Childs Nerv Syst (2017) 33:1969–1976
DOI 10.1007/s00381-017-3548-1

ORIGINAL PAPER

Quality of life in long-term survivors treated for metastatic medulloblastoma with a hyperfractionated accelerated radiotherapy (HART) strategy

L. Veneroni[1] · L. Boschetti[1] · F. Barretta[2] · C. A. Clerici[3,4] · F. Simonetti[1] · E. Schiavello[1] · V. Biassoni[1] · F. Spreafico[1] · L. Gandola[5] · E. Pecori[5] · B. Diletto[5] · G. Poggi[6] · F. Gariboldi[7] · R. Sensi[7] · M. Massimino[1]

Received: 17 February 2017 / Accepted: 17 July 2017 / Published online: 2 August 2017

Abstract
Purpose An intensive therapeutic strategy for metastatic medulloblastoma was launched in 1998 in our Institution. The aim of this study was to examine the long-term quality of life (QoL) in survivor patients at least 3 years after the end of the treatment.
Methods Patients were asked to complete self-administered QoL questionnaires. An index of physical impairment (IPI) was scored (range 0–100; the lower the score the better) based on clinical objective observations. Patients were divided into two groups (lower IPI group, and higher IPI group) and descriptively compared accordingly.
Results The study was completed by 25/33 eligible patients. Despite patients with a higher IPI reported worse perceived health condition, they had better emotional and psychological scores than those with a lower IPI in all QoL questionnaires.
Conclusion In our sample, patients with more severe objective and perceived physical impairments reported a better psychosocial QoL, possibly because the greater attention paid to them by society and family contributes to a better adjustment in long-term survivors. On this base, it should be recommended that all survivors receive a strong support as the most impaired patients.

Keywords Quality of life · HART strategy · Metastatic medulloblastoma · Survivors

Electronic supplementary material The online version of this article (doi:10.1007/s00381-017-3548-1) contains supplementary material, which is available to authorized users.

✉ L. Veneroni
laura.veneroni@istitutotumori.mi.it

[1] Pediatric Oncology Unit, Fondazione IRCCS Istituto Nazionale dei Tumori, Via G. Venezian 1, 20133 Milan, Italy

[2] Unit of Clinical Epidemiology and Trial Organization, Fondazione IRCCS Istituto Nazionale dei Tumori, Milan, Italy

[3] Clinical Psychology Unit, Fondazione IRCCS Istituto Nazionale dei Tumori, Milan, Italy

[4] Department of Oncology and Hematology, University of Milan, Milan, Italy

[5] Pediatric Radiotherapy Unit, Fondazione IRCCS Istituto Nazionale dei Tumori, Milan, Italy

[6] Aquired Brain Injury Unit, Scientific Institute, IRCCS Eugenio Medea, Milan, Italy

[7] Unit of Palliative care, Pain Therapies and Rehabilitation, Fondazione IRCCS Istituto Nazionale dei Tumori, Milan, Italy

Introduction

Central nervous system (CNS) tumors are the second most common pediatric malignancies after leukemia and the most frequent solid tumors in the first 15 years of life, accounting for 20–25% of all malignancies occurring in pediatric age. In Italy, from 400 to 450 children are diagnosed with CNS tumors every year [1].

Medulloblastoma accounts for 20% of all cases of childhood CNS tumor [2]. There was a significant improvement in the survival of children diagnosed between the years 2000 and 2002 vis-à-vis cases diagnosed from 1995 to 1999 and the risk of death dropped by 30% [3]. The currently used protocols (which include surgery, craniospinal irradiation and chemotherapy) achieve an overall survival (OS) rate of 70–80% at 5 years after the end of the treatment for standard-risk patients [4–6], whereas until a few years ago, the 5-year OS for patients presenting with metastatic disease was only 30–50%

[7]. This improvement in the prognosis seems to be thanks to the use of unconventional radiation schedules and/or intensive chemotherapy regimens (myeloablative protocols) [8, 9], though this impression needs to be confirmed in larger studies. An intensive therapeutic strategy for metastatic medulloblastoma was launched at our institute in 1998 [9].

