Radiosurgery for Brain Metastases: Changing Practice Patterns and Disparities in the United States

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Abstract

Background: Management of brain metastases typically includes radiotherapy (RT) with conventional fractionation and/or stereotactic radiosurgery (SRS). However, optimal indications and practice patterns for SRS remain unclear. We sought to evaluate national practice patterns for patients with metastatic disease receiving brain RT. **Methods:** We queried the National Cancer Data Base (NCDB) for patients diagnosed with metastatic non–small cell lung cancer, breast cancer, colorectal cancer, or melanoma from 2004 to 2014 who received upfront brain RT. Patients were divided into SRS and non-SRS cohorts. Patient and facility-level SRS predictors were analyzed with chi-square tests and logistic regression, and uptake trends were approximated with linear regression. Survival by diagnosis year was analyzed with the Kaplan-Meier method. **Results:** Of 75,953 patients, 12,250 (16.1%) received SRS and 63,703 (83.9%) received non-SRS. From 2004 to 2014, the proportion of patients receiving SRS annually increased (from 9.8% to 25.6%; $P<.001$), and the proportion of facilities using SRS annually increased (from 31.2% to 50.4%; $P<.001$). On multivariable analysis, nonwhite race, nonprivate insurance, and residence in lower-income or less-educated regions predicted lower SRS use ($P<.05$ for each). During the study period, SRS use increased disproportionately among patients with private insurance or who resided in higher-income or higher-educated regions. From 2004 to 2013, 1-year actuarial survival improved from 24.1% to 49.6% for patients selected for SRS and from 21.0% to 26.3% for non-SRS patients ($P<.001$). **Conclusions:** This NCDB analysis demonstrates steadily increasing—although modest overall—brain SRS use for patients with metastatic disease in the United States and identifies several progressively widening sociodemographic disparities in the adoption of SRS. Further research is needed to determine the reasons for these worsening disparities and their clinical implications on intracranial control, neurocognitive toxicities, quality of life, and survival for patients with brain metastases.

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More than 20% of patients with cancer will develop brain metastases.¹ Primary malignancies most commonly associated with brain metastases are lung, breast, and gastrointestinal cancers and melanoma, constituting up to 80% of brain metastases.^{1–3} Management of brain metastases often consists of tumor-directed treatment with radiotherapy (RT). Traditionally, RT had been administered with conventionally fractionated whole-brain RT (WBRT), although over the past several decades, stereotactic radiosurgery (SRS), targeted at individual cranial lesions, has become accepted.^{4–6} Several randomized trials demonstrated equivalent survival

with upfront SRS and WBRT for patients with 1 to 3 brain metastases.^{7,8} In the context of these trials, there was a modest national increase in SRS use observed in Medicare patients with metastatic non–small cell lung cancer (NSCLC) from 2000 to 2005.⁹ Since then, several randomized trials showed that SRS upfront without WBRT did not compromise survival and was associated with fewer adverse neurocognitive effects.^{10–12} SRS use may also vary by primary disease site.^{13,14} Additionally, cost concerns and access to facilities with SRS programs may vary and introduce disparities for certain patient groups.

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Utilization of SRS may vary widely on a national scale.^{15,16} Therefore, we sought to evaluate recent national SRS treatment patterns, institutional adoption, and disparities across 4 of the malignancies most associated with brain metastases in the United States.

Methods

Data Source and Study Population

We conducted a retrospective analysis of the National Cancer Data Base (NCDB), a joint project of the Commission on Cancer (CoC) of the American College of Surgeons and the American Cancer Society. It is a hospital-based database that contains deidentified information from approximately 70% of newly diagnosed cancers in the United States. The NCDB contains information that is unavailable in the SEER database, including treatment details pertaining to RT dose, technique, and target. Treatments coded in the NCDB capture a patient's first-course treatment for the corresponding diagnosis. The data used in this study are derived from deidentified NCDB participant user files. The American College of Surgeons and the CoC have not verified and are not responsible for the analytical or statistical methodology used, nor the conclusions drawn from these data by the investigators.

