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Research Article

Three-Year Experience of a Multidisciplinary Central Nervous System Clinic Model for Radiation Oncology and Neurosurgery (RADIANS) in a Community Hospital Setting

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Abstract

Background: As academic centers partner and establish healthcare systems with community hospitals, delivery of subspecialty, multidisciplinary care in community hospital settings remains a challenge. Improving outcomes for central nervous system (CNS) disease is related to integrated care between neurosurgery (NS) and radiation oncology (RadOnc) specialties. Our multidisciplinary community hospital-based clinic, RADIANS, previously reported high patient approval of simultaneous evaluation with NS and RadOnc physicians. Three-year experience is now reported.

Methods: Prospectively collected clinical and demographic patient data over three years was done, and surveys administered. Descriptive statistics reported as mean and percentages for patient characteristics, diagnosis, treatment and outcomes.

Results: Between August 2016 and August 2019, 101 patients were evaluated. Mean age and distanced traveled was 61.2 years, and 54.9 miles, respectively. Patient Satisfaction Score was 4.79 (0-5 Scale, 5-very satisfied). Most common referral source was medical oncologists. Seventy-two patients had malignant CNS disease (brain mets 28; spine mets 27; both 6; primary brain 9; primary spine 2), 29 had benign CNS disease. Post-evaluation treatment: radiation therapy (RT) only (n=29), neurosurgery (NS) only (n=16), both RT and NS (n=22), and no RT/NS intervention (n=34). Fractionated stereotactic radiosurgery was most common RT delivered; craniotomy with tumor resection was most common NS performed. Treatment outcomes: local control=61/67 (91%); radiation necrosis or radiation-induced myelitis=2/51 (3.9%).

Conclusions: The RADIANS multidisciplinary community hospital-based CNS clinic model is first of its kind to be reported, continuing strong patient approval at extended follow-up. Data indicates the model serves as a regional referral center, delivering evidence-based treatment modalities for complex CNS disease in community hospital settings, yielding high rates of local control and low rates of grade 3 or 4 radiation-induced toxicity.

Keywords: central nervous system; metastatic disease; multidisciplinary clinic; neurosurgery; radians; radiation oncology; radiation therapy

Running Title: RADIANS: Multidisciplinary CNS Clinic

Introduction:

Central Nervous System Disease

In 2019, it is estimated that 23,800 adults (13,400 men and 10,400 women) in the United States will be diagnosed with primary malignant tumors of the brain and spinal cord. Brain tumors alone account for nearly

85% of all primary CNS tumors. Brain and other CNS malignancies are considered the 10th leading cause of death for men and women, and roughly 35% have a five-year survival rate when diagnosed. [1,2] It is without question indeed, that the care of patients with CNS disease, both malignant and benign, requires the expertise of specialized providers in a collaborative and multidisciplinary approach to administer the best treatment options and optimize patient outcomes and care.

Multidisciplinary Clinics

Currently with managed care at the forefront of healthcare systems, medical centers are encouraged to develop and implement clinical delivery systems that collaborate with different providers and specialists with the overall goal to improve quality of care, reduce practice variation, define and measure treatment outcomes, and to minimize treatment costs. This is certainly more evident in the setting of cancer care, such that it provides patients with the opportunity to see their providers in one clinic, lessens the travel burden, and allows for concurrent provider visits. [3] Numerous MDC modeling and approaches have been reported for cancer care. The findings have shown to increase overall survival, slow disease progression, improve patient compliance, increase adherence to treatment guidelines, promote early treatment intervention, and decrease treatment costs. [4-8]

RADIANS

In the fall of 2016, the novel RADIANS (RADIation oncology And NeuroSurgery) clinic was formed at a local community hospital as a collaboration between radiation oncology and neurosurgery physicians to evaluate central nervous system disease in one clinic setting. The MDC was formed to align with the delivery of quality of care, as outlined by the American Society of Clinical Oncology (ASCO) [9] for the better part of the community for which it serves. The RADIANS clinic proved to be highly favorable from the patient's view in terms of overall experience and satifisfaction. [10]

