Cost Comparison from a Patient Perspective for Intracranial Stereotactic Radiation Therapy

Rahul N. Prasad

Ohio State University

Vedat O Yildiz

The Ohio State University Department of Radiation Oncology

Tejash Patel

Philadelphia College of Osteopathic Medicine

Trevor J. Royce

University of North Carolina at Chapel Hill

Joshua David Palmer (✉ joshua.palmer@osumc.edu)

Department of Radiation Oncology Ohio State University James Cancer Hospital <https://orcid.org/0000-0003-3311-0129>

Research Article

Keywords: intracranial stereotactic radiotherapy, radiosurgery, Gamma Knife, linear-accelerator based stereotactic radiotherapy, health economics

Posted Date: May 6th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-485563/v1>

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Version of Record: A version of this preprint was published at Advances in Radiation Oncology on October 1st, 2021. See the published version at <https://doi.org/10.1016/j.adro.2021.100816>.

Abstract

Introduction

Financial toxicity is a damaging consequence of oncologic therapy addressable through improved price transparency. The US government recently mandated that hospitals publish a “chargemaster,” or list of “standard charges” for provided services. Patients often travel to tertiary centers for intracranial stereotactic radiotherapy (SRT), but cost comparison is complicated by multiple delivery systems and fractionation schemes. We hypothesized that publicly listed prices vary widely between comparable SRT modalities and by institution.

Methods

Through online query, we obtained chargemasters for clinical National Cancer Institute (NCI)-designated centers. Technical charges for Gamma Knife (GK), single fraction linear-accelerator stereotactic radiosurgery (SRS), and 3-fraction fractionated stereotactic radiation therapy (FSRT) were obtained by billing code and keyword searches. Prices were adjusted by the Medicare geographic cost price index (GPCI). Pairwise comparisons were conducted to compare prices between modalities and geographic regions. Price association between modalities and relationships with cost index were examined using Spearman correlations.

Results

62 chargemasters were obtained, and 58 listed SRT prices. Median prices varied widely (GK-\$49,529; FSRT-\$31,834; SRS-\$22,915) with large interquartile ranges. Adjusting for GPCI, GK ($p = .0003$) and FSRT ($p = .001$) were significantly more expensive than SRS, and no difference in price was noted between regions. FSRT price was positively correlated with GPCI ($p = .033$) but other modalities were not. Modality prices were positively correlated (all $p < .001$).

Conclusions

Published prices for SRT vary by delivery system, fractionation, and by institution. Differences are poorly explained by variable cost of living. These inefficiencies expose patients already at high risk for financial toxicity to unnecessary costs.

Introduction

Financial toxicity is a highly prevalent and damaging consequence of oncologic therapy.[1, 2] Cancer patients’ bankruptcy are more than double that of other patients[3], and economic hardship is linked to poorer quality of life and cancer outcomes.[4–7] Inability to make copayments[8] is a large driver of financial toxicity and is potentially addressable through enhanced price transparency.[9] In 2019, The US Centers for Medicare and Medicaid Services (CMS) required that all US hospitals publish a consumer friendly list of “standard” charges for all offered services called a chargemaster.[10] Intracranial stereotactic radiotherapy (SRT) is well suited for price comparison, as it is a high cost, non-emergent, and short duration (one to five daily treatments) procedure with numerous benign and malignant indications[11] for which patients are frequently referred to high volume centers.[12] While the financial toxicity rate of SRT has not been prospectively studied, a rate of short term financial toxicity of more than 20% has been noted after long course radiation therapy.[13] Multiple referral centers may exist within a city, state, or region, and reliable cost data, if available, could help patients choose a facility minimizing out of pocket cost. However, price comparison is complicated by the presence of multiple delivery systems and fractionation schemes including Gamma Knife/CyberKnife single fraction stereotactic radiosurgery (GK), single-fraction linear accelerator based stereotactic radiosurgery (SRS), and multi-session linac-based fractionated stereotactic radiotherapy (FSRT). To our best knowledge, a robust comparison of the price of these treatment modalities has not been previously reported. We hypothesized that prices for intracranial SRT listed in chargemaster documents vary by delivery system, fractionation scheme, and between institutions.