We pooled the NCDB participant user files for NSCLC, breast cancer, colorectal cancer (CRC), and melanoma. We identified patients aged ≥ 18 years, diagnosed with histology- or cytology-confirmed NSCLC, breast cancer, CRC, or melanoma between 2004 and 2014, with metastatic disease, who were treated with radiation to the brain. Patients with unknown radiation modality and dose were excluded. Radiation treatment modality is explicitly coded in the NCDB, and patients were divided into 2 cohorts: SRS or non-SRS. The SRS cohort was defined as patients who received "stereotactic radiosurgery, NOS [not otherwise specified]," "LINAC radiosurgery," or "gamma knife radiosurgery," or received external-beam RT with fraction size ≥ 6 Gy. The non-SRS cohort included all other patients receiving external-beam RT to the brain who met the inclusion criteria.

Statistical Methodology

Patient-level characteristics included age, year of diagnosis, sex, malignancy type, Charlson-Deyo

comorbidity score (CDS), race/ethnicity, insurance status, distance from facility, median household income in patient's zip code, residence in a metropolitan area, and educational status in the patient's zip code (percentage of adults who did not graduate high school). Income and educational status in the NCDB were derived from the 2012 American Community Survey data.¹⁷ Facility-level characteristics included region and academic affiliation. Data on the number of brain metastases are not available in the NCDB.

Demographic, clinical, and temporal associations were evaluated between patients in the SRS and non-SRS cohorts using graphical assessment, chi-square, and Wilcoxon rank sum tests. Univariable (UVA) multilevel, mixed-effects regression was performed, accounting for the reporting facility as a random effect, and odds ratios (ORs) were calculated. Multivariable (MVA) multilevel, mixed-effects logistic regression, again accounting for the reporting facility, was conducted using all variables with a significant association with SRS on UVA; adjusted ORs (aORs) were calculated. Variables were tested for collinearity and interaction. Sensitivity analysis with MVA logistic regression was also conducted after excluding patients with melanoma, given the predominantly white population reflected by this disease type.

For variables that were significant predictors of SRS use, analysis of temporal trends was conducted to assess for differential uptake across variables over the study period with graphical assessment. Uptake slopes (β) were approximated with linear regression and compared among categories with Wald tests.^{18,19}

A facility-level analysis was conducted to determine the rates of SRS adoption by US facility. For this analysis, only patients who received at least part of their first treatment course at the reporting facility were included. Facilities that reported at least 1 case of SRS during a given year were classified as an SRS facility for that year. Facilities that did not report a single case of SRS were classified as a non-SRS facility for that year.

A survival analysis was conducted after excluding patients without documented follow-up. Follow-up was documented in our NCDB user file through 2013. Survival was defined as time from diagnosis to death or last follow-up. One-year actuarial survival was analyzed annually during the study period using

the Kaplan-Meier method, and cohorts were compared with log-rank tests.

All tests were 2-sided, and $P < .05$ was considered statistically significant. Analyses were performed using Stata/SE 13 (StataCorp, College Station, TX).

Results

Patient Characteristics and Overall Trends of SRS Use

We identified 75,953 patients who met our inclusion criteria for analysis (see [supplemental eFigure 1](#), available online with this article at [JNCCN.org](#)). Of these, 12,250 (16.1%) were in the SRS cohort and 63,703 (83.9%) were in the non-SRS cohort. Of 68,710 patients with NSCLC, 10,799 (15.7%) received SRS; of 3,565 patients with melanoma, 952 (26.7%) received SRS; of 2,909 patients with breast cancer, 348 (12.0%) received SRS; and of 769 patients with CRC, 151 (19.6%) received SRS (Table 1). The overall utilization rate for SRS increased from 9.8% in 2004 to 25.6% in 2014 ($P < .001$), with an average annual increase of 1.6% per year (Figure 1). The annual increase of SRS uptake was higher from 2009 to 2014 than from 2004 to 2009 (2.6% vs 0.5% per year, respectively).

Predictors of SRS Use

Predictors of SRS use on UVA and MVA with ORs and confidence intervals are shown in Table 2. On MVA, predictors of higher SRS use were later year of diagnosis; melanoma, CRC, or NSCLC compared with breast cancer; private insurance, Medicare, or Medicaid compared with no insurance; residence in zip code with a higher rate of high school education; and greater distance from facility. Predictors of lower SRS use were black race, Hispanic ethnicity, CDS 2, residence in zip code with lower median household income, and nonacademic reporting facility. MVA excluding patients with melanoma demonstrated similar results (data not shown).

