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Comparison of survival between the UK and US after surgery for most common pediatric CNS tumors

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Background. We report a population-based study examining long-term outcomes for common pediatric CNS tumors comparing results from the UK with the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) data set and with the literature. No such international study has previously been reported.

Methods. Data between 1996 and 2005 from the UK National Registry of Childhood Tumours (NRCT) and the SEER registry were analyzed. We calculated actuarial survival at each time point from histological diagnosis, with death from any cause as the endpoint. Kaplan–Meier estimation and log-rank testing (Cox proportional hazards regression analysis) were used to calculate survival differences among tumor subtypes, adjusting for age at diagnosis.

Results. Population-based outcomes for each tumor type are presented. Overall age-adjusted survival, stratifying for histology (combining pilocytic astrocytoma, anaplastic astrocytoma, glioblastoma, primitive neuroectodermal tumor, medulloblastoma, and ependymoma), is significantly lower for NRCT than SEER (hazard ratio 0.71, $P < .001$) and at 1, 5, and 10 years. Both NRCT and SEER outcomes are worse than those reported from trials.

Conclusion. Analyzing data from comprehensive registries minimizes bias associated with trials and institutional studies. The reasons for the poorer outcomes in children treated in the UK are unclear. Likewise, the differences in outcomes between patients in trials and those not in trials need further investigation. We recommend that all children with CNS tumors be recruited into studies—even if these are observational studies. We also suggest that registries be suitably funded to publish independent outcome data (including morbidity) at both a national and an institutional level.

Keywords: neuro-oncology, pediatric, population, registry, survival.

Central nervous system tumors are the most common solid tumors in children. In an era of increasing accountability, it is surprising that there is so little published literature comparing outcomes after surgery for CNS tumor.[1] Regulatory bodies, peers, and patients alike expect objective evidence of performance[2,3] so that they can make informed decisions—yet the CNS tumor literature is largely limited to individual or institutional case series or trials comparing different treatment strategies.

We recently reviewed early postoperative mortality for children with CNS tumors in the UK.[4] The 30-day mortality of 2.7% was higher than that seen in most modern series (~1%)—and some rare tumors in the UK series had 30-day mortality rates of 9%–13%. To further examine the outcome of children receiving surgical treatment for CNS tumors in the UK, we report here a population-based study looking at 1-, 5-, and 10-year survival for the most common histologically confirmed pediatric CNS tumor types. In addition, we compared these results from the UK with those published in the literature and those recorded in the USA by the Surveillance, Epidemiology, and End Results (SEER) data set. The SEER program is run by the National Cancer Institute and has evolved over time to collect data covering 28% of the US population.[5] Treatment modalities are not recorded in the UK registry, and we have therefore not tried to analyze for other treatments (chemotherapy or radiotherapy). In effect, our

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study looks at the overall outcome of patients with a tissue diagnosis managed in the US (SEER) and compares this with the outcome of children managed in the UK.

Methods

National Registry of Childhood Tumours Data

Nearly all cases of malignant and nonmalignant CNS tumors diagnosed in children <15 years of age in the United Kingdom (England, Wales, Scotland, and Northern Ireland) are registered with the National Registry of Childhood Tumours (NRCT). The NRCT is the largest population-based registry of childhood cancers in the world.[6]

The topography and morphology of all neoplasms are coded using the *International Classification of Diseases for Oncology, Third Edition* (ICD-O-3) and classified using the third edition of the *International Classification of Childhood Cancer* (ICCC-3).[7]

We defined 1-, 5-, and 10-year survival at each time point from histological diagnosis as those patients remaining after those registered with any cause of death. In order to determine the time-specified postoperative survival for individual tumor categories, we examined data from the NRCT in the time period 1996–2005. Diagnoses included were those with ICD-O-3 behavior code 3 or higher, together with pilocytic astrocytoma (behavior code 1). Optic nerve glioma and unspecified glioma without histology were excluded, as these tumors had not necessarily undergone a surgical procedure. Only first tumors were analyzed. Only microscopically confirmed diagnoses were included.

