Radiation Risk Communications and Conversations: Providing Care or Promoting Scare?

Donald P. Frush, MD, FACR FAAP

Duke University Medical Center

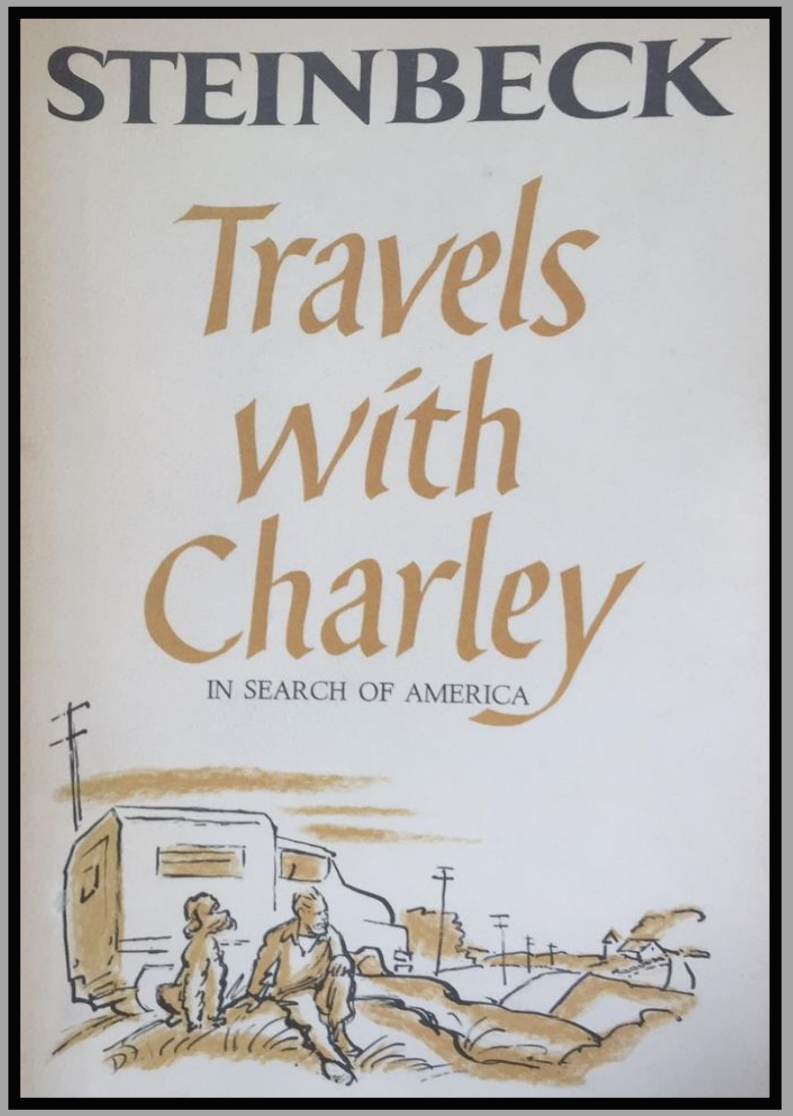
No Disclosures

- **No risk discussion, but…**
- **Landscape**
  - **What is said**
  - **What is heard**
- **Messaging**

- No risk discussion, but…
- **Landscape**
  - **What is said**
  - **What is heard**
- Messaging

Facts

- Radiation in diagnostic imaging is a “hot” topic
- Public and caregivers remain concerned
- There is mis-information
- The “harm and alarm” voice is loud



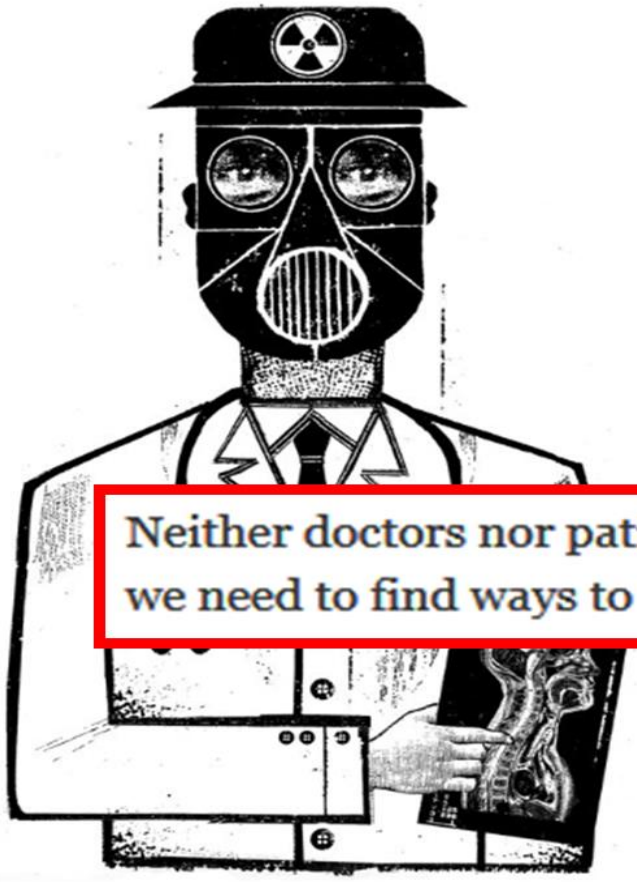
“We value virtue but do not discuss it. The honest bookkeeper, the faithful wife [or husband], the earnest scholar get little of our attention compared to the embezzler, the tramp, the cheat.”

Page 164
John Steinbeck 1961

The Opinion Pages | OP-ED CONTRIBUTORS

We Are Giving Ourselves Cancer

By RITA F. REDBERG and REBECCA SMITH-BINDMAN JAN. 30, 2014



Ben Jones

DESPITE great strides in prevention and treatment, cancer rates remain stubbornly high and may soon surpass heart disease as the leading cause of death in the United States. Increasingly, we and many other experts believe that an important culprit may be our own medical practices: We are silently irradiating ourselves to death.

The use of medical imaging with high-dose radiation — CT scans in particular — has soared in the last 20 years. Our resulting exposure to medical radiation

Neither doctors nor patients want to return to the days before CT scans. But we need to find ways to use them without killing people in the process.

radiation doses of CT scans (a series of X-ray images from multiple angles) are 100 to 1,000 times higher than conventional X-rays.

Of course, early diagnosis thanks to medical imaging can be lifesaving. But there is distressingly little evidence of

Children's Hospitals Cut Down On CT Scans To Prevent Cancer

A new study shows a major drop in uses of the risky procedure.

Joe Satran
Staff Writer, The Huffington Post

Posted: 08/31/2015 07:31 PM EDT

CREDIT: ADELE STARR/ASSOCIATED PRESS

Children's hospitals have cut down on the number of CT scans performed in recent years.

When your children are sick, it's hard not to want doctors to do everything in their power to cure them. But when it comes to CT scans, less is often more.

That's because CT scanners -- which use X-rays to produce richly detailed images of almost any part of the body -- deliver far higher doses of dangerous ionizing radiation than any other

http://www.huffingtonpost.com/entry/childrens-hospitals-ct-scans-study_55df8791e4b0c818f6175b69

Radiologist: "As many as 1 in 300 children who get a CT scan of the abdomen, chest or spine will eventually develop a tumor as a result of the radiation..."

And, from USA accreditation authority in 2016 "...consensus opinion that ... there is harm at low doses"

Consumer Reports: Surprising Dangers of CT Scans and X-rays ...

RADIATION RISKS

The surprising dangers of CT scans and X-rays

Patients are often exposed to cancer-causing radiation for little medical reason, a Consumer Reports investigation finds

Published: January 27, 2015 06:00 AM

When James Duncan, M.D., a radiologist at Washington University in St. Louis, experienced intense pain in his abdomen in 2010, he rushed to a local emergency room. His doctors suspected kidney stones, but they wanted to be sure, so they ordered a CT scan. Duncan remained motionless as the machine captured a detailed, 3D image of his abdomen. He knew that the test was done when the machine stopped whirring. So he was surprised when the scanner kicked back on after a few seconds.

"I later learned that the technician running the CT mistakenly believed that the first scan didn't include the top of my kidneys, and decided to acquire more images 'just to be sure,' " Duncan says. "The irony: I was getting ready to give a lecture on reducing radiation exposure from medical imaging. And there I was, reluctantly agreeing to a CT scan and then getting overexposed."

Duncan will never know whether that specific scan caused any long-term harm, because it's almost impossible to link radiation exposure from any one medical test to a future illness. But like other researchers, he knows that doctors today order millions of radiation-based imaging tests each year, that many of them are unnecessary, and that the more radiation people are exposed to, the greater their lifetime risk of cancer.

