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This is the peer reviewed version of the following article:

Original:

Mallereau, C.-., Ganau, M., Todeschi, J., Cebula, H., Santin, M.-., Virbel, G., et al. (2020). Primary Brain Rhabdomyosarcoma Causing Extracranial Metastases: Case Report with Narrative Review of Atypical Presentations and Their Diagnostic Challenges. WORLD NEUROSURGERY, 138, 363-368 [10.1016/j.wneu.2020.03.110].

Availability:

This version is available <http://hdl.handle.net/11365/1280534> since 2024-12-11T20:33:44Z

Published:

DOI:10.1016/j.wneu.2020.03.110

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Primary Brain Rhabdomyosarcoma Causing Extracranial Metastases. Case Report with Narrative Review of Atypical Presentations and Their Diagnostic Challenges.

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Keywords: rhabdomyosarcoma, brain tumor, metastasis

32 **ABSTRACT**

33 **Background:** Rhabdomyosarcoma (RMS) is a rare malignant tumour
34 originating from striated muscle cells; it accounts for only 3% of all soft tissue
35 sarcomas in adults and its metastases can also reach the central nervous system.

36 Only sporadic cases of primary brain RMS (PBRMS) have been reported so far.

37 **Case presentation:** We discuss the atypical presentation and diagnostic
38 challenge of PBRMS in a 65-year-old man. He presented with a 3-day history of
39 progressive right hemiparesis caused by an unspecific left fronto-parietal
40 heterogeneously enhancing lesion. Total body CT and Positron Emission
41 Tomography (PET) scans performed at baseline did not reveal other
42 secondarisms. Patient underwent radical excision of the lesion, which allowed to
43 establish the diagnosis, with immunohistochemical staining positive for desmin
44 and myogenin. Stereotactic radiotherapy guaranteed local disease control;
45 nonetheless the patient required also adjuvant chemotherapy when he developed
46 large right lung metastases 6-months postoperatively.

47 **Conclusions:** PBRMS can be hardly distinguished from other malignant brain
48 tumours during preoperative radiologic workup; only histology can raise the
49 suspicion of primary or metastatic rhabdomyosarcoma, depending on the
50 presence of other distant lesions. Our review of the literature demonstrates that
51 prognosis is poor: 44% of patients die within one year from diagnosis. Overall
52 survival seems to correlate with radical resection, tolerance of stereotactic or if
53 necessary full neuraxis radiotherapy and adjuvant chemotherapy. Given the high
54 relapse rate close monitoring and re-staging are imperative.

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62 INTRODUCTION

63 Rhabdomyosarcoma (RMS) is a rare malignant tumor arising from striated
64 muscle cells, and accounts for only 3% of all soft tissue sarcomas in adults. Of
65 note, more than 50% of all RMSs are diagnosed in the pediatric population: in
66 fact, they account for roughly 20% of all tumors in children below 3-years of
67 age. Of note, only sporadic cases of primary brain rhabdomyosarcoma
68 (PBRMS) have been reported so far, in fact most of the central nervous system
69 localizations are usually metastatic. In this report we present a new case which
70 to the best of our knowledge constitutes the 18th case of PBRMS in adults and
71 the 3rd case who developed distant metastases during follow up¹⁻¹⁶. This atypical
72 presentation will serve as the basis to critically revise the current literature on
73 PBRMS: we will discuss the complexity of formulating the right diagnosis and
74 optimize adjuvant treatment and postoperative follow up of patients harbouring
75 these rare lesions.

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78 **CASE DESCRIPTION**79 **History:** We report the case of a 65-year-old man who presented to our A&E

80 Department with a 3-day history of progressive right hemiparesis and confusion.

81 Urgent CT head revealed a heterogeneous contrast-enhancing left fronto-parietal

82 lesion surrounded by remarkable edema suggestive of either a metastatic or a

83 high-grade primary brain tumor. The Total Body CT and PET scans did not

84 reveal any other visceral lesion thus delegating the task to reach a definitive

85 diagnosis to the neurosurgical team.