Methods

63 National Cancer Institute (NCI)-designated cancer centers offering clinical care were identified; 7 laboratory-only sites and St. Jude's offering free pediatric care only were excluded. In late 2020, the chargemasters for each institution were obtained through Google online search queries using terms such as "chargemaster," "charge master," and "price list." If no cancer center specific chargemaster was available, hospital-wide chargemasters for the umbrella institution were used. If no chargemaster were identifiable through online search, institutions were approached by email to request price information. Because only publicly listed cost data was used and no human subjects were involved in this analysis, IRB approval and informed consent were not necessary.

For each institution, the listed prices for GK, linac SRS, and 3-fraction FSRT were obtained. Prices for 3-fraction FSRT were used instead of 3-fraction FSRT to avoid amplifying inherent per fraction price ambiguities already captured by the 3-fraction FSRT pricing regimens. When available, the Current Procedural Terminology (CPT) billing codes 77371 for GK radiation treatment delivery, 77372 for single fraction linac SRS treatment delivery, and 77373 for multi-fraction stereotactic therapy were used to obtain cost data. The delivery portion of radiation therapy was assessed, because it is a highly standardized charge that generally captures greater than half the cost of the total price of radiation treatment.[14] When CPT codes were not available, manual search using terms such as "SRS," "stereotactic radiosurgery," and "cranial" was conducted to identify SRT delivery list prices. Additional terms such as "linac" or "linear accelerator" were used to differentiate SRS and terms such as "Gamma Knife," "Cobalt 60," "SRS multisource," and "Cyberknife" were used to identify GK prices. The cost of FSRT was separated out using search phrases such as "fractionated" or "per fraction". If an institution did not report an alternate method of calculating the cost of a course of FSRT, the listed per fraction cost was multiplied out to reflect a 3 treatment course.

The primary study endpoint was the difference in published price between GK, SRS, and FSRT after adjusting for the facility specific reimbursement modifier assigned by Medicare to adjust for differences in cost of living, the practice expense geographic practice cost index (GPCI). Secondary endpoints included the difference in cost by geographic region, relationship between GPCI and price for each modality, and relationship between GK, linac SRS, and FSRT prices. Data was summarized using descriptive statistics with medians with quartiles calculated for continuous variables. Pairwise comparisons were conducted, where appropriate, to compare prices across modalities and geographic regions. Price association between modalities, as well as the relationship between each modality price and cost index, were examined using logistic regression and Spearman correlations. Statistical tests were 2-sided with statistical significance evaluated at the $\alpha = 0.05$ significance level.

Results

Of the 63 NCI-designated cancer centers offering clinical care, 62 had obtainable chargemasters (Fig. 1). These were easily acquired through an internet search using 1 or 2 search attempts with varying phrases. One chargemaster was not obtainable without providing an email address. 2 institutions' chargemasters were not available online, and 1 remained unobtainable even after direct email request. Of the 62 chargemasters that were acquired, 1 chargemaster did not list prices for any form of radiation therapy and attempts to reach the institution by email failed to yield the required information. Three additional chargemasters did not list prices specific to delivery of any form of intracranial SRT. Thus, in total, 58 institutions' chargemasters were included in the quantitative analysis. Fifty-one (88%) chargemasters were downloadable files compatible with Excel or Adobe Acrobat. 7 were not downloadable and searchable by online query only.

Thirty-one, 58, and 57 institutions' listed prices were ultimately obtained for GK, SRS, and FSRT, respectively. Figure 2 depicts the wide variation in mean and median price for GK, SRS, and FSRT as well as large range in prices between institutions. The median prices for GK, SRS, and FSRT were \$49,529, \$22,915, and \$31,834, respectively ($p < 0.0001$), and GK and FSRT were both significantly more costly than SRS ($p = 0.0003$ and $p = 0.001$, respectively) but not significantly more expensive than each other ($p = 0.271$). FSRT price was positively correlated with GPCI ($p = .033$) but GK and SRS prices were not ($p = 0.876$ and 0.051 , respectively)(Table 1). Table 2 shows that all modality prices were positively correlated with one another (all $p < .001$). There was no adjusted difference in SRT price between regions (Table 3).