Surveillance, Epidemiology, and End Results Data

We interrogated the SEER-18 database over a similar time period (1996–2005). Case selection was the same as for NRCT data (ie, children <15 y with a proven histological diagnosis). Site and histology codes were selected for each tumor subtype in order to make them comparable to the NRCT groupings.

During this period, SEER included only tumors coded as malignant as per the ICD-O-2 and ICD-10 criteria. Pilocytic astrocytoma was included because it was only downgraded to nonmalignant in ICD-O-3. Craniopharyngioma, choroid plexus papilloma, subependymal giant cell astrocytoma, dysembryoplastic neuroepithelial tumor, most gangliogliomas, and meningiomas have always been coded as nonmalignant, so there are no SEER data to make a comparison with UK cases. These tumors have therefore been excluded from this analysis.

Statistics

Data were collated and analyzed using SEERStat 6.6.2, Stata v10,[8] and Microsoft Excel. Kaplan–Meier estimation was used to calculate actuarial survival from the date of diagnosis. Observed survival alone is presented, as it corresponds very closely to relative survival in children, since deaths due to competing risks are rare.[9] Observed survival was calculated using the actuarial method.[10] Differences in survival between patient subgroups were tested using the log-rank test. Cox proportional hazards regression analysis[11] was used to model probability of survival in relation to tumor subtype and time epochs, adjusting for age and histology. As age at diagnosis is an independent risk factor for survival for most CNS tumors, separate analyses were undertaken for the whole cohort, for children aged <3 years and for those aged 3–14.

For glioblastoma we have also calculated the 2-year survival rates, as these are probably more relevant for this tumor subtype. As many studies (and virtually all trials) in the literature combine anaplastic astrocytomas and glioblastoma multiforme (GBM) into "high-grade gliomas," we have also examined this combined group. Likewise, historically primitive neuroectodermal tumor (PNET) and medulloblastoma have been combined for analysis—we have therefore also calculated survival data for this group of patients both separately and combined.

Results

The present study has not looked at all CNS tumors and is limited to children under 15 years of age (in keeping with the NRCT data set). Between 1996 and 2005, a total of 1925 (NRCT) and 2411 (SEER) patients had CNS tumor surgery (Table 3). Overall actuarial survival rates for children aged <15 years at 1, 5, and 10 years were 84.4%, 69.5%, and 65.7%, respectively, for NRCT and 88.3%, 77.6%, and 76.1% for SEER. For children aged <3 years, the overall actuarial survival rates at 1, 5, and 10 years were 76.9%, 57.0%, and 51.4%, respectively, for NRCT and 81.1%, 70.6%, and 68.8% for SEER. For children aged 3–14 years, the overall actuarial survival rates at 1, 5, and 10 years were 86.5%, 72.9%, and 68.8%, respectively, for NRCT and 90.4%, 79.7%, and 78.2% for SEER.

When combining all histologies (see Fig. 1), the SEER survival curve is significantly better ($P < .001$) than the NRCT curve, with a hazard ratio of 0.74 (95% confidence interval [CI]: 0.66–0.82) adjusting for age alone and 0.71 (95% CI: 0.64–0.80) adjusting for both age and histology (Table 4). This significant difference is maintained when analyzing this group split by age: <3 years, hazard ratio 0.69 (95% CI: 0.56–0.85), $P < .001$; and 3–14 years, hazard ratio 0.76 (95% CI: 0.67–0.87), $P < .001$.

