BMC Cancer

RESEARCH Open Access

Central nervous system pediatric multidisciplinary tumor board: a single center experience

Rosellina Russo[1*], Tommaso Verdolotti[1], Alessandro Perna[1], Luigi Ruscelli[1], Rosa D'Abronzo[1], Alberto Romano[1], Giuseppe Ferrara[1], Davide Parisi[1], Amato Infante[1], Silvia Chiesa[1], Luca Massimi[2,5], Gianpiero Tamburrini[2,5], Antonio Ruggiero[3,5], Marco Gessi[4,5], Matia Martucci[1] and Simona Gaudino[1,5]

Abstract

Background The Multidisciplinary Tumor Board (MTB) is a collaborative platform involving specialists in oncology, surgery, radiology, pathology, and radiotherapy, and aims to optimize diagnostics and treatments. Despite MTB's widespread benefits, limited literature addresses its application in pediatric neuro-oncology. After a literature revision on pediatric neuro-oncology MTB, our study describes our institute's pediatric neuro-oncology MTB, focuses on evaluating its impact and the neuroradiologist's role in patient-centric approaches, considering recent genetic insights into pediatric brain tumors.

Materials and methods Literature Review concerning pediatric neuro-oncology MTB from January 2002 to June 2024. Clinical Data: retrospective study of all patient files presented in the pediatric neuro-oncology MTB (pnMTB) between 2019 and 2022. Statistical analysis was mainly carried out by directly comparing the absolute or relative values of the respective parameters examined; qualitative variables compared mainly with the chi-square test, quantitative variables mainly with the t-test.

Results Literature Review: 7 papers encompass a multidisciplinary approach for the pediatric CNS tumors.

Clinical data A total of 236 discussions were analyzed representing 107 patients. Median age was 14,3 years (range: 6 months – 17 years). The requests for case evaluations primarily came from the pediatric oncologists (83%) and neurosurgeons (14.8%), and they were mainly addressed to the neuroradiologists (70.3%). Proposals during pnMTB mainly involved imaging follow-up (47.8%) and management with chemotherapy (34.7%). Changes in patient treatment (CPT) occurred in 115 cases, and pediatric neuroradiologist intervention contributed to 72.4% of these changes.

Conclusion Thanks to their multidisciplinarity, high number of cases discussed, and usual respect for their proposals, the pnMTB has made it possible to improve the coordination among specialties involved in patient management, to apply the recent protocols, and to exchange knowledge among teams managing pediatric CNS tumors.

Keywords Multidisciplinary tumor board, Neuro-oncology, Neuroradiology, Pediatric, brain tumors, MRI

*Correspondence:
Rosellina Russo
rosellina.russo@policlinicogemelli.it

Full list of author information is available at the end of the article

Background

A Multidisciplinary Tumor Board (MTB) is characterized as a collective of health-care professionals engaged in the discussion of the diagnosis and management of nearly all recent cancer cases, including updates on previous cases [1–5]. This assembly comprises physicians who are experts in different specialties as medical oncology, radiation oncology, surgery, radiology, and pathology. They convene with the primary objective of optimizing the patient's diagnostic assessment, treatment strategy, and follow-up procedures, with a broader aim of enhancing the care provided to the community's cancer patients through the exchange of insights [6–9].

Since 1987, when Gross initially outlined hospital tumor boards, the utilization of MTB meetings has progressively expanded in the management of both adult and pediatric cancer. These gatherings are now acknowledged as a fundamental component of oncology practice [1, 3, 4, 6, 10]. As scrutinized by various authors, the participation of radiologists in these sessions holds great significance. Given that all or most cases necessitate the assessment or re-evaluation of imaging within the context of known clinical history and treatment perspectives, direct dialogue between radiologists and clinicians facilitates the assignment of an appropriate level of suspicion for a given lesion. This method enhances comprehension of MR findings, improves communication and interpretation compared to written reports, and helps prevent potentially unnecessary and costly initiation of new therapies or procedures [2, 4, 6, 11]. Despite the numerous benefits associated with MTB meetings, there is limited literature on their application in neuro-oncology, particularly in pediatric cases [2, 3, 6], possibly due to the specific prerequisites in this field: neuroradiologists skilled in pediatric neuro-oncology imaging, pediatric oncologists, neurosurgeons experienced in pediatric tumors, and neuropathologists. However, it has been observed that the most successful survival outcomes in pediatric cancer patients result from multidisciplinary treatment approaches encompassing chemotherapy, surgery, radiation oncology, immunotherapy, and targeted therapy. These approaches necessitate collaboration and communication among diverse specialists [3, 4]. This becomes particularly pertinent considering the revolutionary insights of the past two decades into the genetic drivers of pediatric brain tumors, driven by technological advances and innovative applications in molecular diagnostics [12]. Therefore, the interaction between highly specialized physicians focused on specific organs, aligned with current literature, and an individualized patient-centric approach, emerges as crucial. After a literature revision on pediatric neuro-oncology MTB (pnMTB), the objective of our study is to outline our pnMTB, assessing its impact on clinical management decisions and evaluating the role of the neuroradiologist.

