A Survey of Intensity-Modulated Radiation Therapy Use in the United States

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BACKGROUND. The objective of this study was to assess the current level of intensity-modulated radiation therapy (IMRT) use in the United States.

METHODS. Three-hundred thirty-three randomly selected radiation oncologists were sent a 13-question survey regarding IMRT use. IMRT users were asked about the number of patients and sites treated, their reasons for adopting IMRT, and future plans for its use. Physicians who did not use IMRT were asked about their reasons for not using IMRT; whether they intended to adopt it in the future; and, if so, their reasons.

RESULTS. One-hundred sixty-eight responses (50.5%) were received. Fifty-four respondents (32.1%) stated that they currently used IMRT. Most IMRT users (79.6%) had adopted IMRT since 2000. Academic physicians were more likely to use IMRT (P = 0.003) compared with private practitioners. The percent of physicians using IMRT in practices comprised of 1 physician, 2–4 physicians, or > 4 physicians were 15.4%, 28.4%, and 44.2%, respectively (P = 0.02). The most common sites treated were head and neck malignancies and genitourinary tumors. Of the 114 IMRT nonusers, 96.5% planned to use IMRT in the future, with 91.8% planning to use IMRT within 3 years. Among IMRT nonusers, the most common reason cited for not using IMRT was lack of necessary equipment. The most common reasons for adopting IMRT (users) or wanting to adopt IMRT (nonusers) were to improve delivery of conventional doses and to escalate dose.

CONCLUSIONS. Approximately one-third of radiation oncologists in the United States use IMRT. However, this number appears to be growing rapidly. Efforts to ensure the safe and appropriate application of this new technology are warranted.


KEYWORDS: dose escalation, intensity-modulated radiation therapy, radiation oncologists, survey.

Intensity-modulated radiation therapy (IMRT) is a new approach to the planning and delivery of radiation therapy (RT). Unlike conventional approaches, IMRT is an inverse process, whereby the planner specifies the dose-volume constraints of the target tissues and normal tissues. A sophisticated computer algorithm is used to generate beams of nonuniform intensity that conform the prescription dose to the shape of the target tissues in three dimensions. These beams are delivered using dynamic multileaf collimators that move in and out of the beam’s path.1,2

IMRT holds considerable promise for the treatment of both malignant and benign tumors. The ability to highly conform the prescription dose to the shape of the target tissues may decrease the risk of RT-related sequelae by limiting the dose delivered to the surrounding normal tissues. Moreover, IMRT also may allow the delivery of
higher than conventional doses in select tumors, improving tumor control.

Recently, increasing attention in the literature has been focused on IMRT. Numerous investigators have demonstrated the potential benefits of IMRT planning in many tumor sites, including head and neck malignancies, brain tumors, breast carcinoma, lung carcinoma, gastrointestinal tumors, prostate carcinoma, gynecologic tumors, pediatric tumors, and soft tissue sarcomas. Moreover, although follow-up was limited in most studies, recent reports have suggested that IMRT results in less treatment sequelae and, in select sites, improved tumor control. Unsurprisingly, increasing attention has been focused recently on IMRT in the lay press as well.

Despite this tremendous interest in IMRT, to our knowledge relatively little is known regarding its use in the radiation oncology community. In the past, centers that performed IMRT were forced to develop their own planning systems. Today, an increasing number of commercial systems are available. It remains unclear, however, how many radiation oncologists currently treat patients with IMRT, why they adopted it, and which sites are treated. It also is not clear whether physicians who do not currently use IMRT intend to adopt it in the future, their motivations for doing so, and what obstacles they face to its adoption. To answer these and other questions regarding the use of IMRT in the United States, we conducted a survey of practicing radiation oncologists. The objectives of this report were to summarize the results of this survey and to discuss the implications of our findings.

MATERIALS AND METHODS

Study Population

Using a random number generator, we selected 450 of approximately 5000 radiation oncologists who were listed in the 2000 American Society for Therapeutic Radiology and Oncology (ASTRO) directory. ASTRO is the largest society of radiation oncologists, with a total membership of approximately 7000. All physicians designated as active, in addition to junior members who were likely to have completed their residency and were practicing in 2002, were included. All emeritus physicians and radiation oncologists practicing outside the United States were excluded.