86 **Treatment:** Given the rapid onset of neurological symptoms, and the CT

87 findings typical of a solid lesion rather than a cerebral lymphoma, high-dose

88 steroids were started and surgery expedited. Surprisingly the preoperative brain

89 Magnetic Resonance Imaging (MRI) realized within few days for image-guided

90 surgery purposes showed progressive volumetric increase of the lesion (Figure

91 1). Excision was microsurgically radical and the perioeprative course

92 uneventful; with great surprise the intraoperative impression was that of a
93 sarcomatous lesion. An MRI brain performed within 24 hours from surgery
94 showed no residual tumor, and the patient was safely discharged home on the
95 third postoperative day.

96 **Histopathology:** The tissue demonstrated a diffuse infiltration and proliferation
97 of cells with a very pleomorphic nucleus, coarse chromatin and cytoplasm, as
98 well as cells with large nuclei and abundant eosinophilic cytoplasm giving them
99 a rhabdoid appearance (Figure 2). These neoplastic elements were arranged in
100 intersecting bundles in all directions with a striking perivascular tropism. In line
101 with the neurosurgical suspicion the initial histology examination was in
102 keeping with a RMS appearance. The pathology team proceeded with additional
103 immunohistochemical staining which revealed diffuse and strong expression of
104 desmin, myoD1, and more focally myogenin (about 30%). Given the above, the
105 conclusive diagnosis of PBRMS of embryonic type was made.

106 **Clinical evolution:** The case was discussed in our multidisciplinary neuro-
107 oncology meeting and given the malignant nature of this lesion the consensus
108 was in favor of a stereotactic radiotherapy of the tumor bed (33 Gray).

109 At 6 months follow up, the patient developed a progressive right chest pain and
110 a CT scan showed a large right lung mass (Figure 3). The patient underwent CT
111 guided biopsy suggesting a PBRMS metastasis. A restaging of the disease with
112 Total-Body CT scan showed no other secondarisms and the patient responded
113 well to adjuvant chemotherapy with VAC protocol consisting in vincristine,
114 dactinomycine and cyclophosphamide. At 1 year from diagnosis the patient
115 reported a generalized well-being, with good performance status (ECOG 1) and
116 the re-staging did not rule out recurring brain tumor or any new distant
117 progression of the disease elsewhere.

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124 **DISCUSSION**

125 The literature review on PBRMS confirmed the paucity of information available
126 on this class of tumors, which have been only sporadically reported (see Table
127 1). PBRMS are typically found in young adults, with an age at time of diagnosis
128 ranging from 20- to 65-year. PBRMS are considered as composite rhabdoid
129 tumors, which are well-established neoplasms with rhabdoid features; this class
130 includes also rhabdoid meningiomas, rhabdoid glioblastomas, carcinomas and
131 sarcomas with rhabdoid features ¹⁹. The histological features, firstly
132 characterized by Biggs et al. ²⁰ are pretty specific: PBRMS usually appear as
133 diffuse lesions composed by homogeneous, large, round or polygonal neoplastic
134 cells, densely packed and sometimes arranged in columns, with eccentrically
135 located nuclei and abundant, eosinophilic cytoplasm. Similarly to any other high

136 grade tumors of the central nervous system, PBRMS typically demonstrate
137 frequent mitotic figures, noteworthy they are characterized by unspecific
138 features, such as positive immunostaining for ki-67 proliferative labeling index,
139 and more specific ones, such as in our case, with a strong reaction for epithelial
140 membrane antigen, vimentin, desmin, myoD1, and more focally myogenin ^{2,21}.
141 Furthermore, a remarkable trait of malignant RMS regardless of their primary
142 location, is the inactivation by deletions and/or mutations of a tumor suppressor
143 gene, SMARCB1/INI1, located in chromosome band 22q11.2 ^{19,22} hence genetic
144 diagnosis is becoming the new rule ²³.

