Table 1. Prognostic markers in childhood brain tumors

No.	age y.	diagnosis	c-*myc* ampl.	N-*myc* ampl.	aneu-ploidy	del. 17p or *p53*	cytogenetics
1	4	astrocytoma g.1	+	n.d.	–	n.d.	n.d.
2	14	PNET	+	n.d.	–	n.d.	46,XY,i(17)(q10)[20]
3	11	astrocytoma g.2	+	–	n.d.	- (*p53*)	n.d.
4a	1	ependymoma	+	–	–	–	46,XY[13]/45,XY,-22[8]
b	2		+	–	+	–	n.d.
5	6	medulloblastoma	+	n.d.	+	n.d.	n.d.
6	17	astrocytoma g.1	+	n.d.	–	n.d.	33~86<4n>-X,add(4)(p16)x2,+6,+7,-9, -9,-17,add(19)(q13)x2,add(22)(q13) x2,+(3-8)x mar[6]
7	4	astrocytoma g.2	–	–		-(*p53*)	46,XY[1]
8	13	astrocytoma g.1	+	n.d.	–	n.d.	n.d.
9	5	medulloblastoma	+	n.d.	–	n.d.	46,XY,add(2)(q?37)[13]
10	14	medulloblastoma	+	+	–	+(*p53*)	46,XY[11]/46,XY,i(17)(q10)[20]
11	2	astrocytoma	+	–	n.d.	-(*p53*)	n.d.
12	10	astrocytoma g.3	–	n.d.	–	+	n.d.
13	17	rec. glioblastoma multiforme g.4	–	n.d.	+	–	n.d.
14	3	astrocytoma g.1-2	+	n.d.	–	n.d.	46,XX[9]
15	16	astrocytoma g.3	–	–	–	–	46,XX[20]
16	14	astrocytoma g.3	–	–	n.d.	–	n.d.
17	22	astrocytoma g.4	+	+	–	n.d.	46,XY[20]
18	7 m	PNET	–	n.d.	–	n.d.	46,XY[4], contamination
19	15	germ cell tumor-pinealis	–	–	–	+	46,XY,add(12)(p?13)[20]
20	10	choroid. plexus papiloma	–	n.d.	–	–	n.d.
21	7	medulloblastoma	–	–	n.d.	–	n.d.
22	16	brain sarcoma	+	n.d.	+	n.d.	33~36<2n>t(1,4)(q24,q21),add(19)(q?) [13]/62~74<3n>idem[3]
23	20	astrocytoma g.2	+	n.d.	–	n.d.	n.d.
24	12	ganglioglioma	+	n.d.	–	n.d.	n.d.
25	4	ependymoma	+	–	–	–	46,XY[6]/46,XY,add(11)(p15)[3] /92,XXYY,idem[5]
26	2	ependymoma	+	–	–	–	n.d.
27	17	xantoastrocytoma pleiomorf. g.2	–	–	–	n.d.	46,XY[4]
28	10	astrocytoma g.1	–	–	–	n.d.	n.d.
29	8	meningeoma + astrocytoma g.2	n.d.	n.d.	–	n.d.	46,XX[3]
30	4	astrocytoma g.1-2	–	n.d.	–	n.d.	n.d.
31	4	glioma	–	–	–	-(*p53*)	46,XY[11]
32	8	astrocytoma g.1	–	–	–	-(*p53*)	46,XY[9]/86~92<4n>XXYY[5]
33	9	astrocytoma g.3	+	–	+	- (*p53*)	46,XX[9]/33~35<2n>XX,+i(1)(q10)[13]/ 52~53<3n>XX,+i(1)(q10),+2,+5,+7,+11, +12,+17[7]
34	12	medulloblastoma	+	–	–	-(*p53*)	n.d.
35	17	medulloblastoma	–	+	–	-(*p53*)	46,XY[6]
36	17	astrocytoma g.2	n.d.	n.d.	–	n.d.	46,XX[12]/45,XX,-10[1]/44,XX,+6,+7, +7,-9,+12,+17,-10,-13,-18,-21,-22,-22[1]
37	11	medulloblastoma	+	–	tetra-ploid	-(*p53*)	n.d.
38	11	germinoma	–	–	–	-(*p53*)	n.d.
39	6	astrocytoma g.2	n.d.	–	–	n.d.	n.d.
40	9	medulloblastoma	+	–	–	+(*p53*)	n.d.

m – month
n. d. – not done

in cell lines than in tumors by a minor population of cells with amplification of c-*myc* in the original tumors and selection by long-term cultivation *in vitro* or *in vivo* in athymic mice (Bigner et al., 1990). One may speculate that this minor population may also be selected after a longer duration of the disease.

We detected this amplification not only in malignant tumors, but also in low-grade gliomas. There is not enough information about these tumors being at higher risk of malignant transformation. We plan to follow up such patients and in the future to be able to answer this question.

N-*myc* amplification was found only in a few cases of highly malignant tumors – glioma grade 4 and two high-risk medulloblastomas (one with brain metastases and one anaplastic). Our results are in concordance with the literature. Only few cases of brain tumors with N-*myc* amplification were described, but this was a sign of very bad prognosis (Stiles, 1998). We found only a mild elevation of N-*myc* copy number per cell (usually 5–10) as compared to the number of copies of this gene in high-grade neuroblastoma (usually >20 copies).

The normal karyotype in high-grade tumors may be explained by artificial expansion of normal cells during cultivation, which is the main problem of malignant tumor cytogenetic examination. On the other hand, in low-grade glioma a normal karyotype is usual (Bhattacharjee et al., 1997). Aneuploidy found by cytogenetical examination was found in two low-grade gliomas and one low-grade glioma with high-grade foci, but by flow cytometric examination only in two high-grade glial tumors and one medulloblastoma. The concordance of those examinations was seen only in brain sarcoma. The explanation of this phenomenon is difficult, but we suppose that cytogenetic examination may detect aneuploidy in a very rare population which proliferates more actively, and cytometry is able to detect only a population representing at least one percent of cells.

In summary, in malignant brain tumors, and especially embryonic, we often found an increased number of c-*myc* gene copies. The interpretation of c-*myc* amplification in low-grade glial tumors is not yet clear. N-*myc* amplification occurs seldom, but it seems to be a sign of worse prognosis in glial and embryonic brain tumors. DNA aneuploidy was not found very frequently, but in high-grade tumors only.

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