Materials and methods

Literature review

Literature was searched from January 2002 to June 2024 in the medical database PubMed using the following MeSH terms: " Pediatric brain tumor board", "multidisciplinary approach pediatric brain tumor", "multidisciplinary management pediatric brain tumor", "multidisciplinary meeting on pediatric brain tumor". More details on literatures review methods are available on Supplementary Materials.

Clinical data

A retrospective study was designed. We evaluated data from all the cases discussed at our pnMTB from September 2019 to January 2022. pnMTB takes place twice a month and are attended by neurosurgeons, neuroradiologists, neuropathologists, pediatric oncologists, and radiation oncologists specialized in pediatric central nervous system (CNS) tumors. From our records, we abstracted the following data: patient age and gender, final diagnosis, proposing physician, question(s) for MTB, specialist(s) to whom the question was addressed and if there was a change in patient treatment (CPT). A CPT was defined if the final decision after case discussion changed the management of the patient, in our case series the MTB decisions identifiable as CPT were: start chemotherapy, start radiotherapy, start chemotherapy+radiotherapy, stop treatment, surgery, neuroradiological follow-up. We assessed how many times a single patient was discussed. Lastly, from the radiology records of the pnMTB, we calculated the number Magnetic Resonance Imaging (MRI) exams evaluated by the neuroradiologists, the time dedicated each case evaluation and how many exams were performed inside and outside our hospital. Institutional review board approval was obtained.

Statistical analysis

Patient characteristics were summarized using descriptive statistics. The normality of variables was assessed using the Shapiro-Wilk test. Quantitative variables (e.g., age, number of cases discussed, minutes per case) were presented as mean and standard deviation or median and interquartile range, based on distribution. Qualitative variables (e.g., sex, type of tumor, grade) underwent chi-square or Fisher's exact tests. Frequency distributions were expressed in absolute (n) and relative (percent) terms through summary tables. Graphical representations used pie charts. Statistical analysis was performed using SPSS version 27.0, with significance set at $p \leq 0.05$.

Results

Literature review

Regarding the Medline review, we identified 545 articles concerning pediatric brain tumor. Of these 109 were excluded due to duplication; in additional 229 were excluded because they did not align with the objectives of the review. Subsequently, 207 studies were initially selected, with further exclusion made for the presence of adult patients ($n=40$), lack of full-text availability ($n=40$) and insufficient information (120). Finally, only 7 papers encompass a multidisciplinary approach for the pediatric CNS tumors (see supplementary materials).

Clinical data

From September 2019 to January 2022 there were a total of 34 pediatric pnMTB meetings, with 236 cases discussed, representing 107 patients (56.1% female and 43.9% male). The mean patient age was 14.3 years (range: 6 months – 17 years). 54 patients were discussed only once, 20 twice, 12 three times, 7 four times, 9 five times, 3 six times, 1 seven times and 1 eight times, with an average number of discussions per patient of 2.2; the mean number of cases discussed per session was 7 (range: 4–11).

Brain tumors were classified according to WHO 2016 Central Nervous System classification [13]. Out of the 236 cases discussed, 53 were grouped as low grade gliomas (22.4%), 43 as high grade gliomas (18.2%), 30 as other high grade tumors (12.7%), 24 as germ cell tumors (10.1%), 19 as medulloblastomas (8%), 15 as other low grade tumors (6.3%), 9 as craniopharyngiomas (3.8%); finally, 35 cases discussed had other final diagnosis (14.8%) [Figure 1].

The frequency and consequent percentage changed if considered in relation to the number of patients: specifically, 28 patients had low grade gliomas (26%), 13 high grade gliomas (12.1%), 11 medulloblastomas (10.2%), 8 other low grade tumors (7.4%), 9 germ cell tumors (8.4%), 3 ependymomas (2.8%), 7 other high grade tumors (6.5%), 7 craniopharyngiomas (6.5%) and 19 had other diagnosis (17.7%) [Table 1].