Combining all histologies, no statistical difference in survival was found between the 2 eras of diagnosis, 1996–2000 and 2001–2005, in either data set. Similarly, there was no statistical difference between ages of diagnosis for each tumor type in either data set, but we have not determined the age-specific

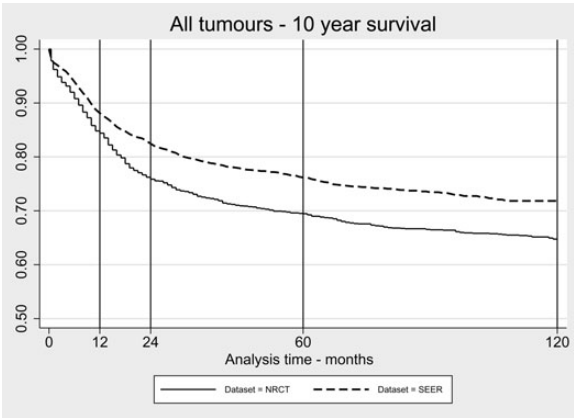

Fig 1. Kaplan–Meier survival curve for all CNS tumors analyzed in the present study over 10 years (SEER = 2411, NRCT = 1925).

Table 1. Summary of literature reporting overall survival related to CNS tumors in population-based studies

	Tumor Type	Survival, %	
		Population-based[9,12,20,32–42]	Present Study
All ages	Low-grade glioma (WHO grades I/II)	5y 91–95	
	High-grade glioma (WHO grades III/IV)	5y 21–28	SEER 5y 26 NRCT 5y 13
	Ependymoma	5y 52–83 10y 55–60	SEER 5y 73 NRCT 5y 65 SEER 10y 70 NRCT 10y 57
	Embryonal (medulloblastoma, sPNET)	5y 46–70	SEER 5y 67 NRCT 5y 59
	Medulloblastoma	5y 56–87 10y 52–55	SEER 5y 71 NRCT 5y 65 SEER 10y 69 NRCT 10y 59
	sPNET	5y 27 10y 18–41	SEER 5y 57 NRCT 5y 33 SEER 10y 54 NRCT 10y 27

Abbreviation: WHO, World Health Organization.

incidence rates. Tables 1 and 2 compare the results from the present study with population-based and clinical trial studies in the literature. Table 3 gives the survival from each registry by tumor type, and Table 4 gives the hazard ratios for each tumor type.

Discussion

This study compares the survival data from 2 well-recognized and validated registries—showing that for most pediatric CNS tumor types, survival at 1, 5, and 10 years was lower in the NRCT group than in the SEER group. The causes of this difference in outcome are unclear but might include: better access to health care, faster initial diagnosis, increased rates of resection by pediatric trained neurosurgeons, greater recruitment into clinical trials, types of adjuvant therapy, aggressiveness of management at relapse, and better supportive care.[12] Certainly, the median interval between symptom onset and diagnosis in the United Kingdom is reported to be 3.3 months,[13] which is longer than the interval reported from other countries, such as Germany (24 days)[14] and Switzerland (60 days).[15] Unfortunately, the NRCT does not yet record sufficient information on treatment received to allow for comparison between the 2 different health-care systems. However, it seems reasonable to assume that for the tumor types chosen, the rate of surgery is likely to be similar between the US and the UK, as most patients with these tumor types will present with symptoms due to mass effect.

The data from the present study indicate that patients in the UK with highly malignant tumors (high-grade gliomas and supratentorial PNETs [sPNETs] in particular) do disproportionately badly in comparison with other tumor types when comparing outcomes with the US. This likely reflects more aggressive surgery or adjuvant therapy either at the time of diagnosis or at relapse.

Children with CNS tumors remain at significantly increased risk of death compared with the general population well beyond 5 years after diagnosis.[16–18] In fact, comparing an age- and sex-matched (US) population, the mortality rate of children who have been treated for a CNS tumor beyond 5 years from time of diagnosis is almost 13 times higher. The time epoch of highest risk is 5–9 years from diagnosis.[19] Reulen et al[17] have shown that there is a persistence of elevated risk of mortality beyond 25 years in survivors of childhood cancer relative to the general population. Causes include second primary neoplasms and cardiorespiratory disease caused by the effects of adjuvant chemoradiotherapy. This study confirms the need for long-term surveillance but interestingly (Table 3) shows only a modest drop-off in overall survival for SEER between 5 and 10 years—but a larger drop-off in the UK (1.5% vs 3.8%, respectively).