145 Similarly to the case presented in this article, the preferential localization of
146 these lesions is anywhere in the supratentorial space, although it appears that the
147 frontal and parietal lobes are those more frequently involved (roughly 62% of
148 the cases). In few cases authors noticed a tendency to leptomeningeal spreading,
149 whereas an extracranial dissemination of PBRMS had always been considered a
150 rather exceptional event and described only twice before the present report. This

151 behavior is similar to other sarcomatous lesions (including gliosarcomas,
152 intracranial solitary fibrous tumors, etc) ^{17,18}, and certainly highlights the
153 relevance of our case, explaining the complexity of reaching a conclusive
154 diagnosis and addressing the clinical challenges of such rare and atypical
155 presentations in the absence of well established international guidelines. In fact,
156 the management of PBRMS is often based on the individual expertise of the
157 many specialists involved; from a neurosurgical perspective radical excision
158 should always be attempted whenever safely achievable, keeping in mind that
159 complete microsurgical resection alone is not enough to guarantee the best
160 possible outcome. The surgical strategy should be tailored not to incur in any
161 medical or surgical perioperative complications, and aimed to expedite
162 stereotactic radiotherapy/radiosurgery on the tumor bed within few weeks ^{1,4,8,24}.

163 While most authors are focusing on local gammaknife or cyberknife treatment
164 as described in our case, the majority of reports conclude that regardless of the
165 modality the radiation dose administered should be the same considered for

166 malignant gliomas^{2, 4-9, 11-16, 25}. Efforts to delay radiation - especially attempted
167 in pediatric cases to spare children from radiation-induced side effects - often
168 fail; our review of the literature suggests that longer overall survivals are
169 frequently attained in isolated PBRMS patients treated with a combination of
170 radical surgery and stereotactic radiosurgery/radiotherapy plus redo surgery and
171 second stage cranio-spinal radiotherapy in case of local recurrence/spreading
172^{2,5,6,9}. Since previously reported cases are scattered across more than 3 decades
173 of scientific literature, the role of chemotherapy regimens is also debatable: on
174 one hand we lack a consensus on the need for adjuvant chemotherapy, on the
175 other hand, owing to the heterogeneity of applied cytostatic agents, a
176 comparison of effectiveness is not even possible. In our patient the decision to
177 eventually consider VAC regimen was taken following discussion of the case
178 with a national center of excellence for the care of rare soft tissue tumors.

179 Our review of the literature demonstrates that PBRMS prognosis is poor,
180 although overall survival is reported to range from 4 months to 6 years¹⁻¹⁶, 44%

181 of patients die within one year from diagnosis. Unfortunately, given the paucity
182 of cases reported, no specific prognostic factors have been identified; as such
183 this additional case represents a substantial contribution to increase the current
184 knowledge about this class of tumors. Going forward, more potential therapeutic
185 targets emerging from a better understanding of the biological mechanisms of
186 tumor growth will help to determine the appropriateness of new chemotherapy
187 regimens, small molecule inhibitors and stem cell rescue ^{19, 26-29}. To this regard,
188 it is worth mentioning the importance of joint projects such as the establishment
189 of EU-RHAB, a registry on rhabdoid tumors, to generate transnational databases
190 and to favor standardization of treatment regimens as the basis for novel phase
191 I/II trials ³⁰. Until new protocols will be made available, we feel appropriate to
192 stress the importance of a strict clinical and radiological follow up, bearing in
193 mind that any red flag for metastatic disease should prompt oncological referral
194 and immediate systemic re-staging.

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199 **Declarations**

200 **Ethics approval and consent to participate :**

201 Not applicable

202

203 **Consent for publication :**

204 Not applicable

205

206 **Availability of data and materials :**

207 Not applicable

208

209 **Competing interests :**

210 Not applicable

211

212 **Funding :**

213 This research did not receive any specific grant from funding agencies in the

214 public, commercial, or not-for-profit sectors.

215

216 **Authors' contributions :**

217 This is to certify that all authors have participated in the present study including
218 its conception, writing and critical revision.

219

220 **LEGENDS :**

221 **Figure 1 :** Pre-operative T1 a) axial, b) sagittal , c) coronal MRI showing a large
222 left frontoparietal heterogeneously enhancing lesion.