There is a paucity of studies assessing the quality of life (QoL) of patients with metastatic disease, especially after very intensive treatments. It is well known that the price of curing cancer is often high in terms of the sequelae experienced by patients treated for medulloblastoma, including motor, sensory, endocrinological, cognitive, neuropsychological and behavioral impairments that can markedly affect patients' quality of life and return to school and social life [10]. A proportion of survivors consequently requires long-term special education services and have lower than normal rates of high-school graduation, employment, and autonomy [11–13], with important implications for their families and communities. Nowadays, the prevention, monitoring, rehabilitation, and correction of their impairments are part of the treatment plan, but it is important to assess physical and psychosocial outcomes over time to enable clinicians to develop the best possible prevention and intervention strategies [14].

Several studies have been conducted to investigate the QoL of standard-risk pediatric cancer survivors over time [15, 16] and to assess the impact of different types of treatment, but none have examined the QoL of patients with metastatic medulloblastoma. We therefore aimed to investigate the impact on QoL for patients with metastatic medulloblastoma treated with chemotherapy and a HART regimen, possibly followed by myeloablative chemotherapy, in 33 consecutive survivors at least 3 years after their diagnosis.

Methods

This study was reviewed and approved by the Ethics Committee of the Fondazione IRCCS Istituto Nazionale dei Tumori di Milano. Participants were identified in the database of the Pediatric Oncology Unit of the Fondazione IRCCS Istituto Nazionale dei Tumori di Milano, from among patients diagnosed between 1998 and 2011.

Inclusion and exclusion criteria

Patients were eligible for this study if they had been diagnosed with metastatic medulloblastoma and had completed any therapy at least 36 months before their enrolment, with no evidence of relapse. Patients were excluded if they already had a neurological or psychiatric disorder unrelated to their medulloblastoma. A signed informed consent form was collected from all participants or from their parents in the case of minors.

Recruitment of study participants

From September 1, 2014 to May 31, 2016, a total of 33 patients were contacted and invited to take part in the study; 25 (76%) agreed and completed the questionnaires; the other 8 refused for various reasons (1 lived abroad; 1 due to the parents' refusal; 1 relapsed and was omitted from the sample; 1 was followed up at another hospital; 1 was unable to complete the questionnaires due to very severe impairments; 3 did not return the questionnaires despite having agreed to participate in the study and having received repeated reminders to do so).

Data collection

QoL data were collected by means of self-report questionnaires. In patients aged between 12 and 17 years, QoL was measured with the Pediatric Quality of Life Inventory (PedsQL, scores range from 0 to 100, higher score indicating a better QoL) [17] and the Strengths and Difficulties Questionnaire (SDQ[1]) [18]. Older patients were administered the PedsQL Young Adult Report (ages 18–25 years) and Adult Report (ages over 26 years), the Short Form (36) Health Survey (SF36, scores range from 0 to 100, higher score indicating better health status, reversed in "Role limitations" subscale) [19], and the European Organization for Research and Treatment of Cancer (EORTC) Quality of Life Questionnaires (QLQ-C30 a high score for a functional scale represents a high/healthy level of functioning, a high score for the global health status/QoL represents a high QoL, but a high score for a symptom scale/item represents a high level of symptomatology/problems) [20], and QLQ-BN20 (scores range from 0 to 100, higher score indicating greater impairment) [21] in long-term treatment effects framework [22, 23]. Not all questionnaires were completed by all participants: 14 patients answered the PedsQL; 17 answered the EORTC QLQ-C30; 17 answered the EORTC QLQ-BN20; and 16 answered the SF36.

Results of objective exams and specialist visits as reported in patient medical folder from the specialist rehabilitation centre Bosisio Parini were collected.

Index of physical impairment score

Based on patients' clinical data, an index (that we called IPI index, i.e., index of physical impairments) was devised, to obtain an overall objective measure of patients' physical impairments at the time of questionnaires filling. The list and graduation of the sequelae considered were the ones reported in patient medical folder and represent the most frequent physical impairments commonly developing in survivors of

[1] This questionnaire was completed by very few patients, so it was omitted from the statistical analysis.

medulloblastoma at 3 years. Six major sequelae were reported in six scales (alopecia, epilepsy, endocrine disorders, hearing loss, walking disabilities, and visual deficits), divided in three levels each (absent, mild/compensable, or severe).