SRS Uptake in Clinical and Sociodemographic Subgroups

SRS use increased across all disease sites during the study period ([supplemental eFigure 2](#)). From 2004 to 2014, the proportion of patients receiving SRS increased from 9.8% to 25.0% for NSCLC, 7.9% to 18.8% for breast cancer, 4.8% to 40.6% for CRC,

and 12.7% to 36.2% for melanoma. According to linear regression approximation, SRS increased most for patients with melanoma ($\beta = 2.13$) compared with those with NSCLC ($\beta = 1.28$; $P < .001$) and breast cancer ($\beta = 1.02$; $P < .001$), although was similar to uptake in patients with CRC ($\beta = 2.09$; $P = .96$). SRS use increased more for patients with income $\geq \$63,000$ than for those with lower income ($\beta = 1.86$ vs 1.13; $P < .001$; Figure 2A); more for patients with private insurance ($\beta = 1.64$) than those with Medicare ($\beta = 1.29$; $P = .001$), Medicaid ($\beta = .99$; $P = .06$ [relative to Medicare]), or no insurance ($\beta = .74$; $P = .01$ [relative to Medicaid]) (Figure 2B). SRS use also increased more for patients treated at academic versus nonacademic facilities ($\beta = 2.26$ vs 1.01; $P < .001$) (Figure 2C); for patients in regions with a greater level of high school education ($\beta = 1.48$ vs 1.10; $P < .001$) (Figure 2D); and among Hispanic versus black patients ($\beta = 1.69$ vs 1.28; $P = .03$), but not more than among white patients ($\beta = 1.34$; $P = .06$) ([supplemental eFigure 3](#)).

Facility-Level Analysis of SRS Uptake

Among the study population, 73,077 patients (96.2%) received at least part of their treatment at the reporting facility, with a total of 1,207 treatment facilities reporting cases from 2004 to 2014. Not all facilities reported cases every year, and the number of facilities reporting yearly ranged from a low of 913 to a high of 1,044. The number of SRS facilities increased yearly from 285 (31.2%) in 2004 to 515 (50.4%) in 2014 (Figure 3).

Survival Trends Analysis

Among the 67,448 patients in the survival analysis, 1-year actuarial overall survival was 26.6% for the entire population; 1-year survival was 40.9% for SRS patients and 24.1% for non-SRS patients ($P < .001$). One-year survival increased for patients with each year of diagnosis, from 21.3% in 2004 (95% CI, 20.2%–22.4%) to 31.5% in 2013 (95% CI, 30.6%–32.6%) (Figure 4). From 2004 to 2013, 1-year survival increased from 24.1% (95% CI, 20.6%–28.3%) to 49.6% (95% CI, 47.4%–52.0%) among SRS patients, and from 21.0% (95% CI, 19.8%–22.2%) to 26.3% (95% CI, 25.3%–27.5%) in non-SRS patients.

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Variable	Total, n (N=75,953)	SRS, n (N=12,250)	%	Non-SRS, n (N=63,703)	%	P Value
Median age, y	64	64		63		<.001
Range	18–90	19–90		18–90		
Year of diagnosis						<.001
2004–2007	21,803	2,537	11.6	19,266	88.4	
2008–2011	29,061	4,187	14.4	24,874	85.6	
2012–2014	25,089	5,526	22.0	19,563	78.0	
Cancer site						<.001
NSCLC	68,710	10,799	15.7	57,911	84.3	
Melanoma	3,565	952	26.7	2,613	73.3	
Breast	2,909	348	12.0	2,561	88.0	
Colorectal	769	151	19.6	618	80.4	
Sex						.008
Male	39,085	6,169	15.8	32,916	84.2	
Female	36,868	6,081	16.5	30,787	83.5	
Race/Ethnicity						<.001
White, non-Hispanic	57,542	9,639	16.8	47,903	83.3	
White, Hispanic	2,028	274	13.5	1,754	86.5	
Black	9,383	1,324	14.1	8,059	85.9	
Other/NOS	7,000	1,013	14.5	5,987	85.5	
Charlson-Deyo comorbidity score						<.001
0	51,627	8,561	16.6	43,066	83.4	
1	17,134	2,666	15.6	14,468	84.4	
2	7,192	1,023	14.2	6,169	85.8	
Insurance status						<.001
None	4,480	424	9.5	4,056	90.5	
Medicaid	7,527	993	13.2	6,534	86.8	
Medicare ^a	34,435	5,779	16.8	28,656	83.22	
Unknown	1,371	225	16.4	1,146	83.6	
Income						<.001
≥\$63,000 USD	20,621	4,011	19.5	16,610	80.6	
<\$63,000 USD	53,652	8,018	14.9	45,634	85.1	
Unknown	1,680	221	13.2	1,459	86.8	
No high school education						<.001
≥13%	29,220	4,057	13.9	25,163	86.1	
<13%	45,079	7,973	17.7	37,106	82.3	
Unknown	1,654	220	13.3	1,434	86.7	
Facility affiliation						<.001
Academic	26,264	5,741	21.9	20,523	78.1	
Nonacademic	48,551	6,293	13.0	42,258	87.0	
Unknown	1,138	216	19.0	922	81.0	
Facility region						<.001
Northeast	16,151	2,918	18.1	13,233	81.9	
South	21,390	3,431	16.0	17,959	84.0	
Midwest	22,404	3,304	14.8	19,100	85.2	
West	14,870	2,381	16.0	12,489	84.0	
Unknown	1,138	216	19.0	922	81.0	
Distance from facility						<.001
<20 miles	53,597	7,777	14.5	45,820	85.5	
≥20 miles	22,356	4,473	20.0	17,883	80.0	
Region						<.001
Metropolitan area	58,105	9,685	16.7	48,420	83.3	
Nonmetropolitan area	14,865	2,072	14.0	12,774	86.0	
Unknown	3,002	493	16.4	2,509	83.6	

