Pediatr Blood Cancer 2012;59:711–716

The Limited Screening Value of Insulin-Like Growth Factor-I as a Marker for Alterations in Body Composition in Very Long-Term Adult Survivors of Childhood Cancer

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Background. The clinical relevance of low IGF-I levels, caused by cranial radiotherapy, in adult childhood cancer survivors has not been studied extensively. We evaluated whether IGF-I is a useful marker for altered body composition and growth hormone deficiency (GHD) in this group. ***Procedure.*** We analyzed retrospective data from 610 adult childhood cancer survivors, retrieved from the late effects clinic. Median age at diagnosis was 6 years (interquartile range 3–11) and follow-up time was 18 years (13–24). We assessed IGF-I standard deviation scores (SDS), anthropometrical measures, growth hormone stimulation tests in patients with clinical signs of GHD, and measures of body composition (assessed by dual X-ray absorptiometry, Lunar Prodigy). ***Results.*** In 58 cranially irradiated acute leukemia survivors (25 Gy (24–25)) and 56 locally irradiated brain tumor survivors (42 Gy (35–54)) we found significantly lower IGF-I SDS ($P < 0.001$), lower height SDS ($P < 0.001$), higher body mass index ($P = 0.01$), higher waist–hip ratio (WHR; $P = 0.001$), higher total fat percentage SDS ($P < 0.001$), and lower lean body mass SDS ($P < 0.001$), as compared to 452 not cranially irradiated survivors. IGF-I showed a weak inverse correlation with BMI ($r = -0.12$, $P = 0.04$), WHR ($r = -0.15$, $P = 0.01$), total fat percentage ($r = -0.14$, $P = 0.02$), and a positive correlation with lean body mass ($r = 0.15$, $P = 0.01$). In patients with low IGF-I levels, IGF-I did not significantly differ between subjects with and without GHD as determined by GH-stimulation testing ($P = 0.39$). ***Conclusion.*** This study shows that IGF-I has limited value as a marker for alterations in body composition in adult childhood cancer survivors. Pediatr Blood Cancer 2012;59:711–716.

Key words: adult childhood cancer survivors; body composition; insulin-like growth factor-I

INTRODUCTION

Childhood cancer survival rates have improved significantly, with 70–80% of patients becoming long-term survivors [1]. It has been estimated that 1 out of 640 young adults in the U.S. is a survivor of childhood cancer [2]. Consequently, the incidence of late, treatment-related complications is increasing. Endocrine sequelae, such as the metabolic syndrome, osteopenia, subfertility, thyroid dysfunction, and growth hormone deficiency (GHD), represent an important category of such late effects [3–8].

GHD, which has an incidence of 29–39% after CRT treatment [9], has many effects on the metabolic system, such as decreased lean body mass and impaired bone mineral density, increased abdominal fat mass, dyslipidemia, insulin resistance, and subsequent raised cardiovascular morbidity later in life [5]. GHD, due to damage of the radiosensitive hypothalamo-pituitary region by CRT, has been associated with low IGF-I levels in adult childhood cancer survivors [6,10]. However, it has been shown that IGF-I is a poor marker for GHD in patients treated with CRT [11] and that only very low levels of IGF-I are predictive of GHD [12].

In a previous study in 114 childhood acute lymphoblastic leukemia (ALL) survivors that were treated with CNS irradiation, it was shown that low IGF-I levels were associated with altered body composition, represented by decreased lean body mass, increased total fat percentage, and 65% more visceral fat in combination with a worsened metabolic risk profile, represented by insulin resistance, and dyslipidemia [13]. This study confirmed results of earlier studies of CRT treated ALL survivors that showed low IGF-I levels associated with total and visceral fat percentage, but not with BMI [6,14]. However, most studies focused on relatively small groups of ALL survivors and after CRT treatment. The value of IGF-I as a marker for body composition, and its association with GHD, is uncertain. Therefore, in this study we analyzed IGF-I levels in a single center cohort of 610 adult childhood cancer survivors.

PATIENTS AND METHODS

Patients

We performed a retrospective single center study. Follow-up at our adult late effects outpatient clinic for long-term childhood cancer survivors starts 5 years after cessation of therapy and consultation is individualized, based on cancer diagnosis and treatment protocol. Out of 885 adult childhood cancer survivors, diagnosed and treated between 1964 and 2005, we identified and included 610 survivors, in which IGF-I had been measured between 2004 and 2009, at least 5 years after cessation of cancer treatment. Twenty survivors were living abroad at the time of follow-up, 21 refused to participate and 201 survivors did not show up at the outpatient clinic, due to the fact that the late effects clinic was a new setting and survivors could be under treatment by another specialist. Up until 2009, IGF-I levels were assessed based on former diagnosis and treatment as routine follow-up screening for GHD. Thereafter, according to the national guidelines of screening for late effects as implemented in 2010

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Conflict of interest: Nothing to declare.

