CT scans and risk of haematological cancer - Questions and answers

What are the key findings of the EPI-CT study (Bosch de Basea et al., 2023) regarding the association between CT radiation exposure and blood cancers?

We analysed data from 876,771 individuals from the EPI-CT cohort who underwent at least one CT scan before the age of 22, of whom 790 blood cancer cases were identified. The results show a **clear association between the total radiation doses** to the bone marrow from CT scans and the **risk of developing both myeloid and lymphoid malignancies**. A dose of 100 mGy[1] increased the risk of developing a blood cancer by a factor of about 3. These results suggest that a typical scan today (with an average bone marrow dose of about 8 mGy) increases the risk of developing these malignancies by **about 16%**. In terms of absolute risk, this means that, for **every 10,000 children** who have a CT scan, we can expect **one or two** of them to develop a haematological malignancy related to the CT dose in the 12 years following the examination

Our results strengthen the body of evidence of increased cancer risk at low radiation doses and highlight the importance of the clinical justification of paediatric CT examinations and optimisation of doses.

What are the potential implications of your findings for medical practice, especially in paediatric radiology? Should we stop doing CT scans? What steps can be taken to minimise the associated risks?

Despite the clear clinical benefits of CT scan imaging, there is broad agreement that it can be overused and not always justified, particularly in the early years of this technology. The trade-off of the valuable information provided by CT scan imaging seems to be a small but non-negligible risk of cancer, including blood cancers as shown in this paper. The data suggest that this risk is cumulative over time. Therefore, it is critical to avoid unnecessary radiation exposure and, when needed, it is paramount that children are exposed to the smallest amount possible of radiation during the CT scanning.

Regarding paediatric radiology, there has been much progress in the last decade in this area: radiation doses in paediatric radiology have generally been going down with the introduction of examination protocols targeted to children of different sizes and ages and emphasis on avoiding unnecessary procedures.

It is important that this trend continues; this involves:

- clinical training on referral guidelines and alternative imaging techniques
- family/patient education,
- making available clinical decision support tools

[1] The gray or Gy is the official unit *for absorbed dose which measures the amount of ionising radiation that has been* absorbed by any material.

- implementing dose recording after any procedure involving ionising radiation and the monitoring of cumulative doses

In addition, the Image Gently Campaign is promoting optimal scanning strategies for children based on:

- Clear clinical justification,
- Use of size-adapted protocols to paediatric patients to reduce radiation exposure
- Scanning of the indicated area and avoidance of multiple scans
- Exposure limited to the minimum required to acquire the necessary information
- Use of alternative imaging procedures when possible (i.e. ultrasound or MRI)

What is the radiation dose that a person receives from a CT scan?

According to the Image Gently campaign, an educational and awareness campaign created by the Alliance for Radiation Safety in Pediatric Imaging, we all are exposed to small amounts of radiation daily from soil, rocks, building materials, air, water, and cosmic radiation. This is called 'naturally occurring background radiation'. The radiation used in CT scans has been compared to background radiation we are exposed to daily. This comparison may be helpful in understanding relative radiation doses to the patient.

Radiation source	**Equivalent time of background radiation**
Chest X-ray (single)	1 day
Head CT scan	Up to 8 months
Abdominal CT scan	Up to 20 months

CT studies can provide critical information for the care of your child, but obtaining the images results in higher exposure than a single X-ray.

Why does exposure to ionising radiation during childhood entail a higher risk than during adulthood?

Epidemiological studies show that children are more sensitive to radiation than adults, specifically with higher risk of cancers including leukaemia, brain, breast, skin, and thyroid cancers following exposures in childhood. In part, this is because of the radiosensitivity of their developing organs and tissues. Also, the longer post-exposure life expectancy increases the lifetime risks of developing radiation-induced malignancies (Kutanzi et al, 2016).

What is the message to the parents?
Parents need to know that CT imaging is a potential life saving tool for diagnosing illness and injury in children. As stated by the US National Cancer Institute, "for an individual child, the risks of CT are small and the individual risk-benefit balance favours the benefit when used appropriately." This is applicable to the blood cancer risks estimated in this paper. However, as presented by the Image Gently campaign: "If parents have concerns regarding radiation exposure to their children, they should first talk to the physician who

is requesting their children's exams. The referring doctor and the radiologist can work together on decisions about which study is best to perform". If parents still have questions, they should ask to speak to the radiologist to be informed on what strategies are in place in the clinical setting to reduce excessive exposure while preserving diagnostic accuracy and help them make informed decisions about their children's health care.

