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A Survey of Stereotactic Body Radiation Therapy Use in the United States

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Abstract

BACKGROUND—Stereotactic body radiation therapy (SBRT) is a technique used to deliver high, ablative doses of radiation in a limited number of fractions to one or more extracranial target(s). The prevalence of SBRT use among radiation oncologists in the United States is unknown.

METHODS—A random sample of 1600 American radiation oncologists was surveyed via email and fax regarding SBRT usage, including year of adoption, motivations, disease sites treated, and common prescriptions used.

RESULTS—Of 1373 contactable physicians, 551 responses (40.1%) were received. The proportion of physicians using SBRT was 63.9% (95% confidence interval: 60–68%), of whom nearly half adopted it in 2008 or later. The most commonly cited reasons for adopting SBRT were to allow delivery of higher than conventional radiation doses (90.3%) and to allow retreatment (73.9%) in select patients. Academic physicians were more likely to report research as a motivation for SBRT adoption, whereas physicians in private practice were more likely to list competitive reasons. Among SBRT users, the most common disease sites treated were lung (89.3%), spine (67.5%), and liver (54.5%) tumors. Overall, 76.0% of SBRT current users planned to increase their use, while 66.5% of nonusers planned to adopt the technology in the future.

CONCLUSIONS—SBRT has rapidly become a widely adopted treatment approach among American radiation oncologists. Further research and prospective trials are necessary to assess benefits and risks of this novel technology.

Keywords

stereotactic body radiotherapy; radiation oncology; survey

Background

Stereotactic body radiation therapy (SBRT) is a technique used to deliver high, ablative doses of radiation in a limited number of fractions to one or more extracranial target(s)^{1, 2}. SBRT has the potential to improve clinical outcomes of patients with a variety of primary and metastatic tumors, by allowing the delivery of higher than conventional doses and retreatment of previously irradiated patients.

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While first used in the early 1990s³, increasing attention has been focused on SBRT in recent years, with encouraging results reported in a number of tumors sites including the lung⁴, spine⁵, and liver⁶. Despite this growing interest, little is known about the prevalence and use of SBRT in the radiation oncology community. While a previous survey was conducted in Japan focusing on SBRT in lung tumors⁷, no surveys have been performed assessing SBRT use in the United States.

We thus conducted and present here a nationwide survey of practicing American radiation oncologists regarding their SBRT usage, including year of adoption and disease sites treated, common prescriptions and technologies used, and underlying motivations for adoption.

Methods

Study population

A group of 1600 radiation oncologists was randomly selected from the approximately 5000 active members listed in the online American Society for Radiation Oncology (ASTRO) directory. All physicians who were designated as active and allied members were included. Emeritus professors and radiation oncologists practicing outside of the United States were excluded. The survey was sent in 2 forms: by email with a link to an online survey and by facsimile. If the email address and fax number were invalid, the physician was designated as uncontactable.

Survey

A 21-question survey was designed to obtain demographic information and the details of SBRT adoption and usage. For the purposes of this survey, SBRT was defined as: high-precision radiotherapy delivered in 5 or fewer fractions to very potent doses of highly conformal radiation with steep dose gradients around an extracranial target. Responses were collected between July 11 and September 7, 2010 and considered evaluable if at least partially completed.

All physicians were asked to supply information about their practice (type, size, specialty) and year graduated from residency. SBRT users were asked about year adopted, motivations, technologies, disease sites treated, common prescriptions, and future plans. Nonusers were asked about reasons behind not adopting SBRT and whether they intended to adopt SBRT in the future.

Statistical Analysis

The survey results are presented as the percentage of evaluable responses. Differences in proportions between groups were analyzed using chi-square tests. Significant values were defined as those with $P < 0.05$.

Results

Study population

Of the 1600 physicians surveyed, 1373 (85.8%) were contactable (Fig. 1). From this, 551 (40.1%) responded, including 21 that declined to participate and 20 that were retired, leaving 510 evaluable respondents.