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224 **Figure 2 :** Photomicrographs showing rhabdomyosarcoma colored with
225 Haematoxylin and Eosin (A) and immunostained with antibodies to MyoD1 (B)
226 and myogenin (C) : Proliferation of highly pleomorphic tumoral cells with
227 abundant eosinophil or nucleated cytoplasm with focal rhabdoid appearance
228 (surrounded) (Haematoxylin and eosin x20) (A) , Diffuse nuclear in favor of
229 MyoD1 expression (x20) (B) and focal nuclear for myogenin (x20) (C)

230

231 **Figure 3** : Postoperative six months total BodyCT scan demonstrating a large
232 lobular mass in the right apex compatible with secondary lesion of
233 rhabdomyosarcoma.

234 **Table 1. Primary brain rhabdomyosarcoma : review of the literature**

235 **Legends table 1** : Act: Actin, Alpha1 chy: Alpha1 Chymotrypsin, B: Biopsy,
236 Des: Desmin, EMA: Epithelial Membrane Antigen, F: Female, GFAP: Glial
237 Fibrillary Acidic Protein, Ker: Keratin, L: Left, M: Male, Myo: Myosine, Myog:
238 Myogenin, Myogl: Myoglobuline, NA: No Available, NSE: S100, R: Right, S:
239 Surgery, SMA: Smooth Muscle Actin, Syn: Synaptophysin, Vim: Vimentine

240 *Indicates the patient was alive at the time of writing

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247 **REFERENCES:**

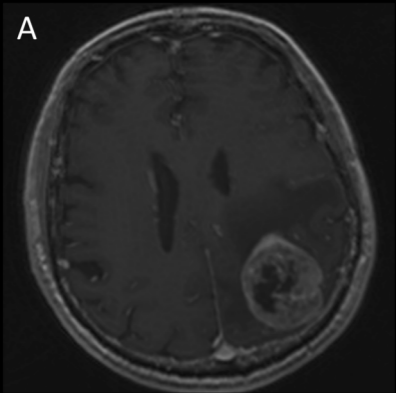
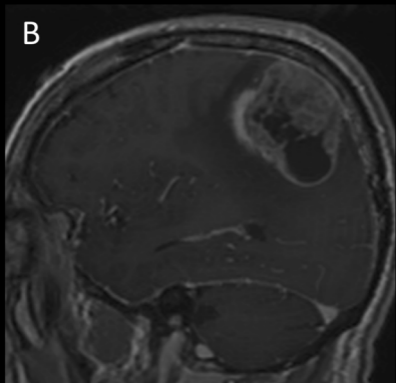
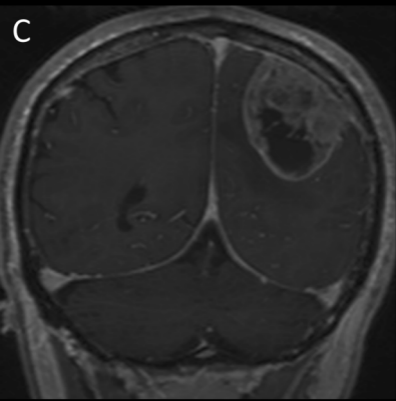
- 248 1. Leedham PW. Primary cerebral rhabdomyosarcoma and the problem of
249 medullomyoblastoma. *J Neurol Neurosurg Psychiatry*. 1972;35(4):551-559.
250 doi:10.1136/jnnp.35.4.551
- 251 2. Horn M, Schlote W, Lerch KD, Steudel WI, Harms D, Thomas E.
252 Malignant rhabdoid tumor: primary intracranial manifestation in an adult.
253 *Acta Neuropathol (Berl)*. 1992;83(4):445-448. doi:10.1007/bf00713540
- 254 3. Fisher BJ, Siddiqui J, Macdonald D, et al. Malignant rhabdoid tumor of
255 brain: an aggressive clinical entity. *Can J Neurol Sci J Can Sci Neurol*.
256 1996;23(4):257-263. doi:10.1017/s0317167100038191
- 257 4. Ashraf R, Bentley RC, Awan AN, McLendon RE, Ragozzino MW.
258 Implantation metastasis of primary malignant rhabdoid tumor of the brain in
259 an adult (one case report). *Med Pediatr Oncol*. 1997;28(3):223-227.
260 doi:10.1002/(sici)1096-911x(199703)28:3<223::aid-mpo14>3.0.co;2-f
- 261 5. Celli P, Cervoni L, Maraglino C. Primary rhabdomyosarcoma of the brain:
262 observations on a case with clinical and radiological evidence of cure. *J*
263 *Neurooncol*. 1998;36(3):259-267. doi:10.1023/a:1005884202389
- 264 6. Sugita Y, Takahashi Y, Hayashi I, Morimatsu M, Okamoto K, Shigemori
265 M. Pineal malignant rhabdoid tumor with chondroid formation in an adult.
266 *Pathol Int*. 1999;49(12):1114-1118. doi:10.1046/j.1440-1827.1999.00988.x
- 267 7. Byram D. Regarding Weiss et al., IJROBP 41:103-109; 1998. *Int J Radiat*
268 *Oncol Biol Phys*. 1999;45(1):247. doi:10.1016/s0360-3016(99)00106-6
- 269 8. Weiss E, Behring B, Behnke J, Christen HJ, Pekrun A, Hess CF. Treatment
270 of primary malignant rhabdoid tumor of the brain: report of three cases and
271 review of the literature. *Int J Radiat Oncol Biol Phys*. 1998;41(5):1013-
272 1019. doi:10.1016/s0360-3016(98)00106-0