We attempted to contact each physician using the listed e-mail address or fax number. If neither the e-mail address nor the fax number was valid, then we searched for current contact information in the 2002 ASTRO online directory. If no such information could be found or if the current fax or e-mail information was invalid, then the physician was designated as un-contactable. The survey was sent by e-mail and/or fax to all contactable physicians.

Survey

A 13-question survey was designed to collect demographic information and address IMRT use by the selected physician. The complete survey is included in Table 1. Accompanying the survey was a cover letter outlining the purpose of the project and the confidential nature of the results obtained. Our intention of evaluating the prevalence and practice of IMRT using inverse planning was described. Physicians were asked to answer all questions in terms of their personal experience, not in terms of the experience of their group (or center) as a whole.

In addition to inquiring about practice type (academic vs. private) and size of practice group, IMRT users were asked about the number of patients they had treated with IMRT, disease sites treated using IMRT, reasons for adopting IMRT, and their future plans for IMRT use. IMRT nonusers were asked about their reasons for not using IMRT as well as whether they intended to adopt IMRT in the future and, if so, their reasons for adopting it.

The survey was designed intentionally to be brief (5–10 minutes) and to be completed by a physician without the assistance of his/her staff. Consequently, the survey did not address detailed issues of plan optimization, software and hardware used, and issues of quality assurance.

Statistical Analysis

The survey was conducted and the results were analyzed in August 2002. Survey responses were considered evaluable if the survey was at least partially completed. Survey results are presented as a percentage of evaluable responses. Differences in proportions between various groups were analyzed using the chi-square test. Differences in means were compared using the unpaired Student t test. Significant values were defined as those with P < 0.05.

RESULTS

Of 450 randomly selected physicians, 333 physicians (74.0%) were contactable. From the 333 contactable physicians, we received 180 responses, for a response rate of 54.1%. Among the 180 respondents, 9 physicians were retired, and 3 physicians returned the survey blank; thus, a total of 168 responses (50.5%) were evaluable. Responses were received from physicians in 44 states and the District of Columbia. Thirty-nine responses were from academic physicians, and 129 responses were from private practitioners.

Table 2 summarizes the characteristics of respon-
### TABLE 1
Intensity-Modulated Radiation Therapy Survey

1. Type of center at which you practice
   - Private practice
   - Academic

2. Total number of radiation oncologists in your practice

3. Are you currently treating patients with IMRT?
   - Yes
   - No

   *If you answered YES to question 3, please complete questions 4 through 9.*
   *If you answered NO to question 3, please complete questions 10 through 13.*

4. What year did you begin treating patients with IMRT?
   - Year:

5. Approximately how many patients have you treated with IMRT to date?
   - 1–10
   - 11–50
   - > 50

6. What was/were your major reason(s) for adopting IMRT (check all that apply):
   - To improve the delivery of conventional radiation doses
   - To allow the delivery of higher than conventional radiation doses in select patients
   - To gain a competitive advantage over other centers in your region
   - To remain competitive with other centers that were using IMRT
   - To perform clinical research
   - Other (please specify):

7. What is the primary anatomic site that you have treated with IMRT?
   - Head and neck
   - Prostate
   - Other (Please specify):

8. Which of the following anatomic sites have you treated with IMRT (check all that apply)?
   - CNS
   - Head and neck
   - Lung
   - GI
   - GU
   - Breast
   - Gyne
   - Pediatrics
   - GU
   - Other (Please specify):

9. Are you planning to:
   - Increase your use of IMRT
   - Maintain your current level of IMRT use
   - Decrease your use of IMRT
   - Cease your use of IMRT

   *If you are planning to decrease or cease the use of IMRT, what is (are) your major reason(s) for doing so (check all that apply)?*
   - Insufficient staff
   - Clinic is too busy
   - Lack of clinical benefit
   - Too few suitable patients
   - Other (please specify):

10. What is (are) the major reason(s) you are not currently treating patients with IMRT (check all that apply)?
    - Lack of necessary equipment (hardware, software, etc.)
    - Insufficient staff
    - Clinic is too busy
    - Lack of convincing data to support the use of IMRT
    - Other (please specify):