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Received 1 September 2011; Accepted 1 November 2011

DOI 10.1002/pbc.24015
Published online 11 December 2011 in Wiley Online Library (wileyonlinelibrary.com).

by the Dutch Childhood Oncology Group (DCOG), routine measurement of IGF-I levels was omitted.

Clinical Parameters

Data concerning treatment protocols, as well as disease and patient characteristics, were retrieved from our local database and completed from the medical records where necessary (Table I). Follow-up time was defined as time between cessation of therapy and the most recent visit. Follow-up data of the most recent visit were evaluated including the following variables: use of medication, weight, height, target height (TH) calculated from the height of the survivors' parents [15], body mass index (BMI) calculated from height and weight [16], and waist–hip ratio (WHR) as measured by waist circumference divided by hip circumference [17]. Final height standard deviation score (SDS) was calculated using reference values for Dutch adults: a mean (SD) of 184.0 (7.1) cm for males and 170.6 (6.5) cm for females [15].

Body Composition

Data on total body fat mass (kg), lean body mass (kg), and percentage of body fat were retrieved from dual energy X-ray absorptiometry (DXA, Lunar Prodigy, GE Healthcare, Madison, WI) (measured in 422 survivors) and assessed as previously described, on the same day as IGF-I measurement. In addition, visceral fat percentage was calculated from intra-abdominal fat (kg) and total fat (kg) using the DXA scan [18]. Values for lean body mass and total fat percentage were compared with normal Dutch reference values and calculated as SDS [19]. WHR and visceral fat percentage were not analyzed in the subset of survivors treated with abdominal radiotherapy because of detrimental local effects on body fat and the frequent occurrence of scoliosis.

Laboratory Assessments

IGF-I was assessed by Immulite 2000 (DPC Biermann GmbH/Siemens, Fernwald, Germany), a solid-phase, enzyme-labeled chemiluminescent immunometric assay, with an intra assay variability of 2–5%, and an inter assay variability of 3–7% [16]. IGF-I levels were compared with reference values by using SDS [20]. In cases where GHD was suspected (i.e., IGF-I below −2 SDS) either insulin tolerance tests or, if contra-indications were present (diabetes mellitus and heart failure), GHRH-Arginine tests were performed [12]. However, only 28 out of the 85 survivors with an IGF-I below −2 SDS were tested for GHD. Eight out of these 28 survivors were tested before 18 years of age because of growth impairment during childhood. One possible reason that only a proportion of the survivors with IGF-I below −2 SDS were tested for GHD is that some endocrinologists are reluctant to treat childhood cancer survivors with growth hormone because of the resultant high recurrence rate [21].

Treatment Groups

Baseline characteristics of the included survivors are shown in Table I. Three hundred and eighty one survivors had been treated with chemotherapy only. Seventy-three subjects, mainly brain tumor survivors, had been treated with cranial irradiation focused on the tumor field (tumor field CRT). Fifty-seven subjects, mainly leukemia survivors, had been treated with irradiation of the whole cranium (CRT). Twenty survivors had received additional irradiation of the spinal cord. In three leukemia survivors both cranial irradiation and total body irradiation (TBI) were administered. The following treatment groups were analyzed separately after excluding survivors that were treated with growth hormone at the time of the study (n = 23): CRT treated leukemia survivors (25 Gy (24–25)), including 57 CRT survivors, plus three survivors that had been treated with CRT and TBI, minus two subjects that received GH therapy at follow-up (n = 58); survivors treated with local irradiation of the cranium (mainly brain tumors) (42 Gy (35–54)) (n = 56); and TBI survivors (8 Gy (8–12)) (n = 21). These three groups were compared separately with all other survivors (n = 452), hereafter, referred to as the not cranially irradiated group.

Confounding Factors

Oral contraceptives can result in lower IGF-I levels, and impaired thyroid function or impaired gonadal function can alter body composition. No subjects were identified with untreated hypothyroidism. Therefore, in our analysis we only adjusted for hypogonadism, represented by oligo- or amenorrhea in women or low testosterone levels in men (<9 nmol/L) and the use of oral contraceptives in women. As previous therapy with corticosteroids may influence body composition, we also adjusted for corticosteroid treatment.

