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Quality Research in Radiation Oncology (QRRO) Analysis of Clinical Performance Measures in the Management of Gastric Cancer

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Abstract

Background—The specific aim was to determine the national patterns of radiotherapy (RT) practice in patients treated for Stage IB–IV (non-metastatic) gastric cancer (GC).

Methods—A National Process Survey was conducted from randomly selected U.S. RT facilities and retrospectively assessed demographics, staging, geographic region, practice setting, and treatment through on-site record review of eligible GC cases treated from 2005–2007. Three clinical performance measures (CPMs): 1) use of CT-based treatment planning; 2) use of dose volume histograms (DVHs) to evaluate RT dose to the kidneys and liver; 3) completion of RT within the prescribed time frame, and three emerging quality indicators: i) use of intensity-

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modulated RT (IMRT); II) use of image-guided tools (IGRT), other than CT, for RT target delineation; III) use of preoperative RT, were assessed.

Results—CPMs were computed for 250 eligible patients at 45 institutions (median age: 62 years; 66% male; 60% Caucasian). Thirteen% were AJCC 2002 stage I, 29% II, 32% IIIA, 10% IIIB & 12% IV. Most patients (43%) were treated at academic centers with 32% at large non-academic centers and 25% small-medium facilities. Almost all (99.5%) patients underwent CT-based planning and 75% had DVHs to evaluate normal tissue doses to the kidneys and liver. Seventy% completed RT within the prescribed time frame. IMRT and IGRT were used in 22% and 17% of patients, respectively. IGRT techniques included: PET (n=20), MRI (n=1), respiratory gating and/or 4D-CT (n=22) and on-board imaging (n=10). Nineteen% of patients received preoperative RT.

Conclusions—This analysis of radiation practice patterns for non-metastatic gastric cancer indicates widespread CT-based planning adoption with DVH use to evaluate normal tissue doses. Most patients completed adjuvant RT in the prescribed time frame. IMRT and IGRT were not routinely incorporated into clinical practice during 2005–2007. These data will be a benchmark for future QRRO gastric cancer surveys.

Introduction

Assessing quality of cancer care has become a national priority. There are wide variations in practice patterns and quality of care in the United States. The introduction of novel technologies and treatment paradigms for specific cancer types have made it imperative that measures are developed to monitor the national quality of cancer care and guide the use of new treatment approaches. Quality assessment and improvement in Radiation Oncology has been a focus of the American College of Radiology (ACR) through the Patterns of Care Studies (PCS) initiated since 1973. [1] PCS has helped to identify and monitor the national standards of radiation oncology practice for multiple disease sites through national practice pattern surveys. [2] Recently, the ACR introduced the Quality Research in Radiation Oncology (QRRO), broadening the aims of the PCS to include developing clinical performance measures (CPMs) that may be used as quality indices. These CPMs can provide feedback to physicians by identifying areas for improvement in the adoption of evidence-based recommendations for radiotherapy (RT) use.

Gastric cancer was chosen in the QRRO process surveys to define the nationwide patterns of care and to examine the penetrance of clinical trial results on those practice patterns. Historically, RT has played a minor role in the treatment of gastric cancer. In 2001, MacDonald et al. reported the Gastric Surgical Adjuvant Trial (INT-0116) showing a clear survival advantage to the use of chemoradiation after resection for gastric cancer, supporting a major role for RT in the adjuvant treatment of this disease. [3] This study established postoperative chemoradiation as a standard of care for patients with resected Stage IB through IV (M0), gastric or gastroesophageal (GE) junction adenocarcinoma. While INT-0116 established postoperative chemoradiation as a validated standard-of-care in North America, most practicing radiation oncologists have not been trained to treat gastric cancer patients in a potentially curative setting. Thus, the technique of RT utilized in the postoperative adjuvant treatment of gastric cancer has varied greatly. Suboptimal RT is associated with worse outcome. [4] Therefore, the aim of the QRRO survey for gastric cancer was to assess the quality of postoperative radiotherapy.

The past decade introduced new technologies into clinical practice, e.g., intensity-modulated radiotherapy (IMRT) and image-guided radiotherapy (IGRT). The QRRO surveys also assessed advanced radiation treatment technology utilization to establish a benchmark for its appropriate use in the management of gastric cancer.