A team of four judges specialist in the field of central nervous system tumors independently evaluated the sequelae based on their severity and rated the scores for each level. To make this task comfortable, each scale could range between 0 and 100. Impairments that were "absent" scored 0, while the scores for the impairments identified were scored all together, irrespectively of the type of impairment. During a consensus meeting, the score for each level was fixed (Table 1). In order to make global IPI easy to interpret, we choose to express it in a score range between 0 and 100 (lower scores being better). To get the result, for each patient, the sum of the scores reported in each impairment scales was divided by 445 (its theoretical maximum equal to the sum of the maximum scores for all the subscale levels) and multiplied by 100.

Assuming that patients suffering blindness or inability to walk need to be considered bearers of major impairment, we classified the study participants in low IPI (LI) group with scores <22 and a high IPI (HI) group with scores ≥22 (where 22 is the score assigned to blindness or inability to walk in the 0–100 IPI scale).

The index score and the classification obtained are only intended to facilitate the presentation of this study's results. They are not intended as a validated instrument for the assessment of the results obtained from patients treated for metastatic medulloblastoma.

Table 1 Weighted severity scores by type of impairment giving rise to the IPI

Physical impairments (PI)	Severity score
Hair loss	(0–25)
Absent	0
Hair thinning/patchy alopecia	15
Total alopecia	25
Epilepsy	(0–60)
Absent	0
Occasional therapy	40
Continuous therapy	60
Endocrinological	(0–70)
Absent	0
Replacement therapy	15
Thyroid carcinoma	70
Hearing	(0–90)
Absent	0
Unilateral/bilateral prosthesis	30
Deafness	90
Gait	(0–100)
Absent	0
Need for technological support	50
Inability to walk	100
Eyesight	(0–100)
Absent	0
Visual impairment	60
Blindness	100

Statistical analysis

Subjects who answered all questionnaires are too few and analyzing responses divided by a topic would not be appropriate because the answers are related to different subjects.

The results obtained from the four questionnaires were analyzed using classical measures of descriptive statistics in the whole study population and by IPI group. Medians and interquartile ranges (IQR) are reported for each QoL item and global assessment (if any) for every questionnaire. The division into two groups has the sole purpose of making the presentation of data and discussion more concise by comparing patients who reported greater vs fewer objective physical sequels.

Results

Demographic characteristics and treatments

Four patients were female (one in LI group) and 21 were male. The median age of the whole sample was 10.8 (IQR 7.0–13.9) years at the time of their diagnosis, 12.4 (IQR 8.2–16.2) years at the end of treatment, and 23.7 (IQR 18.9–27.4) years at the time of patients' completion of questionnaires. Similar distributions were observed in LI group while HI group appeared slightly older (median and IQR 14.1, 5.8–20.6; 15.3, 8.0–22.6; 28.8, 22.4–35.7 at the three time points, respectively).

The median gap between the end of treatment and the time of patients' completion of questionnaires was 12.6 (IQR 7.4–14.9) years without difference between groups.

IPI score

Based on the 22 points threshold for IPI score, 19 subjects were classified in LI group and 6 in HI group. Median IPI score was 16.0 (IQR 8.0–26.5) overall and 13.0 (IQR 7.0–17.0) and 41.5 (IQR 34.0–52.0) in LI and HI groups, respectively (data not shown). Similar large differences of IPI score between groups were observed in all subsets of responders to every questionnaire (Tables 2, 3, 4, and 5). We considered this division internally valid because the difference between the scores obtained from the patients in the two

Table 2 Descriptive statistics of PedsQL scores in whole sample and by IPI subgroups