The requests for case evaluations came almost exclusively from the pediatric oncologists (83%) and neurosurgeons (14.8%), followed by radiotherapist (1.6%) and pathologist (0.4%); they were mainly addressed to the neuroradiologists (70.3%), followed by radiotherapist (9.3%), neurosurgeon (8%), pathologist (8%) and pediatric

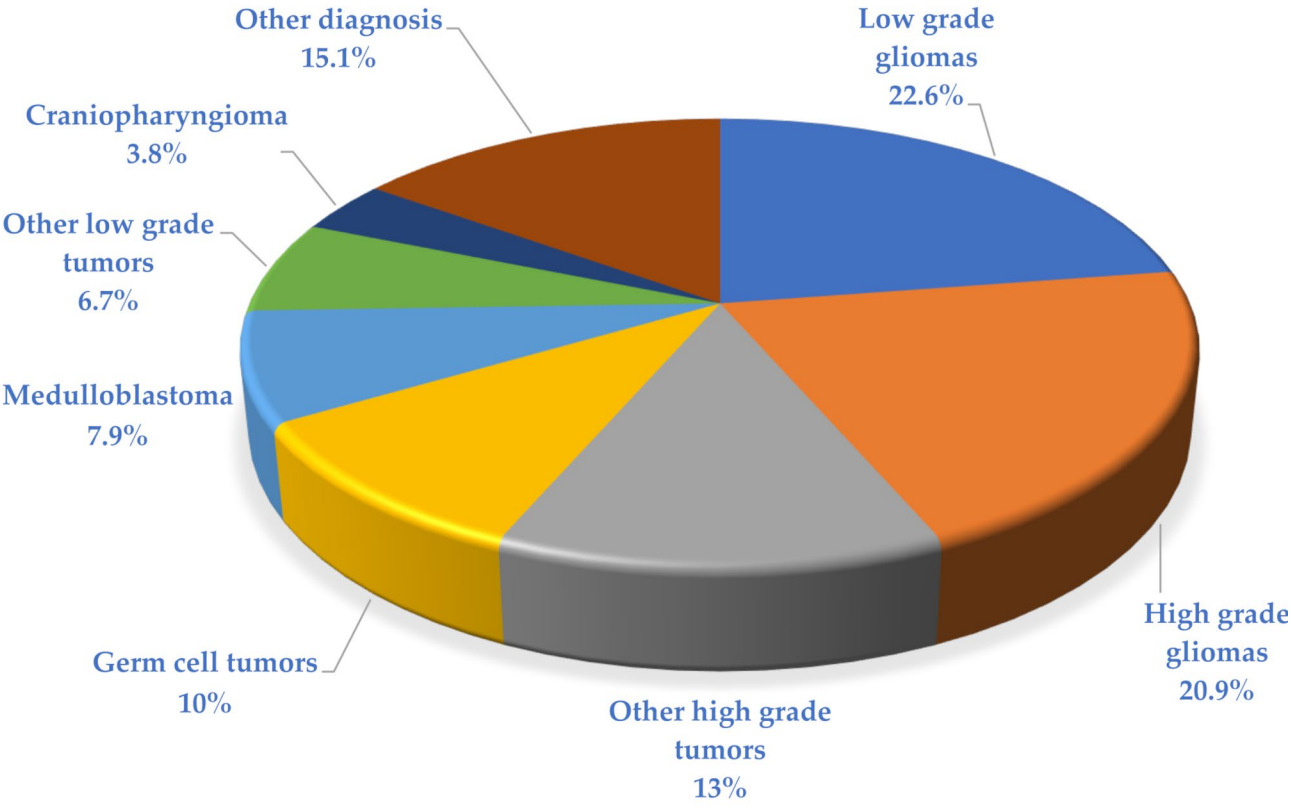

Fig. 1 The chart shows the frequency of the tumors discussed in our pnMTB, with gliomas representing the majority. However, the percentage slightly changes if considered relative to the total of patients (see Table 1)

Table 1 Summary table of the final diagnosis of the cases discussed at our pnMTB

Final diagnosis	Relative to total of discussions		Relative to total of patients	
	n tot (236)	percentage	n tot (107)	percentage
Low grade gliomas	53	22.4%	28	26%
High grade gliomas	43	18.2%	13	12.1%
Other high grade tumors	30	12.7%	7	6.5%
Germ cell tumors	24	10.1%	9	8.4%
Medulloblastoma	19	8%	11	10.2%
Other low grade tumors	15	6.3%	8	7.4%
Craniopharyngioma	9	3.8%	7	6.5%
Ependymoma	8	3.3%	3	2.8%
Other diagnosis	35	14.8%	19	17.7%