As far as we are aware, this is the first study to compare in detail population-based long-term survival from specific surgically treated pediatric CNS tumors. In addition, due to the large numbers of patients recruited to these registries, this study adds significantly to our understanding of patient survival for most common pediatric CNS tumors at a population-based level and may provide a reference point for outcome that is more relevant to daily pediatric neuro-oncological practice.

Comparisons With the Literature

Reviewing the literature shows that studies fall into 3 broad categories: population-based, trial data, and institutional series.

Table 2. Summary of literature reporting overall survival related to CNS tumors in clinical trials, split by ages <3 y and 3–14 y

	Tumor Type	Survival, %	
		Trials[22,24,26,27,29,30,42–57]	Present Study
<3 y	Low-grade glioma (WHO grades I/II)	5y 95 (1–3 y old, 95 <1 y old, 76)	
	High-grade glioma (WHO grades III/IV)	5y 31–66 10y 38	SEER 5y 51 NRCT 5y 35 SEER 10y 51 NRCT 10y 35
	Ependymoma	5y 63	SEER 5y 67 NRCT 5y 56 SEER 10y 62 NRCT 10y 49
	Embryonal (medulloblastoma, sPNET)		SEER 5y 48 NRCT 5y 33
	Medulloblastoma	5y 43	SEER 5y 52 NRCT 5y 42 SEER 10y 49 NRCT 10y 42
	sPNET	5y 31	SEER 5y 43 NRCT 5y 11 SEER 10y 41 NRCT 10y 11
3–14 y	Low-grade glioma (WHO grades I/II)	5y 86 10y 94	
	High-grade glioma (WHO grades III/IV)	2y 21 5y 19	SEER 2y 22 NRCT 2y 13 SEER 5y 22 NRCT 5y 10
	Ependymoma	5y 60–85	SEER 5y 76 NRCT 5y 71 SEER 10y 74 NRCT 10y 63
	Embryonal (medulloblastoma, sPNET)		SEER 5y 73 NRCT 5y 67
	Medulloblastoma	5y 87 10y 81	SEER 5y 76 NRCT 5y 71 SEER 10y 74 NRCT 10y 64
	sPNET	5y 73	SEER 5y 65 NRCT 5y 45 SEER 10y 61 NRCT 10y 36

Abbreviation: WHO, World Health Organization.

Most of the former articles are aimed at looking at overall trends in incidence and outcome—often covering all pediatric malignancies and grouping CNS tumors in ways of limited clinical relevance. From such studies it is therefore usually not possible to predict 1-, 5-, and 10-year survival for specific CNS tumor types.

A systematic review of the literature on clinical trial results for each tumor type was outside the scope of this study. Nevertheless, comparison of the outcomes from the present study with those from relevant contemporaneous trials highlights the substantial differences in survival reported for patients treated as

Table 3. 1-, 5-, and 10-y postoperative survival for patients aged <15 y at diagnosis comparing SEER vs NRCT (1996–2005)