Methods and Materials

Gastric Cancer National Process Survey

A National Process Survey was developed for gastric cancer by the QRRO Gastrointestinal Committee to collect data on patient demographics, diagnosis, staging, history, geographic region, practice setting, insurance status, co-morbidities, treatment (planned and delivered), and toxicities. The Gastric Cancer Process Survey (Appendix A) was conducted for patients treated from 2005 through 2007 at 45 institutions. A stratified two-step cluster sampling method was used to select radiation oncology facilities from a master list of 1,879 United States radiation oncology facilities. Before selection, facilities in the master list had been stratified by type as *academic* (main teaching hospital of a medical school or National Cancer Institute–designated Comprehensive Cancer Center); *large nonacademic* (other facility with 3 linear accelerators actively treating patients); *medium nonacademic* (other facility with 2 linear accelerators actively treating patients), and *small nonacademic* (other facility with 1 linear accelerator actively treating patients). In all, 106 facilities were randomly selected by stratum and invited to participate in a survey of radiation therapy practices. Of these facilities, 45 (42%) participated in the study: 14 (of 25) academic, 13 (of 27) large nonacademic, 7 (of 27) medium nonacademic, and 11 (of 27) small nonacademic facilities.

In the second sampling stage, individual gastric cancer cases were randomly selected for review and data abstraction based on lists of all eligible patients provided by the treating facilities. QRRO randomly selected 10 eligible patients at each facility (or all eligible patients if fewer than the required number had been treated during the study period). Eligibility criteria included receipt of adjuvant or neoadjuvant RT for gastric cancer between 2005–2007, histologic diagnosis of adenocarcinoma, squamous cell carcinoma or adenosquamous carcinoma of the stomach or gastroesophageal (GE) junction, AJCC 2002 stage Ib, II, III, or IV (non-metastatic) disease, no evidence of distant metastases, Karnofsky performance status of ≥60%, and no prior malignancies within the past 5 years. The facility and process survey data were collected through retrospective patient record review by ACR Clinical Data Abstractors.

Clinical Performance Measures (CPM)

The QRRO GI committee defined quality indicators to measure clinical performance, including adherence to published national practice guidelines, appropriateness criteria, penetration of results of clinical trials, and integration of emerging and advanced technologies. Three core CPMs were developed to assess the adherence to current (CM) practice guidelines for RT in the management of gastric cancer.

CM IA. Use of CT-based simulation and treatment planning

CM IB. Use of Dose volume histograms (DVH) to evaluate normal tissue doses to the kidneys and liver

CM II. Completion of the planned RT course within the prescribed time frame (33–45 days)

An additional three emerging (EM) quality indicators were also developed, based on best available evidence and expert consensus to assess the incorporation of emerging and advanced technologies and practices that have not been validated by clinical trials, but may be integrated into practice as part of RT for gastric cancer.

EM IA. Use of Intensity Modulated Radiotherapy (IMRT) treatment delivery when 3D conformal technology is used in treatment planning

EM IB. Use of image-guided tools (IGRT), other than computed tomography scans, for RT target delineation and treatment delivery

EM II. Use of preoperative (neoadjuvant) RT prior to a planned surgical resection (in contrast to upfront surgery followed by adjuvant chemoradiotherapy)

Each CPM was then calculated to characterize the proportion of patients that met the defined criteria for that performance measure. Survey data corresponding to the outcomes and techniques defined in the performance measures were used to measure compliance with these quality indicators or utilization of the indicated techniques.

Computation of CPM

Proportion of patients that meet the CPM = (Sub-set of the patient population with the condition that meets the defined criteria)/ (Patient population with the condition less patients with exclusions)

Statistical Analysis

Statistical analysis was conducted using SUDAAN statistical software (RTI International, Research Triangle Park, North Carolina), [5] incorporating the design elements (the two stages of stratification) and weights that reflect the relative contribution of each institution and each patient in the analysis of this survey, providing estimates of national figures for patients meeting the survey eligibility requirements. Weights were calculated for each patient record based on the relative sample and population size of each institution and patient. Stratum-specific weighted percentages were calculated to reflect the distribution in the whole population. These percentages were used to estimate national averages and make statistically valid inferences for national process measures.