What does this study add to the existing evidence?

The results of this study strengthen the findings from previous low dose studies of a consistent and robust dose-related increased risk of radiation-induced haematological malignancies.

What was known previously

Exposure to moderate (≥100 mGy) to high doses (≥1Gy) of ionising radiation is a well-established risk factor for cancer in general and leukaemia in particular, both in children and adults. However, the risk associated with exposure of children, adolescents and young adults to low doses (under 100 mGy), which is the range typically associated with CT, has been the subject of debate for decades.

While many studies on the effect of medical, environmental and occupational exposures have reported increased risks of blood cancers (mainly leukaemia and lymphoma) in the low radiation dose range, they have been criticised because of potential biases and uncertainties.

What the study adds

The EPI-CT study is the first large-scale multi-centre study designed to directly estimate the risk of haematological malignancies associated with ionising radiation exposure from CT examinations during childhood, adolescence and young adulthood, addressing previous criticisms related to dosimetry, statistical power and potential biases. The size of the study (nearly one million patients) has considerably increased the statistical power compared to previous national studies. The individual organ dose estimation approach, characterising uncertainty associated with missing imaging parameters, as well as the focus on potential biases that may challenge the validity of risk estimates, greatly contribute to the reliability of the results.

Why is this study important?

The study is relevant because over 1 million children undergo computed tomography (CT) scans each year in Europe. Additionally, given the fact that CT imaging accounts for the majority of the total radiation exposure from medical applications and has a significant contribution in the average radiation exposure per capita in Western countries, it is important to adequately quantify the risk of radiation-induced deleterious effects. Herein lies the underlying rationale of the EPI-CT study. Haematological malignancies were selected as the outcome under study based on two main reasons: the incidence of this type of cancers in children and the fact that the bone marrow, where blood cells are produced, is very sensitive to radiation.

How can these findings influence policies related to paediatric CT scans?

Unlike exposures in occupational and environmental settings, it is not appropriate to apply dose limits or dose constraints to medical radiation exposures, since these would often do more harm than good. As stated by the International Commission on Radiological Protection, "Often, there are concurrent chronic, severe, or even life-threatening medical conditions that are more critical than the radiation exposure."

The EPI-CT results, together with previous findings, reinforce the need to continue to apply the principle of optimisation to ensure that doses are as low as reasonably achievable (ALARA), that unproductive exposure is avoided, and that the benefit to risk ratio is maximised for all CT examinations (ICRP 2007). “In order to optimise the risk-benefit ratio, organ dose exposure and image quality parameters have to be determined and documented in a way that does not add to the workload of the clinicians, and dose evaluation should ideally be patient-specific, equipment-specific and protocol-specific” (MEDIRAD, 2022).

A helpful tool for this would be the establishment at the European level of diagnostic reference levels and image quality reference levels for each indication and procedure, as recommended by the Medical Imaging guidelines of the European Commission. Further, because effects of exposures are thought to be cumulative, recording and monitoring of the ionising radiation doses received by both paediatric and adult patients is desirable. This can be in the form of dose registries or of radiation “passports”. In most countries, close monitoring is currently applicable only to occupational settings, where workers may be exposed to doses near or above the recommended limit. Experiences in hospitals in Spain, for example, show the beneficial impact of tracking radiologic procedures and radiation doses for individual patients.

How was the study conducted?

The EPI-CT cohort includes nearly 1 million persons who underwent at least 1 CT examination before the age of 22 years in one of the 276 participating hospital radiology departments from Belgium, Denmark, France, Germany, the Netherlands, Norway, Spain, Sweden and the UK.

For each patient, information from the radiological department records was used to reconstruct their history of CT scans and estimate their radiation dose to the bone marrow for each examination. The bone marrow was selected as it is the main tissue responsible for the production of blood cells. Over a person’s lifetime, radiation-induced mutations in the DNA of these cells may eventually lead to blood cancers.

By linking the EPI-CT cohort to national and regional mortality and cancer registries in a way which maintained the confidentiality and security of the patients’ data, the researchers were able to evaluate whether those who developed a blood cancer tended to be those who received higher radiation doses.

The study was approved by the ethics committee at the International Agency for Research on Cancer (coordinating centre), and the appropriate national, regional and hospital ethics committees in participating countries before starting the epidemiological study. This was a record linkage study with no contact with individual patients.

Sources

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Additional resources

- EUROSAFE Imaging http://www.eurosafeimaging.org/ask-eurosafe-imaging/tips-tricks/paediatric-imaging