiation schedules in terms of patient-reported quality of life metrics.[3–5] For example, bone metastases represent a very common cause of metastatic disease,[19] and radiation represents a common treatment with the goal of reducing pain. With bone metastases, numerous randomized trials have found no difference in response rate with single-fraction (one day) radiation compared with courses extending daily over one to two weeks.[3] The likelihood of retreatment was higher with single-fraction radiation, although this may represent a patient or physician's willingness to retreat after a single fraction as opposed to retreatment after multiple fractions.[3] With brain metastases, single-fraction whole-brain radiotherapy has shown increased toxicity, but a recent Cochrane review of whole-brain radiation found no difference between five daily fractions compared with longer treatment regimens in terms of symptom control, neurologic function, or overall

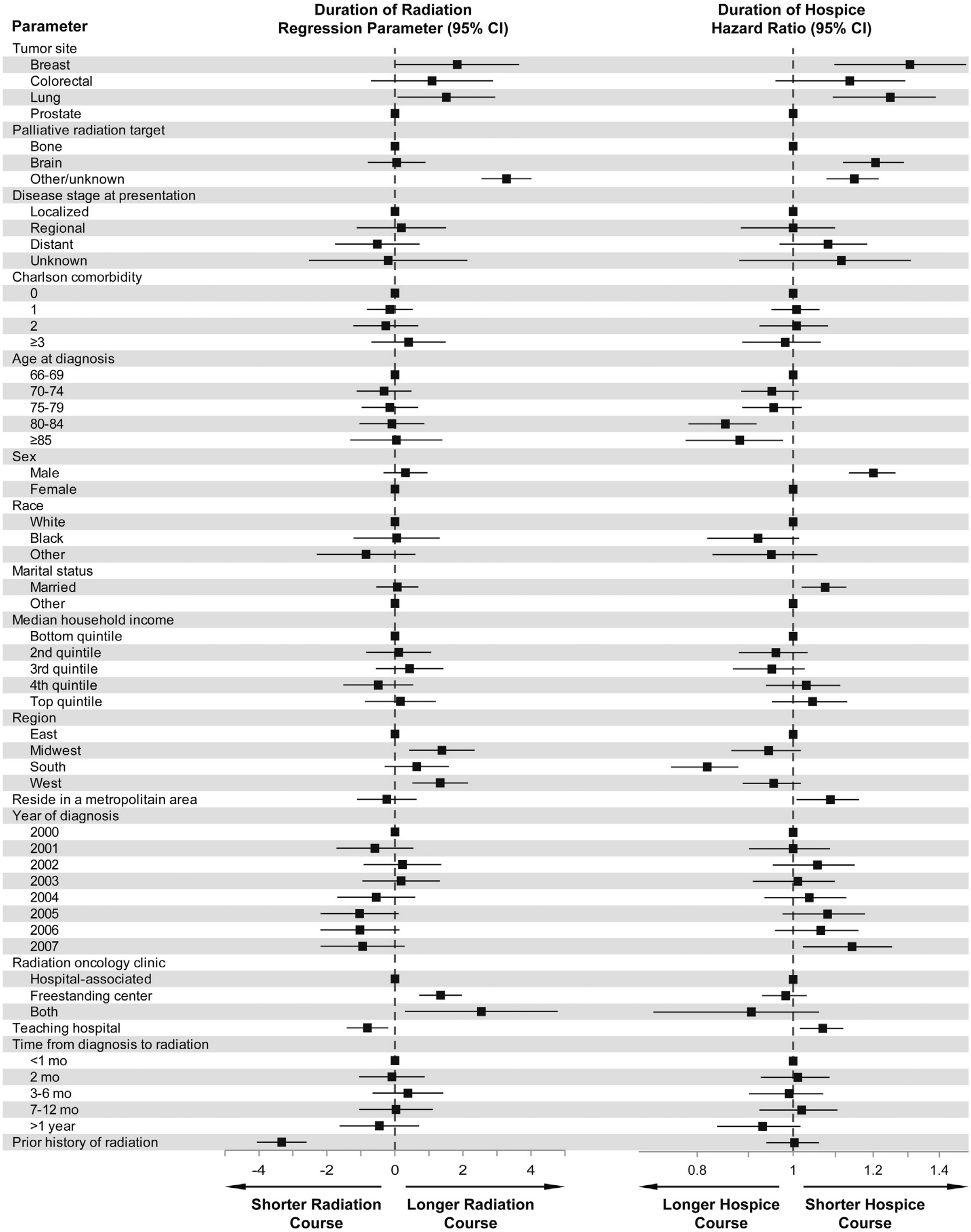

Fig. 3. Predictors of length of radiation course and hospice duration. This figure represents the results of a multivariate linear regression to determine the predictors of the duration of radiation before hospice enrollment (left) and a multivariate Cox regression to determine the predictors of the duration from hospice enrollment through death (right). The filled squares represent regression coefficients (left) and hazard ratios (right), and error bars represent 95% CIs.