Table 1
Relationship between Medicare cost index and price of Gamma Knife stereotactic radiosurgery (GK), linear accelerator stereotactic radiosurgery (SRS), and linear accelerator fractionated stereotactic radiotherapy (FSRT)

Modality	Spearman Correlation coefficient	p-value
GK	-0.029	0.876
SRS	0.257	0.051
FSRT	0.281	0.033

Table 2
Relationship (Spearman correlation coefficient) between prices of Gamma Knife stereotactic radiosurgery (GK), linear accelerator stereotactic radiosurgery (SRS), and linear accelerator fractionated stereotactic radiotherapy (FSRT)

Modality	SRS	p-value	FSRT	p-value
GK	0.58	0.0005	0.46	0.0008
SRS	-	-	0.66	< 0.0001

Table 3
Price comparison by region after adjusting for cost of living. GK = Gamma Knife stereotactic radiosurgery. SRS = linear accelerator stereotactic radiosurgery. FSRT = linear accelerator fractionated stereotactic radiotherapy

	GK			SRS			FSRT			p-value
	median	P25	P75	median	P25	P75	median	P25	P75	
East North Central	57241.5	41245.7	89935.5	16768	10350	28081	28857	15573	32352	0.017
East South Central	56169.3	32916.7	79422	16308	9659	22957	30405.5	28977	31834	0.101
Mid Atlantic	64480	42237	67050	26331	22872	48512	49173	29658	78552	0.125
Mountain	55731.6	48602.1	62861	26946	19583.5	29737.5	67008.9	35162.5	92660.4	0.232
New England	4910	4910	4910	23924	6902	27355.1	21728.9	17214	58788	0.318
Pacific	48696.2	26480	64792.3	25643.5	21326	28642	39701	22518	51363	0.086
South Atlantic	39519.5	8243	65000	16024	5619	23908	21643	13918.5	43324.5	0.173
West North Central	27527	8374.74	53978	23059	8374.74	29654	26606.3	18498	33816	0.741
West South Central	48934	40819	57049	8514	7361	14779	19620	8520	44337	0.102
p-value	0.16			0.398			0.351			

Discussion

Our analysis of list prices obtained from publically available chargemasters from NCI-designated cancer centers demonstrates that despite overlapping indications, cost of living adjusted list prices for GK and FSRT are higher than for SRS. Additionally, price variation for single-fraction radiosurgery is poorly explained by cost of living regardless of delivery system, and prices for all three modalities are positively correlated. These findings are highly significant because to our best knowledge, a robust comparison of the price of these treatment modalities has not been previously reported, and economic distress after cancer therapy is a significant concern with patient-reported subjective rates of financial toxicity in this population reaching 50–75% in meta-analyses[1, 2] including issues meeting copayments.[8]. Mitigating these financial consequences is essential, as financial toxicity is associated with inferior outcomes.[4–7] Although economic hardship specific to intracranial SRT has not been documented, one prospective study found that 22% of radiation oncology patients receiving mostly long course radiation therapy developed financial issues ranging from job loss to homelessness.[13]