National estimates were calculated from the survey data using SUDAAN statistical software (RTI International), incorporating the design elements and weights that reflect the relative contribution of each patient in the analysis of this complex survey. [5] The weights for each case in a stratum were the product of the following two factors:

$$\frac{\text{Estimated number of eligible cases in population}}{\text{Number of eligible cases in sample}} \times \frac{\text{Proportion of eligible cases in the population}}{\text{Proportion of eligible cases in sample}}$$

Two SUDAAN procedures were used to do this analysis: one for percentages and tests on categorical variables (PROC CROSSTAB) and the other for descriptive statistics and tests on continuous variables (PROC DESCRIPT). Tests for association were performed using the Pearson chi-square statistic in SAS and SUDAAN. [5,6] Differences were deemed significant if the associated *p* values were <0.05.

Although national estimates were computed using weights reflecting the relative contribution of each institution and each patient in the sample (Tables 1, 2), results comparing small subsets of patients are reported for the surveyed sample. Since the CPMs are computed for small subsets of patients, they are reported as unweighted case counts in each category (Table 3).

Results

Patient and Facility Characteristics

Charts of 250 patients treated for gastric cancer at 45 institutions met the criteria for inclusion in this survey, representing a weighted national sample size of 9,567 patients.

Patient and tumor characteristics are listed in Table 1. The median age of patients treated was 63 years of age and 65% were male. The racial distribution of patients was: 68% Caucasian, 17% African American, 6% Asian, and 8% were other race or unknown. The majority (96%) of patients had a histologic diagnosis of adenocarcinoma. Primary tumor location was in the antrum in 35%, corpus in 14%, cardia in 12%, and GE junction in 33%, per the pathology report. Staging was based on the AJCC 2002 pathologic staging system. Fourteen percent had stage IB disease, 27% had stage II, 30% had stage IIIA, 9% had stage IIIB, and 14% of patients were coded as having stage IV disease, presumably non-metastatic, but with the primary tumor involving adjacent structures in the presence of involved nodes or those with N3 disease.

The largest proportion of patients (36%) was treated at small non-academic centers followed by medium (29%) and large (24%) non-academic facilities, with only 11% of patients at academic centers. Forty-nine percent of the patients were treated at radiation oncology facilities located in the Southern United States; the remainder was evenly split between the Northeast (19%), the Midwest (16%), and the West (16%). The primary payment method for the most patients (39%) was Medicare, while 29% had private insurance and 13% were covered by a Health Maintenance Organization; only 4% had Medicaid as a primary payor.

Quality Indices/Clinical Performance Measures

Data from specific survey items addressing the treatment course and particular treatment techniques as they applied to the performance measures were collected (Table 2).

The core CPMs demonstrated excellent adherence to national guidelines (Figure 1) [7,8]. Almost all (99.6%) patients underwent CT-based planning and 75% had DVHs to evaluate normal tissue doses to the kidneys and liver. The median prescribed dose was 4,493 cGy, corresponding to the 4500 cGy dose prescribed in the INT-0116 trial. The median duration of radiotherapy was 36 days for patients who completed treatment. Seventy-one percent completed RT within the prescribed time frame of 33–45 day, a quality indicator of appropriate treatment delivery.

For the emerging quality indicators (Table 3a–3b, Figure 2), there was a lower frequency of utilization of advanced technology. During this time period, IMRT was used for treatment planning in only 22% of patients. Most patients (46%) were treated with a 4-field plan, 20% were treated with >4 fields, 15% were treated with an anteroposterior/posteroanterior (AP/PA) field arrangement and 14% with a 3-field plan. There was a statistically significant difference ($p < 0.0001$) in the use of IMRT between academic and non-academic centers indicating increased use of emerging techniques in the academic centers (Table 3). Image guidance was used in only 18% of patients with no statistical difference between facility types in regard to IGRT use. IGRT techniques included: PET scans ($n=20$), MRI ($n=1$), respiratory gating and/or 4D-CT ($n=22$) and on-board imaging ($n=10$). Among patients receiving radiotherapy as part of their management of gastric cancer, only a minority (19%) received it in the pre-operative setting (EM II). Only six percent of patients were treated on a clinical protocol (Table 4).