"that about one-third of those scans serve little if any medical purpose"

Pediatr Radiol (2015) 45:465–470
DOI 10.1007/s00247-014-3198-3

COMMENTARY

ALARA, Image Gently and CT-induced cancer

Mervyn D. Cohen

Received: 9 August 2014 / Accepted: 28 September 2014 / Published online: 14 February 2015

Introduction

The term As Low As Reasonably Achievable (ALARA) goes back to articles in 1980, 1986 and 1999 [1–3]. In 2001, a group of inspired pediatric radiologists introduced the ALARA concept into routine clinical radiology practice [4–7]. The ALARA and the Image Gently campaigns have been very successful in achieving their goals of reducing unnecessary imaging and radiation exposure, inspiring the development of new technology, and expanding our understanding of measuring radiation dose in humans [6–15].

ALARA and Image Gently evolved from a belief that even

incidence from the survivors of the atom bo
can be extrapolated back in a linear fashion t
cancer risk from tiny radiation doses. This
threshold exists for cancer risk from radiation
linear no threshold theory. With new data fro
survivors, this linear no threshold theory is b
challenged [16–20]. Finally, I will discuss re
logical studies that have linked CT to cancer.
must be interpreted with great caution. I wil
pediatric radiologist with information regardi
nesses in these studies that they can share
parents and referring physicians.

Table 1 Media comments on the 2012 Pearce Lancet article, "Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study" [32]

"CT scans in kids linked to leukemia, brain cancer risk"
ABC World News, June 6, 2012

"CT scans increase children's cancer risk, study finds"
New York Times, June 6, 2012

"CT scans boost cancer risks for kids"
National Public Radio (NPR), June 7, 2012

"CT scans warning after study claims too many could lead to brain cancer"
Guardian newspaper (UK), June 6, 2012

"CT scans can triple the risk of children getting leukemia"
The Times Newspaper (London), June 7, 2012

"CT scans could triple risk of a brain tumour in children"
The Telegraph Newspaper (London), June 7, 2012

"Multiple CT scans on children can increase risk of developing cancer"
BBC News, 7 June 7, 2012

"CT scans on children could triple brain cancer risk'"
BBC News, June 6, 2012

"CT scans in children raise risk of cancer"
American Cancer Society, June 7, 2012

"Multiple CT scans in kids triples cancer risk, but researchers caution overall risk low"
CBS News' June 7, 2012

"Child CT scans could raise cancer risk slightly"
USA Today, June 6, 2012

"Childhood CT scans may raise brain cancer, leukemia risks slightly"
Huffington Post, June 6, 2012

"NIH study finds childhood CT scans linked to leukemia and brain cancer later in life"
National Institute of Health NIH News, June 7, 2012

"Child CT scans may up risk of brain cancer, leukemia"
U.S. News and World Report, June 7, 2012

"Children's CT scans pose cancer risk"
Wall Street Journal, June 7, 2012

www.sportsgamesrules.com

CT Scans May Reduce Rather than Increase the Risk of Cancer

Bobby R. Scott, Ph.D.
Charles L. Sanders, Ph.D.
Ron E. J. Mitchel, Ph.D.
Douglas R. Boreham, Ph.D.

ABSTRACT

Extrapolating from data on atomic bomb survivors on the basis of the linear no-threshold (LNT) model as applied to radiation exposure, a recent paper concludes that within a few decades 1.5–2 percent of all cancers in the U.S. population could be caused by current rates of use of computed tomography (CT). This paper ignores the other war-related exposures of the Japanese population, which would be expected to shift the dose-response relationship for cancer induction to the left. Moreover, the LNT model is shown to fail in four tests involving low-dose radiation exposures. Considering the available information, we conclude that CT scans may reduce rather than increase lifetime cancer risk.

Introduction

In a Nov 29, 2007, article in the *New England Journal of Medicine*[1] Brenner and Hall argue that the potential carcinogenic effects from using computed tomography (CT) may be underestimated and that one-third of all CT scans performed in the United States may not be medically necessary. They estimated that more than 62 million CT scans per year are currently done in the United States as compared to 3 million in 1980.[1] With such an increased rate Brenner and Hall speculate, based on extrapolations from cancer data derived from survivors of the atomic bombings in defenses. This effect has been called radiation activated natural protection (ANP).[2] Radiation ANP includes selective removal of aberrant cells (e.g., precancerous cells) via apoptosis and stimulated immunity against cancer cells. Thus, radiation ANP can prevent some cancers (sporadic and hereditary) that would otherwise occur in the absence of radiation exposure.[3]

Recent papers by Bauer[4] and by Portess et al.[5] describe how low-dose radiation activates the selective removal of precancerous cells via apoptosis. The selective removal is mediated via intercellular signaling involving reactive oxygen and nitrogen species and specific cytokines (e.g., transforming growth factor ß).

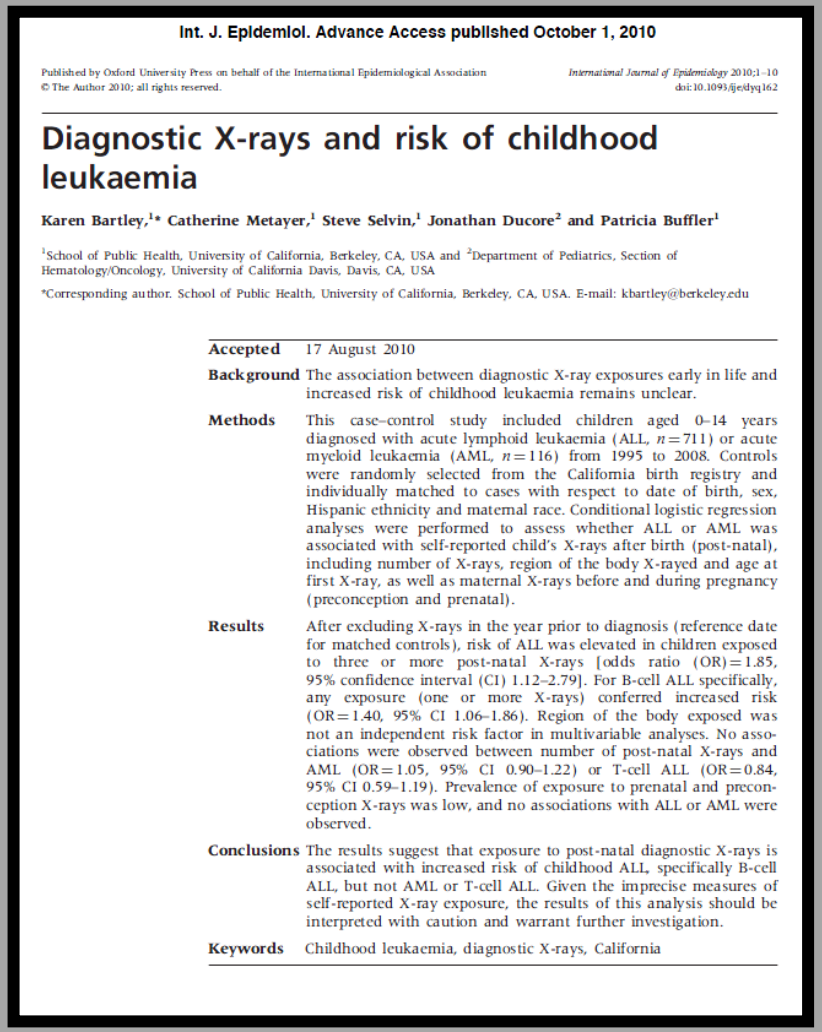
Numerous papers have been published related to low-dose radiation stimulating immunity against cancer cells.[6-8] Because of radiation ANP, low doses and low dose-rates of x-rays and gamma rays can actually reduce rather than increase cancer occurrences.[3] Conversely, high radiation doses suppress immunity and inhibit selective removal of aberrant cells via apoptosis, leading to an increase in the number of cancer cases to a rate greater than the spontaneous level.[3,6-8]

Extrapolating Observed Radiation Effects from High to Low Doses

In order to obtain lifetime cancer risk predictions from small radiation doses such as those received from CT scans, many researchers extrapolate the risk from observed effects after moderate and high radiation doses using the LNT model. With this model, any amount of radiation is considered to cause some cancer fatalities in any large irradiated population. Doubling the radiation

Journal of American Physicians and Surgeons Volume 13 Number 1 Spring 2008

“Risk of ALL was elevated in children exposed to three or more post natal x-rays…”



Int. J. Epidemiol. Advance Access published October 1, 2010

Published by Oxford University Press on behalf of the International Epidemiological Association

International Journal of Epidemiology 2010;1–10
doi:10.1093/ije/dyq162

Diagnostic X-rays and risk of childhood leukaemia

Karen Bartley,[1]* Catherine Metayer,[1] Steve Selvin,[1] Jonathan Ducore[2] and Patricia Buffler[1]

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Accepted 17 August 2010

Background The association between diagnostic X-ray exposures early in life and increased risk of childhood leukaemia remains unclear.