Respondents represented physicians from 48 states and the District of Columbia (Table 1). Three hundred nineteen responses (62.5%) were from private practice while the remaining 191 (37.5%) were from academic physicians. The median practice size was 5 physicians (range: 1-60). The median time in practice was 16 years (range: 1-31).

SBRT Users

Of the 510 evaluable respondents, 63.9% (95% confidence interval: 60-68%) reported having used SBRT in their practice. As seen in Figure 2, approximately half of the current SBRT users adopted it in 2008 or later.

Experience with SBRT was more prevalent with physicians at academic centers as compared to those in private practice (70 vs 61%; $P=0.04$), practices with more than 1 physician (67 vs 39%; $P<0.001$), physicians practicing 1-10 years compared to >10 years (73 vs 59%; $P<0.01$), and those who identified themselves as specialists (71 vs 60%; $P=0.02$). SBRT usage was similar across geographic regions of the West, South, East, and Midwest at 56%, 63%, 64%, and 70%, respectively ($P=0.13$). SBRT was adopted more recently among private practice physicians, with a median start year of 2008 compared to 2007 for academic physicians.

The most common reasons for adopting SBRT were to allow delivery of higher than conventional radiation doses (90.3%) and retreatment (73.9%) in select patients (Fig. 3). Physicians in academic centers were more likely to cite clinical research as a motivation for SBRT adoption (59 vs 18%; $P<0.0001$) whereas physicians in private practice were more likely to list gaining a competitive advantage or remaining competitive (42 vs 20%; $P<0.0001$) as reasons for adoption. Of the SBRT users, 76.0% reported plans to increase their use of SBRT and 21.7% plan to maintain the current level of use.

Most SBRT users (61.4%) reported not using a stereotactic body frame (SBF). For those that reported using an SBF in their patients, its primary function was for immobilization (96.4%). Overall, 13.3% of SBRT users reported using an SBF to establish an external coordinate system. For target localization, most SBRT users relied on image-guidance, with in-room volumetric imaging the most popular (69.0%), followed by in-room planar imaging (50.8%). Physicians at academic centers were more likely to use in-room volumetric (77 vs 64%; $P=0.01$) and/or in-room planar imaging (61 vs 44%; $P<0.01$) as compared to those in private practice.

SBRT Disease Sites

The cumulative adoption of SBRT among all respondents at the 3 most common disease sites of lung (51.8%), spine (39.0%), and liver (31.0%) is shown in Figure 4. The majority of respondents who were using SBRT for lung, spine, and liver adopted it by 2008, 2007, and 2008, respectively. The largest yearly increase in cumulative adoption for all 3 disease sites occurred in 2009 (14.4%, 8.1%, and 8.7% for lung, spine, and liver, respectively).

Lung was the most common disease site treated with SBRT (89.3% of all users). A minority of physicians that have treated lung tumors (31.3%) reported using fiducial markers. Fiducial usage was less common in academic centers compared to private practice (22 vs 38%; $P<0.01$). To manage respiratory-induced motion, physicians most commonly reported using abdominal compression (55.6%) or respiratory gating (54.2%), while breath hold techniques (14.4%) and real-time tumor tracking (15.3%) were less prevalent. The most commonly reported fraction number for lung tumor patients was 3 (47%) (Table 2). For 3 fraction regimens, the most common doses are 20 Gy (46%) or 18 Gy (45%) per fraction to a median isodose line (IDL) of 80% (range: 70-100%).

Spine was the second most common disease site treated with SBRT (67.5% of the SBRT users). Fiducial markers were rarely used (12.4%) in spine patients. The most commonly reported fraction number for spine tumor patients was 1 (57%) (Table 2). For single fraction regimens, the most common prescription was 18 Gy (40%) or 16 Gy (34%) per fraction to a median IDL of 85% (range: 70-100%) with a median maximum cord dose of 10 Gy (range:

7-18 Gy). The median maximum cord dose was 4 Gy for both 3 and 5 fraction treatments with ranges of 3-6 Gy and 2-6 Gy, respectively.