Facilitating price comparison for patients is one proposed way to decrease the risk of financial toxicity in this population, as it makes particular sense for expensive, non-urgent, and brief episodes of care such as SRT. In 2019, to try to improve price transparency, CMS decreed that US hospitals must publish a consumer friendly list of standard charges for all items and services in a machine-readable document called a chargemaster.[10] Overall, online chargemasters were moderately easy to obtain with a few exceptions, and only four chargemasters had either no RT prices or no intracranial SRT prices. Our analysis of the 58 chargemasters inclusive of intracranial SRT data found that prices for all three modalities varied together. More expensively listed institutions tended to be more costly across all treatment types. These findings suggest that even if patients may not know upfront which type of SRT they will be offered or even that multiple options exist, if they can find at least one valid price to compare between institutions, then they will have a reasonable chance of selecting the less expensively listed institution. Additionally, we found that cost of living adjusted list prices for GK were higher than for SRS, suggesting that patients offered GK for brain metastases, if interested in cost control, should ask providers whether SRS is a safe and effective option. Additionally, we found that cost of living variation did not explain variation in the price of single-fraction radiosurgery (GK and SRS) which suggested significant inefficiencies in pricing between institutions. Lastly, we found no significant difference in cost between geographic regions for any modality, which suggests that cost comparing within a reasonably sized geographic region, may be sufficient as opposed to traveling farther in search of cost advantages.

Study Limitations

Limitations of this analysis primarily stem from concerns inherent to chargemaster documents. The primary issue with chargemaster reliability is the utilization of “standard” rather than negotiated prices[15] which as previously shown in a cost analysis for intensity modulated radiation therapy for prostate cancer leads to a large range of listed prices that exceeds predicted ranges in reimbursement by insurance providers.[14] CMS very recently required that hospitals also provide negotiated prices for at least 300 common services,[16] but oncology prices are not routinely included. Although the precise effect of insurer negotiations on pricing cannot be assessed using chargemasters, they remain SRT patients’ sole source of published information and thus warrant investigation; it is expected that the price inefficiencies we identified persist after insurer intervention. In addition, standard charges may even be valid for some patient populations such as patients from overseas. Additionally, we analyzed the technical fees for radiation delivery, which may account for only 50–75% of the total cost of therapy.[14, 17] However, our goal was to make the most reliable relative cost comparisons, and attempting to identify every possible additional applicable charge piecemeal to approximate a 100% charge burden would introduce substantially more uncertainty. Lastly, we only analyzed price data from NCI-designated centers, which may limit generalizability to lower volume institutions, but referral centers treat a disproportionately high volume of SRT patients.

Conclusions

Published prices for intracranial SRT vary by delivery system, fractionation, and between institutions with differences poorly explained by variable cost of living. These inefficiencies expose patients already at high risk for financial toxicity to unnecessary costs. Policy changes are needed to either better standardize the cost of SRT or ensure the availability of reliable cost data for oncology patients.

Declarations

Acknowledgements: None

Funding: None

Conflicts of Interest: None. Joshua D. Palmer discloses Honoraria from Huron Consulting group and Novocure, research support from Varian Medical Systems and Kroger outside the submitted work

Availability of Data and Material: Data available upon reasonable request to the corresponding author

Code Availability: N/A

Authors' contributions: All authors contributed to the study conception and design. Material preparation and data collection were performed by Rahul Prasad. Data analysis was performed by Vedat Yildiz. The first draft of the manuscript was written by Rahul Prasad and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

COMPLIANCE WITH ETHICAL STANDARDS

Ethics approval: Because only publicly listed cost data was used and no human subjects were involved in this analysis, IRB approval was not necessary

Consent to participate: N/A. Because only publicly listed cost data was used and no human subjects were involved in this analysis, consent was not necessary