Abbreviations: NOS, not otherwise specified; NSCLC, non-small cell lung cancer; SRS, stereotactic radiosurgery.

^aMedicare group includes Medicare and other government insurance.

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Figure 1. Brain stereotactic radiosurgery for patients with metastatic non-small cell lung cancer, breast cancer, colorectal cancer, or melanoma in the United States (2004–2014).

Discussion

In this large national database analysis of 4 of the malignancies most commonly associated with brain metastases, overall use and adoption of upfront SRS for RT of brain metastases increased steadily from

2004 to 2014, although remaining modest overall. In the most recent study year, 50% of facilities did not report using brain SRS, demonstrating potential access barriers to SRS use. The study further revealed socioeconomic and racial/ethnic disparities in the use and uptake of SRS. Finally, findings showed improvement in 1-year survival among patients with metastatic cancer receiving brain RT over the course of the study period. This improvement was seen predominantly in patients selected to receive SRS, although causality cannot be determined.

This study provides an overview of the use and adoption of brain SRS in the modern era of RT for brain metastases, serves as a foundation for further research into drivers of uptake and disparities, and highlights the need for prospective comparative effectiveness research in this area.

To our knowledge, no prior study has investigated the use and uptake of brain SRS across multiple disease sites and age groups. Our findings expand on prior study of SRS use for NSCLC brain metastases

Table 2. Predictors of Stereotactic Radiosurgery Use

Variable (ref)	Univariable Analysis			Multivariable Analysis		
	OR	P Value	95% CI	aORs	P Value	95% CI
Age, y (continuous)	1.01	<.001	1.01–1.01	1.01	<.001	1.00–1.01
Year of diagnosis (continuous)	1.12	<.001	1.11–1.13	1.12	<.001	1.11–1.12
Cancer site (NSCLC)						
Breast	0.72	<.001	0.63–0.82	0.74	<.001	0.65–0.84
Colorectal	1.43	.001	1.17–1.76	1.35	.004	1.10–1.66
Melanoma	1.80	<.001	1.65–1.97	1.64	<.001	1.49–1.80
Sex (male)						
Female	1.03	.25	0.98–1.07	–	–	–
Race/Ethnicity (white)						
Black	0.71	<.001	0.66–0.76	0.88	.001	0.81–0.95
White Hispanic	0.72	<.001	0.62–0.83	0.85	.045	0.73–0.99
Other/NOS	0.79	<.001	0.73–0.86	0.92	.049	0.84–0.99
Charlson-Deyo comorbidity score (0)						
1	0.98	.50	0.93–1.04	0.97	.26	0.92–1.02
2	0.86	<.001	0.80–0.93	0.84	<.001	0.77–0.91
Insurance status (none)						
Private	1.86	<.001	1.65–2.09	1.77	<.001	1.57–1.99
Medicaid	1.37	<.001	1.19–1.56	1.34	<.001	1.17–1.54
Medicare ^a	1.96	<.001	1.74–2.20	1.71	<.001	1.51–1.93
Median income (≥\$63,000 USD)						
<\$63,000 USD	0.80	<.001	0.76–0.85	0.90	<.001	0.84–0.95
No high school education (≥13%)						
<13%	1.28	<.001	1.22–1.35	1.18	<.001	1.12–1.25
Facility affiliation (academic)						
Nonacademic	0.50	<.001	0.43–0.58	0.52	<.001	0.44–0.60
Distance to facility (<20 miles)						
≥20 miles	1.39	<.001	1.32–1.46	1.36	<.001	1.29–1.44
Facility region (Northeast)						
South	0.85	.13	0.69–1.05	–	–	–
Midwest	0.84	.09	0.69–1.03	–	–	–
West	1.04	.69	0.85–1.29	–	–	–
City environment (metropolitan area)						
Nonmetropolitan area	1.05	.16	0.98–1.12	–	–	–