Discussion

The QRRO gastric process survey was performed to evaluate the quality of radiotherapy in the management of gastric cancer over a time period during which both new guidelines for adjuvant radiotherapy were being adopted into clinical practice and new techniques were being introduced into the planning and delivery of radiotherapy for many tumor types. Adjuvant chemoradiation was shown in the Gastric Surgical Adjuvant Trial (Intergroup 0116) to improve both disease-free and overall survival, presumably by sterilizing occult

regional microscopic disease. [3] This was a large phase III, randomized trial of surgery alone versus surgery followed by 5-FU/leucovorin and radiation therapy (45 Gy). These results led to the adoption of postoperative chemoradiation as the standard of care in the U.S. for resected gastric cancer patients. However, adjuvant radiotherapy for gastric cancer had not been incorporated routinely into the educational curriculum in radiation oncology training programs so that many radiation oncologists were not adequately trained to plan adjuvant gastric radiotherapy, as demonstrated in the quality of the radiotherapy fields on the INT 0116 trial. As a protocol requirement, radiotherapy plans were centrally reviewed as part of the quality assurance before initiating therapy. Of the initial radiation plans, 35% had major or minor deviations from the protocol treatment planning requirements. After the plans were sent back for re-planning, 6.5% contained major deviations in a second review after RT delivery. [4] Poor compliance with the protocol treatment-planning recommendations may have reflected unfamiliarity with the postoperative abdominal anatomy, but may have also been due to concerns about potential toxicity associated with large fields. [4]

In order to address the variation in radiotherapy treatment planning for gastric cancer, a consensus report was published in February 2002 to address anatomic considerations in the postoperative abdomen after total or partial gastrectomy and to define areas at highest risk for harboring subclinical disease. [9] Also, the National Comprehensive Cancer Network (NCCN) guidelines have incorporated further recommendations in regard to radiotherapy techniques, dose, fractionation, and normal tissue constraints. [7] The level I evidence from the randomized trial and the published national guidelines were the basis for the quality indicators that were measured through the QRRO gastric cancer process survey.

The three core clinical performance measures were based on accepted, standard-of-care techniques that have been routinely integrated into radiotherapy practices. In particular, CT-based radiotherapy simulation and planning techniques have been shown to improve the precision of the radiotherapy delivery in many cancers and can improve the accuracy of delineating areas at risk in the abdomen for patients receiving adjuvant radiotherapy for gastric cancer while minimizing the volume of normal tissue irradiated. Dosimetric analyses of AP/PA versus CT-based 3D conformal radiotherapy (3DCRT) plans have shown reduced doses to the kidneys using 3DCRT. [10] Clinical studies have demonstrated a decrement in renal function after adjuvant radiotherapy for gastric cancer which may be reduced by using 3-dimensional treatment planning techniques. [11] The NCCN guidelines strongly encourage the use of CT simulation and 3D treatment planning (apparently universally practiced with 99.6% of patients reported herein). [7] There was also excellent adherence to the use of dose-volume histograms to evaluate normal tissue doses and to limit the doses to the liver and kidneys based on the known radiation tolerance doses of these organs (75% of patients reported herein). Finally, completion of radiotherapy without prolonged treatment breaks has been associated with better clinical outcomes for several tumor sites, including head and neck, cervical and anal canal carcinomas. [12–14] Adjuvant chemoradiotherapy for gastric cancer can be associated with large radiation fields and significant acute toxicity. [3] In the Intergroup 0116 trial, completely resected gastric cancer patients received adjuvant radiation using AP-PA fields and 41% of patients reported grade 3 or 4 toxicity, with 17% unable to complete the protocol radiation course. With improved planning techniques using CT-based planning to spare normal tissue, fewer patients should require prolonged treatment breaks or discontinuation of radiotherapy. [15] In this cohort of patients who received treatment using 3DCRT, over 70% were treated in a timely fashion and only 9% did not complete therapy, an indicator that the quality of care is improving with the incorporation of better treatment techniques.