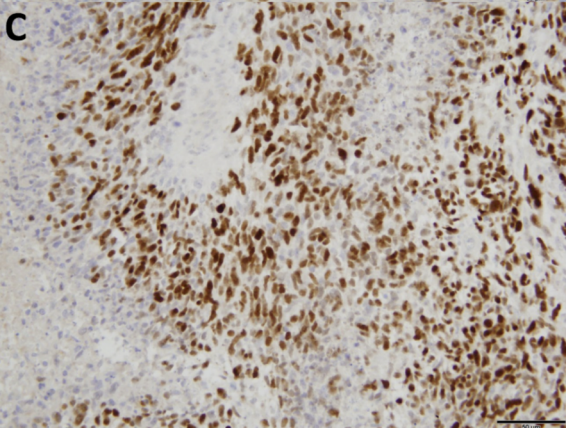
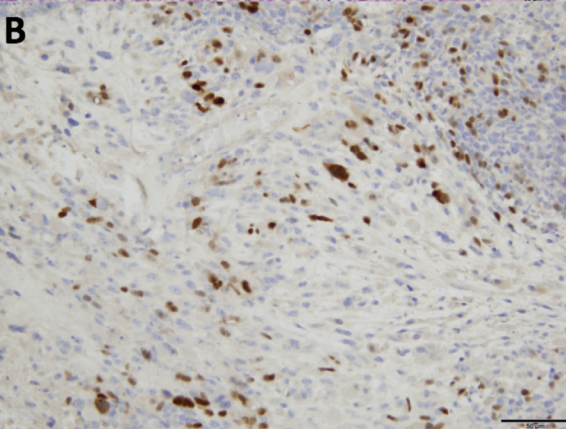
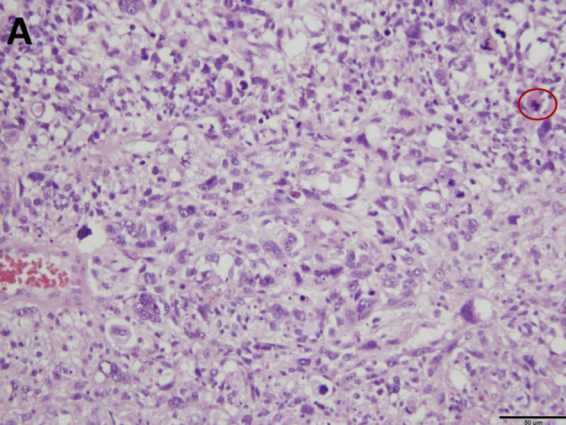
- 273 9. Arrazola J, Pedrosa I, Méndez R, Saldaña C, Scheithauer BW, Martínez A.
274 Primary malignant rhabdoid tumour of the brain in an adult.
275 *Neuroradiology*. 2000;42(5):363-367. doi:10.1007/s002340050900
- 276 10. Pimentel J, Silva R, Pimentel T. Primary malignant rhabdoid tumors of the
277 central nervous system: considerations about two cases of adulthood
278 presentation. *J Neurooncol*. 2003;61(2):121-126.
279 doi:10.1023/a:1022135518846
- 280 11. Erickson ML, Johnson R, Bannykh SI, de Lotbiniere A, Kim JH. Malignant
281 rhabdoid tumor in a pregnant adult female: literature review of central
282 nervous system rhabdoid tumors. *J Neurooncol*. 2005;74(3):311-319.
283 doi:10.1007/s11060-004-7560-4
- 284 12. Grebe HP, Steube D. Primary cerebral rhabdomyosarcoma presenting as
285 haemorrhagic stroke. *Zentralbl Neurochir*. 2008;69(2):93-95.
286 doi:10.1055/s-2007-1004581
- 287 13. Palta M, Riedel RF, Vredenburg JJ, et al. Primary meningeal
288 rhabdomyosarcoma. *Sarcoma*. 2011;2011:312802.
289 doi:10.1155/2011/312802
- 290 14. Caporlingua F, Lapadula G, Antonelli M, Missori P. Pleomorphic
291 rhabdomyosarcoma of the cerebellopontine angle in an adult: a review of
292 literature. *BMJ Case Rep*. 2014;2014. doi:10.1136/bcr-2013-203257
- 293 15. Lau SKM, Cykowski MD, Desai S, et al. Primary rhabdomyosarcoma of the
294 pineal gland. *Am J Clin Pathol*. 2015;143(5):728-733.
295 doi:10.1309/AJCP9ZON4ZIHODIG
- 296 16. Scull C, Amar S, Feiz-Erfan I, Dave H, Gridley D. Adult Onset Primary
297 Pineal Rhabdomyosarcoma. *J Clin Oncol Off J Am Soc Clin Oncol*.
298 2016;34(15):e137-140. doi:10.1200/JCO.2013.50.8036
- 299 17. Meloni M, Serra S, Bellisano G, Syrmos N, Jeyaretna S, Ganau M. Primary
300 Gliosarcoma of the Cerebellum in a Young Pregnant Woman: Management
301 Challenges and Immunohistochemical Features. *Case Rep Surg*.
302 2019;2019:7105361. doi:10.1155/2019/7105361
- 303 18. Gubian A, Ganau M, Cebula H, et al. Intracranial Solitary Fibrous Tumors:
304 A Heterogeneous Entity with an Uncertain Clinical Behavior. *World*
305 *Neurosurg*. 2019;126:e48-e56. doi:10.1016/j.wneu.2019.01.142
- 306 19. Tomasello F, Granata F, Alafaci C. Rhabdoid sarcoma of the brain in
307 adults: which treatment?. *World Neurosurg*. 2014; 81(3-4):e13–e14.