	Total (*n*)		1-y Survival, %		5-y Survival, %		10-y Survival, %	
	SEER	NRCT	SEER	NRCT	SEER	NRCT	SEER	NRCT
All ages								
Pilocytic astrocytoma	1111	805	98.6	98.3	97.5	96.1	97.0	94.4
Anaplastic astrocytoma	123	95	57.7	51.6	30.1	18.9	28.5	17.9
Glioblastoma	121	142	44.6	35.9	22.3	8.5	20.7	7.0
Medulloblastoma	492	525	86.0	85.0	71.3	65.0	68.7	59.0
PNET	230	120	75.7	62.5	57.4	32.5	54.3	26.7
Ependymoma	334	238	93.1	89.5	72.5	64.7	69.8	56.7
Overall	2411	1925	88.3	84.4	77.6	69.5	76.1	65.7
<3 y								
Pilocytic astrocytoma	214	130	97.2	97.7	94.9	90.8	94.4	87.7
Anaplastic astrocytoma	20	12	70.0	50.0	65.0	41.7	65.0	41.7
Glioblastoma	17	11	35.3	45.5	35.3	27.3	35.3	27.3
Medulloblastoma	96	113	68.8	65.5	52.1	41.6	49.0	41.6
PNET	80	45	56.3	35.6	42.5	11.1	41.3	11.1
Ependymoma	117	101	87.2	88.1	66.7	56.4	62.4	48.5
Overall	544	412	81.1	76.9	70.6	57.0	68.8	54.1
3–14 y								
Pilocytic astrocytoma	897	675	98.9	98.4	98.1	97.2	97.7	95.7
Anaplastic astrocytoma	103	83	55.3	51.8	23.3	15.7	21.4	14.5
Glioblastoma	104	131	46.2	35.1	20.2	6.9	18.3	5.3
Medulloblastoma	396	412	90.2	90.3	76.0	71.4	73.5	63.8
PNET	150	75	86.0	78.7	65.3	45.3	61.3	36.0
Ependymoma	217	137	96.3	90.5	75.6	70.8	73.7	62.8
Overall	1867	1513	90.4	86.5	79.7	72.9	78.2	68.8

part of a trial and unselected populations treated at the discretion of the clinician. This difference in survival is almost certainly underscored by this study, as many of the patients within both SEER and NRCT will have been in clinical trials, presumably improving the overall survival for the cohort. Part of the difference in survival between trial and nontrial patients can almost certainly be explained by the strict entry requirements of most trials, but more research is required in both health-care settings in order to understand this more fully. Efforts to close this gap could be an effective way of improving the overall outcome for children with CNS tumors.

For some time there has been evidence of poor survival in the UK for both children and young adults with CNS tumors.[9] Recently, Solheim et al[20] reported that the Norwegian CNS tumor survival rates in children (1988–2008) were 90%–91% at 1 year and 78%–79% at 5 years. The Solheim paper is the only other population-based study limited to operated cases in the literature that we are aware of, but it does not give sufficient breakdown by tumor type to allow direct comparison.

In this study we have specifically looked at the most common pediatric CNS tumor types. For each specific tumor studied, the literature suggests that outcome is independently related to the extent of surgical resection and evidence of dissemination at time of diagnosis. Likewise, young age (<3 y) is usually associated with a worse outcome, although this may in part reflect the avoidance of radiotherapy in this age group. Age is the only variable that we can stratify for using the present data, and this age-related finding is confirmed in this study in both health-care settings (see Table 3).

Presently most research is aimed at better understanding the biology of the various tumor types so that clinical trials can be tailored to lower the burden of treatment and toxicity in low-risk patients while improving survival in high-risk patients. Long-term survival and, perhaps more importantly, quality of life are now recognized as the aims of treatment. With this in mind, we would strongly recommend that national registries, in collaboration with neuro-oncologists, develop an internationally agreed-upon extended data set, to include staging, treatments received, and morbidity.

Specific Tumor Types

Pilocytic astrocytomas

These are the most common pediatric CNS tumors and are generally treated by surgery alone, with very good long-term survival rates being seen in patients in whom resection of 95% or more has been achieved.[21] It is therefore surprising to see a hazard ratio of 0.69 (95% CI: 0.44–1.10) for children treated in NRCT compared with SEER regions. One possible explanation for this difference, which it is not possible to explore with these data sets, is that there were a greater proportion of children in the SEER data set for whom a more complete resection was achieved.