Variable/item	All			LI group			HI group		
	N	Median	IQR	*N*	Median	IQR	*N*	Median	IQR
Age at the questionnaire fulfillment	14	21.0	16.0; 25.0	12	21.0	17.5; 24.5	2	19.0	11.0; 27.0
Physical functioning	14	71.9	50.0; 84.4	12	73.5	57.8; 86.0	2	54.7	37.5; 71.9
Emotional functioning	14	62.5	55.0; 75.0	12	62.5	55.0; 80.0	2	67.5	60.0; 75.0
Social functioning	14	67.5	60.0; 90.0	12	67.5	57.5; 95.0	2	70.0	60.0; 80.0
School functioning	14	65.0	50.0; 85.0	12	70.0	55.0; 87.5	2	55.0	50.0; 60.0
Psychosocial health summary score	14	65.0	58.3; 78.3	12	66.7	57.4; 85.8	2	64.2	63.3; 65.0
Physical health summary score	14	71.9	50.0; 84.4	12	73.5	57.8; 86.0	2	54.7	37.5; 71.9
Total scale score	14	64.1	55.4; 81.5	12	66.3	59.4; 85.9	2	53.8	52.2; 55.4
IPI	14	14.5	9.0; 18.0	12	13.0	6.0; 17.0	2	34.0	34.0; 34.0

groups is relevant and likely representing true objective physical sequelae grade differences.

PedsQL

The median overall QoL measured with the PedsQL was 64.1 (IQR 55.4–81.5) and higher in the LI group (median and IQR 66.3; 59.4–85.9) than in the HI group (median and IQR 53.8; 52.2–55.4). Items analysis showed that the median scores were higher in the LI group than in the HI group for physical health (median and IQR 73.5; 57.8–86.0 vs 54.7; 37.5–71.9, respectively) and for school activities (median and IQR 70.0; 55.0–87.5 vs 55.0; 50.0–60.0, respectively), but the median scores on the emotional and social subscales were slightly higher in the HI group than in the LI group (median and IQR 67.5; 60.0–75.0 vs 62.5; 55.0–80.0 and 70.0; 60.0–80.0 vs 67.5; 57.5–95.0, respectively) (Table 2; supplementary Fig. 1).

QLQ BN20

The median scores were very low for all subscales, many scoring zero, while the highest score was 66.0 (IQR 33.0–66.7) for alopecia in the HI group. The low levels in many subscales are probably due to the nature of the QLQ BN20, specifically designed to detect the short-term effects of treatments. The median scores on the physical scales were all at least as bad or worse in the HI group than in the LI group. The median on the subscale for uncertainty about the future was slightly higher in the LI group (median and IQR 20.9; 12.5–29.0) than in the HI group (median and IQR 16.0; 11.0–50.0) (Table 3; supplementary Fig. 2).

Table 3 Descriptive statistics of QLQ BN20 scores in whole sample and by IPI subgroups

Variable/item	All			LI group			HI group		
	N	Median	IQR	*N*	Median	IQR	*N*	Median	IQR
Age at the questionnaire fulfillment	17	27.0	24.0: 32.0	12	25.0	23.5; 29.0	5	32.0	27.0; 36.0
Future uncertainty	17	16.7	11.0; 33.0	12	20.9	12.5; 29.0	5	16.0	11.0; 50.0
Visual disorder	17	11.0	0.0; 22.0	12	5.0	0.0; 11.1	5	22.0	20.0; 33.3
Motor dysfunction	17	22.0	0.0; 33.3	12	11.0	0.0; 44.3	5	33.3	22.0; 33.3
Communication disorder	17	11.0	0.0; 22.2	12	5.5	0.0; 22.1	5	22.0	11.0; 76.7
Headaches	17	0.0	0.0; 33.3	12	0.0	0.0; 33.3	5	0.0	0.0; 33.3
Seizures	17	0.0	0.0; 33.0	12	0.0	0.0; 16.5	5	0.0	0.0; 33.3
Sleep disorder	17	0.0	0.0; 33.3	12	0.0	0.0; 33.3	5	0.3	0.0; 33.0
Itching of skin	17	0.0	0.0; 33.3	12	0.0	0.0; 33.3	5	0.0	0.0; 33.0
Alopecia	17	0.0	0.0; 66.0	12	0.0	0.0; 33.3	5	66.0	33.0; 66.7
Weakness in legs	17	0.0	0.0; 33.0	12	0.0	0.0; 33.2	5	0.0	0.0; 33.0
IPI	17	16.0	7.0; 34.0	12	10.0	3.0; 16.0	5	49.0	34.0; 52.0

Table 4 Descriptive statistics of QLQ C30 scores in whole sample and by IPI subgroups