- 308 20. Biggs PJ, Garen PD, Powers JM, Garvin AJ. Malignant rhabdoid tumor of
309 the central nervous system. *Hum Pathol.* 1987; 18:332-337
- 310 21. Ganau L, Paris M, Ligarotti GK, Ganau M. Management of Gliomas:
311 Overview of the Latest Technological Advancements and Related
312 Behavioral Drawbacks. *Behav Neurol.* 2015;2015:862634.
313 doi:10.1155/2015/862634
- 314 22. Sigauke E, Rakheja D, Maddox DL, et al. Absence of expression of
315 SMARCB1/INI1 in malignant rhabdoid tumors of the central nervous
316 system, kidneys and soft tissue: an immunohistochemical study with
317 implications for diagnosis. *Mod Pathol.* 2006; 19(5):717-725.
318 doi:10.1038/modpathol.3800581
- 319 23. Ganau L, Prisco L, Ligarotti GKI, Ambu R, Ganau M. Understanding the
320 Pathological Basis of Neurological Diseases Through Diagnostic Platforms
321 Based on Innovations in Biomedical Engineering: New Concepts and
322 Theranostics Perspectives. *Medicines (Basel).* 2018;5(1):22.
323 doi:10.3390/medicines5010022
- 324 24. Ganau M, Foroni RI, Gerosa M, Zivelonghi E, Longhi M, Nicolato A.
325 Radiosurgical options in neuro-oncology: a review on current tenets and
326 future opportunities. Part I: therapeutic strategies. 2014;100(4):459-465.
327 doi:10.1700/1636.17912
- 328 25. Han L, Qiu Y, Xie C, et al. Atypical teratoid/rhabdoid tumors in adult
329 patients: CT and MR imaging features. *AJNR Am J Neuroradiol.* 2011;
330 32:103-108.
- 331 26. Hoffman LM, Richardson EA, Ho B, et al. Advancing biology based
332 therapeutic approaches for atypical teratoid rhabdoid tumors [published
333 online ahead of print, 2020 Mar 4]. *Neuro Oncol.* 2020;noaa046.
334 doi:10.1093/neuonc/noaa046
- 335 27. Ganau M, Foroni RI, Gerosa M, Ricciardi GK, Longhi M, Nicolato A.
336 Radiosurgical options in neuro-oncology: a review on current tenets and
337 future opportunities. Part II: adjuvant radiobiological tools. 2015;101(1):57-
338 63. doi:10.5301/tj.5000215
- 339 28. Ginn KF, Gajjar A. Atypical teratoid rhabdoid tumor: current therapy and
340 future directions. *Front Oncol.* 2012; 2:114.
- 341 29. Ganau M, Paris M, Syrmos N, et al. How Nanotechnology and Biomedical
342 Engineering Are Supporting the Identification of Predictive Biomarkers in
343 Neuro-Oncology. *Medicines (Basel).* 2018;5(1):23.