Methods This case–control study included children aged 0–14 years diagnosed with acute lymphoid leukaemia (ALL, $n=711$) or acute myeloid leukaemia (AML, $n=116$) from 1995 to 2008. Controls were randomly selected from the California birth registry and individually matched to cases with respect to date of birth, sex, Hispanic ethnicity and maternal race. Conditional logistic regression analyses were performed to assess whether ALL or AML was associated with self-reported child's X-rays after birth (post-natal), including number of X-rays, region of the body X-rayed and age at first X-ray, as well as maternal X-rays before and during pregnancy (preconception and prenatal).

Results After excluding X-rays in the year prior to diagnosis (reference date for matched controls), risk of ALL was elevated in children exposed to three or more post-natal X-rays [odds ratio (OR) = 1.85, 95% confidence interval (CI) 1.12–2.79]. For B-cell ALL specifically, any exposure (one or more X-rays) conferred increased risk (OR = 1.40, 95% CI 1.06–1.86). Region of the body exposed was not an independent risk factor in multivariable analyses. No associations were observed between number of post-natal X-rays and AML (OR = 1.05, 95% CI 0.90–1.22) or T-cell ALL (OR = 0.84, 95% CI 0.59–1.19). Prevalence of exposure to prenatal and preconception X-rays was low, and no associations with ALL or AML were observed.

Conclusions The results suggest that exposure to post-natal diagnostic X-rays is associated with increased risk of childhood ALL, specifically B-cell ALL, but not AML or T-cell ALL. Given the imprecise measures of self-reported X-ray exposure, the results of this analysis should be interpreted with caution and warrant further investigation.

Keywords Childhood leukaemia, diagnostic X-rays, California

Lancet June 2012
First direct assc of CT and cancer

Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study

Mark S Pearce, Jane A Salotti, Mark P Little, Kieran McHugh, Choonsik Lee, Kwang Pyo Kim, Nicola L Howe, Cecile M Ronckers, Preetha Rajaraman, Sir Alan W Craft, Louise Parker, Amy Berrington de González

Summary

BMJ

BMJ 2013;346:f2360 doi: 10.113

Cancer risk
tomography
linkage stud

OPEN ACCESS

John D Mathews *epid*
Martin W Butler *data a*
G Giles *epidemiologis*
Tenniel A Guiver *data*
Dowty *research fellow*

BJC

FULL PAPER

British Journal of Cancer (2014), 1–7 | doi: 10.1038/bjc.2014.103

Keywords: computed tomography; radiation-induced cancer; brain tumour; leukaemia; cohort study

Paediatric head CT scan and subsequent risk of malignancy and benign brain tumour: a nation-wide population-based cohort study

W-Y Huang[1,2], C-H Muo[3], C-Y Lin[4], Y-M Jen[1], M-H Yang[2,5], J-C Lin[1], F-C Sung[3,6] and C-H Kao*[,6,7]

[1]Department of Radiation Oncology, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan; [2]Institute of Clinical Medicine, National Yang-Ming University, Taipei, Taiwan; [3]Management Office for Health Data, China Medical University Hospital, Taichung 404, Taiwan; [4]Department of Radiation Oncology, Chang Gung Memorial Hospital, Taoyuan, Taiwan; [5]Division of Hematology-Oncology, Department of Medicine, Taipei Veterans General Hospital, Taipei, Taiwan; [6]Graduate Institute of Clinical Medicine Science and School of Medicine, College of Medicine, China Medical University, Taichung, Taiwan and [7]Department of Nuclear Medicine and PET Center, China Medical University Hospital, Taichung, Taiwan

Background: To evaluate the possible association between paediatric head computed tomography (CT) examination and increased subsequent risk of malignancy and benign brain tumour.

Methods: In the exposed cohort, 24 418 participants under 18 years of age, who underwent head CT examination between 1998 and 2006, were identified from the Taiwan National Health Insurance Research Database (NHIRD). Patients were followed up until a diagnosis of malignant disease or benign brain tumour, withdrawal from the National Health Insurance (NHI) system, or at the end of 2008.

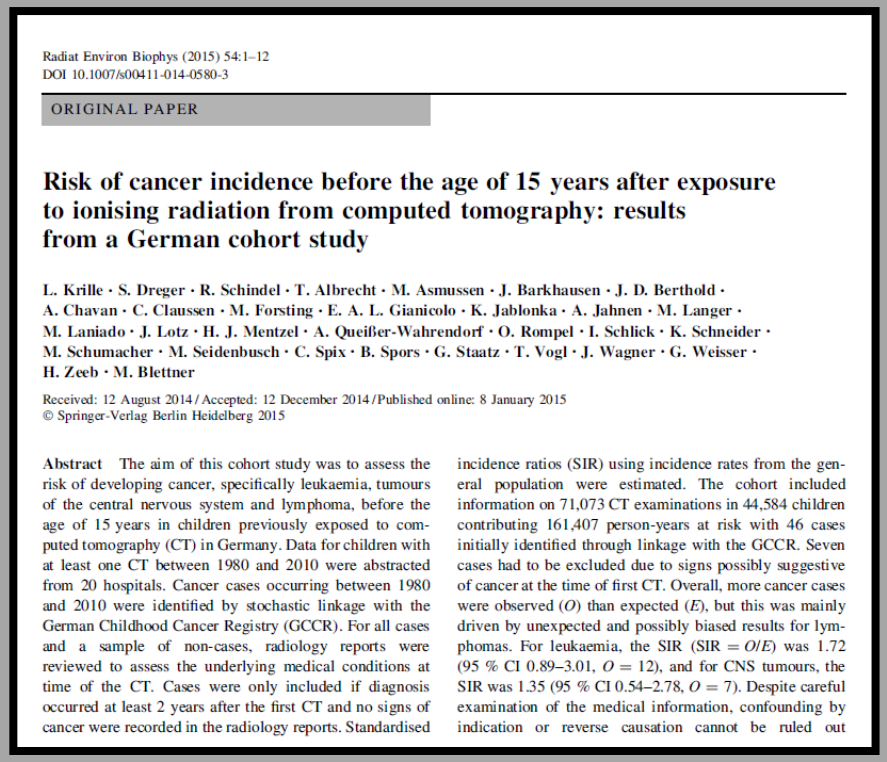
Results: The overall risk was not significantly different in the two cohorts (incidence rate = 36.72 per 100 000 person-years in the exposed cohort, 28.48 per 100 000 person-years in the unexposed cohort, hazard ratio (HR) = 1.29, 95% confidence interval (CI) = 0.90–1.85). The risk of benign brain tumour was significantly higher in the exposed cohort than in the unexposed cohort (HR = 2.97, 95% CI = 1.49–5.93). The frequency of CT examination showed strong correlation with the subsequent overall risk of malignancy and benign brain tumour.

Conclusions: We found that paediatric head CT examination was associated with an increased incidence of benign brain tumour. A large-scale study with longer follow-up is necessary to confirm this result.

Increased risk of leukemia and brain tumors with childhood CT

"1 additional brain tumor per 10,000 childhood brain CTs"

Although…



Radiat Environ Biophys (2015) 54:1–12
DOI 10.1007/s00411-014-0580-3

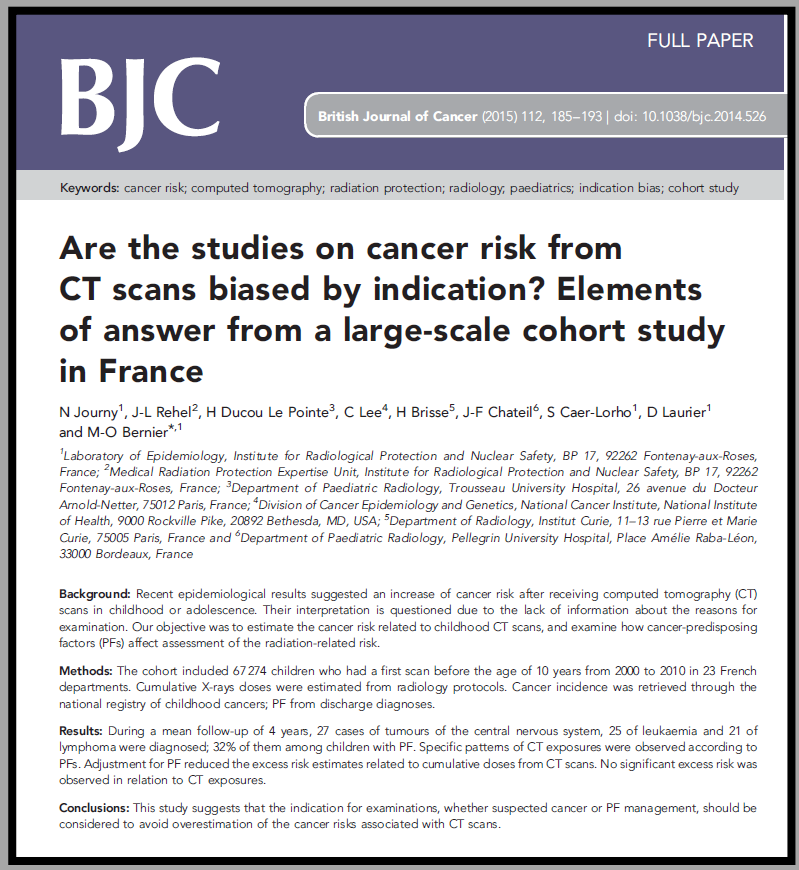
ORIGINAL PAPER

Risk of cancer incidence before the age of 15 years after exposure to ionising radiation from computed tomography: results from a German cohort study