11. Are you planning to treat patients with IMRT in the future?
    - Yes
    - No

   *If you answered yes to question 11, please answer questions 12 and 13.*

12. When do you expect to begin treating patients with IMRT?
    - Within 1 year
    - 1–3 years
    - 3–5 years
    - > 5 years

13. What is (are) your major reason(s) for wanting to adopt IMRT (check all that apply):
    - To improve the delivery of conventional radiation doses
    - To allow the delivery of higher than conventional radiation doses in select patients
    - To gain a competitive advantage over other centers in your region
    - To remain competitive with other centers that were using IMRT
    - To perform clinical research
    - Other (please specify):

**IMRT:** intensity-modulated radiation therapy; **CNS:** central nervous system; **Gyne:** gynecologic; **GI:** gastrointestinal; **GU:** genitourinary.
dents and nonrespondents. The geographic distribution differed between the two groups, with Midwesterners more likely to respond and Easterners less likely to respond ($P = 0.008$). Respondents were more likely to be from an academic institution; however, this difference was not statistically significant ($P = 0.12$). The mean number of years of practice was similar in both groups ($P = 0.92$).

Of the 168 evaluable respondents, 54 physicians (32.1%) stated that they currently used IMRT. The standard error for this estimate was 3.6%. The percentages of physicians who used IMRT in the West, Midwest, South, and East were 32.1%, 34.0%, 37.5%, and 21.0%, respectively ($P = 0.51$). Academic radiation oncologists were more likely to use IMRT (51.2% vs. 26.4%; $P = 0.003$) than private practice radiation oncologists. No differences were seen in terms of IMRT use based on the number of years of practice. The percentages of physicians who used IMRT with $<10$ years, 11–20 years, and $>20$ years in practice were 31.4%, 34.0%, and 29.5% ($P = 0.90$), respectively. The percentage of physicians who used IMRT in practices with a total of 1 physician, 2–4 physicians, and $>4$ physicians were 15.4%, 28.4%, and 44.2% ($P = 0.02$), respectively. Excluding academic physicians, the corresponding respective percentages were 15.4%, 25.7%, and 36.4% ($P = 0.19$).

Of the 54 IMRT users, the majority (79.6%) had adopted IMRT since 2000 (Fig. 1). The percentages of IMRT users who had treated $<10$ patients, 11–50 patients, and $>50$ patients with IMRT were 25.9%, 38.8%, and 35.2%, respectively. Figure 2 displays the reasons given for adopting IMRT among IMRT users. The two most common reasons were to improve delivery of conventional doses and to allow dose escalation. Among academic physicians, performing clinical research was another common reason cited (16 of 20 respondents; 80.0%).

The disease sites IMRT users had treated with IMRT are summarized in Figure 3. The most common sites were head and neck malignancies and genitourinary tumors. However, many physicians had used IMRT to treat tumors of the central nervous system (CNS), lung, and breast. It is noteworthy that all physicians who reported treating pediatric tumors, lymphomas, and sarcomas with IMRT were at academic institutions. The majority of IMRT users (81.4%) stated that they planned to increase their IMRT use in the future, whereas 16.7% of IMRT users planned to maintain their current level of IMRT use. Even among experienced IMRT users (i.e., those who treated $>50$ patients), 84.2% stated that they planned to increase their IMRT use.

Of the 114 radiation oncologists not currently using IMRT, the most commonly cited reasons for not using IMRT were lack of necessary equipment (hardware and/or software) and insufficient staff (Fig. 4).

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Characteristics of Survey Population¹</th>
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<tr>
<td>Characteristic</td>
<td>Respondents</td>
</tr>
<tr>
<td>No. of physicians</td>
<td>180</td>
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<td>Geographic location (%)²</td>
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<td>West</td>
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<td>Practice type (%)</td>
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<td>Private</td>
<td>76.9</td>
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<tr>
<td>Mean years in practice</td>
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</table>

¹ Seven respondents returned the survey anonymously; therefore, their demographic information could not be distinguished from nonrespondent demographic information. Thus, the percentages shown are based on a total of 173 respondents and 160 nonrespondents.

² East: CT, DC, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VT, WV; South: AL, AR, GA, LA, MS, NC, SC, TN, TX, VA; Midwest: IA, IL, IN, KS, KY, MI, MN, MO, ND, NE, OH, OK, SD, WI; West: AK, AZ, CA, CO, HI, ID, MT, NM, NV, OR, UT, WA, WY.