survival.[4] The situation with lung metastases is more complicated. A meta-analysis in patients with lung cancer found no difference in hemoptysis, cough, or chest pain among those receiving longer or shorter courses of radiation.[5] However, this same meta-analysis found a slightly improved one-year overall survival in patients receiving higher effective doses for a longer period of time. One must recognize that the one-year overall survival in this meta-analysis ranged from 21.7% to 26.5%, which was much higher than our survival at one year (<1%), highlighting the differences in study cohorts. Guidelines have recently emerged for common indications such as bone, brain, and lung metastases,[20–22] which defend the use of shorter treatment schedules, especially in patients with limited life expectancy.

Although our study limited its analysis to those receiving palliative radiation before hospice, other studies have evaluated patterns of care of palliative radiation among different cancer populations.[7–10] A recently published study by Guadagnolo et al.[8] evaluated palliative radiation use in the last 30 days of life. The authors found that those enrolling in hospice received shorter courses of radiation compared with those who did not enroll in hospice. In general, Guadagnolo et al. found a shorter duration of radiation across the whole study cohort, although their study appeared to limit their radiation capture window at 30 days before death. Their ascertainment of radiation differed from our study where we required a patient to finish radiation within 30 days before hospice enrollment, but we included the entire course of radiation (even where it extended outside the 30-day window). Consequently, the different definitions of radiotherapy make direct comparisons between studies difficult. Additionally, it would be interesting to analyze patients who receive radiation while on hospice, although the numbers in this subgroup were small, making formal analysis infeasible.

This study attempted to identify potential factors that influence length of radiation and hospice duration. Notably, the factors that predicted longer courses of radiation failed to translate into longer durations of hospice, potentially because longer courses of radiotherapy delay enrollment into hospice. The finding that patients treated in freestanding centers had longer courses of radiation as compared with those treated in hospital-based clinics may relate to different incentive models given that more freestanding clinics may be privately owned. Also, the finding that breast and lung cancer patients had longer courses of radiation compared with prostate cancer patients likely represents different patterns of disease spread leading to differing indications for palliative radiation. Although this study failed to find impactful prognostic variables, the available data do not allow for evaluation of other important prognostic factors such as performance status. One of the main challenges that clinicians face when confronting cancer patients relates to prognostication. It is quite possible that inaccurate or overoptimistic assessment of prognosis led to longer fractionation schemes. Despite limitations of prognostication tools, and the accepted challenges of estimating survival,[23] hospice enrollment is generally considered a marker of limited life expectancy,[24,25] consistent with the findings in this study that found a median of 13 days from hospice enrollment through death.

There are a number of limitations to our study. First, SEER-Medicare fails to capture treatment intent. The timing of radiation before hospice enrollment suggests palliative intent, although a subset of patients could have received treatment with definitive intent and suffered rapid disease progression resulting in hospice enrollment. Our initial patient selection attempted to remove these patients, and ultimately, we believe the remaining definitively treated subset accounts for a small fraction unlikely to impact our conclusions. A second limitation relates to our ascertainment of radiation duration, where a patient who received sequential short courses of radiation for different indications could appear to have received one long course. A third limitation relates to our assessment of bone or brain metastases, where our use of secondary neoplasm codes to identify radiation target has not been validated; therefore, there is a possibility of misclassification. Plus, the *ICD-9* code used to identify brain metastases also includes spinal cord metastases (not spinal bone metastases). Although we suspect the rates of spinal cord metastases are low compared with brain metastases, we cannot exclude the introduction of bias into our analysis. A fourth limitation comes from the lack of quality of life measures as this information was not provided in the SEER-Medicare data. Thus, it is uncertain what clinical impact resulted from the various courses of radiation. Also, the lack of younger patients in our cohort limits the generalizability of our findings in patients younger than 65 years. Despite this restriction, the younger subsets of patients in our study had shorter hospice durations, which suggests that our findings could actually be magnified in patients younger than 65 years. A final limitation with the interpretation of our results relates to the lack of a standard course length of palliative radiation. Some might consider 10 radiation treatments (the median in this study), the standard of care during the years evaluated (2000–2007). Even if 10 were considered standard, nearly 40% of our study cohort received more than 10 treatments, and little data support palliative courses of radiation longer than 10 fractions.

To conclude, this study found that a substantial fraction of cancer patients received long courses of palliative radiotherapy before short lengths of survival on hospice. Further research should concentrate on constructing and validating prognostic tools to help providers identify patients with short life expectancy and should seek to identify barriers to shorter courses of palliative radiotherapy.