L. Krille · S. Dreger · R. Schindel · T. Albrecht · M. Asmussen · J. Barkhausen · J. D. Berthold · A. Chavan · C. Claussen · M. Forsting · E. A. L. Gianicolo · K. Jablonka · A. Jahnen · M. Langer · M. Laniado · J. Lotz · H. J. Mentzel · A. Queißer-Wahrendorf · O. Rompel · I. Schlick · K. Schneider · M. Schumacher · M. Seidenbusch · C. Spix · B. Spors · G. Staatz · T. Vogl · J. Wagner · G. Weisser · H. Zeeb · M. Blettner

Received: 12 August 2014 / Accepted: 12 December 2014 / Published online: 8 January 2015

Abstract The aim of this cohort study was to assess the risk of developing cancer, specifically leukaemia, tumours of the central nervous system and lymphoma, before the age of 15 years in children previously exposed to computed tomography (CT) in Germany. Data for children with at least one CT between 1980 and 2010 were abstracted from 20 hospitals. Cancer cases occurring between 1980 and 2010 were identified by stochastic linkage with the German Childhood Cancer Registry (GCCR). For all cases and a sample of non-cases, radiology reports were reviewed to assess the underlying medical conditions at time of the CT. Cases were only included if diagnosis occurred at least 2 years after the first CT and no signs of cancer were recorded in the radiology reports. Standardised incidence ratios (SIR) using incidence rates from the general population were estimated. The cohort included information on 71,073 CT examinations in 44,584 children contributing 161,407 person-years at risk with 46 cases initially identified through linkage with the GCCR. Seven cases had to be excluded due to signs possibly suggestive of cancer at the time of first CT. Overall, more cancer cases were observed (O) than expected (E), but this was mainly driven by unexpected and possibly biased results for lymphomas. For leukaemia, the SIR (SIR $= O/E$) was 1.72 (95 % CI 0.89–3.01, $O = 12$), and for CNS tumours, the SIR was 1.35 (95 % CI 0.54–2.78, $O = 7$). Despite careful examination of the medical information, confounding by indication or reverse causation cannot be ruled out



BJC

FULL PAPER

British Journal of Cancer (2015) 112, 185–193 | doi: 10.1038/bjc.2014.526

Keywords: cancer risk; computed tomography; radiation protection; radiology; paediatrics; indication bias; cohort study

Are the studies on cancer risk from CT scans biased by indication? Elements of answer from a large-scale cohort study in France

N Journy[1], J-L Rehel[2], H Ducou Le Pointe[3], C Lee[4], H Brisse[5], J-F Chateil[6], S Caer-Lorho[1], D Laurier[1] and M-O Bernier*[,1]

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Background: Recent epidemiological results suggested an increase of cancer risk after receiving computed tomography (CT) scans in childhood or adolescence. Their interpretation is questioned due to the lack of information about the reasons for examination. Our objective was to estimate the cancer risk related to childhood CT scans, and examine how cancer-predisposing factors (PFs) affect assessment of the radiation-related risk.

Methods: The cohort included 67 274 children who had a first scan before the age of 10 years from 2000 to 2010 in 23 French departments. Cumulative X-rays doses were estimated from radiology protocols. Cancer incidence was retrieved through the national registry of childhood cancers; PF from discharge diagnoses.

Results: During a mean follow-up of 4 years, 27 cases of tumours of the central nervous system, 25 of leukaemia and 21 of lymphoma were diagnosed; 32% of them among children with PF. Specific patterns of CT exposures were observed according to PFs. Adjustment for PF reduced the excess risk estimates related to cumulative doses from CT scans. No significant excess risk was observed in relation to CT exposures.

Conclusions: This study suggests that the indication for examinations, whether suspected cancer or PF management, should be considered to avoid overestimation of the cancer risks associated with CT scans.

BJC: "This study suggests that the indication for examinations, whether suspected cancer or [predisposing factors] management, should be considered to avoid overestimation of the cancer risks associated with CT scans."

Recently…

-----Original Message-----
From:
To: imagegently
Sent: Tue, Jan 26, 2016 10:25 am
Subject: 6 Month Old Skull X-rays

Dear Dr. Frush,

Yesterday our 6-month-old son pulled a cord by a coffee table, and a lamp fell onto him, hitting his head. Although bruised, he seemed all right. Nevertheless, we had him checked at the ER, where he was given 5 skull x-rays.

This radiation dose for such a young age had me concerned. Not knowing where to go with my questions, I found your website and would greatly appreciate any insight on how this may affect him. Some sources indicate that infant skull x-rays can damage IQ. Should we be worried?

Thank you kindly for any feedback you may provide.

Sincerely,

Content is important…

- **Image Gently**
- **Image Wisely**
- **RadiologyInfo.org**

Global validation of need for communication and education

Tenets: Should Remember

- **Imaging (CT) is beneficial**
- **Professionalism: patient autonomy**
- **We have responsibility to inform**
- **Content is important**

Tenets: Should Remember

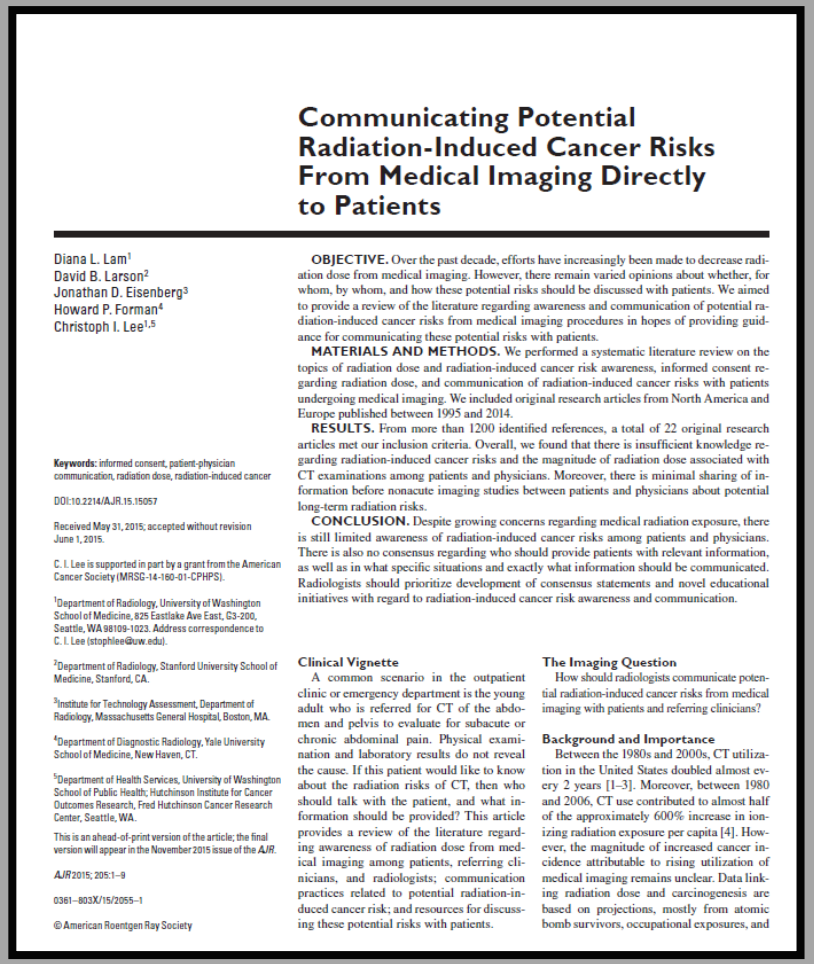
Legalplanet.wordpress.com

- Imaging (CT) is beneficial
- Patient rights
- We have responsibility to inform
- Content is important
- **Delivery is equally important**
  - **when, who, how**

Medical (Imaging) Environment

- Potential lack of control (helplessness)
- Unfamiliarity
- Decisions for others
- High anxiety
- Sense of urgency
- Potential consequences
- Limited access

Need for Communication



Communicating Potential Radiation-Induced Cancer Risks From Medical Imaging Directly to Patients

Diana L. Lam[1]
David B. Larson[2]
Jonathan D. Eisenberg[3]
Howard P. Forman[4]
Christoph I. Lee[1,5]

OBJECTIVE. Over the past decade, efforts have increasingly been made to decrease radiation dose from medical imaging. However, there remain varied opinions about whether, for whom, by whom, and how these potential risks should be discussed with patients. We aimed to provide a review of the literature regarding awareness and communication of potential radiation-induced cancer risks from medical imaging procedures in hopes of providing guidance for communicating these potential risks with patients.

