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Paediatric CT Practice - How safe is imaging in different countries?

The Dutch study on leukaemia and brain tumours due to radiation exposure from paediatric computed tomography (CT) scans

JM Meulepas[1], CM Ronckers[2], RAJ Nievelstein[3], AM Smets[4], A Jahnen[5], C Lee[6], M Kieft[1], JS Lameris[4], M van Herk[7], MJW Greuter[8], CR Jeukens[9], M van Straten[10], O Visser[11], FE van Leeuwen[1], M Hauptmann[1]*

1 Department of Epidemiology and Biostatistics, Netherlands Cancer Institute, Amsterdam, The Netherlands; 2 Department of Paediatric Oncology, Emma Children's Hospital, Academic Medical Center Amsterdam, The Netherlands
3 Department of Paediatric Radiology, Wilhelmina Children's Hospital, University Medical Center Utrecht, The Netherlands; 4 Department of Radiology, Academic Medical Center Amsterdam, The Netherlands
5 Public Research Center Henri Tudor, Luxembourg; 6 Radiation Epidemiology Branch, Division of Cancer Epidemiology and Genetics, National Cancer Institute, USA
7 Department of Radiation Oncology, Netherlands Cancer Institute, Amsterdam, The Netherlands; 8 Department of Radiology, University of Groningen, University Medical Center Groningen, The Netherlands
9 Department of Radiology, Maastricht University Medical Center, Maastricht, The Netherlands; 10 Department of Radiology, Erasmus MC University Medical Center, Rotterdam, The Netherlands
11 Department of Registration and Research, Comprehensive Cancer Centre Netherlands, Utrecht, The Netherlands
*Corresponding author: **Dr. M. Hauptmann,** Netherlands Cancer Institute, Department of Epidemiology and Biostatistics, Plesmanlaan 121, 1066 CX, Amsterdam; **Contact: m.hauptmann@nki.nl**, Telephone +31 20 512 1047

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The Dutch Paediatric CT Study is an ongoing nationwide retrospective record-linkage cohort study regarding the risk of leukaemia and brain tumours due to radiation exposure from paediatric CT scans.

1. Objectives

» Risk of leukaemia and brain tumours from paediatric CT scans
» Patterns of CT scan use and associated radiation dose in Dutch children in the past decade

2. Plan of Investigation

Design: nationwide retrospective record-linkage cohort study

Population: children with ≥ 1 electronically archived CT scan in a Dutch hospital at age 0-17 years and cancer free at first scan

Exposure: bone marrow dose and brain dose from CT scans

Outcome: incidence of leukaemia and brain tumours following first CT scan

3. Data collection

Information will be obtained from radiology departments of all 59 Dutch hospitals regularly performing paediatric CT scans covering the calendar period since the introduction of digital archiving until 2012. For each archived paediatric CT scan, date of examination, scanned body part and the radiologist's report, as well as technical parameters for organ dose estimation will be collected. We expect to enrol more than 100,000 children with about two CT scans per child on average.

The data collection to date:

	Patients	CT scans	Period
Academic hospitals (N=8)	73,706	137,851	1979-2013
General hospitals (N=5)	19,047	23,427	1988-2013
Total	**92,753**	**161,278**	**1979-2013**

Cancer incidence through 2012 will be obtained by record-linkage with the Netherlands Cancer Registry. Information on potential confounders such as socioeconomic status, congenital disorders, familial cancer syndromes and leukemogenic conditioning prior to bone marrow transplantation will be obtained by linkage with Statistics Netherlands (CBS), EUROCAT, a population-based registry of congenital anomalies, and the European Bone Marrow Transplant Registry (EBMT). First results are expected towards the end of 2014.

Preliminary results based on data obtained from one large academic hospital (AMC Amsterdam) are presented in Tables 1 and 2. About 15% of children received 3-10 CT scans, while about 1% received more than 10 scans (Table 2). Actual numbers will be slightly larger since some of those children might have had CT scans in other hospitals as well, which will eventually be linked.

We estimated doses to the bone marrow and the brain for 249 CT scans on 230 randomly selected patients from the AMC Amsterdam. These were stratified by calendar year in order to represent different time periods. Organ dose estimation was based on age- and sex-specific computational human phantoms coupled with Monte Carlo radiation transport simulations [Lee et al. 2011, Lee et al. 2012]. Estimated bone marrow dose averaged 4.3 mGy per series (range, 1.8-8.0), average brain dose per series was 8.7 mGy (range, 2.5-16.9) (Table 3). For risk analyses, cumulative doses will be used which sum series-specific organ doses over all series and scans received.

4. Radiation protection

The findings of this nationwide retrospective record-linkage study will be of great interest for radiation protection purposes and will provide empirical evidence to suitably inform doctors, patients and their parents whenever a CT scan is considered. Moreover, the results will be informative for clinical guidelines and protocols on diagnostic imaging.