Disclosures and Acknowledgments

This work was supported by an American Society of Clinical Oncology Young Investigator Award (Dr. Murphy), NIH KL2 RR031978 (Dr. Murphy), and research funding from Varian Medical Systems (Drs. Murphy and Le). The authors declare no conflicts of interest. This study used the linked SEER-Medicare database. The interpretation and reporting of these data are the sole responsibility of the authors.

The authors acknowledge the efforts of the Applied Research Program, National Cancer Institute; the Office of Research, Development and Information, Centers for Medicare and Medicaid Services; Information Management Services, Inc.; and the SEER Program tumor registries in the creation of the SEER-Medicare database.

References

1. Konski A, James J, Hartsell W, et al. Economic analysis of radiation therapy oncology group 97-14: multiple versus single fraction radiation treatment of patients with bone metastases. Am J Clin Oncol 2009;32:423–428.

2. Hall EJ, Giaccia AJ. Radiobiology for the radiologist, 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins, 2006.

3. Chow E, Harris K, Fan G, Tsao M, Sze WM. Palliative radiotherapy trials for bone metastases: a systematic review. J Clin Oncol 2007;25:1423–1436.

4. Tsao MN, Lloyd N, Wong RK, et al. Whole brain radiotherapy for the treatment of newly diagnosed multiple brain metastases. Cochrane Database Syst Rev 2012;CD003869.

5. Fairchild A, Harris K, Barnes E, et al. Palliative thoracic radiotherapy for lung cancer: a systematic review. J Clin Oncol 2008;26:4001–4011.

6. Lester JF, Macbeth FR, Toy E, Coles B. Palliative radiotherapy regimens for non-small cell lung cancer. Cochrane Database Syst Rev 2006;CD002143.

7. Chen AB, Cronin A, Weeks JC, et al. Palliative radiation therapy practice in patients with metastatic non-small-cell lung cancer: a Cancer Care Outcomes Research and Surveillance Consortium (CanCORS) Study. J Clin Oncol 2013;31:558–564.

8. Guadagnolo BA, Liao KP, Elting L, et al. Use of radiation therapy in the last 30 days of life among a large population-based cohort of elderly patients in the United States. J Clin Oncol 2013;31:80–87.

9. Kapadia NS, Mamet R, Zornosa C, et al. Radiation therapy at the end of life in patients with incurable nonsmall cell lung cancer. Cancer 2012;118: 4339–4345.

10. Murphy JD, Nelson L, Chang D, Mell L, Le Q. Patterns of care in palliative radiotherapy: a population-based study. J Oncol Pract 2013;9: e220–e227.

11. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2013. CA Cancer J Clin 2013;63:11–30.

12. Virnig BA, Warren JL, Cooper GS, et al. Studying radiation therapy using SEER-Medicare-linked data. Med Care 2002;40(Suppl 8):IV-49–IV-54.

13. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 1987;40: 373–383.

14. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. J Clin Epidemiol 1992;45: 613–619.

15. Smith BD, Pan IW, Shih YC, et al. Adoption of intensity-modulated radiation therapy for breast cancer in the United States. J Natl Cancer Inst 2011;103:798–809.

16. Buck CJ. ICD-9-CM for hospitals, volumes 1, 2 and 3, professional edition. Elsevier and American Medical Association, 2013.

17. Kaplan EL, Meier P. Nonparametric estimation from incomplete observations. J Am Stat Assoc 1958;53:457–481.

18. O'Neill SM, Ettner SL, Lorenz KA. Paying the price at the end of life: a consideration of factors that affect the profitability of hospice. J Palliat Med 2008;11:1002–1008.

19. Roodman GD. Mechanisms of bone metastasis. N Engl J Med 2004;350:1655–1664.

20. Lutz S, Berk L, Chang E, et al. Palliative radiotherapy for bone metastases: an ASTRO evidence-based guideline. Int J Radiat Oncol Biol Phys 2011;79:965–976.

21. Rodrigues G, Videtic G, Sur R, et al. Palliative thoracic radiotherapy in lung cancer: an American Society for Radiation Oncology evidence-based clinical practice guideline. Pract Radiat Oncol 2011;1:60–71.

22. Tsao M, Rades D, Wirth A, et al. Radiotherapeutic and surgical management for newly diagnosed brain metastasis(es): an American Society for Radiation Oncology evidence-based guideline. Pract Radiat Oncol 2012;2:210–225.

23. Vigano A, Dorgan M, Bruera E, Suarez-Almazor ME. The relative accuracy of the clinical estimation of the duration of life for patients with end of life cancer. Cancer 1999;86:170–176.

24. Christakis NA, Escarce JJ. Survival of Medicare patients after enrollment in hospice programs. N Engl J Med 1996;335:172–178.

25. McCarthy EP, Burns RB, Davis RB, Phillips RS. Barriers to hospice care among older patients dying with lung and colorectal cancer. J Clin Oncol 2003;21:728–735.