Pediatric Germ Cell Tumors From 1987 to 2011: Incidence Rates, Time Trends, and Survival

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abstract

BACKGROUND: Malignant germ cell tumors (GCTs) are a rare and a heterogeneous group of pediatric cancers. The incidence rate has increased in some populations or subgroups. However, only a few recent publications on epidemiologic data showing the trends in incidence of pediatric GCTs are available.

METHODS: We analyzed the incidence rates, time trends, and survival for 1366 GCTs in children 0 to 14 years old registered in the nationwide, population-based German Childhood Cancer Registry in 1987–2011.

RESULTS: The incidence rate of GCTs was slightly higher in girls (age-standardized rate: girls, 5.3; boys, 4.4 per million). A bimodal age distribution was seen. In children aged <1 year, the highest age-specific incidence rates were seen for girls with GCTs in the pelvis (12.7 per million) and for boys with GCTs in the testis (9.5 per million). For 10- to 14-year-old boys, the tumors occurred most often in the central nervous system (3.1 per million); for girls, the most common site was in the ovaries (4.5 per million). Only the incidence rate for ovarian GCTs increased statistically significantly. The 5- and 20-year survival probabilities for the patients diagnosed between 1987 and 2010 were 92% and 90%, respectively. Survival rates improved notably for intracranial and extragonadal GCTs from 1987 to 2006.

CONCLUSIONS: The localization and histology of the GCTs varied between the genders and age groups. During 1987 to 2011, the incidence rate increased only for ovarian GCTs. The increase, however, may be due to changes in reporting. The survival rates were excellent.

WHAT'S KNOWN ON THIS SUBJECT: Germ cell tumors in children are heterogeneous and rare neoplasms that occur in various locations, such as gonads, the central nervous system, and the pelvis. The incidence rate has been increasing in some countries.

WHAT THIS STUDY ADDS: Population-based analyses of germ cell tumors in children are rare. This population-based study describes the incidence rates, trends, and survival of germ cell tumors in German children from 1987 to 2011.

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Malignant germ cell tumors (GCTs) are a rare and heterogeneous group of tumors that account for 3% of pediatric cancers. Generally, in children aged <15 years GCTs predominate in female subjects (boy: girl ratio: 0.8:1).[1] The age distribution of GCTs is bimodal, in which the first peak is seen before the age of 1 year and the second peak starts in adolescence.[2,3] The incidence rates of GCTs have increased in children in Europe, the United States, and Australia.[4–6] The reason for the increase is unknown.

GCTs are assumed to originate from the primordial germ cells in a developing embryo, which migrate during embryogenesis along the midline of the body to the gonadal ridges.[7–9] The tumors in extragonadal locations are believed to originate from germ cells that failed to migrate to the gonads.[10] The risk factors for GCTs are poorly understood but are presumed to be prenatal.

GCT survival improved dramatically after the introduction of platinum-based chemotherapy in the 1980s. Five-year survival rates of >90% have been reported.[3] Better survival has been observed for gonadal tumors compared with extragonadal tumors.

The goal of the present study was to determine the incidence rates, time trends, and outcomes of GCTs in children aged 0 to 14 years registered over a 25-year period (1987–2011) in the population-based German Childhood Cancer Registry (GCCR) in Germany.

METHODS

The data were obtained from the population-based GCCR. It is a nationwide registry and includes all malignant diseases as well as benign central nervous system (CNS) tumors. The level of completeness has been estimated to be >95% since 1987.[11,12] In general, the data are regularly validated and completed through therapy optimization studies (TOS) of the German Society of Pediatric Oncology and Hematology (GPOH), in which ~95% of the patients participate.[13] Comprehensive data verification with the corresponding studies was performed.

For children resident in Germany aged <15 years, 1402 cases were registered in the diagnostic group X "germ cell tumors, trophoblastic tumors and neoplasms of gonads" of the *International Classification of Childhood Cancer, Third Edition* (ICCC-3), between 1987 and 2011.[14] Gonadal carcinomas X(d) (n = 12), as well as other and unspecified malignant gonadal tumors X(e) (n = 24), were omitted from the analyses. The tumors analyzed for incidence rates and timely trends (N = 1366) were malignant tumors in the subgroups X(b) and X(c) (malignant extracranial and extragonadal GCTs and malignant gonadal GCTs, respectively). In addition, in accordance with international rules (ICCC-3), malignant tumors as well as benign tumors were registered as X(a) (intracranial and intraspinal GCTs) and included in the analysis. For the analyses of location and histology, 5 cases with missing location information of the subgroup X(b) were omitted.