MATERIALS AND METHODS. We performed a systematic literature review on the topics of radiation dose and radiation-induced cancer risk awareness, informed consent regarding radiation dose, and communication of radiation-induced cancer risks with patients undergoing medical imaging. We included original research articles from North America and Europe published between 1995 and 2014.

RESULTS. From more than 1200 identified references, a total of 22 original research articles met our inclusion criteria. Overall, we found that there is insufficient knowledge regarding radiation-induced cancer risks and the magnitude of radiation dose associated with CT examinations among patients and physicians. Moreover, there is minimal sharing of information before nonacute imaging studies between patients and physicians about potential long-term radiation risks.

CONCLUSION. Despite growing concerns regarding medical radiation exposure, there is still limited awareness of radiation-induced cancer risks among patients and physicians. There is also no consensus regarding who should provide patients with relevant information, as well as in what specific situations and exactly what information should be communicated. Radiologists should prioritize development of consensus statements and novel educational initiatives with regard to radiation-induced cancer risk awareness and communication.

Keywords: informed consent, patient-physician communication, radiation dose, radiation-induced cancer

DOI:10.2214/AJR.15.15057

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This is an ahead-of-print version of the article; the final version will appear in the November 2015 issue of the *AJR*.

AJR 2015; 205:1–9

0361–803X/15/2055–1

Clinical Vignette

A common scenario in the outpatient clinic or emergency department is the young adult who is referred for CT of the abdomen and pelvis to evaluate for subacute or chronic abdominal pain. Physical examination and laboratory results do not reveal the cause. If this patient would like to know about the radiation risks of CT, then who should talk with the patient, and what information should be provided? This article provides a review of the literature regarding awareness of radiation dose from medical imaging among patients, referring clinicians, and radiologists; communication practices related to potential radiation-induced cancer risk; and resources for discussing these potential risks with patients.

The Imaging Question

How should radiologists communicate potential radiation-induced cancer risks from medical imaging with patients and referring clinicians?

Background and Importance

Between the 1980s and 2000s, CT utilization in the United States doubled almost every 2 years [1–3]. Moreover, between 1980 and 2006, CT use contributed to almost half of the approximately 600% increase in ionizing radiation exposure per capita [4]. However, the magnitude of increased cancer incidence attributable to rising utilization of medical imaging remains unclear. Data linking radiation dose and carcinogenesis are based on projections, mostly from atomic bomb survivors, occupational exposures, and

CONCLUSION. Despite growing concerns regarding medical radiation exposure, there is ***still limited awareness*** of radiation-induced cancer risks among patients and physicians. There is also ***no consensus regarding who should provide patients with relevant information,*** as well as in what specific situations and exactly what information should be communicated.

Radiologists [the imaging team] should prioritize development of consensus statements and novel educational initiatives with regard to radiation-induced cancer risk awareness and communication.

Need for Communication

TABLE 3: Physician Understanding of the Ionizing Radiation Risk of Ultrasound and MRI[a]

Reference	Year	Location	Method	Population	Ultrasound	MRI
Shiralkar et al. [27]	2003	England	Written survey	130 physicians (120 nonradiologists, 10 radiologists)	6/130 (5)	11/130 (8)
Jacob et. al. [12]	2004	England	Written survey	240 physicians (218 nonradiologists, 22 radiologists)	23/240 (10)[b]	68/240 (28)[b]
Thomas et al. [14]	2006	Canada	Written survey	220 pediatricians	8/220 (4)[b]	—
Soye and Paterson [17]	2008	England	Written survey	153 physicians (140 nonradiologist, 13 radiologists)	15/153 (10)	34/153 (22)
McCusker et al. [18]	2009	Ireland	Written survey	269 medical students and junior physicians	—	73/269 (27)[b]
Heyer et al. [24]	2010	Germany	Written survey	134 pediatricians	—	19/134 (14)
Bosanquet et al. [28]	2011	England	Written survey	112 physicians	16/112 (14)[c]	
Uri [21]	2012	UK	Online survey	100 physicians	15/100 (15)[c]	15/100 (15)[c]

Note—UK = United Kingdom. Numeric data are given as no. (%), where numbers represent participants who believed ultrasound or MRI emitted ionizing radiation. Dash indicates not reported. Numbers may not add up owing to rounding.

[a]Population noted was the total number included in the data analysis of the study, and the denominators for the reported results are based on the number of respondents per survey question.

[b]Extrapolated from reported percentages.

[c]This study did not separate ultrasound and MRI results and thus was not included in our weighted averages.

Risk Communication

- Uncertainty is a challenge to discuss
- Patient/caregiver perspectives are challenges
- Low probability generally overemphasized

What do parents hear when you say "1 in 2,000 risk of cancer"

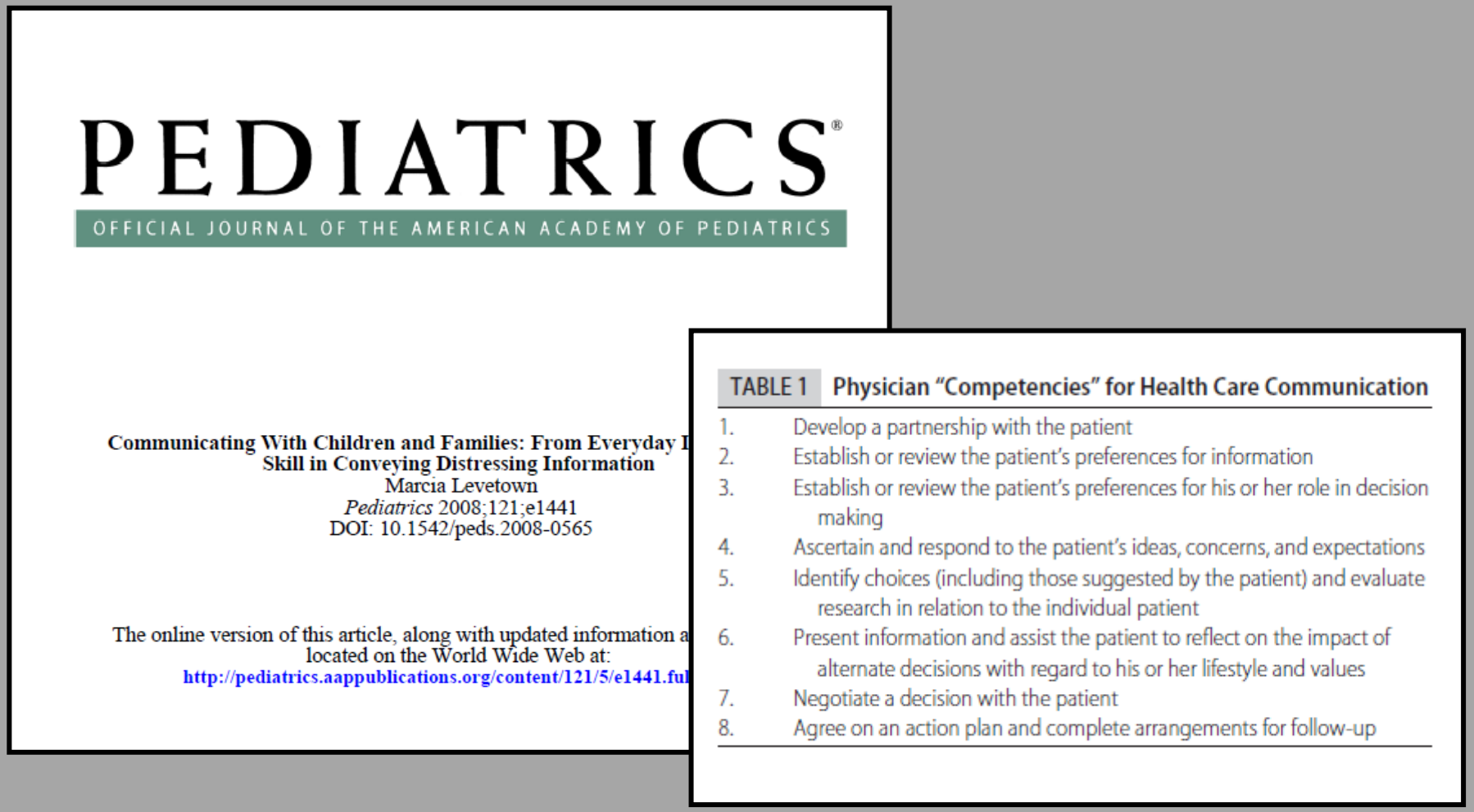
1 in 2,000 = "my child" AND 1999 others

- No risk discussion, but…
- Landscape
  - What is said
  - What is heard
- **Messaging**