Table 1: Characteristics of 12,456 patients from the Academic Medical Center Amsterdam who received at least one CT scan in the period 1983-2012 while under the age of 18 years.

Body part	Male		Female		All	
	N	%	N	%	N	%
Head & neck	8776	66.2	6456	63.2	15241	64.9
Chest	1808	13.6	1345	13.2	3153	13.4
Extremities	911	6.9	969	9.5	1880	8.0
Abdomen & pelvis	1007	7.6	840	8.2	1847	7.9
Spine	548	4.1	434	4.3	983	4.2
Miscellaneous/Unknown	207	1.6	174	1.7	381	1.6

Table 2: Number of CT scans by sex and body part among 12,456 patients from the Academic Medical Center Amsterdam who received at least one CT scan in the period 1983-2012 while under the age of 18 years.

	Male		Female		All	
	N	%	N	%	N	%
Age at first scan (yr)						
<1	1161	16.8	888	16.1	2050	16.5
1-4	1262	18.2	918	16.7	2182	17.5
5-9	1534	22.1	1075	19.5	2611	21.0
10-14	1636	23.6	1452	26.3	3092	24.8
15-18	1339	19.3	1182	21.4	2521	20.3
Number of CT scans						
1	4526	65.3	3656	66.3	8190	65.8
2	1208	17.4	972	17.3	2181	17.5
3-10	1108	16.0	831	15.1	1939	15.6
11-20	63	0.9	34	0.6	128	1.1
>20	10	0.1	8	0.2	18	0.2
Calendar year of first recorded CT scan[1]						
1984-1987	312	5.2	269	4.9	583	4.7
1988-1991	586	13.6	435	7.9	1021	8.2
1992-1995	994	14.4	743	13.5	1739	14.0
1996-1999	913	16.5	665	15.2	1579	15.9
2000-2003	982	14.2	750	13.6	1733	13.9
2004-2007	1253	18.1	1032	18.7	2285	18.3
2008-2011	1613	23.3	1394	25.3	3008	24.2

[1]Calendar years 1983 and 2012 not shown because these calendar years were not complete.

Table 3: Estimated radiation doses to the red bone marrow (RBM) and the brain by scan type and age at CT scan for 150 series with sufficient data from 249 paediatric CT scans[1].

		RBM dose *(mGy)*				Brain dose *(mGy)*			
	N	Mean	Range			Mean	Range		
Head CT									
< 1 yr	5	4.5	1.0	-	7.7	11.9	3.1	-	21.3
1 -< 2.5 yr	11	4.9	1.6	-	11.4	13.6	4.4	-	32.1
2.5 -< 7.5 yr	14	6.3	3.0	-	15.8	18.0	8.2	-	47.7
7.5 -< 12.5 yr	28	7.0	2.1	-	13.3	28.7	10.4	-	52.3
12.5 -< 16.5 yr	33	5.0	0.7	-	10.7	24.9	3.6	-	51.0
16.5 yr -< 18 yr	14	4.5	0.8	-	7.4	22.6	3.9	-	29.0
Chest CT									
< 1 yr	9	2.1	1.5	-	3.6	1.1	0.2	-	2.6
1 -< 2.5 yr	4	2.1	1.8	-	2.6	0.2	0.1	-	0.2
2.5 -< 7.5 yr	4	4.4	3.5	-	5.3	0.3	0.2	-	0.4
7.5 -< 12.5 yr	7	2.9	0.8	-	5.3	0.2	0.0	-	0.4
12.5 -< 16.5 yr	2	2.3	1.4	-	3.1	0.1	0.1	-	0.2
16.5 yr -< 18 yr	5	2.4	1.4	-	4.6	0.1	0.0	-	0.2
Abdomen-pelvis CT									
< 1 yr	-	-	-	-	-	-	-	-	-
1 -< 2.5 yr	-	-	-	-	-	-	-	-	-
2.5 -< 7.5 yr	4	3.8	1.9	-	6.5	0.1	0.0	-	0.2
7.5 -< 12.5 yr	4	6.6	3.9	-	12.2	0.2	0.0	-	0.5
12.5 -< 16.5 yr	-	-	-	-	-	-	-	-	-
16.5 yr -< 18 yr	-	-	-	-	-	-	-	-	-
Head-chest-abdomen-pelvis CT									
< 1 yr	-	-	-	-	-	-	-	-	-
1 -< 2.5 yr	-	-	-	-	-	-	-	-	-
2.5 -< 7.5 yr	-	-	-	-	-	-	-	-	-
7.5 -< 12.5 yr	-	-	-	-	-	-	-	-	-
12.5 -< 16.5 yr	6	6.4	2.2	-	10.0	9.0	3.1	-	15.0
16.5 yr -< 18 yr	-	-	-	-	-	-	-	-	-

[1]Empty cells represent types of scans that are relatively rare in the respective age groups, and as such were not represented in this small pilot study.

Poster References:

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