Variable/item	All			LI group			HI group		
	N	Median	IQR	*N*	Median	IQR	*N*	Median	IQR
Age at the questionnaire fulfillment	17	27.0	24.0; 32.0	12	25.0	23.5; 29.0	5	32.0	27.0; 36.0
Physical functioning	17	80.0	54.0; 87.0	12	84.0	66.7; 90.2	5	47.0	47.0; 60.0
Role functioning	17	67.0	50.0; 100	12	75.5	66.9; 100	5	50.0	40.0; 84.0
Emotional functioning	17	84.0	67.0; 91.7	12	79.5	63.0; 91.7	5	84.0	84.0; 100
Cognitive functioning	17	84.0	50.0; 100	12	84.0	50.0; 92.0	5	50.0	40.0; 100
Social functioning	17	80.0	50.0; 100	12	81.7	58.5; 100	5	17.0	0.0; 84.0
Fatigue	17	11.0	11.0; 53.3	12	11.0	5.5; 44.0	5	11.0	11.0; 53.3
Nausea/vomiting	17	0.0	0.0; 0.0	12	0.0	0.0; 0.0	5	0.0	0.0; 0.0
Pain	17	0.0	0.0; 33.0	12	0.0	0.0; 24.9	5	16.0	0.0; 33.3
Dyspnea	17	0.0	0.0; 0.0	12	0.0	0.0; 0.0	5	0.0	0.0; 0.0
Insomnia	17	0.0	0.0; 33.3	12	0.0	0.0; 33.2	5	33.0	0.0; 33.3
Appetite loss	17	0.0	0.0; 0.0	12	0.0	0.0; 0.0	5	0.0	0.0; 0.0
Constipation	17	33.0	0.0; 33.3	12	16.5	0.0; 33.3	5	33.0	0.0; 33.3
Diarrhea	17	0.0	0.0; 0.0	12	0.0	0.0; 16.5	5	0.0	0.0; 0.0
Financial problems	17	0.0	0.0; 33.3	12	0.0	0.0; 16.7	5	33.0	0.0; 33.3
Global health status	17	83.3	66.6; 91.7	12	79.2	66.6; 95.9	5	83.3	50.0; 91.6
IPI	17	16.0	7.0; 34.0	12	10.0	3.0; 16.0	5	49.0	34.0; 52.0

QLQ C30

In the sample as a whole, the median score for physical functioning was 80.0 (IQR 54.0–87.0), for emotional functioning was 84.0 (IQR 67.0–91.7), for cognitive functioning was 84.0 (IQR 50.0–100), and for social functioning was 80.0 (IQR 50.0–100). Role functioning reached a lower median of 67.0 (IQR 50.0–100.0). All median scores on the symptom subscales (e.g., fatigue, pain, dyspnea) were at least as bad or worse in the HI group than in the LI group. The same was true for the score for financial issues. There were larger differences that followed the same trend in the median scores for physical functioning (median and IQR 84.0; 65.7–90.2 vs 47.0; 47.0–60.0), role functioning (median and IQR 75.5; 66.9–100 vs 50.0; 40.0–84.0), cognitive functioning (median and IQR 84.0; 50.0–92.0 vs 50.0; 40.0–100), and social functioning (median and IQR 81.7; 58.5–100 vs 17.0; 0.0–84.0). Only the median score for emotional functioning suggested a

Table 5 Descriptive statistics of SF36 scores in whole sample and by IPI subgroups