For survival analyses, 1256 cases diagnosed during the years 1987 and 2010 were used. Cases diagnosed between 1987 and 2010 with missing follow-up data (n = 41) and all the cases diagnosed in 2011 (n = 69) were omitted from the survival estimations. Follow-up information is provided by the TOS until the end of the first clinical treatment phase and clinical follow-up, of which the latter usually lasts 5 years; thereafter, the GCCR conducts the follow-up. In addition to regular data exchange with the TOS, data are collected from various sources, such as hospitals, state cancer registries, municipalities, and from the patients themselves. Follow-up information (until January 15, 2014) was available for 97% of the cases diagnosed between 1987 and 2010.

Site and histology codes of the *International Classification of Diseases for Oncology, Third Edition*, were used.[15] The site codes were as follows: testis, C62.9; ovary, C56.9; pelvis (including sacrococcygeal region), C49.5 or C76.3; mediastinum, C38.1 or C38.3; retroperitoneum, C48.0; and CNS, C70.0 to C75.3. In "other location," atypical locations were grouped together, namely C05.9, C11.9, C16.9, C22.0, C37.9, C38.0, C48.1, C49.0, C49.3, C49.4, C49.8, C52.9, C53.9, C55.9, C57.1, C57.4, C57.8, C57.9, C60.2, C63.2, C63.9, C64.9, C68.9, C69.2, C69.6, C74.9, C75.8, C76.0, C76.1, and C76.2.

Age- and gender-specific incidence rates were calculated and adjusted, where indicated, to the World Health Organization world standard population proposed by Segi[16] and expressed per million person-years. Trend analyses followed the principles of age-period-cohort (APC) models.[17,18] The APC model was reduced to an age-corrected estimation of a simple annual average percent change (AAPC). The trends were presented with 95% confidence intervals (CIs). The AAPC is considered statistically significant if the 95% CI does not include 0.

Survival predictions were made by applying the life table method extension proposed by Brenner and Spix.[19]

RESULTS

Incidence Rates, Gender Ratios, Median Age, and Time Trends

The overall age-standardized incidence rate for GCTs (X[a–c]) was 4.8 per million (boys, 4.4; girls, 5.3) (Table 1). The majority of the GCTs were diagnosed in girls, leading to a male:female gender ratio of 0.8:1. The incidence rates (X[a–c]) were

TABLE 1 Absolute Number, Percentage, Incidence Rate, Gender Ratio, Median Age, and AAPC (95% CI) by ICCC-3 Group for Children Aged 0 to 14 Years Diagnosed With a GCT (1987–2011) in Germany (N = 1366)

ICCC-3 Group	Gender	*n*	%	Group %	Incidence Rates (Per Million)					Gender Ratio Male:Female	Median Age (years, months)	AAPC (95% CI)
					Age Specific				ASR[a]			
					0	1–4	5–9	10–14	0–14			
X(a–c)		1366	100.0	100.0	19.6	3.5	2.2	5.1	4.8	0.8	7.4	0.3 (–0.4 to 1.1)
	Boys	621	—	45.5	19.8	3.9	1.2	4.2	4.4		3.2	−0.5 (–1.6 to 0.6)
	Girls	745	—	54.5	19.3	3.2	3.2	5.9	5.3		8.7	1.0 (0.0 to 2.1)
X(a), intracranial and intraspinal GCTs		380	27.8	100.0	1.3	0.3	1.1	2.2	1.2	1.8	10.10	0.2 (–1.3 to 1.7)
	Boys	243	—	63.9	1.3	0.3	1.1	3.1	1.4		11.4	−0.2 (–2.0 to 1.6)
	Girls	137	—	36.1	1.2	0.3	1.1	1.2	0.9		9.8	0.9 (–1.5 to 3.4)
X(b), malignant extracranial and extragonadal GCTs		406	29.7	100.0	13.4	1.7	0.1	0.3	1.7	0.6	0.6	−0.1 (–1.4 to 1.3)
	Boys	146	—	36.0	9.2	1.0	0.0	0.3	1.2		0.4	−0.7 (–3.0 to 1.6)
	Girls	260	—	64.0	17.9	2.3	0.1	0.2	2.2		0.7	0.3 (–1.4 to 2.1)
X(c), malignant gonadal GCTs		580	42.4	100.0	4.9	1.6	1.0	2.6	2.0	0.7	9.6	0.7 (–0.5 to 1.9)
	Boys	232	—	40.0	9.4	2.6	0.1	0.8	1.8		1.5	−0.6 (–2.4 to 1.2)
	Girls	348	—	60.0	0.2	0.6	2.0	4.5	2.2		11.6	1.7 (0.1 to 3.2)

[a] World standard age-standardized incidence rate.

highest for children aged <1 year and were rather similar in boys and girls (Table 1, Supplemental Fig 1A).