METHODS

With approval from the Institutional Review Board (IRB), a prospective patient registry was developed, and clinical and demographic data were collected. Data was stored in a secure database where only IRB-approved research team members had access. Patients that were referred into the RADIANS clinic were seen simultaneously by both physicians, the radiation oncologist and neurosurgeon, in a single clinic visit setting. Prior imaging and workup were reviewed before the initial visit. Discussion regarding diagnosis and treatment options were done and questions were answered. Family members and/or caregivers were included in the discussion with the consent and approval of the patient. A patient survey was given to all patients prior to the conclusion of their visit to collect data regarding overall patient experience and satisfaction. Patients had the option of completing the survey before leaving the clinic or returning the survey in the mail.

RESULTS

In total, 101 patients were evaluated in RADIANS from August 2016 through August 2019 with CNS disease. Patient characteristics are presented in **Table 1.**

Table 1 Characteristics for patients evaluated in RADIANS between August 2016 and August 2019, n=101

Age		**Co-Morbidities**	n, (%)
Mean (years)	61.2	≥4	5 (4.9)
Median (years)	63.0	3	8 (7.9)
Sex	n, (%)	2	17 (16.8) 1
Females	65 (64.3)		32 (31.7)
Males	36 (35.6)	0	38 (37.6)
Distance from RADIANS		**BMI (kg/m²)†**	n, (%)
Mean (miles)	54.9	< 20	3 (2.9)
Median (miles)	13	20-24.9	33 (32.7)
Range (miles)	(0.3 – 340)	25-29.9	28 (27.7)
Referral Source	n, (%)	30-34.9	20 (19.8)
Medical Oncology	43 (42.6)	≥ 35	15 (14.8)
Neurosurgery	22 (21.8)	**Systemic Disease Status**	n, (%)
Emergency Room	17 (16.8)		
Primary Care Physician	13 (12.9)	Hypertension	26 (25.7)
Other*	6 (5.9)	Diabetes	19 (18.1)
KPS	n, (%)	CAD	25 (24.8)
100	22 (21.8)	COPD	27 (26.7)
90	38 (37.6)	Thyroid Disease‡	13 (12.9)
80	21 (20.8)	CVA History	2 (1.9)
≤ 70	20 (19.8)	MI History	1 (0.9)

* Neurology=4; Pulmonology=1; Endocrinology=1. † Two patients unknown (% not equal to 100).
‡ Hypothyroidism=11; Hyperthyroidism=2.

The mean patient age was 61.2 years and females nearly doubled the number of males seen (F=65; M=36). Patients travelled an average of 54.9 miles (median = 13.0; range = 0.3 to 340) for their initial clinic visit. Patient Satisfaction Score (PSC) was 4.79 (respondents, n=39). PSC was calculated on a 0-5 scale, 0=not satisfied and 5=very satisfied.

Patterns of referral were as following: approximately half (42.6%, n=43) were referred from medical oncologists. Systemic disease status of

patients evaluated in RADIANS showed eighty percent having a Karnofsky Performance Status (KPS) of ≥ 70 and about two-thirds (61.4%, n=62) had at least one co-morbidity, while 12.9% (n=13) had three or more at the time of their initial visit. The two most common co-morbidities seen in the clinic were chronic obstructive pulmonary disease (26.7%, n=27) and hypertension (25.7%, n=26). Twenty patients had an Obesity Class I classification [BMI (kg/m^2) = 30-34.9] and 15 had an Obesity Class II classification [BMI (kg/m^2) = 35-39.9]. [11]

Patients with eleven different histologies were evaluated in RADIANS, see **Table 2.** Lung cancer (26.7%, n=27) was the most common metastatic cancer diagnosis, of which 73% (20/27) were non-small cell lung cancer. Breast cancer (17.8%, n=18) was the second most commonly seen metastatic malignancy. Of the primary brain malignancies evaluated, glioblastoma (81.8%, 7/9) was most commonly diagnosed. Among patients with primary benign CNS brain lesions, meningiomas were most commonly diagnosed (83.3%, 15/18).