Abbreviations: aORs, adjusted odds ratios; NOS, not otherwise specified; NSCLC, non-small cell lung cancer; OR, odds ratio.
^aMedicare subgroup includes patients with Medicare or “other government” insurance.

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Figure 2. Brain stereotactic radiosurgery (SRS) utilization trends for patients with metastatic non-small cell lung cancer, breast cancer, colorectal cancer, or melanoma by sociodemographic characteristics. (A) Brain SRS utilization by median income, which represents the median household income in the patient's zip code. (B) Brain SRS utilization by insurance type. (C) Brain SRS utilization by reporting facility affiliation. (D) Brain SRS utilization by high school (HS) education, with HS education representing percentage of the adult population without a HS degree in the patient's zip code.

within Medicare-eligible patients that showed an increase in SRS use to 8.2% by 2005.⁹ Although direct comparison is not possible given substantial differences in the patient populations, our study is in line with these results, with an SRS use rate of 11.1% in the NCDB NSCLC subgroup in 2005. Our results suggest that the trend of increasing SRS use has not only continued but also accelerated during the most recent years.

Management of brain metastases is evolving, and the specific reasons for the increasing use of brain SRS remain unclear. RT recommendations for brain metastases vary widely and are dependent on the patient's performance status (PS) and extent of systemic and intracranial disease. Even with these clinical parameters defined, national guidelines leave ample room for clinician preference in using SRS and/or conventional WBRT in most clinical situations.^{6,15} Over the past decade, findings from several clinical trials have supported the use of SRS for brain metastases. Results of RTOG 9508, published during the

first year of our study period, showed improved survival in patients with a single intracranial metastasis receiving brain SRS after WBRT and improved local control, PS, and steroid requirement for patients with up to 3 lesions.⁷ Three randomized trials published during the early-to-mid part of our study period suggested that SRS alone, without WBRT, had equivalent survival and was associated with relatively improved neurocognitive outcomes.^{8,10,11} The timing of publication of these studies coincides with an observed increase in the uptake of SRS. During our study period, multiple institutional SRS series were published, demonstrating promising efficacy for up to, and beyond, 10 intracranial lesions,^{20–22} in elderly patients,²³ and in the postoperative setting,²⁴ indicating an increased practitioner comfort level with brain SRS for a number of clinical situations. Additionally, further refinement of SRS technology occurred during our study period, including adoption of linear accelerator-based SRS²⁵ and other frame-

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Figure 3. Number and proportion of facilities using brain stereotactic radiosurgery (SRS) from 2004 to 2014. Facilities captured are those that reported to the National Cancer Data Base during the diagnosis year; SRS facilities reported at least 1 case of brain SRS during the diagnosis year.

less SRS systems,²⁶ which may have contributed to increased uptake.

Although SRS use increased substantially during the study period, it continues to be used in a low percentage of patients receiving brain RT overall. Whether the low overall rate is appropriate based on evidence-driven recommendations is unclear. Low overall SRS use may be due to clinical considerations, such as the presence of a high number of brain lesions, poor expected patient survival, diminished regional brain control, and lack of survival benefit compared with WBRT in randomized trials. Additionally, a recent secondary analysis of the JROSG 99-1 randomized trial suggested that patients with good prognoses may benefit from use of WBRT upfront followed by SRS compared with SRS alone.²⁷ However, the low use rate may also reflect institutional biases, barriers to patient access, and cost concerns. A recent multi-institutional study suggested that the availability of on-site SRS was the most predictive factor for its use.²⁸ The study indicates that access to SRS-equipped institutions may remain a barrier to SRS receipt, given that 50% of facilities in 2014 did not report a single patient who received brain SRS.