The incidence rates for the group X(a) were the highest for the age group 10 to 14 years, with boys having a slightly higher rate than girls (Table 1, Supplemental Fig 1B). The single highest age-specific incidence rate (17.9 per million) was observed for infant girls for group X(b), which includes the sacrococcygeal tumors (Table 1, Supplemental Fig 1C). Group X(b) tumors typically occurred in early childhood only. For boys, a high incidence of gonadal tumors (group X[c]) was seen in infancy; for girls, the ovarian tumors appeared mainly toward puberty (Table 1, Supplemental Fig 1D).

The median age for girls for all GCTs (groups X[a–c]) was higher (8 years 7 months) than for boys (3 years 2 months). The most diverging median ages between the genders were detected in the gonadal group X(c), in which the median for boys was 1 year 5 months and for girls, it was 11 years 6 months. The lowest median age of 6 months for both genders was observed in the group X(b).

The incidence rate for the whole group of GCTs (X[a–c]) increased slightly but was not statistically significant (AAPC: 0.3% [95% CI: –0.4 to 1.1] per year) during the years 1987 to 2011. However, a statistically significant increasing trend for ovarian tumors (X[c]; AAPC: 1.7% [95% CI: 0.1 to 3.2]) was seen.

Locations and Histologic Subtypes

Incidence rates for CNS X(a) and gonadal X(c) tumors are presented in Table 1. The various locations for the X(b) tumors are presented separately in Table 2. Five cases of the group X(b) with missing location information were not analyzed for locations and histologic subtypes. The extragonadal tumors (groups X[a–b]) covered 58% of the GCTs in children. Nevertheless, gonadal GCTs (X[c]) constituted the single biggest diagnostic subgroup (580 cases [43% of all cases]; age-standardized rate: 2 per million).

The most common locations for the age groups 0 and 1 to 4 years were the pelvis and gonads (testis); for the age groups 5 to 9 years and 10 to 14 years, the CNS and gonads (ovaries) were the most common locations (Tables 1 and 2). Approximately 60% of the tumors in the group X(b) (241 of 401) were in the pelvic region, and of these, approximately three-fourths (178 of 241) were in girls (Table 2). Ovarian tumors (X[c]) accounted for 47% of all GCTs in girls (348 cases of 744; age-standardized rate: 2.2 per million) (Table 1). The ovarian tumors were most frequent in 10- to 14-year-olds (age-specific incidence rate: 4.5 per million). The testis was the most common location for boys in the age groups 0 and 1 to 4 years (age-specific incidence rates: 9.4 and 2.6, respectively); in the age groups 5 to 9 years and 10 to 14 years, CNS tumors were more frequent (age-specific incidence rates: 1.1 and 3.1, respectively).

The most common histologic subtypes were yolk sac tumors (439 cases) (Table 3) and teratomas (388 cases), each accounting for roughly one-third. Germinomas constituted one-fifth of the histologic subtypes

TABLE 2 Absolute Number, Percentage, and Incidence Rates for ICCC-3 Group X(b) Tumors for Different Locations for Children Aged 0 to 14 Years Diagnosed Between 1987 and 2011 in Germany (N = 401)

Location	Gender	n	Group %	Incidence Rate (Per Million)				ASR[a] 0–14
				Age Specific				
				0	1–4	5–9	10–14	
Pelvis		241	100.0	8.3	1.2	0.0	0.0	1.0
	Boys	63	26.1	4.0	0.6	0.0	0.0	0.5
	Girls	178	73.9	12.7	1.7	0.0	0.0	1.6
Mediastinum		29	100.0	0.5	0.1	0.0	0.1	0.1
	Boys	19	65.5	0.7	0.0	0.0	0.2	0.1
	Girls	10	34.5	0.4	0.2	0.0	0.0	0.1
Retroperitoneum		27	100.0	1.1	0.0	0.0	0.1	0.1
	Boys	16	59.3	1.1	0.1	0.0	0.1	0.1
	Girls	11	40.7	1.0	0.0	0.0	0.0	0.1
Other		104	100.0	3.4	0.4	0.0	0.1	0.4
	Boys	45	43.3	3.1	0.3	0.0	0.1	0.4
	Girls	59	56.7	3.7	0.4	0.1	0.1	0.5

[a] World standard age-standardized incidence rate.