Risk Communication

- Uncertainty is a challenge to discuss
- Patient/caregiver perspectives are challenges
- Low probability generally overemphasized
- **Relative risks: many ways to frame**
  - **CXRs, other radiation, other life events, days lost**
- **Keep it (simple) direct, anticipate divergence**

Communication Skills



PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Communicating With Children and Families: From Everyday I
Skill in Conveying Distressing Information

Marcia Levetown

Pediatrics 2008;121;e1441
DOI: 10.1542/peds.2008-0565

TABLE 1 Physician "Competencies" for Health Care Communication

1.	Develop a partnership with the patient
2.	Establish or review the patient's preferences for information
3.	Establish or review the patient's preferences for his or her role in decision making
4.	Ascertain and respond to the patient's ideas, concerns, and expectations
5.	Identify choices (including those suggested by the patient) and evaluate research in relation to the individual patient
6.	Present information and assist the patient to reflect on the impact of alternate decisions with regard to his or her lifestyle and values
7.	Negotiate a decision with the patient
8.	Agree on an action plan and complete arrangements for follow-up

Effective Communication

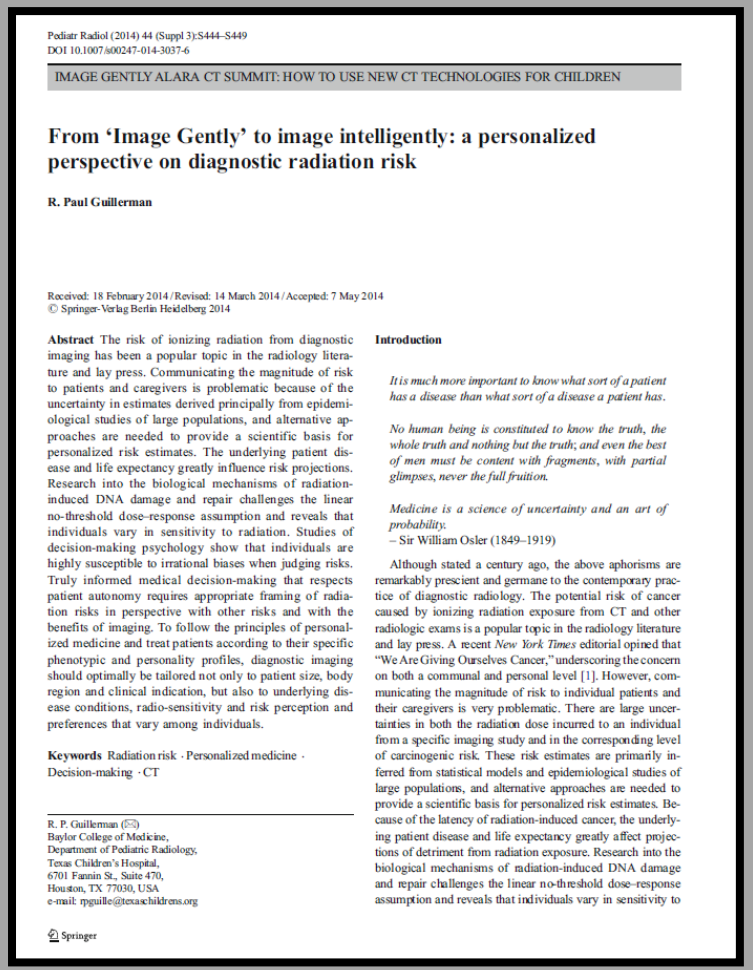
- **Informativeness:** quantity and quality of health information provided by the physician;

- **Interpersonal sensitivity:** affective behaviors that reflect the doctor's attention to, and interest in, the parents' and child's feelings and concerns;

- **Partnership building:** the extent to which the physician invites the parents (and child) to state their concerns, perspectives, and suggestions during the consultation.

PEDIATRICS Volume 121, Number 5, May 2008

Risk Communication



Pediatr Radiol (2014) 44 (Suppl 3):S444–S449
DOI 10.1007/s00247-014-3037-6

IMAGE GENTLY ALARA CT SUMMIT: HOW TO USE NEW CT TECHNOLOGIES FOR CHILDREN

From 'Image Gently' to image intelligently: a personalized perspective on diagnostic radiation risk

R. Paul Guillerman

Received: 18 February 2014 / Revised: 14 March 2014 / Accepted: 7 May 2014

Abstract The risk of ionizing radiation from diagnostic imaging has been a popular topic in the radiology literature and lay press. Communicating the magnitude of risk to patients and caregivers is problematic because of the uncertainty in estimates derived principally from epidemiological studies of large populations, and alternative approaches are needed to provide a scientific basis for personalized risk estimates. The underlying patient disease and life expectancy greatly influence risk projections. Research into the biological mechanisms of radiation-induced DNA damage and repair challenges the linear no-threshold dose–response assumption and reveals that individuals vary in sensitivity to radiation. Studies of decision-making psychology show that individuals are highly susceptible to irrational biases when judging risks. Truly informed medical decision-making that respects patient autonomy requires appropriate framing of radiation risks in perspective with other risks and with the benefits of imaging. To follow the principles of personalized medicine and treat patients according to their specific phenotypic and personality profiles, diagnostic imaging should optimally be tailored not only to patient size, body region and clinical indication, but also to underlying disease conditions, radio-sensitivity and risk perception and preferences that vary among individuals.

Keywords Radiation risk · Personalized medicine · Decision-making · CT

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Introduction

It is much more important to know what sort of a patient has a disease than what sort of a disease a patient has.

No human being is constituted to know the truth, the whole truth and nothing but the truth; and even the best of men must be content with fragments, with partial glimpses, never the full fruition.

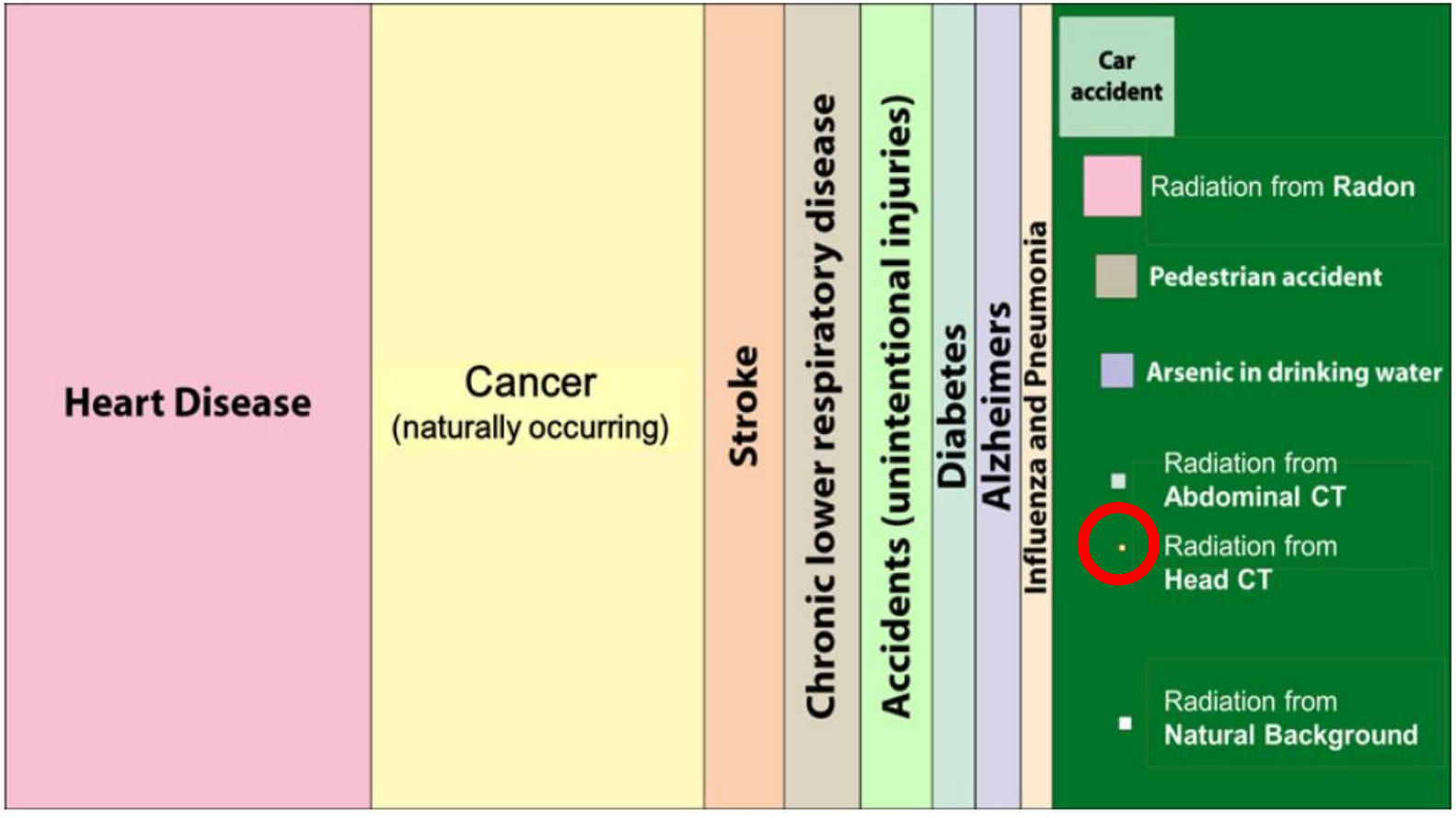
Medicine is a science of uncertainty and an art of probability.
– Sir William Osler (1849–1919)

