Permanent intracavitary Cs131 brachytherapy for previously-irradiated recurrent brain metastases: initial clinical and radiation safety experience

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Objective

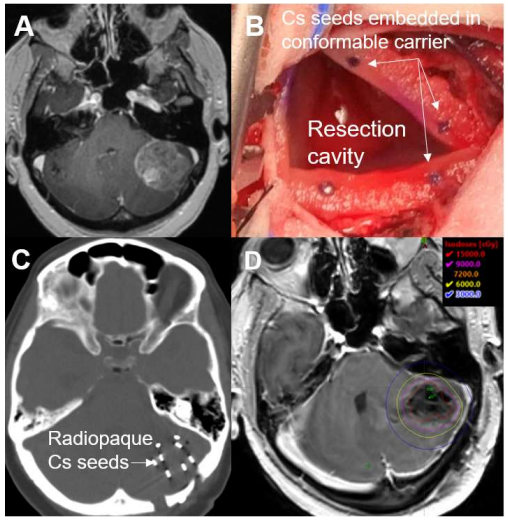
Recurrence of previously-irradiated brain metastases (BrM) presents a significant challenge. We describe our initial experience using salvage resection with Cs131 brachytherapy in previously-irradiated BrM.

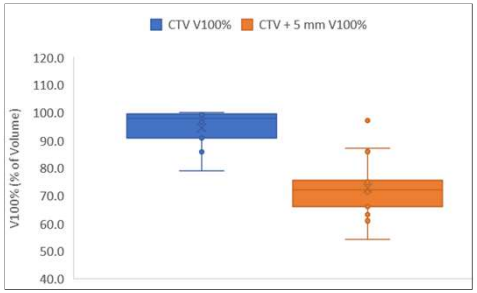
Methods

Between September 2019 and June 2020, 15 recurrent BrM underwent maximally-safe metastatectomy and permanent Cs131 brachytherapy following pathological confirmation of viable recurrence. Cs131 seed impregnated plaques were procured commercially (GammaTile, GT Medical Technologies) and prescribed dose was 60Gy at 5mm depth from the cavity. Postimplant dosimetry (V100%) was calculated on postoperative day 1 using fused CT/MRI. Intraoperative team exposure was recorded using ring dosimetry, and patient dose-rate measurements informed patient, family and medical-staff exposure modeling.

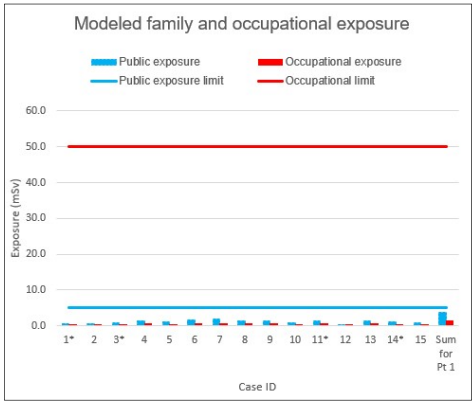
Age (n=12)	62.8 (41.6-74.8)
Male Sex (n=12)	6 (50%)
Histology	
- NSCLC	6
- Breast	3
- Gastrointestinal	2
- RCC	2
- Oral cavity squamous cell carcinoma	1
- Prostate carcinoma	1
Tumor location	
- Supratentorial	10
- Infratentorial	5
Preoperative maximal diameter (median)	3.6 cm (1.1-6.3)
Prior local therapy	
- SBRT	11
- SBRT + Resection	2
- SBRT + LITT	2
Time since prior irradiation	11.9 months (2.6-35.9)
Preoperative plasma volume	
- Elevated	11
- Focally elevated	3
- Equivocal/not elevated	1
Systemic tumor burden at time of surgery	
- NED	11
- Stable disease	3
- Progressive disease	1
Extent of resection	
- GTR	13
- NTR	2
Surgical pathology finding	
- Pure or overwhelmingly viable tumor	11
- Tumor admixed with treatment effect	4

Patient Characteristics. Per-lesion data is presented unless otherwise specified. *Includes patient with 4 craniotomies, who was a woman with NSCLC; her age is listed at the time of first craniotomy. Abbreviations: NSCLC = non-small-cell lung carcinoma; RCC = renal cell carcinoma; SBRT = stereotactic body radiotherapy; LITT = laser interstitial thermal therapy; NED = no evidence of disease; GTR = gross-total resection; NTR = near-total resection.





Dosimetry: Boxplots representing V100% for CTV and CTV_{5mm}.



Modeled exposure for healthcare workers and the public. Regulatory limits reflect public exposure limits of 50 mSv/year for medical personnel and 5 mSv/year for members of the public. Cases denoted with an asterisk (*) reflect the same patient who underwent 4 implantations.

Illustrative case: Panel A demonstrates the patient's 3.6cm posterior fossa tumor resulting in fourth ventricular effacement. After gross total metastasectomy, 4 brachytherapy implants containing 16 Cs131 seeds were implanted (B, C). Post-implant dosimetry as generated from fused CT-MR imaging is depicted in D.

Results

Following multidisciplinary discussion, twelve patients (50% female, median age 54) underwent 15 implantations (10 supratentorial, 5 infratentorial). Median preoperative maximum diameter was 3.6cm (range 1.1-6.3) and histologies included breast, gastrointestinal, lung, kidney, prostate and oral cavity squamous cell carcinomas. All lesions received >/=1 prior course of stereotactic irradiation a median of 11.9 months (range 2.6-35.9) earlier. Five metastases had also undergone prior resection or laser ablation. Thirteen lesions (87%) were gross-totally resected. Median number of implanted Cs131 seeds was 16 (range 6-28) with median seed strength of 61.0U (range 20.6-98.0). Preoperative cavity size was moderately correlated with the number of implanted seeds (Spearman's rank correlation ρ=0.47, p=0.08). Median V100% dose coverage of the cavities and uniform 5mm expansion of the cavities were 98% and 72%, respectively. Median measured exposure rates were 1.17 mSv/hr (range 0.28-1.70) on contact, 0.097 mSv/hr (0.027-0.139) at 30cm and 0.0127 mSv/hr (0.0040-0.0230) at 1 meter from the patient surface. Corrected ring dose for the operation was 0.23-0.57 mSv for the neurosurgeon, and less for other operative team members. Modeled lifetime family-member and visitor exposure was 1.1 mSv (range 0.3-1.9), and healthcare worker exposure was 0.4 mSv (0.1-0.6), all well below regulatory limits including for one patient who underwent 4 discrete brachytherapy implantations for CNS-only disease palliation, and for one with attenuated native cranial shielding due to craniectomy. There were no early wound complications or unanticipated neurologic injuries.

Conclusions

In our early experience, salvage intracavitary Cs131 implantation was safely employed for recurrent brain metastases.