Table 2 Summary table of the role of physician in our pnMTB: shows instances of each physician acting as a requester (asking questions) and a respondent (answering questions)

Physician	Requester		Respondent	
	n tot (236)	percentage	*n* tot (236)	percentage
Pediatric oncologist	198	83.8%	10	4.2%
Neurosurgeon	33	13.9%	19	8%
Radiotherapist	4	1.6%	21	8.8%
Pathologist	1	0.4%	19	8%
Neuroradiologist	0	0%	167	70.7%

Table 3 Summary table of the requests submitted at our pnMTB

Submitted questions	*n* tot (236)	percentage
Stability of disease (SD)	101	42.7%
Progression of disease (PD)	50	21.1%
Remission of disease (RD)	29	12.2%
Diagnosis	27	11.4%
Chemotherapy and/or Radiotherapy	19	8%
Biopsy/Surgery	8	3.3%
Other	2	0.8%

oncologist (4.2%). In 18.8% of cases the requests were addressed to at least two physicians [Table 2].

The most submitted question was about the state of the disease, whose definition was based on the review of MRI images and on the discussion of clinical status, neurological examination and treatment regimen, according to the Response Assessment in Pediatric Neuro Oncology (RAPNO) criteria [14, 15]; specifically, in 101 cases was requested if there was stability of the disease (42.7%), in 50 progression of the disease (21.1%), in 29 remission of the disease (12.2%). In the remaining, the request for case discussion was for diagnosis in 29 cases (12.2%), for the management with chemotherapy and/or radiotherapy in 19 cases (8%), for evaluation of surgical treatment in 8 (3.3%). In 2 cases there were other kinds of requests (0.8%) [Table 3].

Table 4 Summary table of the decisions made after pnMTB meeting

Consensus recommendation	*n* tot (236)	percentage
Follow up	113	47.8%
Chemotherapy	82	34.7%
Surgery	17	7.2%
Chemotherapy and Radiotherapy	14	5.9%
Radiotherapy	11	4.6%
Integration with other molecular studies	7	2.9%
Palliative cure	3	1.2%
STUPP protocol	3	1.2%
No decision	2	0.8%

Consensus recommendations after pnMTB mainly included imaging follow-up (47.8%), followed by management with chemotherapy (34.7%), surgery (7.2%), combination of chemotherapy and radiotherapy (5.9%), radiotherapy (4.6%), molecular study integration (2.9%), palliative care (1.2%), STUPP protocol (1.2%). In 2 cases no decision was made (0.8%) [Table 4].

There was a change in patient treatment (CPT) in 115 cases (48.7%); 72.4% of these was due to the neuroradiologist intervention. The rate of CPT was higher for ependymomas (75%), high grade glial tumors (65.1%), other high grade tumors (53.1%) and germinomas (58.3). Out of 236 MRI examined, only 11 exams (4.6%) were not performed in our institution. The time employed to review all MRI exams was 42.6 h overall, with an average of 10.7 min per case (range: 8–15 min). There was no correlation between tumor subtype and time to review.

Discussion

The Multidisciplinary Tumor Board (MTB) is a multidisciplinary meeting that was born to maximize the customization of the clinical path of patients through the interaction of multiple hospital professionals, in response to increased possibilities in therapeutic and surgical management [1–4]. This approach has a significant impact both on the clinical management of the patient with a better therapeutic chance of response and on the educational activity: in fact, apart from participant physicians, also medical students, and house staff, if part of the institution, are a welcome addition to the meetings and enhance the educational qualities of the board [1, 6].

It is important to note, however, that our review of the literature, which focuses on the multidisciplinary approach to pediatric neuro-oncology patients, indicates limited literature on this topic. Nonetheless, all articles concur that a multidisciplinary approach has a significant impact on the therapeutic management of patients in both in high-income and developing countries. It has been observed that in high-income countries, the multidisciplinary approach is now integral to clinical practice in most hospital facilities.

For instance, in the United States Abdel-Baki MS et al. reported clinics treating pediatric brain tumors use a multidisciplinary approach to diagnosis and treatment, yielding excellent patient outcomes in early diagnosis, treatment, and patient/parent satisfaction (…). However, while evidence-based data on the benefits of multidisciplinary teams on patient outcomes is limited, it has to considered that satisfaction extends beyond early diagnosis and treatment to encompass parental knowledge of this approach [3].