Statistics

All data were expressed as median (interquartile range, IQR) unless specified otherwise. Differences between treatment groups were tested using the Mann–Whitney *U*-test for scaled data and the Chi-squared test or the Fisher's exact test for nominal data. Correlations were tested using partial correlations. Regression analysis was used to correct for possible confounding factors. If no SD scores were available, body composition parameters were adjusted for sex and age. *P*-values are all measured in the two-way classification with $P < 0.05$ considered statistically significant. Statistical analysis was performed using SPSS 17.0 software (SPSS, Chicago, IL).

RESULTS

IGF-I Values

IGF-I SDS of the total group was −0.35 (range −5.55–2.55), which indicates that IGF-I in this group of adult childhood cancer survivors was lower compared to normal subjects. After correction for possible confounders, both cranially irradiated leukemia survivors and brain tumor irradiated survivors had significantly lower IGF-I SDS, as compared to those treated without cranial irradiation ($P < 0.001$) (Table III). No significant difference in IGF-I SDS was found when comparing the TBI/BMT group with the not cranially irradiated group ($P = 0.06$). Compared with not irradiated survivors, the risk of having an IGF-I SDS below −1 is 4.3 times higher in CRT survivors and 3.2 times higher in survivors treated with localized irradiation therapy for brain tumors (OR 4.3 $P < 0.001$ and OR 3.2, $P < 0.001$).

Pediatr Blood Cancer DOI 10.1002/pbc

TABLE I. Details of Diagnosis and Therapy in the Cohort of Studied Adult Childhood Cancer Survivors

	Complete group	No radiotherapy	Radiotherapy					
	N = 610	N = 381	Tumor field CRT (42 Gy (35–54)) N = 73	CRT (25 Gy (24–25)) N = 57	TBI (8 Gy (8–12)) N = 22	CRT & TBI (22 Gy (18–25)) N = 3	Abdominal RT (20 Gy (20–30)) N = 44	Other RT (40 Gy (20–45)) N = 30
	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)
Sex (male) n (%)	344 (56)	211 (55)	51 (70)	30 (53)	14 (64)	2 (67)	19 (43)	16 (53)
Age at diagnosis (yrs)	6 (3–11)	6 (2–12)	10 (7–12)	3 (2–6)	10 (7–12)	4 (3–11)	4 (0–6)	7 (5–11)
Follow-up time (yrs)	18 (13–24)	17 (12–21)	16 (11–25)	25 (21–28)	14 (11–21)	15 (13–29)	29 (24–34)	14 (12–23)
Diagnosis	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
ALL	183 (30)	116 (30)	0	56 (90)[a] 5 (9)	8 (36)	2 (67)	0	1 (3)
AML	20 (3)	10 (3)	0	1 (2)	8 (36)	1 (33)	0	0
T-NHL	6 (1)	5 (1)	1 (2)	0	0	0	0	0
B-NHL	51 (8)	44 (12)	2 (3)	0	3 (14)	0	0	2 (7)
Hodgkin lymphoma	49 (8)	34 (9)	8 (11)	0	1 (5)	0	0	6 (20)
Bone tumor	29 (5)	19 (5)	1 (1)	0	0	0	0	9 (30)
Wilms tumor	70 (12)	37 (10)	0	0	0	0	33 (75)	0
Neuroblastoma	41 (7)	31 (8)	0	0	0	0	8 (18)	2 (7)
Germ cell	12 (2)	12 (3)	0	0	0	0	0	0
MMT	52 (9)	31 (8)	10	0	0	0	2 (5)	9 (30)
LCH	13 (2)	11 (3)	2	0	0	0	0	0
Brain tumor	63 (10)	17 (5)	46 (63)[a] 15 (33)	0	0	0	0	0
Other	21 (3)	14 (4)	3 (4)	0	2 (9)	0	1 (2)	1 (3)
Recurrence (≥1) n (%)	62 (11)	30 (8)	19 (26)	14 (25)	13 (59)	3 (100)	8 (18)	7 (23)
Corticosteroid use n (%)	299 (49)	192 (50)	21 (29)	57 (100)	18 (82)	3 (100)	2 (5)	6 (20)
GH therapy at follow-up n[b]	23	3	17	2	1	—	—	—