Liver tumors were treated by 54.5% of SBRT users. Liver was the only disease site where fiducial markers were used by the majority (56.9%) of respondents. Physicians commonly used respiratory gating (57.9%) or abdominal compression (51.9%) to manage respirator-induced tumor motion. Alternative methods such as real-time tracking (17.2%) and breath hold techniques (15.0%) were not commonly used. The most commonly reported fraction number for liver tumor patients was 3 (48%) (Table 2). For 3 fraction regimens, the most common dose was 15 Gy (40%) or 20 Gy (25%) per fraction to a median IDL of 80% (range: 70-100%).

The breakdown of disease sites currently treated by SBRT users is shown in Figure 5. In addition to the most common sites of lung, spine, and liver, 36.7% of SBRT users reported having treated at least one other disease site. The most common other sites treated were the adrenal glands (8.6%), pancreas (8.6%), prostate (7.9%), and retroperitoneum (6.9%).

SBRT Nonusers

Among respondents who do not use SBRT, a majority (62.6%) cited the lack of necessary equipment as a reason for their lack of adoption. The next most common reason was that a partner handles the SBRT cases (16.1%), which was seen more frequently among physicians in academic centers (28 vs 11%; $P<0.01$).

A majority (66.5%) of SBRT nonusers reported plans to adopt SBRT, a finding more common in private practice physicians (75 vs 49%; $P<0.001$). The most commonly cited reasons were to allow the delivery of higher than conventional doses (84.1%) and to facilitate retreatment (66.7%). Academic physicians were more likely to report research as a motivation for planned SBRT adoption (41 vs 13%; $P<0.001$) whereas those in private practice were more likely to cite the desire to remain competitive (52 vs 16%; $P<0.001$).

Discussion

The objective of this study was to assess the current usage of SBRT in the United States. We found that SBRT is rapidly becoming a widely adopted treatment approach, currently employed by 63.9% of respondents, with nearly half having adopted it in 2008 or later. Use of SBRT will most likely increase in the coming years since approximately two-thirds of respondents who do not currently use SBRT reported planning to adopt it.

SBRT usage was more prevalent among physician respondents who practice in academic centers or non-solo practices. This is not surprising given the equipment and staffing requirements to clinically implement a new technology. Nevertheless, almost 40% of solo practitioners reported treating patients with SBRT, suggesting that the technology has become accessible to the broader radiation oncology community.

Consistent with the growing published literature, the 3 most common disease sites treated by SBRT users in this survey were lung^{4, 8-16}, spine^{5, 17-21}, and liver^{6, 22-28}. Nonetheless, respondents also reported using SBRT in a variety of other disease sites with less published experience, including pancreas²⁹⁻³², adrenal gland and retroperitoneum³³⁻³⁶, and prostate³⁷⁻⁴².

In response to the query of common SBRT prescriptions, myriad fractionation and dose combinations were reported. Consistent with Radiation Therapy Oncology Group (RTOG) Trial 0236, the most commonly reported lung prescription was 20 Gy $\times$ 3⁴. Almost as

frequently reported for lung tumor patients was $18 \text{ Gy} \times 3$, which has been used in other studies⁹. The most commonly reported dose prescription from the Japanese survey of lung SBRT⁷ ($12 \text{ Gy} \times 4$) was the third most common among our responses. The most commonly reported dose prescription for SBRT of the spine was a single fraction of 18 Gy , a dose lower than the mean dose of 20 Gy used in the largest available single institution series⁵. A dose of 18 Gy also does not reflect the results of another study that showed a dose response to 24 Gy as compared to $18\text{--}23 \text{ Gy}$ ²¹. Liver SBRT showed the most variation in reported prescription doses, with the most common being $15 \text{ Gy} \times 3$, consistent with the largest Phase II SBRT study of patients with colorectal metastases²⁵.

Early implementations of SBRT included the use of an SBF to establish an external coordinate system³. However, in our survey, less than 15% of SBRT reported using a frame for stereotactic localization. In fact, the majority of SBRT users did not use a frame at all and instead rely upon image guidance. When an SBF was employed, its primary function was to provide immobilization only. Most physicians instead relied on in-room planar or volumetric imaging for target localization^{43, 44}.