Our center, thanks to a multidisciplinary approach to pediatric neuro-oncology patients, aligns with these positive outcomes, similar to other centers in high-income countries, such as Germany [16].

In particular, our center also communicates to all parents of pediatric neuro-oncology patients what emerges from multidisciplinary meetings and makes them participate in relation to the resulting multidisciplinary approach.

However, our experience differs from centers in low-middle income countries. In developing countries, late diagnosis and high treatment costs result in a high dropout rate among cancer patients. Nevertheless, in few areas where hospitals can ensure a multidisciplinary approach, improved patient management is observed, leading to better therapeutic outcomes, reduced treatment abandonment, and decreased patient loss to follow-up [17].

An important asset to tumor boards is the use of online platforms, facilitating the organization of tumor boards in hybrid mode. This approach to multidisciplinary meetings is beneficial in both low- and high-income countries. In low- and middle-income countries, such an approach (which may also include consultations with specialists from other countries) enables physicians to access real-time, high-level subspecialist expertise, providing a valuable platform for worldwide information exchange [18].

In high-income countries, including our center, online platforms for tumor boards were adopted as a solution during the COVID-19 pandemic. To date, our pnMTB continues to operate in a hybrid mode.

Our sessions involve the participation of neurosurgeons, neuropathologists, oncologists, radiotherapists, and two pediatric neuroradiologists, each with a decade of experience. Notably, pediatric neuroradiologists often engage in double readings, especially for difficult cases. Our analysis showed that 236 cases were discussed, corresponding to 107 patients; compared to adult MTB [2], a greater number of patients were discussed more than once (49%), due to a better prognosis of several pediatric brain cancers than those of adults [3, 4, 19, 20]. Notably, the average number of discussions per individual patient has been 2.2 times, with certain patients undergoing as many as 6–7 discussions. The frequencies of the histotypes discussed at our pnMTB are partially indicative of their prevalence in the general population. Notably, the histotypes most often brought into discussion include both low-grade and high-grade gliomas [19, 21].

A significant majority (95%) of the 236 pediatric MRI examinations were conducted within our institution. This high percentage is a result of the specialized requirements of pediatric MRI, frequently necessitate anesthesia —a service exclusively available in a few diagnostic centers, including ours. Consequently, the limited use of anesthesia in other hospitals contributes to a low number of reassessments, totaling 11 exams. This trend differs from the literature on adult patients, suggesting unique considerations for pediatric cases, particularly in the context of anesthesia requirements [2].

Regarding these 11 reassessments, it is noteworthy that there was a change in patient treatment (CPT) for all cases, either due to different diagnoses (7/11) or follow-up assessments (4/11) by the pnMTB neuroradiologist. Several authors have demonstrated the critical role of expert radiologist reviews in multidisciplinary team settings and their impact on patient management [2]. Our high figure is likely attributable to the fact that many exams were performed at other locations where the number of radiologists with expertise in neuro-oncology, especially pediatric neuro-oncology, is low. Additionally, external radiologists often lack the support of integrated clinical and therapeutic data. A practical example: a two-year-old girl who, following a seizure in a febrile episode, performs an MRI at another center documenting the presence of an area of altered signal in the periventricular deep white substance adjacent to the left frontal horn, hyperintense in FLAIR, without contrast enhancement, in which the suspicion of inflammatory injury was placed. The case was subsequently submitted to the pnMTB by our neurosurgeons with a request for characterization of the lesion, directed to neuroradiologists. The initial case review raised suspicion of glial infiltrative lesion without features of biological aggression. The pnMTB's final decision was in favor of surgery intervention. During the subsequent MTB meeting, the case was re-discussed, and histological examination confirmed the suspicion of neuroradiologists, documenting it as a diffuse astrocytic glial neoplasm.

In our department, MRI reporting of the pediatric central nervous system cases is performed by a team of neuroradiologists. Therefore, it is rare that the pre-pnMTB diagnosis is changed by the neuroradiologist during the pnMTB. However, assessing tumor response to treatment in pediatric neuro-oncology remains highly challenging, especially with the advent of new therapies (such as antiangiogenic agents) and the necessity to use Response Assessment in Pediatric Neuro-Oncology (RAPNO) criteria. This expertise is held by pediatric

neuroradiologists, who are too few to assess all pediatric MRIs. Consequently, the impact of pediatric neuroradiologists during pnMTB is mainly related to CPT, where it was decisive in 72 of the 115 cases in which there was a change in therapeutic management (especially in the case of ependymomas 75%) this figure is not to be related to an initial misdiagnosis but rather to modification in tumor response assessments.