ALL, acute lymphoblastic leukemia; AML, acute myeloid leukemia; T-NHL, T-cell non-Hodgkin lymphoma; B-NHL, B-cell non-Hodgkin lymphoma, Burkitt lymphoma; MMT, malignant mesenchymal tumor; LCH, Langerhans cell histiocytosis; CRT, cranial radiotherapy; TBI, total body irradiation; RT, radiotherapy; other RT, radiotherapy not including the cranium, abdomen, and total body irradiation, for example, radiotherapy on the thorax, mediastinum, pelvis, testes, and extremities. [a]Craniospinal radiotherapy. [b]Twenty three survivors received growth hormone therapy at the time of the study and, therefore, were excluded from further analyses.

IGF-I and Growth Hormone Deficiency

Twenty-eight out of the 85 subjects with an IGF-I below −2 SDS were tested with a growth hormone stimulation test, as described earlier (a GHRH-Arginine test was performed in 11 survivors). Seventeen patients were diagnosed with severe GHD by growth hormone stimulation testing, defined as a GH peak <3 μg/L (insulin tolerance test) or <9 μg/L (GHRH-Arginine test) [22], whereas, 11 subjects did not have GHD. The 17 GHD subjects had a median IGF-I SDS of −4.6 (−5.7; −2.3), the 11 non-GHD subjects had a median IGF-I SDS of −3.8 (−5.6; −2.7), ($P = 0.39$).

Final Height and Body Composition

Raw data on height and body composition data of the total cohort are depicted in Table II. Adjusted regression coefficients of the different radiotherapy groups as compared to the not cranially irradiated group are depicted in Table III, which is referred to in the following section. Survivors treated with cranial irradiation and irradiated brain tumor patients had significantly lower height SDS ($P < 0.001$) and higher total fat percentage SDS ($P < 0.001$). Leukemia survivors treated with cranial irradiation had higher BMI ($P < 0.001$), higher WHR ($P < 0.05$), and higher visceral fat percentage ($P < 0.001$) than those treated without radiotherapy. Irradiated brain tumor survivors had a higher total fat percentage and lower lean body mass, than those treated without radiotherapy ($P < 0.05$ and $P < 0.001$, respectively). Survivors treated with TBI had significantly lower height SDS ($P < 0.05$), lower BMI ($P < 0.05$), and lower lean body mass ($P < 0.001$). To correct for TH, the difference between TH SDS and final height SDS was calculated. This was significantly greater in all cranially irradiated groups compared to the not cranially irradiated group ($P < 0.001$).

IGF-I and Body Composition

After correction for possible confounders, in the whole cohort, IGF-I SDS was positively correlated with height SDS (r = 0.23, $P < 0.001$) and lean body mass SDS (r = 0.15, $P = 0.01$); IGF-I SDS was inversely correlated with BMI (r = − 0.12, $P = 0.04$), WHR (r = − 0.15, $P = 0.01$), and total fat percentage SDS (r = − 0.14, $P = 0.02$). Visceral fat percentage, measured by DXA, was not correlated with IGF-I (r = − 0.1, $P = 0.1$). When analyzing only the subgroup that had been treated with cranial irradiation (n = 135), IGF-I SDS was positively correlated with height SDS (r = 0.24, $P = 0.02$) and lean body mass (r = 0.23, $P = 0.03$). IGF-I SDS was not significantly correlated with BMI (r = − 0.07, $P = 0.58$), WHR (r = − 0.1, $P = 0.37$), or total fat percentage (r = − 0.07, $P = 0.51$).

DISCUSSION

The value of IGF-I as a marker for body composition in long-term childhood cancer survivors has not been studied extensively. Here, we show significantly lower IGF-I SDS and altered body composition in subgroups of survivors, that is, ALL survivors treated with CRT and brain tumor survivors treated with local irradiation. However, IGF-I and all measures of body composition are so weakly correlated that the value of IGF-I as a marker for

TABLE II. IGF-I Levels and Body Composition in the Different Radiotherapy Groups Compared to the not Irradiated Group