Table 4. Cox proportional hazards regression analysis for patients aged <15 y at diagnosis comparing SEER vs NRCT (all age-adjusted unless otherwise stated)

	Survival	Person Years at Risk	*N* Subjects	*N* Deaths	Hazard Ratio	95% CI	*P*
All ages							
Pilocytic astrocytoma	10 y	12934	1916	78	0.69	0.44–1.10	.117
Anaplastic astrocytoma	10 y	559	218	166	0.77	0.57–1.05	.095
Glioblastoma	10 y	426	263	228	0.72	0.55–0.93	.013
Medulloblastoma	10 y	5465	1017	369	0.80	0.65–0.99	.036
PNET	10 y	1355	350	193	0.51	0.38–0.67	<.001
Ependymoma	10 y	2986	572	204	0.85	0.64–1.12	.240
Overall	10 y	23725	4336	1238	0.74	0.66–0.82	<.001
Overall (age and histology adjusted)	10 y	25521	4336	1250	0.71	0.64–0.80	<.001
Anaplastic and GBM	5 y	783	481	387	0.70	0.57–0.85	<.001
PNET and medulloblastoma	5 y	4650	1367	504	0.75	0.63–0.89	<.001
<3 y							
Pilocytic astrocytoma	10 y	2180	344	28	0.57	0.27–1.22	.146
Anaplastic astrocytoma	10 y	127	32	14	0.52	0.19–1.48	.219
Glioblastoma	10 y	68	28	19	1.07	0.43–2.67	.883
Medulloblastoma	10 y	827	209	115	0.80	0.55–1.16	.234
PNET	10 y	323	125	87	0.50	0.32–0.76	<.001
Ependymoma	10 y	1067	218	96	0.82	0.55–1.23	.346
Overall	10 y	4593	956	359	0.69	0.56–0.85	<.001
Anaplastic and GBM	5 y	139	60	33	0.75	0.38–1.48	.400
PNET and medulloblastoma	5 y	803	334	198	0.71	0.57–0.87	<.001
3–14 y							
Pilocytic astrocytoma	10 y	10754	1572	50	0.75	0.42–1.33	.325
Anaplastic astrocytoma	10 y	432	186	152	0.83	0.60–1.14	.244
Glioblastoma	10 y	358	235	209	0.68	0.51–0.89	.006
Medulloblastoma	10 y	4637	808	254	0.84	0.66–1.08	.183
PNET	10 y	1031	225	106	0.57	0.39–0.81	.004
Ependymoma	10 y	1920	354	108	0.86	0.59–1.26	.446
Overall	10 y	19132	3380	879	0.76	0.67–0.87	<.001
Anaplastic and GBM	5 y	644	421	354	0.69	0.52–0.91	.009
PNET and medulloblastoma	5 y	3848	1033	306	0.85	0.69–1.07	.163

High-grade gliomas

Survival from high-grade gliomas has changed little in the past 20–25 years.[22] It is becoming increasingly clear that the biology of these tumors in children is different than that in adults,[23] and tumors in young children are different from those in older children. In particular, there is evidence of superior survival in children <3 years with high-grade glioma (5-y overall survival 66.3%).[24] This is borne out in the present study with significantly more children <3 years with anaplastic astrocytoma and GBM surviving to 5 and 10 years compared with older children. Nonetheless, in the literature, overall long-term survival remains dismal, with 5-year figures ranging from 17% to 40% in anaplastic astrocytoma and 5% to 29% in GBM.[23]

Ependymoma

Good evidence exists of the impact of gross total resection on outcome; however, controversy still exists regarding the degree of neurological dysfunction that should be accepted in pursuit of this aim. Investigation of the role of postoperative radiotherapy (including protons) and chemotherapy continues, as does the hunt for potential biological markers to guide treatment.[25] A recent report looking at children in the US recruited to a phase II preirradiation chemotherapy trial (1995–1999) showed an overall 5-year survival of 71% ± 6%.[26] This is in keeping with most trial and review articles, which quote 5-year survival in the range of 60%–85% (see Table 2) and 10-year survival on the order of 50%. Merchant et al[27] reported a 93% 5-year survival after gross total removal, as opposed to 52.4% after sub- or near-total removal, and overall 5-year survival of 85% for their total cohort of ependymoma patients.