As reported by several authors also in our study it was observed that cases are more frequently presented by oncologists (88.3%) and to a lesser extent neurosurgeons (13.9%) with questions targeted at the disease status (76%) and radiological diagnosis (11%); these questions are mainly addressed to neuroradiologists (70%).

Data analysis showed that the most frequently shared pnMTB decisions were follow-up (47%) and chemotherapy treatment (34%), while less frequently surgical treatment (7%); it has also been observed that based on similar diagnostic questions similar clinical-therapeutic paths have been undertaken, thus denoting a substantial decision homogeneity of pnMTB.

Our study showed that the time devoted to the discussion of the individual case during pnMTB is 9–12 min and this data is not affected by the clinical question or by the tumor subtype.

However, it should be considered how the neuroradiologist, in the preparation of each patient before the pnMTB, must re-evaluate every single examination of the patient integrating the clinical-anamnestic data and sometimes re-elaboration of diffusion and/or perfusion sequences.

Based on the findings of the Snyder et al. study [22], the preparation of a case takes on average 9 min, and with an average number of 7 cases, it can be estimated that the preparatory effort for each neuroradiologist is about 60 min with an additional of 60 to 80 min per pnMTB session. The pediatric neuroradiologist has a central role in pnMTB since he must re-evaluate the examinations of all patients, regardless of the clinical question posed, in a large percentage of cases resulting in a change in CPT. It is therefore necessary that the figure of the dedicated neuroradiologist is an expert with a wide knowledge of the therapies used and the modifications that these determine on the MRI findings, knowing how to use advanced imaging techniques necessary for the differential diagnosis between progression and post-treatment modifications to be able to correctly determine the disease status and consequently to direct the best therapeutic path for the patient. In supplementary materials, Table 5 summarizes and compares the multidisciplinary approach between different countries [23–25].

This study has several limitations. First, our study conducted retrospectively at a single tertiary care academic medical center, may not offer a representative sample of cases for generalization to other nMTBs. Secondly, the absence of comprehensive clinical information about patient outcomes makes it difficult to establish a clear association between MTB discussions and improved prognosis for the patients discussed.

Conclusion

From our study emerges the importance of the role of Multidisciplinary Tumor Board in the management of the treatment path of the cancer patient, particularly of the pediatric one, which is turning on a personalized approach based on the interaction of many specialists. It is evident the impact that the expert radiologist has in the pediatric neuro-oncology MTB, having to re-evaluate these images to better determine the disease response and consequently indicate the best therapeutic management for the patient, although this has a cost in terms of the time and effort spent preparing for it.

Abbreviations

MTB	Multidisciplinary Tumor Board
pnMTB	Pediatric neuro-oncology MTB
CPT	Changes in patient treatment
MRI	Magnetic Resonance Imaging
RAPNO	Response Assessment in Pediatric Neuro Oncology

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-024-12882-7.

Supplementary Material 1

Acknowledgements

Not applicable.

Author contributions

Conceptualization, R.R. and S.G.; methodology, R.R and T.V.; software, A.I.; validation, S.G., A.R. and G.T.; formal analysis, M.M.,D.P.; resources, G.F. and M.G.; data curation, A.R. and R.DA; writing—original draft preparation, RR.; writing—review and editing, S.G., L.R.; visualization, S.C. and L.M.; supervision, S.G. All authors have read and agreed to the published version of the manuscript.

Funding

No funding to declare.

Data availability

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Data supporting Fig. 2; Table 5 are not publicly available in order to protect patient privacy. These datasets can be accessed on request from the corresponding author R. Russo.

Declarations

Ethics approval and consent to participate

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Fondazione Policlinico Universitario A. Gemelli IRCCS (03/2023 no 5608). Informed consent was obtained from parents or legal guardians for all participants under the age of 18. All patients involved in this study were minors.

Consent for publication

Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]ARC Advanced Radiology Center (ARC), Department of Oncological Radiotherapy, and Hematology, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy
[2]Pediatric Neurosurgery, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy
[3]Pediatric Oncology Unit, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy
[4]Neuropathology Unit, Fondazione Policlinico Universitario Agostino Gemelli IRCCS, Rome, Italy
[5]Facoltà di Medicina e Chirurgia, Università Cattolica del Sacro Cuore, Rome, Italy

Received: 2 May 2024 / Accepted: 30 August 2024
Published online: 13 September 2024

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