Consent for publication: N/A

References

1. Altice CK, Banegas MP, Tucker-Seeley RD, Yabroff KR (2017) Financial Hardships Experienced by Cancer Survivors: A Systematic Review. *J Natl Cancer Inst* 109:. <https://doi.org/10.1093/jnci/djw205>
2. Gordon LG, Merollini KMD, Lowe A, Chan RJ (2017) A Systematic Review of Financial Toxicity Among Cancer Survivors: We Can't Pay the Co-Pay. *Patient* 10:295–309. <https://doi.org/10.1007/s40271-016-0204-x>
3. Ramsey S, Blough D, Kirchhoff A, et al (2013) Washington State Cancer Patients Found To Be At Greater Risk For Bankruptcy Than People Without A Cancer Diagnosis. *Health Affairs* 32:1143–1152. <https://doi.org/10.1377/hlthaff.2012.1263>
4. Carrera PM, Kantarjian HM, Blinder VS (2018) The financial burden and distress of patients with cancer: Understanding and stepping-up action on the financial toxicity of cancer treatment. *CA Cancer J Clin* 68:153–165. <https://doi.org/10.3322/caac.21443>
5. Fenn KM, Evans SB, McCorkle R, et al (2014) Impact of financial burden of cancer on survivors' quality of life. *J Oncol Pract* 10:332–338. <https://doi.org/10.1200/JOP.2013.001322>
6. Hazell SZ, Fu W, Hu C, et al (2020) Financial toxicity in lung cancer: an assessment of magnitude, perception, and impact on quality of life. *Ann Oncol* 31:96–102. <https://doi.org/10.1016/j.annonc.2019.10.006>
7. Ramsey SD, Bansal A, Fedorenko CR, et al (2016) Financial Insolvency as a Risk Factor for Early Mortality Among Patients With Cancer. *J Clin Oncol* 34:980–986. <https://doi.org/10.1200/JCO.2015.64.6620>
8. Zafar SY, Peppercorn JM, Schrag D, et al (2013) The financial toxicity of cancer treatment: a pilot study assessing out-of-pocket expenses and the insured cancer patient's experience. *Oncologist* 18:381–390. <https://doi.org/10.1634/theoncologist.2012-0279>

9. Henrikson NB, Shankaran V (2016) Improving Price Transparency in Cancer Care. JOP 12:44–47.
<https://doi.org/10.1200/JOP.2015.006171>
10. Frequently Asked Questions Regarding Requirements for Hospitals To Make Public a List of Their Standard Charges via the Internet. 1
11. Gilbo P, Zhang I, Knisely J (2017) Stereotactic radiosurgery of the brain: a review of common indications. Chinese Clinical Oncology 6:7. <https://doi.org/10.21037/cco.v0i0.16081>
12. Solberg TD, Balter JM, Benedict SH, et al (2012) Quality and safety considerations in stereotactic radiosurgery and stereotactic body radiation therapy: Executive summary. Pract Radiat Oncol 2:2–9.
<https://doi.org/10.1016/j.ppro.2011.06.014>
13. Palmer JD, Patel TT, Eldredge-Hindy H, et al (2018) Patients Undergoing Radiation Therapy Are at Risk of Financial Toxicity: A Patient-based Prospective Survey Study. International Journal of Radiation Oncology, Biology, Physics 101:299–305. <https://doi.org/10.1016/j.ijrobp.2018.03.014>
14. Agarwal A, Dayal A, Kircher SM, et al (2020) Analysis of Price Transparency via National Cancer Institute–Designated Cancer Centers’ Chargemasters for Prostate Cancer Radiation Therapy. JAMA Oncol 6:409.
<https://doi.org/10.1001/jamaoncol.2019.5690>
15. Furlow B (2019) Skepticism about new US Government hospital pricing transparency rule. The Lancet Oncology 20:188.
[https://doi.org/10.1016/S1470-2045\(19\)30002-6](https://doi.org/10.1016/S1470-2045(19)30002-6)
16. Hospital Price Transparency Frequently Asked Questions. 21
17. Moore A, Stav I, Den RB, et al (2019) The Financial Impact of Hypofractionated Radiation for Localized Prostate Cancer in the United States. In: Journal of Oncology. <https://www.hindawi.com/journals/jo/2019/8170428/>. Accessed 26 Oct 2020

Figures

Figure 1

Schematic documenting process for obtaining intracranial stereotactic radiotherapy (SRT) cost data NCI = National Cancer Institute CPT = current procedural terminology

Figure 2

List price comparison for Gamma Knife stereotactic radiosurgery (GK), linear accelerator stereotactic radiosurgery (SRS), and linear accelerator fractionated stereotactic radiotherapy (FSRT), $p < 0.0001$ after adjusting for cost of living