344 30. Bartelheim K, Nemes K, Seeringer A, et al. Improved 6-year overall
345 survival in AT/RT - results of the registry study Rhabdoid 2007. *Cancer*
346 *Med.* 2016;5(8):1765–1775. doi:10.1002/cam4.741

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A**B****C**





	Reference	Age	Sex	Tumor location	Surgery	Adjuvant therapy	Metastasis	Survival (months)	Hic staining positivity
1	Leedham et al. 1972	45	F	R frontal	S	None	No	10	Act, Myo
2	Horn et al. 1992	21	M	L temporal	S	Radiation	NA	72	Vim, EMA, Alpha1 chy
3	Fisher et al. 1996	32	M	L frontal	B	None	NA	5	Vim, GFAP, S100
4	Ashraf et al. 1997	34	M	L parietal	B	Radiation	NA	6	Vim
5	Celli et al. 1998	46	M	R fronto-parietal	S	Radiation, Chemotherapy	No	30	Myo, Myog, Act
6	Sugita et al. 1999	27	M	Pineal	S	Radiation, Chemotherapy	Pulmonary site	24	Vim, EMA, Syn, NSE, S100, SMA
7	Byram et al. 1999	35	M	L temporal	S	Radiation	No	60	Vim, EMA, Ker
8	Arrazola et al. 2000	20	M	L parietal	S	Radiation	No	24 *	Vim, EMA, ker, S100
9	Pimentel et al. 2003	31	F	R parietal	S	Radiation, Chemotherapy	Carcinomatous Meningitis	6*	GFAP, Vim, Alpha1 antitry
10	Erickson et al. 2005	20	F	R occipital	S	None (pregnancy)	No	Total removal	GFAP, Vim, EMA
11	Grebe et al. 2008	40	F	L frontal	S	Radiation	No	11	Act, Des
12	Mirone et al. 2009	27	F	L frontal	S	Radiation, Chemotherapy	No	14 *	SMA, EMA
13	Pirillo et al. 2011	51	F	L parietal	S	Radiation	No	20	Syn, Vim, Des
14	Palta et al. 2011	44	M	L fronto-parietal	S	Radiation, Chemotherapy	No	NA	Myo, Des, Myogl
15	Caporlinghua et al. 2014	50	F	R cerebellopontine angle	S	Radiation, Chemotherapy	Cervical paravertebral muscles, Upper mediastinum	7	Myog, Des
16	Lau et al. 2015	33	F	Pineal	S	Radiation, Chemotherapy	Carcinomatous Meningitis	5	MyoD1, Myog, Des
17	Scull et al. 2016	43	F	Pineal	S	No	No	4	Des, Act
18	Present patient	65	M	L fronto-parietal	S	Radiation, Chemotherapy	Pulmonay	12*	Des, MyoD1, Myog