More than half of patients evaluated at the RADIANS clinic received radiation therapy with no surgical intervention (54.5%), with fractionated stereotactic radiosurgery being the most common type (74.5%) of radiation therapy delivered. Two patients with a diagnosis of glioblastoma (2/7, 28.6%) received tumor treating fields (TTF), one of whom received both conventional fractionated RT and TTF to follow, see **Table 3.**

Table 2: Metastatic cancer types and central nervous system lesions for patients evaluated in RADIANS between August 2016 and August 2019, n=101

+Breast	**18**	**Malignant**		**Benign**	
Lung	**27**	**Primary Brain**	**9**	**Primary Brain**	**18**
SCLC*	7	GBM*	7	Meningioma	15
NSCLC*	20	Astrocytoma	2	Glioma	2
				Pituitary Adenoma	1
Kidney	**6**	**Primary Spine**	**2**	**Primary Spine**	**4**
Multiple Myeloma	**3**	Plasmacytoma	2	Schwannoma	2
Other†	**7**			Myxopapillary Ependymoma	1
Metastatic Brain‡	**28**			Meningioma	1
Metastatic Spine‡	**27**				
Both	**6**			**Non-Tumoral CNS¥**	**7**

* SCLC=small cell lung cancer; NSCLC=non-small cell lung cancer; GBM=glioblastoma.
† Ovarian=1; Prostate=1; Colorectal=1; Sarcoma=1; Esophagus=1; Carcinoid=1; Unknown=1.
‡ Neuroendocrine carcinoma (n=1). ¥ Cavernoma=1; Frontal bone lesion=1; Hemangioma=1; Multiple sclerosis=1; Pineal cyst=1; Subdural hematoma=1.

Table 3: Treatment allocation and outcomes for patients evaluated in RADIANS between August 2016 and August 2019, n=101

Treatment Allocation	n, (%)	**Patient Outcomes**	
Radiation Therapy (RT) Only	29 (30.7)	**Active Follow-Up**	63
Neurosurgery (NS) Only	16 (15.8)	**Transfer of Care‡**	8
Both RT and NS	22 (21.8)	**Hospice Care**	6
No RT nor NS	34 (33.7)	**Declined Treatment**	1
Observation	20	**Lost to Follow-Up**	1
Transferred Care	6	**Deceased¥**	22
Hospice Care	3		
Declined Treatment	1		
Lost to Follow-Up	1		
Radiation Therapy Received		**RT treated group** (n=51)	**(%)**
Stereotactic Radiosurgery/Body RT	41 (40.6)	**All treatment group** (n=67)	
Conventional Fractionated RT	13 (12.9)	Radiation Necrosis (1/51)	1.9
		Radiation-Induced Myelitis (1/51)	1.9
Tumor Treating Fields (TTF)*	2 (28.6)	Local Control (61/67)	91.0
		CNS Disease Progression (16/67)	23.9
Neurosurgery Performed (n=38)			
Craniotomy with Mass Resection	28 (73.7)		
Separation Surgery†	8 (21.1)		
Laminectomy/Laminotomy with Mass Resection	2 (5.2)		

* Two of seven GBM patients received TTF, one patient received conventional fractionated RT, followed by TTF. †Separation Surgery involved spinal stabilization/fusion with maximal safe resection and decompression. ‡Decision to receive RT closer to place of residence and NS at the university hospital. ¥18 of deceased had Stage IV disease.

Nearly a quarter of patients (24%) received both radiation and neurosurgical intervention. Craniotomy with mass resection was the most common neurosurgical intervention [Table 3]. Since the beginning of this study, 22 patients are deceased, and 6 patients have entered hospice. Of the 22 patients, 86% (n=19) had stage IV metastatic cancer. A low rate of radiation necrosis or myelitis (2/51, 3.9%), and a high rate of local control (61/67, 91%) was experienced.

DISCUSSION

The Multidisciplinary Tumor Board provides patients with CNS malignancies the most coordinated care for their complex diseases. Current models have shown success in both pediatric and adult CNS disease. [12,13] Research also shows that multidisciplinary teams result in better clinical and organizational outcomes for patients. [14] While the use of weekly or monthly multidisciplinary tumor boards to review select oncologic cases has been adopted at many institutions, formal single-site, single-day multidisciplinary clinics have not been common.