Another objective of the QRRO gastric process survey was to track the distribution and utilization of advanced radiotherapy technology with the goal of assessing the appropriate use of these emerging technologies. As radiation oncologists incorporate new technology into their practice, re-assessment of quality of care is necessary to inform practitioners of their professional performance and to hold radiation oncologists accountable for the use, misuse, over-use, or under-use of advanced radiotherapy technology. While the findings from QRRO's analysis of radiation practice patterns for gastric cancer indicate widespread adoption of CT-based planning with the use of DVHs to evaluate normal tissue doses, only 22% and 18% of patients were treated with emerging RT techniques such as IMRT and IGRT, respectively. In addition, the last emerging CPM (EM II) - assessed the use of preoperative radiotherapy in gastric cancer since it has become standard for many gastrointestinal malignancies, most notably for rectal cancer, where there is clearly a benefit to preoperative chemoradiotherapy for both toxicity and local control. [16] This may also hold true for gastric cancers since the diverse and widespread patterns of direct extension and lymphatic drainage oblige the radiation oncologist to treat very large fields to cover areas of potential relapse. [3, 9] Preoperative treatment facilitates tumor downstaging prior to resection and allows adjuvant treatment to be delivered when local tissue has been surgically undisturbed. Phase II data from M.D. Anderson Cancer Center have demonstrated excellent R0 resection rates with preoperative chemoradiation for gastric cancer. [17] Early results suggest promising preliminary outcomes and toxicity profiles. Pathologic response rates following preoperative chemoradiation is predictive of overall survival in gastric cancer. [18] Interestingly, the use of pre-operative radiotherapy was only used in a minority (19%) of patients, implying that despite phase II data [17] evaluating the use of pre-operative chemoradiation for gastric cancer, when radiotherapy is used in a non-protocol setting in the management of non-metastatic gastric cancer, it is being incorporated as per the guidelines outlined by the INT-0116 trial. These data on emerging quality indicators will serve as a benchmark for future QRRO gastric cancer surveys.

A limitation of this analysis is that our institution and gastric cancer case cohorts were not exhaustive, and despite using weighting techniques to reflect the relative contribution of each institution and each patient, there were only 45 institutions assessed. In addition, while there is an indication that academic centers may be using emerging techniques more than other centers, with this design we cannot infer a definite causality link. Finally, further changes in practice patterns have occurred between time of observation and this publication, for example, peri-operative chemotherapy has become more commonly practiced since the publication of the MAGIC trial [19] and neoadjuvant chemoradiation may be used more often for gastroesophageal junction cancers as they are being considered more closely related to esophageal cancer. Thus, recent practice changes may impact the applicability of these results. However, these data provide a validated measure of gastric cancer care in the U.S. that demonstrate relatively good compliance with national guidelines [7,8].

Future Directions

As radiotherapy techniques become more complex with the integration of stereotactic approaches, on-board imaging, and motion management methods into daily practice, there will be an on-going need for quality assurance. The QRRO is developing processes using web-based platforms, to download de-identified patient data, including imaging information, to a central site. Treatment quality can then be assessed in an almost real-time manner, allowing for more immediate feedback through comparisons of individual outcomes with quality measures defined for this particular treatment type. A pilot study to evaluate this approach has been performed for prostate brachytherapy and has demonstrated the feasibility of remote central review to assess the quality of implant procedures [20].

Advances in statistical methods and computing power have made Comparative Effectiveness Research studies possible using comprehensive detailed data extracted from the electronic medical record systems. Clinically relevant alternative interventions can be analyzed in diverse populations from heterogeneous practice settings leading to a broad range of health outcomes. A wide range of potentially confounding factors can be accounted for through rigorous study designs in naturalistic settings that can determine the generalizability of results from randomized controlled trials. QRRO will continue to play a critical role in maintaining the high quality of radiation oncology practice through expanding opportunities for self-assessment, setting standards for quality of care, and conducting rigorous studies of the outcomes of care.

Acknowledgments

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Summary

We report U.S. national patterns of radiotherapy practice for non-metastatic gastric cancer treated from 2005–2007 inclusive, using a novel national process survey. Three clinical performance measures indicated widespread adoption of CT-based treatment planning and dose-volume histogram use to evaluate normal tissue doses and completion of adjuvant radiation in the prescribed time frame. The three emerging quality indicators demonstrated that IMRT, IGRT, and neoadjuvant radiotherapy were not routinely incorporated into clinical practice during that time frame.