(267 cases). However, differences in frequency were seen between the age groups (Table 4). Germinoma was the most common histology of the CNS both in boys and girls (49% and 50.4% of the tumors in CNS, respectively). The tumors in the pelvis were mainly teratomas (52.4% in boys and 44.9% in girls) and yolk sac tumors (42.9% in boys and 46.6% in girls). Gonadal GCTs were mostly yolk sac tumors (in the ovaries, 31.1%; in the testis, 61.2%) and teratomas (in the ovaries, 25.1%; in the testis, 20.7%). In the ovaries, approximately every fifth tumor was a germinoma (19.9%).

In infants, teratoma was the most common histology (age-specific incidence rate: 12.8 per million) (Table 4). Approximately one-half of the teratomas in infants occurred in the pelvis (109 of 233; boys, 31; girls, 78 [data not shown]). For 1- to 4 year-olds, yolk sac tumors occurred most frequently (age-specific incidence rate: 2.7 per million). For children aged <5 years, these 2 histologic subtypes accounted for 91% of the cases.

The frequency of germinomas increased toward adolescence. For the age groups 5 to 9 years and 10 to 14 years, germinoma was the most common histology (age-specific incidence rate: 0.7 and 1.9, respectively) (Table 4). In 5- to 14-year-old boys, germinomas occurred almost exclusively in the CNS (117 of 121 cases; data not shown). In 5- to 14-year-old girls, however, almost one-half of the germinomas were in the ovaries (67 of 138; data not shown).

Survival

The 5-year survival probability for the whole group was 92%; the 20-year survival rate was 90% (Table 5). The best survival probabilities (20-year: 97%) were observed for the gonadal GCTs. The lowest survival probability was seen for the group X(a), in which the 5-year survival was 85% and the 20-year survival was 80%.

The 5-year survival probability for all GCTs (X[a–c]) improved between the time periods 1987–1991 (89%) and 2002–2006 (96%). All the subgroups (X[a–c]) achieved >90% 5-year survival probabilities by 1997–2001. The most impressive improvement in survival, from 76% (1987–1991) to 92% (2002–2006),

TABLE 3 Absolute Number and Relative Number (%) of Tumors According to Location and Histology in Children Aged 0 to 14 Years Diagnosed With GCTs Between 1987 and 2011 in Germany (N = 1361)

Tumor	CNS (n = 380)				Pelvis (n = 241)				Mediastinum (n = 29)				Retroperitoneum (n = 27)				Other Location (n = 104)				Gonads (n = 580)			
	Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls		Boys		Girls	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Yolk sac tumor (n = 439)	17	7.0	10	7.3	27	42.9	83	46.6	2	10.5	5	50	3	18.8	2	18.2	11	24.4	29	49.2	142	61.2	108	31.0
Teratoma (n = 389)	43	17.7	21	15.3	33	52.4	80	44.9	6	31.6	3	30	10	62.5	8	72.7	30	66.7	19	32.2	48	20.7	88	25.3
Germinoma (n = 267)	119	49.0	69	50.4	0	0	0	0	1	5.3	1	10	0	0	1	9.1	1	2.2	3	5.1	3	1.3	69	19.8
Tumors of mixed forms (n = 167)	34	14.0	21	15.3	3	4.8	14	7.9	6	31.6	1	10	0	0	0	0.0	3	6.7	4	6.8	26	11.2	55	15.8
Choriocarcinoma (n = 83)	26	10.7	14	10.2	0	0	1	0.6	4	21.1	0	0	2	12.5	0	0	0	0	4	6.8	5	2.2	27	7.8
Embryonal carcinoma (n = 16)	4	1.6	2	1.5	0	0	0	0	0	0	0	0	1	6.3	0	0	0	0	0	0	8	3.4	1	0.3
Total number (n = 1361)	243	100	137	100	63	100	178	100	19	100	10	100	16	100	11	100	45	100	59	100	232	100	348	100

CNS, central nervous system.