When the RADIANS MDC clinic model was first established, investigators hypothesized that the model would optimize patient and physician time by reducing clinic visits and avoiding unnecessary duplication of tests, while improving quality of care, delivering evidence-based treatment modalities, and providing access for on-going clinical trials. Contrary to standard tumor boards, this model serves a unique role for the patient and their caregivers because of its direct involvement with patients and their caregivers in the discussion of their treatment plan. Despite advances in surgical procedures, chemotherapy, and targeted molecular and radiation therapies, breakdown in the continuum of cancer treatment can remain high. [15] This breakdown is attributed to failure of communication with involved providers resulting into delays in treatment, increased patient anxiety, decreased patient satisfaction, and declines in quality of life. [16]

One unique feature of the RADIANS clinic is that it is based at a small community hospital. Patient approval remains high since the initial published report back in July 2018. Trending similarly, patient volume has increased. The previous report showed a total patient census of 42 since the start---a span of approximately two years. [10] Since that published report, the clinic has seen a marked increase in patient volume (n=101), a 140.5% increase. The increase could be attributed to several factors. Our analysis identified that the current MDC model favors an improved practice pattern that's patient-centric. The simultaneous provider visits increase efficiency in the workup and management for newly diagnosed CNS disease, fostering faster collaborative decision-making, thus avoiding potential treatment delays and additional referrals to another specialist. Both radiation oncologist and neurosurgeon prior to the new patient visit, review the workup, imaging, and labs and engage dynamically, interdependently, and adaptively towards a common goal. Dialogue between the two specialists are structured to adhere to standard clinical practice guidelines---an integral component for a successful MDC. [16]

Our data also shows that patients come from a vast array of provider referrals and varying degrees of systemic disease status. Primary care physicians and medical oncologists may refer patients into RADIANS for further workup with associated neurologic focal signs and preliminary work-up with imaging and labs, whether benign or malignant CNS disease. Patient referrals that come from emergency room consults are the direct result from patients requiring immediate neurosurgical intervention and are then referred to RADIANS for post-op workup, or from patients presenting with stable disease requiring further management and workup. Patients are then given treatment recommendations offering various radiation therapy planning or neurosurgical intervention based on standard of care guidelines whether for curative or palliative intent. All of which are openly discussed with the patients and their caregivers---a dynamic that patients showed high appreciation for based on the administered surveys.

We acknowledge, however, limitations to the current clinic model and our three-year experience. Patient scheduling and clinic flexibility can be challenging as the clinic is dependent upon provider availability. As the clinic continues to expand and grow, flexibility could be achieved by the addition of more clinic days or providers for broader coverage. Another area that should be pursued is the impact and effect the MDC clinic model may have on the caregivers involved. Their role in the overall quality of cancer care should be considered. Finally, another area of consideration and not often studied, as pointed out by Fennel et al., [17] is how external regulatory influences (especially reimbursement incentives) play a role in the sustainability of MDCs in the community hospital setting. Despite these limitations, the model has proven to be highly effective in the community hospital setting for CNS disease.

CONCLUSIONS

To date, we are the first to report on an outpatient community hospital-based multidisciplinary CNS clinic model where patients with benign or malignant CNS disease are evaluated jointly and simultaneously by the radiation oncologist and neurosurgeon. Our three-year data demonstrates that the patient-centric, clinic model optimizes both patient and physician time and patient approval remains high at extended follow-up. The clinic model proves to be a reliable, regional referral center that contributes substantially to improving the care of cancer patients, while providing access to ongoing clinical trials.

RADIANS give patients the option to be evaluated and treated in the community hospital-based setting, rather than at large tertiary centers. Patients are offered evidence-based treatment modalities, where outcomes have shown to have low rates of post-radiation therapy side effects and good local control. Despite being in a community hospital setting, the clinical model could serve beneficial in larger urban medical centers.

Data collection and treatment analysis will continue as we investigate the potential cost-benefit, clinical long-term outcomes, morbidity and mortality rates, impact on caregiver outcomes, and possible mechanisms for early detection by means of vigilant follow-up and imaging surveillance.

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