**FIGURE 1.** Cumulative adoption of intensity-modulated radiation therapy (IMRT) among IMRT users.

**FIGURE 2.** Reasons for adopting intensity-modulated radiation therapy (IMRT) among IMRT users.
However, nearly all IMRT nonusers (96.5%) stated that they planned to adopt IMRT in the future, with 46.4%, 45.4%, 7.3%, and 0.9% of IMRT nonusers planning to adopt it within 1 year, 1–3 years, 3–5 years, and > 5 years, respectively. The most common reasons non-users wanted to adopt IMRT were to allow dose escalation and to improve delivery of conventional doses (Fig. 5). Performing clinical research was an additional common reason cited among academic IMRT nonusers (13 of 18 respondents; 72.2%).

DISCUSSION

The purpose of this survey was to assess the current use of IMRT in the United States. Our results revealed that approximately one-third of practicing radiation oncologists surveyed currently use IMRT in their clinical practice. However, the use of IMRT in this country appears to be growing rapidly. The majority of IMRT users stated that they had only begun using IMRT since 2000, and nearly all IMRT nonusers planned to begin using IMRT within the next 1–3 years.

IMRT use was more common among academic radiation oncologists. Given the potential for both clinical and physics research, it is not surprising that IMRT would have been adopted first by academic physicians. With the increasing implementation of IMRT by private practice physicians, however, this disparity is likely to decrease over time. Although it was more common among academic physicians compared with private practice physicians, IMRT use still was seen only in approximately half of the surveyed academic physicians. This result may suggest that many current radiation oncology residents are not gaining exposure to this emerging technology, particularly because most IMRT nonusers cited lack of equipment as a major factor precluding its use. The optimal planning and delivery of IMRT is a complicated process. Given the increasing, widespread adoption of IMRT, it behooves academic centers with residency programs to ensure proper training in this technology.

IMRT use was comparable throughout the country, except for a lower percentage in Eastern states. The reasons for this observation are not clear. In contrast, no difference in IMRT use was seen based on the number of years in practice. One might have expected that the adoption of a new technology such as IMRT would have been more prevalent among radiation oncologists with fewer years in practice. We were not surprised, however, that IMRT use correlated with practice size. Larger practices may be more capable of supporting the additional start-up costs and the increased staffing requirements. Nonetheless, nearly all solo practitioners surveyed who were not using IMRT planned to do so in the future.

The most common reasons for adopting IMRT cited by nearly all IMRT users were to improve the delivery of conventional doses and to allow dose escalation. It is not known from our survey which dis-
ease sites are being treated with higher than conventional doses. The inclination to dose escalate, nonetheless, should be a cause for concern; because dose escalation, per se, remains experimental. However, promising results with higher than conventional doses have been reported recently in a variety of sites, particularly prostate carcinoma.40

Another common motivation for adopting IMRT among IMRT users was competition (either to gain a competitive advantage or to remain competitive), particularly among private practice physicians. Given the tremendous media interest in IMRT and increased patient awareness of IMRT, this result was not unexpected. Patients may be seeking centers that use IMRT; lack of this technology may result in lost patient referrals and, consequently, less revenue. This is particularly true given the recent increased reimbursement possible with IMRT. Unsurprisingly, research opportunities were a common motivation for adopting IMRT among academic physicians.

Many IMRT users already have gained considerable clinical experience with this technology, despite the fact most only recently have adopted IMRT. Moreover, their experience spans a wide spectrum of disease sites. By far, the two most common sites were genitourinary and head and neck tumors, most likely reflecting the ample clinical experience in these disease sites.31,32,35–37,41,42 Many physicians also had treated patients with tumors of the CNS, breast, and lung. Although some outcome studies have appeared in patients with CNS tumors,39 published clinical experience in patients with breast carcinoma and lung carcinoma is very limited.40 A modest number of respondents had treated patients with gastrointestinal and gynecologic tumors using IMRT, possibly in light of recent clinical results in these sites.33,34,39 Only academic physicians reported having treated pediatric patients with IMRT. However, the use of IMRT in pediatric patients may rise, given the number of recent favorable outcome studies.29,36

The overwhelming majority of IMRT users planned to increase their IMRT use in the future. Although this may be due in part to the recent adoption of IMRT by most users in our survey, even those with extensive experience (>50 patients treated) planned to increase their IMRT use, suggesting a strong commitment to this technology. It also was noteworthy that no IMRT users planned to decrease their usage. It may have been expected that some physicians would have found IMRT too time consuming or less beneficial than they had expected and, thus, would have planned to decrease its use. However, this was not the case.