Variable/item	All			LI group			HI group		
	N	Median	IQR	*N*	Median	IQR	*N*	Median	IQR
Age at the questionnaire fulfillment	16	26.0	23.5; 31.0	11	25.0	23.0; 28.0	5	32.0	27.0; 36.0
Physical functioning	16	31.5	3.0; 44.0	11	38.0	5.0; 48.0	5	5.0	1.0; 28.0
Role limitations due to physical health	16	26.0	18.5; 54.0	11	28.0	13.0; 55.0	5	24.0	22.0; 43.0
Bodily pain	16	50.0	28.0; 55.0	11	50.0	22.0; 57.0	5	50.0	29.0; 55.0
General health	16	47.5	21.5; 54.0	11	47.0	19.0; 60.0	5	48.0	32.0; 50.0
Vitality	16	50.5	40.0; 53.5	11	50.0	34.0; 57.0	5	52.0	42.0; 53.0
Social functioning	16	39.0	26.0; 53.5	11	36.0	30.0; 58.0	5	42.0	22.0; 44.0
Role limitations due to emotional problems	16	53.0	37.0; 55.0	11	54.0	40.0; 55.0	5	40.0	34.0; 52.0
Mental health	16	51.0	46.5; 60.0	11	53.0	44.0; 62.0	5	49.0	49.0; 58.0
Global physical status	16	30.5	27.5; 37.2	11	33.1	28.3; 38.9	5	28.0	27.0; 29.6
Global mental status	16	42.2	37.4; 46.3	11	43.4	37.5; 46.6	5	41.0	37.3; 46.0
IPI	16	16.0	5.0; 34.0	11	7.0	3.0; 16.0	5	49.0	34.0; 52.0

slightly better result for the HI group than for the LI group (median and IQR 84.0; 84.0–100 vs 79.5; 63.0–91.7, respectively) (Table 4; supplementary Fig. 3).

SF36

In our sample as a whole, the median scores on psychological subscales was 51.0 (IQR 46.5–60.0), on physical subscales was 30.5 (IQR 27.5–37.2), and on mental health subscales was 42.2 (IQR 37.4–46.3).

As for the IPI subgroups, there were large differences in the median scores for: physical activity, which was higher in the LI group than in the HI group (median and IQR 38.0; 5.0–48.0 vs 5.0; 1.0–28.0, respectively); social activity, which was higher in the HI group than in the LI group (median and IQR 42.0; 22.0–44.0 vs 36.0; 30.0–58.0, respectively); and role limitation due to emotional problems, which was lower in the HI group than in the LI group (median and IQR 40.0; 34.0–52.0 vs 54.0; 40.0–55.0, respectively) (Table 5; supplementary Fig. 4).

Discussion

Survival is the main object of most reports on the outcome of medulloblastoma patients but, with improved treatments and a consequently better prognosis, the quality of life for survivors becomes an increasingly important indicator of successful outcome [24, 25].

For survivors of pediatric medulloblastoma, QoL can be influenced by several factors, such as physical impairments, including difficulty walking and running, balance and coordination problems, weakness, vision and speech problems, long-term cognitive deficits, and endocrine issues. The impact of these sequelae on QoL can be significant in the standard risk patients [26–28]. In our sample, QoL in general was not severely impaired, consistently with a study by Maddrey and colleagues [13], who reported profound and permanent neuropsychological and functional deficits in medulloblastoma survivors in the second decade after their diagnosis, but no impairment in their self-reported QoL.

In the present study, self-reported overall QoL—as measured with the PedsQL Generic Core Scales—was actually rather low with a median PedsQL total score of 64.10, but still in average compared to the general population [17].

Differences emerged between the LI and HI groups on the physical and psychosocial scales (which included school performance), in which the HI group had worse scores. Physical activities and schooling are fields in which the impairments experienced by pediatric medulloblastoma survivors are particularly evident, and their distance from their peers is easy for patients to perceive. It is worth noting, however, that the HI group scored better than the LI group on the emotional and social scales, possibly due to a compensatory effect in the form of a psychological defense mechanism of emotional and social adaptation.

The picture emerging from the QLQ BN20 scores is similar. The median scores on the various scales generally did not exceed the clinical threshold (i.e., 50.0), though there was a considerable variability among patients. This result is likely linked to the fact that QLQ BN20 is a short-term treatment effect scale. The data confirmed not only a worse physical QoL in the HI group (with more severe symptoms on all the physical scales) but also a more positive attitude (with lower scores on the scale for uncertainty about the future). Like the better emotional and social scores in the PedsQL, this result could be interpreted as an adaptive mechanism and as a result of the more severely impaired patients having lower expectations regarding their future.

Such an emotional adaptation to physical impairments was also confirmed in the QLQ C30. In the sample as a whole, the median score for physical, emotional, cognitive, and social functioning were no lower than in the general population [20]. Daily functioning reached a lower median of 67.0 (IQR 50.0–100.0), but not below the clinical threshold (i.e., 50.0).