TABLE 4 Absolute Number, Percentage, and Incidence Rates According to Tumor Histology for Children Aged 0 to 14 Years Diagnosed With GCTs From 1987 to 2011 in Germany (N = 1361)

Histology	Gender	*n*	%	Incidence Rate (Per Million)				ASR[a] 0–14
				Age Specific				
				0	1–4	5–9	10–14	
Yolk sac tumor		439	32.3	5.1	2.7	0.4	0.9	1.7
	Boys	202	14.8	5.5	3.2	0.1	0.4	1.6
	Girls	237	17.4	4.7	2.2	0.7	1.5	1.7
Teratoma		389	28.6	12.8	0.4	0.5	0.7	1.5
	Boys	170	12.5	12.6	0.4	0.3	0.4	1.3
	Girls	219	16.1	12.9	0.5	0.6	1.1	1.7
Germinoma		267	19.6	0.1	0.1	0.7	1.9	0.8
	Boys	124	9.1	0.1	0.1	0.3	1.9	0.7
	Girls	143	10.5	0.0	0.1	1.0	1.8	0.9
Tumors of mixed forms		167	12.3	1.4	0.2	0.4	0.8	0.5
	Boys	72	5.3	1.3	0.2	0.3	0.8	0.5
	Girls	95	7.0	1.4	0.3	0.5	0.9	0.6
Choriocarcinoma		83	6.1	0.1	0.0	0.2	0.6	0.2
	Boys	37	2.7	0.0	0.0	0.1	0.5	0.2
	Girls	46	3.4	0.2	0.0	0.2	0.6	0.3
Embryonal carcinoma		16	1.2	0.1	0.0	0.0	0.1	0.0
	Boys	13	1.0	0.1	0.0	0.0	0.2	0.1
	Girls	3	0.2	0.0	0.0	0.0	0.0	0.0

[a] World standard age-standardized incidence rate.

was seen for the intracranial tumors. It is notable that the improvement in survival for diagnostic groups X(a) and X(b) occurred between the time periods 1992–1996 and 1997–2001. Hardly any change was detected before or after that. The 5-year survival for the group X(c) was extremely high (96%–99%) throughout the entire study period.

DISCUSSION

The incidence rate for GCTs in childhood in Germany was similar to rates reported for the United States.[3,4,20] In contrast to the GCTs in adulthood, which are mostly gonadal and encountered in male subjects,[21] the tumors in childhood were mostly extragonadal and in girls. The ratio of extragonadal/gonadal tumors (58% extragonadal) was equal to the other published ratios.[22]

Median age at diagnosis varied according to tumor location, type, and gender, indicating the heterogeneity of the GCTs. The tumors of the group X(b) were typical for infants, whereas CNS tumors were diagnosed in older children (mostly in boys). The large difference seen in the median age at diagnosis between boys and girls for the gonadal GCTs most likely reflects biological differences. In boys, the germ cells undergo mitotic proliferation before and after birth, whereas in unborn girls, the cells are subjected to meiotic arrest and are reactivated only in puberty. Accordingly, the incidence rate of testicular tumors peaked in boys before the age of 2 years and experienced a new rise at the onset of puberty, whereas in girls, the incidence rate of ovarian GCTs started to increase after the age of 5 years and continued toward puberty and was the highest for 10- to 14-year-olds.

The GCTs in early childhood and in older children were histologically distinct and occurred at different sites. In children <5 years of age, the tumors occurred mostly in the pelvis (girls) and in the testis (boys), whereas in children aged >5 years, the CNS (boys) and the ovaries (girls) were the most frequent locations. In children aged <5 years, the tumors were predominantly teratomas and yolk sac tumors, whereas in older children, various histologic subtypes (with germinomas being the prevalent type) were seen. Therefore, GCTs in early childhood were biologically different from the tumors of older children, as has been noted in other studies as well.[22–24]

No significant change in the incidence rate for the whole group of GCTs was detected. However, increases have been reported elsewhere: for

TABLE 5 Various Survival Probabilities (5-, 10-, and 20-Year) With 95% CIs, Estimated as in Brenner and Spix,[19] for Children Aged 0 to 14 Years With GCTs Diagnosed 1987 to 2010 and 5-Year Survival Probabilities (95% CIs) by 5-Year Time Period for Children Diagnosed Between 1987 and 2006