In our analysis, the major reason cited by IMRT nonusers for not using IMRT was lack of necessary equipment. Given the amount of new software and hardware needed, it is natural that this represents a major obstacle to IMRT implementation. It is noteworthy that only a minority of respondents cited insufficient staff or lack of time as a reason for not using IMRT. The implementation of IMRT, at least initially, is a time-consuming endeavor, particularly with regard to commissioning and quality assurance procedures. Moreover, IMRT use places additional time demands on both physicians and physicists compared with conventional approaches. The lack of convincing data also was cited as a barrier to IMRT adoption. However, in light of the increasing number of clinical studies that have demonstrated a benefit to IMRT in many tumor sites,31–42 this concern should decrease in the future.

Despite the various barriers cited, nearly all IMRT nonusers (97.2%) stated that they planned to adopt IMRT in the future, with most planning to adopt it within 3 years. Similar to current users, improved delivery of conventional doses and dose escalation were the two most common reasons cited for wanting to adopt IMRT, and the opportunity to do research was a common reason among academic physicians. Competition also was a major factor cited, especially the desire to remain competitive. This is not surprising given the current widespread adoption of IMRT.

This study had several limitations. First, we relied on self-report of IMRT use, which may not reflect reality. Some respondents may have construed IMRT to include forward planning, although this was discouraged in our initial cover letter. Differences in self-defined IMRT use potentially may overestimate its prevalence or may bias comparisons of groups like academics and private practitioners. Furthermore, IMRT nonusers may have felt compelled to state their intention to adopt IMRT, given the great interest in this technology, even though they had little or no intention of adopting it. It would be worthwhile to follow-up with these respondents to see whether they ultimately adopt IMRT. Our sample also included a greater proportion of academic physicians, who were more likely to use IMRT. Finally, uncontactable physicians, nonrespondents, or radiation oncologists who did not belong to ASTRO may have been less likely to use IMRT. Thus, the true proportion of radiation oncologists currently using IMRT may be lower than that reported here.

Moreover, we did not strictly define IMRT use or reveal how IMRT is being performed. IMRT delivery is a complicated process; hence, its proper application requires diligent attention to quality assurance. Although issues such as patient selection, target delin-
eation, treatment plan evaluation, and quality assurance exceeded the scope of our survey, they are important questions to be addressed by future research. Standardized education and treatment guidelines do not exist but may be needed in the near future to ensure the safe and appropriate use of IMRT.

It is unclear what will be the ramifications of increasing IMRT adoption. Clearly, if IMRT truly reduces toxicity and improves tumor control, then it will represent a major advancement in the field of radiation oncology. However, defining the appropriate use of IMRT is a work in progress. Research still must be conducted to determine which areas can be treated safely with higher or lower radiation doses and which sites are most suitable for IMRT. For example, a lung treated with IMRT may have a greater tissue volume receiving a toxic dose than a lung treated with conventional RT. Although, to date, IMRT has not been associated with unforeseen toxicity, with longer follow-up, unexpected adverse consequences of treatment may be observed with time. Close follow-up of all treated patients is essential to fully evaluate the impact of this technology.

To our knowledge, the current survey represents the first assessment of IMRT use in this country and provides valuable insight into the changing field of radiation oncology. Although approximately one-third of physicians surveyed currently use IMRT, this number appears to be increasing rapidly. IMRT use is becoming increasingly common in both academic and private practices, large and small groups alike. Nearly all physicians not currently using IMRT stated an intention to adopt it in the near future. Although follow-up is warranted, even if only a modest proportion of those who intend to adopt IMRT actually do so, the majority of practicing radiation oncologists in the United States soon will be using this technology. The field of radiation oncology is undergoing a radical change in its approach to the planning and delivery of radiation. These findings suggest an imperative need to ensure that this new technology is applied appropriately and safely.

REFERENCES