Although stated a century ago, the above aphorisms are remarkably prescient and germane to the contemporary practice of diagnostic radiology. The potential risk of cancer caused by ionizing radiation exposure from CT and other radiologic exams is a popular topic in the radiology literature and lay press. A recent *New York Times* editorial opined that "We Are Giving Ourselves Cancer," underscoring the concern on both a communal and personal level [1]. However, communicating the magnitude of risk to individual patients and their caregivers is very problematic. There are large uncertainties in both the radiation dose incurred to an individual from a specific imaging study and in the corresponding level of carcinogenic risk. These risk estimates are primarily inferred from statistical models and epidemiological studies of large populations, and alternative approaches are needed to provide a scientific basis for personalized risk estimates. Because of the latency of radiation-induced cancer, the underlying patient disease and life expectancy greatly affect projections of detriment from radiation exposure. Research into the biological mechanisms of radiation-induced DNA damage and repair challenges the linear no-threshold dose–response assumption and reveals that individuals vary in sensitivity to

"Truly informed medical decision-making that respects patient autonomy requires appropriate framing of radiation risks in perspective with other risks and with the benefits of imaging. To follow the principles of personalized medicine and treat patients according to their specific phenotypic and personality profiles, diagnostic imaging should optimally be tailored not only to patient size, body region and clinical indication, but also to underlying disease conditions, radio-sensitivity and risk perception and preferences that vary among individuals."

Pediatric Radiology 44; 2014

Risk Communication

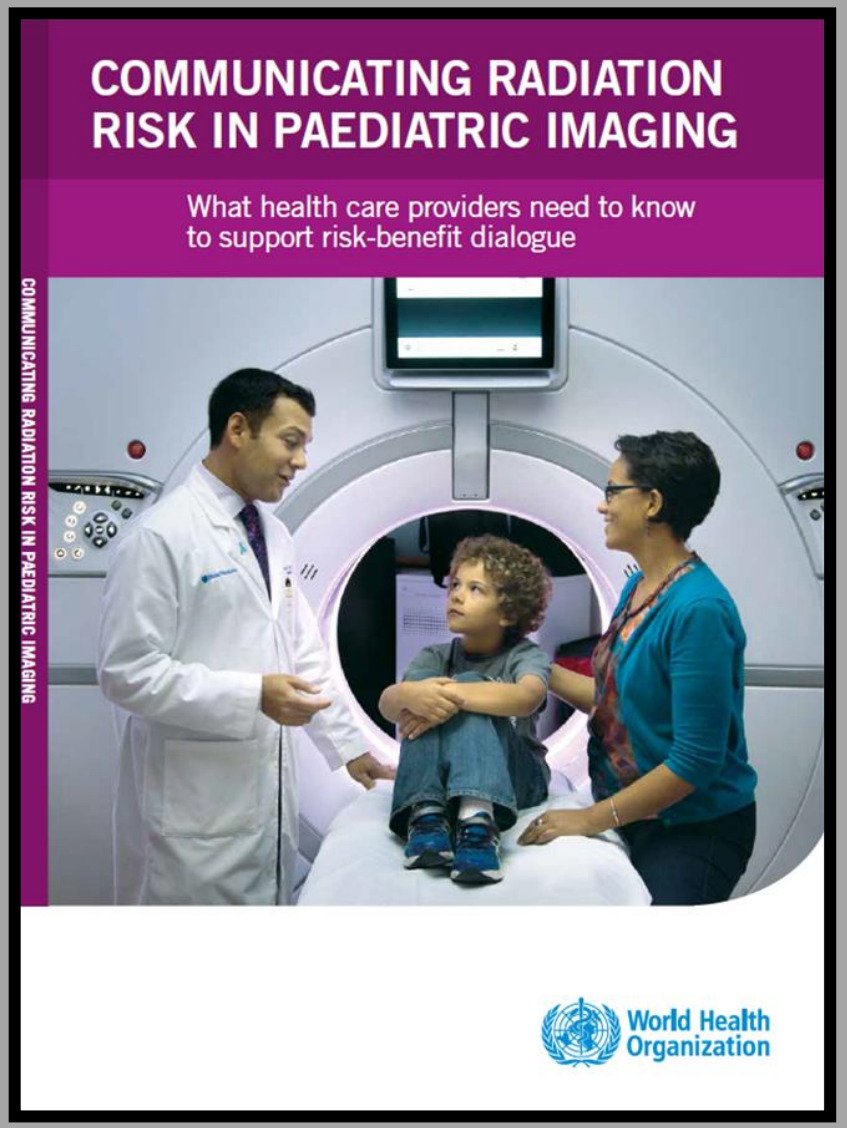


Fletcher et al. Perspective on Radiation Risk in CT imaging. Abdominal Imaging 2012

Table 1. Clinical questions about risks of CT, with distilled answers

Question (May Be Posed by Patient, or Framed by Physician)	Possible Response
"Why are you recommending CT?"	"We need more information to clarify your child's diagnosis, and to direct our treatment. CT can rapidly and accurately provide that information."*
"Are there any risks of CT?"	"One concern is the possibility of cancer resulting from radiation from CT."
"How great is this risk?"	"The risk from CT is very small, if a risk at all. We are not certain that there is a risk at very low doses, like those doses in the vast majority of x-ray procedures or CT."
"How does the risk from CT compare to the risk of [my child's presenting condition]?"	"I have considered your current situation carefully, taking into account many factors." Depending on the circumstances: • "I have significant concern that your child has an injury or serious medical condition. The risk of CT is at most very small by comparison, so CT is the right test to perform." • "At the present time, your child appears to have very low risk for a serious medical condition. Although the potential risks from CT are very small, CT is not the best test at this time. If your child's condition worsens, CT might become necessary."
"When will these risks be evident?"	"The risk of missing a serious diagnosis will occur now, in the coming minutes/hours/days. The effects from small radiation doses such as CT would take longer, even years, if these small risks exist."
"What is the safest course of action?"	"Comparing the potential risks of CT against the risk of your child's condition, the safest course is…"
"What are my options?"	"The options include performing CT now, or waiting. Other options include using a different medical test, such as ultrasound or MRI, performing surgery or medical therapy based on the information at hand (without CT), or watching for changes in your child's condition. If your child's condition worsens, CT may be necessary."

*If the clinician cannot legitimately state that both diagnosis and treatment require CT, the decision to perform CT may warrant reconsideration.


COMMUNICATING RADIATION RISK IN PAEDIATRIC IMAGING
What health care providers need to know to support risk-benefit dialogue
COMMUNICATING RADIATION RISK IN PAEDIATRIC IMAGING
World Health Organization

April 2016

Message Mapping

- **Tool for public health risk communication.**
- **Messages few in number (e.g., 3)**
- **Brief i.e., 9-10 words**
- **Language clear: 8th grade**
- **Layered, hierarchically organized:**

- anticipate the questions and concerns
- organize in response to those questions and concerns
- develop key messages and supporting information

Stakeholder: parents Anticipated question: How much radiation will my child receive from this head CT?		
Key message 1	**Key message 2**	**Key message 3**
This CT is recommended now to aid in diagnosis and guide the treatment of your child	Your child will receive the lowest possible dose without decreasing the diagnostic quality of the images	This CT is medically indicated and will be properly done, thus the benefits will outweigh the radiation risks
Supporting information 1-1	**Supporting information 2-1**	**Supporting information 3-1**
We have evaluated the clinical condition of your child and agreed that we need to confirm the diagnosis to make a decision about the treatment (examples/stories)	There are many techniques to lower the dose without compromising the diagnosis (examples, visual communication)	The radiation dose will be small, similar to several months of exposure to natural background radiation (analogies, tables, visual communication)
Supporting information 1-2	**Supporting information 2-2**	**Supporting information 3-2**
We have considered alternative tests and agreed that this is the examination indicated for your child (referral guidelines)	This imaging facility uses equipment, protocols and techniques suitable for children (accreditation, audits)	The radiation risk is low and the likelihood of an adverse outcome (cancer risk) will be nearly the same as it is for any other child: lifetime cancer incidence risk of 35-40% (analogies, tables, pictorial resources for visual communication)
Supporting information 1-3	**Supporting information 2-3**	**Supporting information 3-3**
This examination has to be done now to avoid any delay in the treatment, in case the diagnosis is confirmed (examples, scientific data)	This facility periodically compares its doses with national and international reference values and stays within those ranges (paediatric DRLs)	The CT will be interpreted by imaging specialists trained to identify abnormalities and their significance. The report will be communicated to the referring physician who will make decisions about treatment and follow-up (stories, examples)

WHO Communicating Radiation Risk in Pediatric Imaging 2016

Your child may have a significant brain injury… so we need to do a CT scan

- **Question: "I heard that CT scans can cause cancer. Will my son get cancer?**
- **Answer: "Possibly."**

- **Question: "What is the radiation for the CT?"**
- **Answer: "Relatively high; I don't know exactly."**

- **Question: "How do you do CT scans in children?"**
- **Answer: "I don't know."**

…confidence?