ICCC-3	Survival Probability 1987–2010 (n = 1256[a])			5-Year Survival Probability (n = 1094[a])			
	5 y	10 y	20 y	1987–1991 (n = 241[a])	1992–1996 (n = 278[a])	1997–2001 (n = 302[a])	2002–2006 (n = 273[a])
	%	%	%	%	%	%	%
X(a–c)	92 (91–94)	91 (90–93)	90 (88–92)	89 (85–93)	89 (86–93)	96 (93–98)	96 (94–98)
X(a), intracranial and intraspinal GCTs	85 (82–89)	83 (79–88)	80 (73–86)	76 (65–87)	80 (70–89)	91 (84–97)	92 (86–98)
X(b), malignant extracranial and extragonadal GCTs	92 (90–95)	91 (88–94)	88 (84–93)	89 (82–96)	89 (82–96)	97 (93–100)	95 (90–100)
X(c), malignant gonadal GCTs	97 (96–99)	97 (95–98)	97 (95–98)	98 (95–100)	96 (92–99)	98 (95–100)	99 (97–100)

[a] Patients with follow-up.

example, in earlier European studies (Northwest England, 2.6% per year, 1954–1998)[25] and in a study covering several European countries (2.3%, 1970–1999).[26] The analyzed time periods in these studies, however, were notably longer than in our study. In a previous study conducted at the GCCR, no trend for GCTs was detected until 2004.[27]

In young men (15–34 years old), testicular GCT is the most common solid tumor; this incidence rate has been increasing for decades.[28] We did not detect an increase in testicular tumor incidence rates for children during the analyzed period (1987–2011), and no increase was detected in Danish children (1943–1982),[29] and in US children (1973–2005).[30,31] However, an increase was seen in England and in Wales (1962–1995).[32] Nonetheless, we detected a significant increasing trend for the ovarian GCTs in girls.

For GCTs, the diagnostics have been improved by the introduction of certain biochemical methods and computer tomography in the mid-1980s, which may have led to increased incidence rates in the 1980s.[33] However, we have analyzed the time after these innovations, and therefore the slight increase detected in ovarian tumors cannot be explained by such changes. Moreover, we found an increase only in this GCT subgroup. However, it is possible that this increase was a result of changes in clinical and treatment practices for childhood ovarian tumors. The inclusion of ovarian GCTs for patients aged <18 years in all European pediatric GCT protocols starting in the 1990s increased registration to the GCCR and survival of patients in this disease group. Since then, ovarian tumors have been increasingly treated within a multidisciplinary setting, including pediatric oncologists, pediatric surgeons, and gynecologic specialists. Earlier treatment of part of these tumors was only by gynecologists.

High survival probabilities were seen for all GCTs, especially for gonadal GCTs, as has been reported by others.[3] The survival probabilities increased from 1987–1991 to 2002–2006. A stepwise improvement was detected for the diagnostic groups X(a) and X (b) between the time periods 1992–1996 and 1997–2001. The improvement coincides with the introduction of systematic treatment optimization protocols in the 1990s. In 1996, two new therapy optimization studies were started: the first European protocol for CNS GCTs (SIOP CNS GCT 96) and "MAKEI 96" for malignant GCTs in Germany, Austria, Switzerland, and part of Benelux countries. Better survival can thus be attributed to changes in diagnostics and therapies introduced by these new study protocols. For example, the changes included the increment of the total cisplatin dose for secreting intracranial tumors to 200 to 400 mg/m^2.[34] In MAKEI 96, the percentage of patients with preoperative chemotherapy (eg, malignant sacrococcygeal tumors) was increased. In addition, deep local hyperthermia with chemotherapy in the so-called Hyper-PEI protocol was introduced in therapies for recurrent tumors.[35] Technological developments in the 1990s improved both diagnostics and follow-up of GCTs as magnetic resonance tomography was established as the standard radiologic diagnostics tool.

We observed a slight weakening of the survival probability in all diagnostic subgroups during the last years (2007–2010). Because this occurrence seems to be the result of reporting bias and likely does not reflect the real situation, we did not provide these results. We have encountered a similar bias in other diagnostic groups, which results from the fact that the deaths are likely reported while the survivors go unnoticed for certain time. Survivors with no follow-up data are discarded from the survival analysis, leading to an overrepresentation of the deceased cases during the last years of registration.

The strength of our study is that it was conducted by using the data of a population-based childhood cancer registry that has been validated by the well-established TOS of the GPOH. The possible changes in reporting, especially regarding female gonadal tumors, represent a weakness of the study.

CONCLUSIONS

We have confirmed that the GCT localization and histology in children vary among genders and age groups. The incidence rates were similar to other reported rates. An increase in the incidence rate was observed for ovarian GCTs only; however, the increase may be due to changes in reporting. The long-term survival probability for these tumors, particularly for gonadal tumors, was excellent. A notable increase in the survival probabilities for intracranial and extragonadal GCTs was seen.

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