	Not cranially irradiated survivors Median (IQR)	Tumor field CRT (40 Gy (35–45)) Median (IQR)		CRT (leukemias) (25 Gy (24–25)) Median (IQR)		TBI (8 Gy (8–12)) Median (IQR)	
	N=452	N=56	*P*-value*	N=58	*P*-value*	N=21	*P*-value*
Height SDS	−0.4 (−1.2–0.2)	−1.3 (−2.1–−0.3)	<0.001	−1.6 (−2.–−0.4)	<0.001	−1.1 (−2.–−0.1)	0.02
Target height SDS	0.1 (−0.4–0.7)	0.3 (−0.3–0.5)	0.84	−0.3 (−0.6–0.3)	0.06	−0.1 (−0.6–0.1)	0.18
ΔTH SDS − height SDS	0.6 (0.2–1.2)	1.5 (0.9–2.6)	<0.001	1.5 (0.8–2.2)	<0.001	1.6 (0.3–3.5)	0.03
Body mass index (kg/m^2)	23 (21–25)	24 (21–28)	0.02	26 (23–29)	<0.001	21 (19–22)	0.004
Waist–hip ratio	0.84 (0.8–0.88)	0.88 (0.84–0.92)	<0.001	0.89 (0.86–0.93)	<0.001	0.86 (0–84–0.9)	0.03
Visceral fat percentage (%)	7.4 (6.4–8.6)	7.9 (7–9.3)	0.008	8.6 (7.8–9.6)	<0.001	8.3 (7.2–8.8)	0.04
Total fat percentage SDS	1.2 (0.7–1.8)	1.9 (1.2–2.5)	<0.001	2 (1.4–2.2)	<0.001	1.8 (1.3–2.1)	0.02
Lean body mass SDS	−0.7 (−1.3–0.2)	−1.2 (−2.1 –0.7)	0.005	−1 (−2.–−0.1)	0.04	−2.3 (−3.–−1.9)	<0.001
IGF-I SDS (IQR, range)	−0.28 (−0.9–0.5; −4.9–2.5)	−0.6 (−2.–0; −5.3–2.6)	<0.001	−1.3 (−2.5; −0.7; −5.6–0.5)	<0.001	−0.75 (−1.8–0.11; −2.4–1.2)	0.06
IGF-I SDS ≤ 1	85 (23)	24 (43)	<0.001	35 (60)	<0.001	8 (38)	0.06

SDS, standard deviation score; TH, target height; ΔTH SDS − height SDS, difference between target height SDS and height SDS; IQR, interquartile range. *P-value is calculated using Mann–Whitney U-test for scaled variables and Chi-squared test or Fisher's exact test for nominal variables.

TABLE III. Adjusted Regression Coefficients (95% CI) of IGF-I Levels and Components of Body Composition of the Different Radiotherapy Groups Compared to the not Cranially Irradiated Group (n = 452), Adjusted for Possible Confounders[†]

	Tumor field CRT (42 Gy (35–54))	CRT (25 Gy (24–25))	TBI (8 Gy (8–12))
	N = 56	N = 58	N = 21
Height SDS	−0.8 (−1.2; −0.5)**	−0.7 (−1.1; −0.4)**	−0.7 (−1.3; −0.2)*
ΔTH SDS − height SDS	1.2 (0.8–1.7)**	0.8 (0.4–1.2)**	1.1 (0.5–1.8)**
Body mass index (kg/m^2)	3.7 (−12.2–8.9)	11.9 (6.8–17.2)**	−10.2 (−16.7; −3)*
Waist–hip ratio	0.02 (0 –0.04)	0.04 (0.02 –0.07)*	0.02 (−0.01–0.06)
Visceral fat percentage (%)	−0.2(−0.4–0.8)	1.1 (0.6–1.7)**	0.8 (0–1.6)
Total fat percentage (%) SDS	0.4 (0.1–0.7)*	0.6 (0.3–0.9)**	0.4 (−0.02–0.9)
Lean body mass (kg) SDS	−0.7 (−1.2; −0.3)*	−0.1 (−0.5–0.3)	−1.6 (−2.2; −0.9)**
IGF-I SDS	−0.9 (−1.2; −0.6)**	−1.2 (−1.5; −0.8)**	−0.2 (−0.7–0.4)
IGF-I SDS ≤ 1 (OR, 95% CI)	3.2 (1.7–6)**	4.3 (2.3–8.2)**	1.4 (−0.5–4.1)

SDS, standard deviation score; TH, target height; ΔTH SDS − height SDS difference between target height SDS and height SDS; OR, odds ratio; CI, confidence interval. *$P < 0.05$. **$P < 0.001$. [†]Regression coefficient adjusted for sex, age at diagnosis, follow-up time, recurrence, use of oral contraceptives, and hypogonadism (expressed as testosterone <9 nmol/L (m) or oligo/amenorrhea without OC use (f)). IGF-I SDS and SD scores are adjusted for all these variables minus sex and follow-up time. Height, body mass index, waist hip ratio, visceral fat percentage, total fat percentage, and lean body mass are also adjusted for treatment with corticosteroids.

clinically relevant alterations in body composition has to be considered insufficient.