Additionally, our findings demonstrate differences in SRS uptake across socioeconomic groups. Patients from less wealthy and less educated areas and with Medicaid or lack of insurance were less likely to

receive SRS, and this gap widened during the study period. Disparities across racial and ethnic groups are also seen, with black and Hispanic patients less likely to receive SRS overall, although uptake across race and ethnicity subgroups was equivalent during the study period. Much of the increase in SRS use appears to be driven by patients treated at academic facilities, which may have greater resources and multidisciplinary expertise necessary for directing an SRS program. Of note, we were not able to account for extent of intracranial or extracranial disease or PS,

Figure 4. One-year actuarial overall survival from 2004 to 2013 by brain radiotherapy modality. Abbreviation: SRS, stereotactic radiosurgery.

which may confound these results, because it is possible that patients from lower socioeconomic backgrounds and with inferior insurance present with a greater burden of disease that precludes them from receiving brain SRS. It would be less likely, however, that this phenomenon would explain the growing disparity within these groups during the study period.

A diagnosis of melanoma was most highly associated with receipt of SRS, followed by CRC, NSCLC, and breast cancer. Rate of SRS use also increased most rapidly in melanoma, followed by CRC, NSCLC, and breast cancer. The association between SRS and melanoma is likely in part due to a general belief that SRS can be effective in treating radioresistant histologies,¹³ and to the successful incorporation of immunotherapy in the treatment of metastatic melanoma in the past 2 decades. Interestingly, CRC saw a dramatic increase in SRS use in the final year of the study period, although given the low number of patients with CRC overall, it is difficult to determine whether this is a statistical anomaly or indicates an actual trend.

This study showed that survival for patients receiving brain RT for metastatic disease is improving, and that this improvement is largely observed in patients selected to receive SRS. Although survival for SRS and non-SRS patients was similar in the early years of the study period, the discrepancy increased substantially in subsequent years.

The observed survival improvement during the study period is likely multifactorial. Substantial improvements in systemic therapy for metastatic disease have occurred during the past decade, including the advent of targeted agents and immunotherapy, which is likely improving survival in these patients. Given these improvements, it is plausible that more patients are becoming eligible for SRS.^{29,30} It is also possible that intracranial control has become more important in prolonging survival.^{27,31} Whether the increase in SRS use itself is causative for improved survival cannot be deduced from this study, and given the significant selection biases between the treatment cohorts and lack of potential confounder variables in the NCDB, we did not attempt such an analysis.

There are several additional limitations to this study. The NCDB captures only first-course treatment of particular diagnoses, and thus we cannot exclude the possibility that patients receiving SRS

later went on to receive WBRT, or that patients in the non-SRS cohort went on to receive SRS later in their disease course. This study is only able to assess the upfront treatment strategy for patients. Despite this limitation, we believe the study adds valuable information in assessing the overall landscape of SRS use in the current management of brain metastases. The NCDB also lacks information regarding number of brain metastases, an important factor in the consideration of brain SRS use.

Although SRS is likely better accepted and more widely used in patients with ≤ 3 brain metastases, the NCCN Clinical Practice Guidelines in Oncology for Central Nervous System Cancers⁶ now list SRS as an option for select patients with >3 brain metastases who have low tumor volume and good PS. There are several other important variables lacking in the NCDB that may confound the associations observed in our MVA regression analysis, including PS, extent of intracranial and extracranial disease, neurologic symptoms, and systemic therapy details, and we cannot control for this possibility. Additionally, although the NCDB captures approximately 70% of new cancer diagnoses, a recent study has suggested that, compared with population-based registries, Hispanic patients and certain geographic regions and diagnoses may be underrepresented within the NCDB, which may limit the generalizability of our results to the entire US population.³² However, the NCDB has the benefit of specific radiation site, modality, dose, and fractionation information, as well as the ability to conduct facility-level analyses, making it a particularly well-suited source for this study.

Conclusions

This national database analysis demonstrates steadily increasing—although modest overall—use and adoption of brain SRS in the United States during the past decade. The study identifies progressively widening sociodemographic disparities in the adoption of SRS, likely related to lack of access to this important technique. Further research is needed to determine the reasons for these worsening disparities and their clinical implications on intracranial control, neurocognitive toxicities, quality of life, and survival for patients with brain metastases.

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