However, patients in the HI group reported a worse physical, social, daily, and cognitive functioning than patients in the LI group, as expected (given the former's more severe physical impairments), but the HI group scored higher for emotional functioning. It seems that survivors of pediatric medulloblastoma may well have physical and cognitive impairments and difficulties in their daily and social lives, but they are able to adjust in a way that protects them from excessive emotional pain.

Possible explanations for normal QoL ratings may relate to a need to give positive answers to improve the patient's social desirability or to defense mechanisms such as denial in self reporting, as seen in children with other chronic medical conditions (e.g., children with Down syndrome or other neurological disorders) [29]. There may also be other factors involved, such as adaptation and habituation to one's limitations. It has been demonstrated that cancer survivors report greater satisfaction with life over time, and this has been attributed to their acceptance of their disease and their limitations. As the questionnaires are all based on self-assessment and there are no other reporters, it is not possible to compare personal judgment with that of other experienced informants, such as parents and teachers. A lack of awareness of organic insults in some domains may also contribute to a patient not reporting an impaired QoL, and such a lack of awareness may be due to deficits in executive function that are common in medulloblastoma survivors [30]. Cognitive impairments naturally mediate patient awareness [31].

The scores obtained with the SF 36 questionnaire on psychological, physical, and mental subscales were very lower

(i.e., worse) in the sample as a whole and in both the IPI subgroups than in the general population [19].

It may be that, as patients grew older, they also became increasingly aware of their impairments and how they differed from their peers. It is worth noting, on the other hand, that patients in the subgroup with more severe physical sequelae were more satisfied with their social role, sense of vitality, and global health. Perhaps a compensatory mechanism helps these patients to avoid paying too much attention to their physical impairments and to reinforce their sense of vitality. Receiving more attention in the social setting may also help the more severely impaired patients to compensate for their objective limitations. In fact, many of the medulloblastoma survivors in our sample received social support in various ways (including special education services, tailored rehabilitation programs and sports activities, programs to help them socialize with peers) and economic support too. Some studies have underscored the importance of environmental factors in reducing disability, demonstrating that life can be complicated—especially in terms of social inclusion and participation—for children and adolescents with brain tumors and that they need specific rehabilitation projects, based on the International Classification of Functioning, Disability, and Health for Children and Youth (ICF-CY) [32].

Patients' perception of their disabilities may also differ in relation to their prognosis. A large study involving 3006 respondents estimated the importance of attributes influencing decision-making concerning the treatment of medulloblastoma [33]. On the whole, respondents whose children had a good prognosis were more concerned about their disabilities, whereas respondents coped better with mild or partial disabilities occurring in children with molecular variants carrying a poor prognosis.

A review [13] demonstrated an increased use of special services at school as compared with general population. Similar results were reported in other studies, which found that medulloblastoma survivors needed special education and social services at 10-year follow-up [34]. This could correlate with patients receiving more social attention and having a better QoL. Ultimately, it is impossible for pediatric medulloblastoma survivors not to be aware of their physical impairments, but—with a little help—they seem to be capable of adjusting to them emotionally.

The main limitation of the present study lies in the small size of our sample. The information emerging from this study is nonetheless important for physicians treating these patients, given the lack of published studies on this population of long-term cancer survivors.

Another limitation of the study concerns its cross-sectional design. It would be desirable to repeat QoL assessments at regular intervals, because questionnaires only measure this construct at a given point in time, while QoL may vary significantly from time to time because it is influenced by numerous variables related to daily life.

A better understanding of pediatric cancer survivors' long-term QoL is important because of the implications of physical disabilities due to the disease and its treatments in the patient's everyday life. Further studies are needed to monitor long-term survivors in real-world settings, at school and at home. Obtaining more information will enable us to help these patients learn compensatory strategies (e.g., special behavioral training).

Compliance with ethical standards This study was reviewed and approved by the Ethics Committee of the Fondazione IRCCS Istituto Nazionale dei Tumori di Milano. Participants were identified in the database of the Pediatric Oncology Unit of the Fondazione IRCCS Istituto Nazionale dei Tumori di Milano, from among patients diagnosed between 1998 and 2011.

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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