Outcomes of Medulloblastoma Treated with Volumetric Modulated Arc Therapy Craniospinal Irradiation: A Retrospective Study

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OBJECTIVE

Craniospinal irradiation (CSI) is essential in medulloblastoma, but conventional 3D-conformal CSI struggles with junction hot/cold spots, dose uniformity and hematological toxicity (25–30%). Data on VMAT-CSI from resource-limited settings are scarce.

Aim: to evaluate the feasibility, dosimetry, acute toxicity and early outcomes of VMAT-CSI at a tertiary care center in Pakistan.

113 patients	**12 y** median age
69.4% high-risk	**15 mo** median follow-up

METHODS

Design: IRB-approved retrospective study of the first 113 adult and pediatric medulloblastoma patients treated with post-operative VMAT-CSI at our center (2018–2024).

- **Simulation:** supine or prone; 5-point thermoplastic mask and vacuum bag; large-bore CT, 3-mm slices, vertex to sacrum; co-registered with MRI.
- **Target:** CTV = whole brain, cribriform plate, temporal lobes, pituitary fossa, meninges and entire spinal canal to the CSF extent on MRI; PTV = CTV + 5 mm.
- **OARs:** eyes and lenses, parotids, lungs, kidneys, liver, heart, gonads; vertebral bodies ≥18 Gy in children.
- **Plan quality:** PTV coverage, V95/V107/V110%, conformity index (CI) and homogeneity index, HI = (D2% − D98%) / D50%.
- **Follow-up:** weekly CTCAE v5.0 toxicity review and blood counts; assessment at 6 weeks; long-term follow-up with pediatric oncology.
- **Endpoint:** disease-free survival (DFS).

TABLE 1. RISK-ADAPTED PRESCRIPTION

Group	*CSI*	*Boost*
Standard-risk	23.4 Gy	54–55.8 Gy
High-risk	36 Gy	54–55.8 Gy
Spinal mets	—	45–50.4 Gy

TREATMENT

- **Planning:** Varian Eclipse v15; 6 MV photons; simultaneous optimization across isocenters.
- **Isocenters:** 2 or 3 along the craniospinal axis, differing only in superior–inferior position.
- **Arcs:** 360° arcs with anterior lens avoidance (supine) or two partial arcs (prone).
- **Junctions:** ≥2 cm overlap for auto-feathering to limit hot spots.
- **Goal:** ≥95% of PTV receives 100% of the prescribed CSI and boost dose.

TABLE 2. PATIENT CHARACTERISTICS

Characteristic (N = 113)	*Value*
Median age, y (range)	12 (4–37)
Pediatric (<18 y)	76 (67.3%)
Male : Female	70 : 43
High-risk disease	78 (69.4%)
GTR/NTR*	43 (38.1%)
CSF positive*	16 (14.2%)
Surgery-to-RT <6 wk	69 (61.1%)
Concurrent chemo	76 (67.3%)
Supine position	89 (78.7%)
Prone position	24 (21.2%)

*GTR/NTR = gross/near-total resection; CSF = cerebrospinal fluid.

TABLE 3. DOSIMETRIC PLAN QUALITY

Parameter	*Value*
PTV coverage	96% ± 1.23
PTV D99%	93.8% ± 2.34
PTV D1%	106% ± 1.45
Conformity index	1.02 (0.98–1.08)
Homogeneity index	0.10 (0.09–0.14)
Mean PTV length	62.4 ± 9.78 cm
>2 isocenters	102 (90.3%)
Median arcs	5 (3–7)

RESULTS

- **76% two-year DFS** at median follow-up of 15 months (range 5–56) – Fig 1.
- **Acute toxicity** mostly grade 1; grade ≥2 in ≤12% for each type – Table 4.
- **OAR mean doses** ≈6–7 Gy – Fig 2.
- **Excellent plans:** CI 1.02, HI 0.10; 90.3% needed >2 isocenters.

Fig 1: Disease-free survival (Kaplan–Meier)

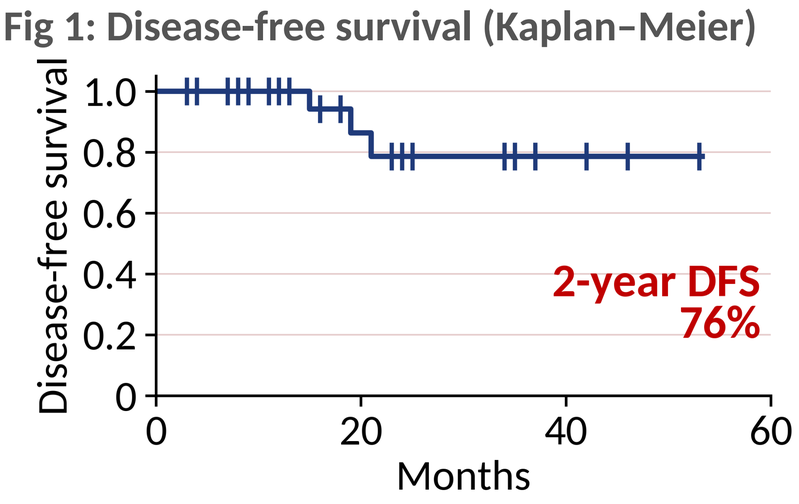


Fig 2: Mean dose to organs at risk

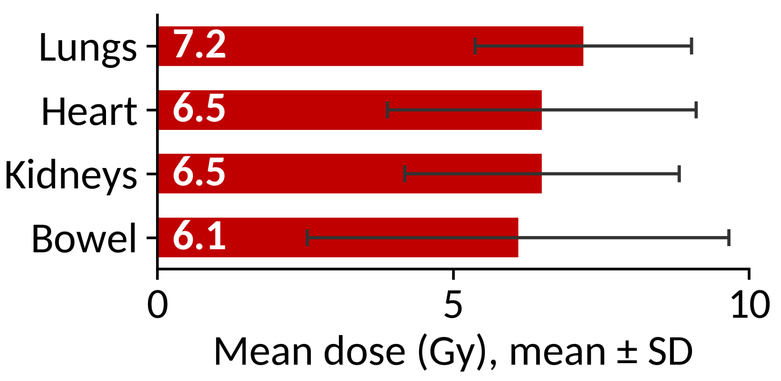


TABLE 4. ACUTE TOXICITY (GRADE ≥2)

Toxicity	*n (%)*
Bone marrow suppression	13 (11.5%)
Esophagitis	12 (10.6%)
Nausea / vomiting	12 (10.6%)
Weight loss	10 (8.8%)
Diarrhea	5 (4.4%)
Vision changes	2 (1.8%)

CONCLUSION

VMAT-CSI is feasible and effective for medulloblastoma in a resource-constrained setting – excellent conformity and homogeneity, low organ doses and manageable acute toxicity.

Supports wider adoption of advanced radiotherapy in similar settings.

Limitations: retrospective, single center, short follow-up – late effects not yet assessed.

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