In the present study (Table 3), there was again a trend for better results in the SEER group. As a potential reflection of the common brainstem involvement, the 1-year survival for both SEER (93.1%) and NRCT (89.5%) is lower than that for other tumors in which surgery is initially considered to be the most important form of treatment. Interestingly and particularly evident in

children <3 years is the drop-off in survival between 1 and 5 years in the UK (88.1% to 56.4%). It would be of great interest to know the rate of complete resections in this cohort.

Medulloblastoma/primitive neuroectodermal tumors

Medulloblastomas, located in the posterior fossa, are the most common type of malignant CNS tumor seen in children. Recurrence, usually within 2 years of diagnosis, remains a major problem. At the time of recurrence, despite second surgery, chemotherapy, and autologous stem cell rescue, the prognosis remains very poor and most patients die within 1 year.[28] For medulloblastomas, the SEER data set (Table 3) again shows better survival. The 1-year survival rate for SEER and NRCT (86% and 85%, respectively) are very similar, but the NRCT rate is lower at 5 years and beyond. Perhaps even more striking is the difference in 5-year survival between both the SEER (71%) and NRCT (65%) data sets and figures of well over 80% reported in clinical trials.[29] This lower survival at 5 years and beyond in the NRCT group is particularly pronounced in the <3-year age group (65.5% at 1 y and 41.6% at 5 y) and may reflect less aggressive treatment at time of presentation or recurrence.

Children with PNET fared particularly badly in the UK, with only 11.1% and 45.3% of children aged <3 years and 3–14 years, respectively, surviving to 5 years. Geyer et al[30] report a 5-year overall survival of 31% in infants with sPNET in a US clinical trial. The difference with the SEER data (42.5% and 65.3% for the respective age groups) may in part reflect differences in diagnostic practice between the US and UK (see below).

Solheim et al,[20] in a Norwegian population-based study, reported the 5-year survival of combined PNET/medulloblastoma as 65% in low-volume regions (but somewhat surprisingly 42% in the high-volume region). The 65% figure is similar to the 67% for SEER in the present study.

Study Limitations

The comparability of results between different time periods can be impaired by changes in cancer coding.[9] We have tried to limit the impact of this by comparing the same periods and including the same tumor types in both data sets. Another limitation is intraobserver variability amongst histopathologists, causing skewed distributions of histopathological subgroups, and their subsequent analyses. This is best exemplified by PNETs, which make up 9.5% of the SEER cohort that we have analyzed but only 6% of the NRCT cohort, while GBM makes up 5% and 7%, respectively. However, while this might be used to question the reliability of comparing SEER with NRCT data for specific histological tumor types, it does not explain the significant differences seen in outcome for the whole cohort of patients between the 2 health-care settings.

Although there might be geographical variation in survival, SEER data remain the best source of population-based survival in the US. All hospitals in SEER areas are required to submit data on reportable neoplasms to the central SEER registry in their area/state. SEER registries are assessed annually by the National Cancer Institute for completeness, and a 98% ascertainment is expected. The population covered by SEER is comparable to the general US population with regard to measures of poverty and education but is more urban and has a higher proportion of foreign-born persons than the general US population.[31]

Conclusions

This study adds to our understanding of the survival of children with pediatric CNS tumors. Being population based, the results also give more reliable estimates of survival than can be ascertained from the literature. The gap in survival exposed by this study between most children treated in trials and those receiving care outside of such studies needs addressing by health-care providers—perhaps by delivering these treatments in a limited number of accredited centers. We would recommend strongly that all children with CNS tumors who are not entered into a clinical trial be registered in an observational study.

This study also highlights the need for continued systematic national data collection, with increased input and use by those involved in treating pediatric neuro-oncology patients. We urge health-care purchasers to suitably fund national registries so as to allow comparison of outcomes between institutions and between countries.

Lastly, this study exposes worrying differences in outcomes for children diagnosed and treated in the UK compared with those treated in the US (SEER), although this study is unable to shed light on the causes for these differences.

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