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Figure 1.
Core Clinical Performance Measures of Radiotherapy Practice for Gastric Cancer

Figure 2.
Emerging Clinical Performance Measures to Assess Incorporation of Newer Radiotherapy Techniques in the Management of Gastric Cancer

Table 1**Patient & Tumor Characteristics**

Characteristic	Weighted Patients * (n =9,567)		Unweighted No. of Patients (n = 250)
	No.	% *	
Age at start of RT (years)			
Mean	62		
Median	63		
Range	33–94		
Sex			
Male	6,187	64.7	166
Female	3,380	35.3	84
Race			
White	6,519	68.1	150
Black/African-American	1,654	17.3	58
Asian	611	6.4	17
Other/Unspecified	782	8.2	25
Ethnicity			
Hispanic	1,370	14.3	30
Not Hispanic/Unspecified	8,197	85.7	220
Marital status			
Married	6,473	67.7	175
Single	2,046	21.4	53
Not specified	1,048	11.0	22
Primary payment method			
Medicare	3,731	39.0	85
Private Insurance	2,811	29.4	85
Health Maintenance Organization	1,231	12.9	29
Medicaid	365	3.8	14
Government Insurance	699	7.3	19
Self-Pay	374	3.9	11
Not specified	355	3.7	7
Stratum			
Academic	1,074	11.2	108
Large Non-Academic (3 linacs)	2,259	23.6	79
Medium Non-Academic (2 linacs)	2,763	28.9	30
Small Non-Academic (1 linac)	3,470	36.3	33
Census Region			
Northeast	1,774	18.5	43
Midwest	1,546	16.2	59
South	4,716	49.3	104
West	1,531	16.0	44
Karnofsky Performance Status **			

Weighted Patients* (n =9,567)			
Characteristic	No.	%*	Unweighted No. of Patients (n = 250)
60	249	2.6	4
70	823	8.6	18
80	2,541	26.6	69
90	4,499	47.0	122
100	1,445	9.8	36
Stage			
Stage IB	1,314	13.7	33
Stage II	2,623	27.4	73
Stage IIIA	2,881	30.1	81
Stage IIIB	879	9.2	25
Stage IV	1,293	13.5	29
Stage Unknown	577	6.0	9
Histology			
Squamous cell	57	0.6	2
Adenocarcinoma	9,203	96.2	242
Adenosquamous	277	2.9	5
Unknown	29	0.3	1
Primary location of tumor			
Antrum	3,345	35.0	94
Corpus	1,337	14.0	34
Cardia	1,119	11.7	32
GE junction	3,145	32.9	70
Unknown	621	6.5	20

Abbreviations: RT, radiation therapy; linac, linear accelerator. GE, gastroesophageal.

* Percentages are based on the weighted number of patients and may not add up to 100 due to rounding errors.

** KPS was not recorded for 1 patient (weighted sample, n=10)

Table 2**Treatment Characteristics**

Characteristic	Weighted Patients (n=9,567)		Unweighted Patients (n=250)	
Total Radiation dose (cGy)				
All patients:				
Mean	4,554			4,550
Median	4,493			4,500
Range	180 – 6,640			180 – 6,640
Patients who completed RT (n=8,688)			(n=223)	
Mean	4,679			4,668
Median	4,494			4,500
Range	2,000 – 6,640			2,000 – 6,640
Patients who did not complete RT (n=879)			(n= 27)	
Mean	3,317			3,568
Median	3,234			4,140
Range	180 – 5,100			180 – 5,100
Duration of RT (days) ⁽¹⁾				
All patients (n =9,538) ⁽²⁾			(n=249) ⁽²⁾	
Mean	37.7			37.1
Median	36.2			36.0
Range	0 – 122			0 – 122
Patients who completed RT (n=8,659)			(n=222)	
Mean	38.6			38.1
Median	36.4			36.0
Range	4 – 122			4 – 122
Patients who did not completed RT (n=879)			(n= 27)	
Mean	28.6			29.1
Median	28.0			32.0
Range	0 – 53			0 – 53
	<u>No.</u>	<u>%</u> ⁽³⁾	<u>No.</u>	<u>%</u> ⁽³⁾
Technique				
AP/PA	1,409	14.7	48	19.2
3 field	1,360	14.2	42	16.8
4 field	4,390	45.9	87	34.8
>4 field	1,895	19.8	64	25.6
Other/Unknown	513	5.4	9	3.6
Investigational Protocol				
None	8,962	93.7	226	90.4
NCI, Clinical Trials Cooperative Group	286	3.0	9	3.6
IRB-approved institutional clinical trial	242	2.5	11	4.4
IRB-approved PHARMA/Device clinical trial	77	0.8	4	1.6

Abbreviations: QRRO, Quality Research in Radiation Oncology; cGy, centigray; RT, Radiation Therapy; AP/PA, anteroposterior/, posteroanterior; NCI, National Cancer Institute; IRB, Institutional Review Board.