In this study we assessed the value of IGF-I as a marker for body composition and GHD. Several studies have shown that IGF-I is the best marker for GH secretory status [23–25]. For this reason, it was initially assumed that IGF-I would also be predictive in the diagnosis of GHD, and therefore IGF-I was used as screening instrument in adult childhood cancer survivors. Our data showed that more than 60% of the 28 survivors that were tested for GHD turned out to be severely GH deficient, leading us to conclude that low IGF-I is a useful screening instrument. Indeed, pathologically low IGF-I levels (below −2 SDS) have been reported to be a sensitive screening marker, especially in young adults with severe GHD [26]. However, low IGF-I levels do not always represent GHD, because IGF-I levels are dependent upon many other states, such as thyroid function, insulin action, nutritional status, or chronic disease and, therefore, do not fully represent GH status [27]. Furthermore, it is known that IGF-I levels can be artificially normal after CRT treatment because of neurosecretory dysfunction [27] and therefore, the general consensus guideline for adult GHD screening prescribes a mandatory GH stimulation test in cases of clinically suspected GHD [12].

Previous studies in childhood ALL survivors have shown that low IGF-I levels associate with high BMI, high total and visceral fat percentage, and low lean body mass [6,13–14]. BMI is often used to quantify the level of obesity; however, it is known to be only a crude indicator of body fat mass [28–31]. High amounts of total body fat, high visceral fat percentage, and low lean body mass are more accurate markers for true body composition and subsequently are more reliable as risk factors for the development of cardiovascular disease or diabetes mellitus [28–31]. Our study in a large heterogeneous group of adult childhood cancer survivors, confirms that there is a significant negative correlation between IGF-I levels and BMI, WHRs and total fat percentage, and a positive correlation with lean body mass. However, if we focus on the subgroups that had been treated with cranial irradiation, IGF-I SDS showed a stronger positive correlation with lean body mass, whereas, the other measures of body composition were not correlated with IGF-I SDS. However, the correlation coefficients were very weak, meaning that only 2–5% of the change in body composition is explained by low IGF-I levels.

According to the national guidelines of screening for late effects as implemented by the DCOG, routine measurement of IGF-I levels was omitted, except in groups that are at high risk for GHD, that is, CRT treated ALL survivors and locally irradiated brain tumor survivors [32]. Whereas, low IGF-I levels can guide us to test for GHD, normal IGF-I levels, especially after CRT treatment, do not exclude GHD. Therefore, we recommend that routine IGF-I measurement in these groups be replaced with regular assessment of an insulin tolerance test, which is the gold standard test for GHD. Furthermore, because IGF-I is not a useful marker for clinically relevant alterations in body composition, DEXA scans are recommended in risk groups, as defined in the current study, to assess fat mass and lean body mass.

In this large study we evaluated BMI and body composition in different treatment groups and concluded that after CRT treatment BMI, total fat percentage, WHR, and visceral fat percentage, which is a major risk factor for cardiovascular morbidity, were significantly raised in comparison with not cranially irradiated survivors. Lean body mass was not significantly different. This finding is in agreement with earlier smaller studies in ALL survivors which showed higher BMI, higher total and visceral fat percentage in CRT survivors, in combination with lower lean body mass, which was not found in our CRT survivors [13–14]. This is the first study to measure body composition in a large group of irradiated brain tumor survivors, whereas, most of the previous studies on body composition are in ALL survivors. Alterations in body composition were represented by higher total fat percentage and lower lean body mass, without significantly higher BMI. Gurney et al. [6] showed that brain tumor survivors treated with high dose radiotherapy of the hypothalamus had increased BMI. We did not find raised BMI in irradiated brain tumor survivors, which might be explained by the fact that we did not make a distinction between hypothalamic and non-hypothalamic irradiation.

CONCLUSION

This study shows that IGF-I is not of additional value for identifying subjects at risk for alterations in body composition. Patients who had cranial irradiation had higher total fat percentage and lower lean body mass than patients not treated with cranial ìrradiation.

ACKNOWLEDGMENT

We would like to thank Dr. Patric Delhanty and Mrs. Rina de Wolff for their support in English writing.

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