A significant technical challenge in SBRT is accounting for respiratory-induced target motion^{45, 46}. The majority of surveyed SBRT users addressed this problem in lung and liver tumor patients with the use of respiratory gating^{47, 48} or abdominal compression^{49, 50}. Other methodologies such as active breathing control⁵¹ and real-time tracking^{52, 53} were less prevalent. These findings were similar to the Japanese lung SBRT survey which showed the predominance of abdominal compression for respiratory-induced motion management⁷.

Our study has a number of important limitations. We received responses from 40.1% of randomly selected, contactable physicians who represented a wide variety of demographics. Despite repeated attempts to collect responses, nonresponse and recall bias may exist. It is possible that SBRT nonusers were less likely to respond, which would lead to an overestimation of the true prevalence of SBRT use.

This study is the first to assess the usage of SBRT in the United States. We found that approximately two-thirds of surveyed physicians currently use SBRT in their clinics and the number appears to be rapidly increasing. These findings reinforce the need for prospective studies to assess the benefits and risks of this novel technology. Fortunately, several multi-institutional phase I and II trials have been completed and Phase III trials are currently underway in the United States and Europe.

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Figure 1. Flowchart of the stereotactic body radiation therapy (SBRT) survey respondents.

Figure 2.
Cumulative adoption of stereotactic body radiation therapy (SBRT) for the treatment of any disease site.

Figure 3. Reasons cited by academic and private practice physicians for adopting stereotactic body radiation therapy (SBRT). Asterisks denote $P < 0.05$.

Figure 4. Cumulative adoption of stereotactic body radiation therapy (SBRT) for the three most common disease sites treated: lung, spine, and liver.

Figure 5. Disease sites treated by stereotactic body radiation therapy (SBRT) users that responded to the survey.

Table 1**Characteristics of Physician Respondents**

Characteristic	No. Respondents (%)
No. of physicians	510
Geographic location ^a	
Midwest	145 (28.4)
South	129 (25.3)
East	117 (22.9)
West	117 (22.9)
Unknown	2 (0.4)
Practice Type	
Academic	191 (37.5)
Private	319 (62.5)
Specialist ^b	180 (35.3)
Median time in practice (range), y	16 (1-31)
Median no. physicians in practice (range)	5 (1-60)

^a East: CT, DC, DE, ME, MD, MA, NH, NJ, NY, PA, RI, VT, WV; Midwest: IL, IN, IA, KS, KY, MI, MN, MO, NE, ND, OH, OK, SD, WI; South: AL, AR, FL, GA, LA, MS, NC, SC, TN, TX, VA; West: AK, AZ, CA, CO, HI, ID, MT, NV, NM, OR, UT, WA, WY

^b Specialist: central nervous system, breast, lung, prostate, others

Table 2

Most commonly reported SBRT prescriptions for lung, spine, and liver tumors

	Fractions (%)	Common Dose/Fraction, Gy (%)	Median Dose/Fraction, Gy (range)	Median IDL ^a , % (range)
Lung (n=262)	3 (47%)	20 (46%), 18 (45%)	18 (10-20)	80 (70-100)
	4 (21%)	12 (78%), 12.5 (11%)	12 (10-16)	85 (80-100)
	5 (30%)	10 (51%), 12 (34%)	10 (3-20)	90 (75-100)
Spine (n=170)	1 (57%)	18 (40%), 16 (34%)	18 (7-24)	85 (70-100)
	3 (22%)	8 (51%), 7 (14%)	8 (6-12)	80 (75-95)
	5 (18%)	6 (60%), 7 (10%)	6 (4-12)	100 (90-100)
Liver (n=142)	3 (48%)	15 (40%), 20 (25%)	15 (8-20)	80 (70-100)
	4 (9%)	12 (77%), 10 (8%)	12 (8-12)	80 (80-95)
	5 (38%)	10 (38%), 12 (19%)	10 (5-12)	90 (70-100)

^aIDL: isodose line.