Preliminary Analysis of cfDNA Dynamics in Pediatric CNS Tumors via CSF Liquid Biopsy

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INTRODUCTION

Pediatric central nervous system (CNS) tumors, including medulloblastomas and embryonal neoplasms, represent a major cause of cancer-related mortality. Standard monitoring relies on neuroimaging and invasive procedures providing limited resolution for minimal residual disease (MRD). Liquid biopsy offers a minimally invasive alternative for real-time assessment of tumor burden. Specifically, cerebrospinal fluid (CSF)-derived circulating cell-free DNA (cfDNA) may provide a more direct and dynamic snapshot of tumor biology in CNS malignancies. This study presents preliminary evidence evaluating cfDNA concentration and integrity in CSF samples from two pediatric patients with CNS tumors at distinct clinical time points.

MATERIALS & METHODS

Two 1 mL patient CSF samples were analyzed: one collected at initial diagnosis (pre-treatment) from a patient with a CNS embryonal tumor via external ventricular drain (EVD), and another post-treatment from a patient with Group 4 medulloblastoma via lumbar puncture (LP). Each sample was processed in duplicate. cfDNA was isolated using the nRichDX Revolution cfDNA Max 20 Kit. Quantification was performed via Qubit, and fragment quality was assessed by TapeStation electrophoresis. Tumor-derived cfDNA fractions were estimated based on fragment size distribution and cfDNA integrity index.

RESULTS

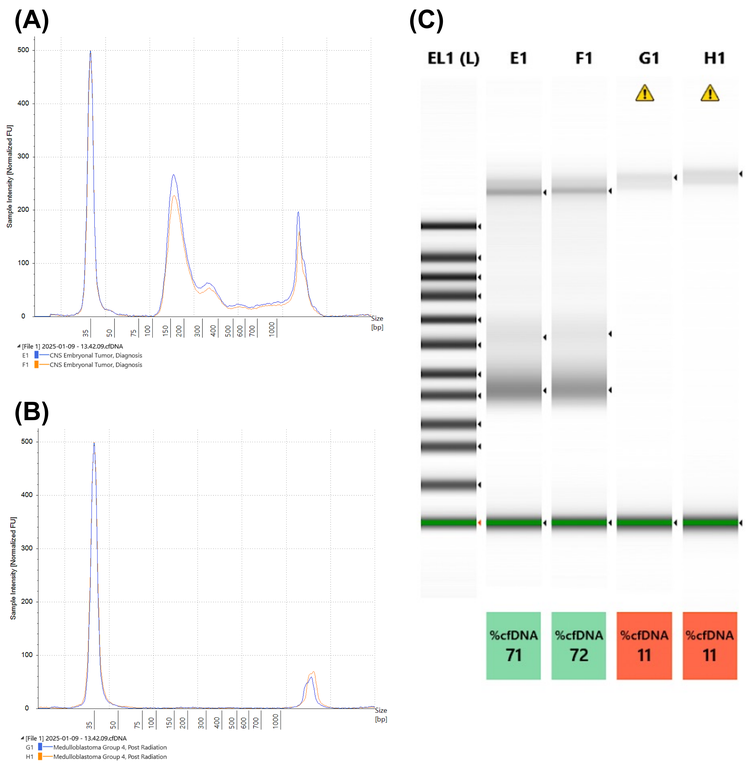

Figure 1. Agilent TapeStation profiles of CSF cfDNA.
(A) Electropherograms from Pre-treatment CSF.
(B) Electropherograms from Post-treatment CSF.
(C) Pseudo-gel showing fragment-size distributions. Lanes **E1–F1**:Pre-Treatment CSF; lanes **G1–H1**: Post-treatment CSF.

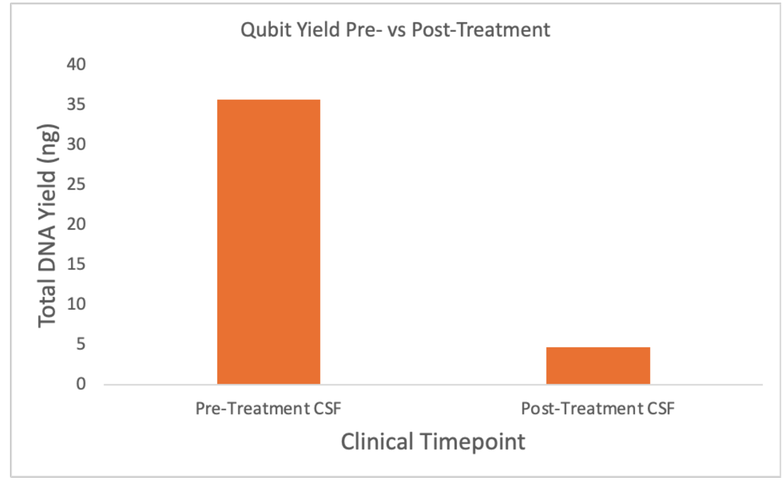

Figure 2. Total cfDNA yield (Qubit) from CSF, pre- vs post-treatment.
Pre-treatment CSF: **35.7 ± 0.71 ng**.
Post-treatment CSF: **4.7 ± 0.07 ng**.

CONCLUSION

These findings highlight the potential of CSF cfDNA as a sensitive biomarker for monitoring CNS tumor burden and therapeutic response in pediatric patients. The substantial reduction in tumor-derived cfDNA following radiation may indicate effective treatment and supports the feasibility of using as little as 1 mL CSF for reliable longitudinal assessment. Future work will focus on expanding cohort size, integrating mutational profiling, and establishing correlations between cfDNA metrics and clinical outcomes to support adoption in routine neuro-oncology care.