- (1) Duration was computed as treatment end date minus treatment start date. Thus, if only one fraction was given, duration was computed as 0 days.
- (2) Duration of RT was not recorded for 1 patient (weighted sample, n=29).
- (3) Percentages are based on the weighted number of patients and may not add up to 100 due to rounding.

Table 3

Clinical Performance Measures by type of facility

Clinical Performance Measures	Academic		Large non-academic		Medium non-academic		Small non-academic		Chi-Sq p
	No.	%*	No.	%*	No.	%*	No.	%*	
CM IA: Use of CT-based simulation & planning (N=249) ^a	107		79		30		33		
YES (n=249)	107	100.0	79	100.0	30	100.0	33	100.0	n/a
CM IB: Use of DVH to evaluate normal tissue dose to the kidneys & liver (N=249) ^a	107		79		30		33		
NO (n= 62)	14	13.1	30	38.0	13	43.3	5	15.2	
YES (n=187)	93	86.9	49	62.0	17	56.7	28	84.9	<0.0001
CM II: Completion of planned RT course within the prescribed time frame of 33–45 d (N=191)	83		59		25		24		
NO (n= 56)	23	27.7	21	35.6	7	28.0	5	20.8	
YES (n=135)	60	72.3	38	64.4	18	72.0	19	79.2	0.5561
EM IA: Use of IMRT for RT treatment delivery when 3D conformal technology is used in treatment planning (N=249) ^a	107		79		30		33		
NO (n=194)	68	63.6	73	92.4	28	93.3	25	75.8	
YES (n= 55)	39	36.5	6	7.6	2	6.7	8	24.2	<0.0001
EM IB: Use of image-guided tools, other than CT scans, for radiation therapy (RT) target delineation (N=250)	108		79		30		33		
NO (n=206)	85	78.7	69	87.3	24	80.0	28	84.9	
YES (n= 44)	23	21.3	10	12.7	6	20.0	5	15.2	0.4569
EM II: Use of pre-operative (neoadjuvant) RT (N=201) ^b	90		60		26		25		
NO (n=163)	71	78.9	50	83.3	20	76.9	22	88.0	
YES (n= 38)	19	21.1	10	16.7	6	23.1	3	12.0	0.6698

Abbreviations: QRRRO, Quality Research in Radiation Oncology; CM, Current Measure; EM, Emerging Measure; IMRT, Intensity-Modulated Radiation Therapy; RT, Radiation Therapy; CT, Computed Tomography; n/a, not applicable.

* Percentages shown are column percents and may not add up to 100 due to rounding errors.

^a Use of 3D conformal technology was unknown for 1 patient.

^b Surgical resection was not planned for 35 patients and 14 patients were excluded for comorbidities.

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50% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

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Table 4

Emerging Measure 2 by Investigational Protocol

Emerging Measure	Not on any Investigational Protocol			On NCI Clinical Trials			On IRB-approved Inst/PHARMA/Device CT		
	Unweighted			Unweighted			Unweighted		
	No.	%*		No.	%		No.	%*	Pearson Chi-Sq P#
EM II: Use of pre-operative (neoadjuvant) RT (n=201) ^b	179	89.1		9	4.5		13	6.5	
No (n= 163)	150	92.0		7	4.3		6	3.7	
Yes (n= 38)	29	76.3		2	5.3		7	18.4	<0.0036

Abbreviations: NCI, National Cancer Institute; IRB, Institutional Review Board; Inst, Institutional; CT, Clinical Trial; EM, Emerging Measure; RT, Radiation Therapy.

* Percentages shown are row percents and may not add up to 100 due to rounding errors.

33% of the cells have expected counts less than 5. Chi-Square may not be a valid test.

^b Surgical resection was not planned for 35 patients; 14 patients were excluded for comorbidities.