- **Question: "How much medical radiation has he had?"**
- **Answer: "I don't know."**

What Should You Say?

1. That is a good question
2. I can answer that
3. We have (*hopefully*) expertise
   - know the doses
   - minimize radiation
4. This is a necessary/important exam
   - I avoid “numbers”
5. Other questions?

May 2016, 24 yr old professional:

“I don’t know how to use a house phone”

AJR 204, 2015: W48-W51

Imbalance of Opinions Expressed on Twitter Relating to CT Radiation Risk: An Opportunity for Increased Radiologist Representation

Vinay Prabhu[1,2]
Andrew B. Rosenkrantz[1]

OBJECTIVE. The purpose of this study was to assess perspectives and information relating to CT radiation risk on Twitter, a popular microblogging social network.

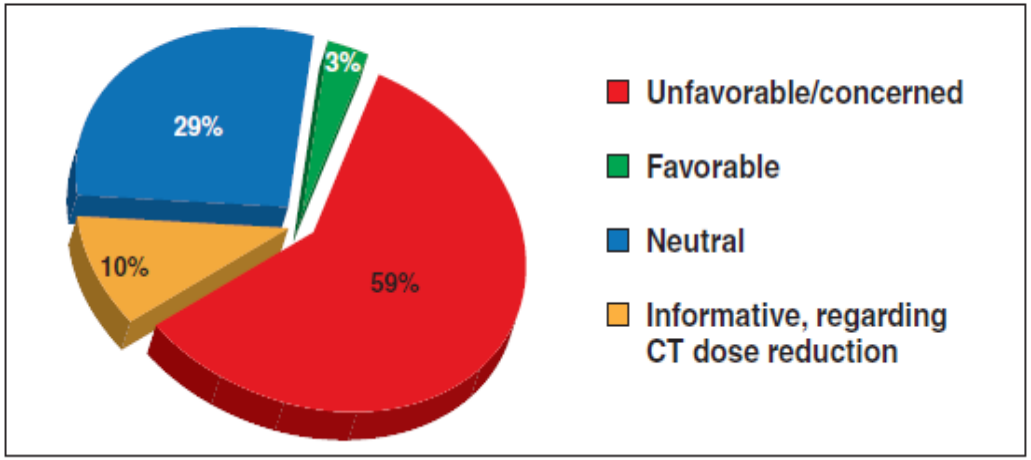
MATERIALS AND METHODS. Publicly available posts on Twitter ("tweets") containing both the words "CT" and "radiation" were identified from the 1st week of each month in 2013. Type of user posting and source of linked articles were recorded. Two reviewers assessed the content of tweets and links regarding CT's benefit-to-risk ratio (favorable, unfavorable, etc.).

RESULTS. Six hundred twenty-one relevant tweets were tweeted by 557 unique users, of whom 90 (16%) were physicians (17 of these were radiologists), 30 (5%) were medical practices or hospitals, 34 (6%) were patients, 8 (1%) were physicists or technologists, and 395 (71%) were other types of users. Two hundred twenty-seven tweets included user commentary regarding CT's benefit-to-risk ratio, of which 134 (59%) were unfavorable or concerned, 65 (29%) were

One recommendation was for more active engagement by radiologists on Twitter

Prabhu and Rosenkrantz

Fig. 1—Pie chart shows subjective categorization of user commentary in tweets ($n = 227$).



What About Consent?

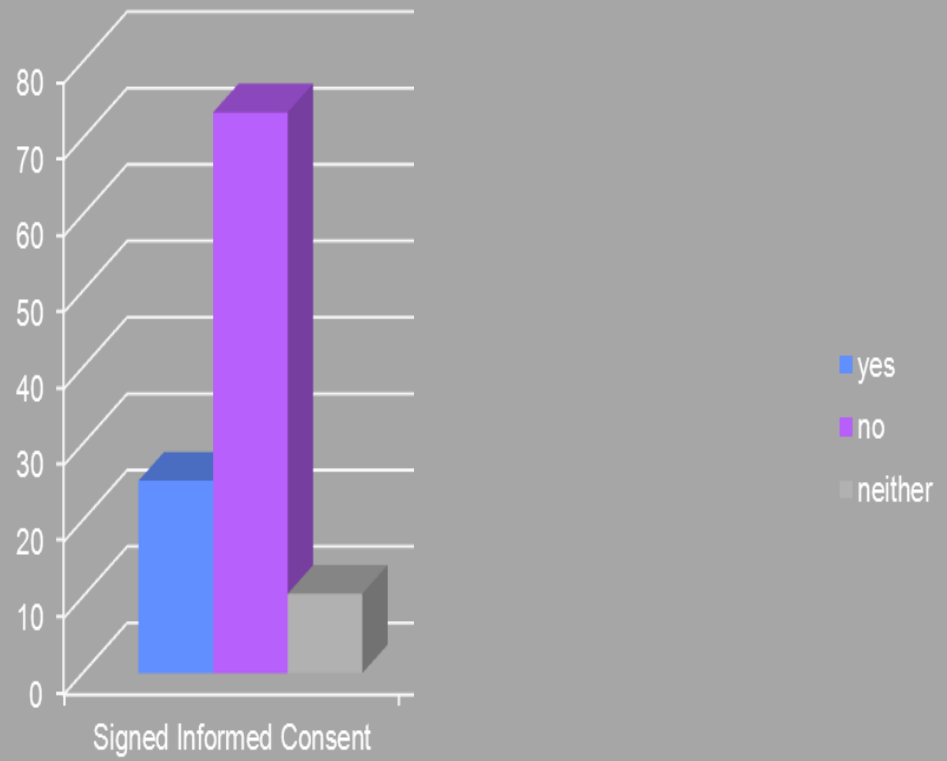
2-2-11 Duke/UNC Survey:
34 Emergency Medicine MDs

- **"Signed, informed consent for CT?"**
  - **27 (79%) : No**
  - **6 (18%) : No opinion**
  - **1 (3%) : Yes, but then apologized for not understanding original question**

… so, 0% wanted this consent

WHO Radiation Risk Communication in Paediatric Imaging

Informal Survey September 20th, 2010



- *Patient/Parent Advocates*
- *Radiologists*
- *Medical Physicist*
- *Communication experts/officers*
- *Family Practitioners*
- *Pediatricians*
- *Regulators*
- *Nurses*
- *Technologists*
- *Ethicists*
- *Radiation Biologists*
- *Epidemiologists*
- *Radiation oncologists*
- *Public policy experts*

Debriefing the Brief: It is Time for the Provision of Informed Consent before Pediatric CT[1]

Diane M. Armao, MD
J. Keith Smith, MD, PhD
Richard C. Semelka, MD

Radiology May 2015

Informed Consent for Radiation Risk from CT Is Unjustified Based on the Current Scientific Evidence[1]

H. Benjamin Harvey, MD, JD
James A. Brink, MD
Donald P. Frush, MD

Over the past several years, many sources of information have emerged regarding the potential risks of low-dose ionizing radiation from medical imaging. Many published educational materials and scientific studies have heightened awareness among patients, the public, and medical professionals. The press has extensively reported on this topic, sometimes omitting nuances regarding the strength of evidence supporting various statements or conclusions. With this background, some con-

The Evidence Regarding the Carcinogenicity of LDR

For many, the current interest in the risks of diagnostic radiation in the field of medicine started in 2006, when the Biological Effects of Ionizing Radiation (BEIR) VII report endorsed a linear no-threshold (LNT) risk model for low-dose radiation (LDR) based on available data (1). The LNT model states that the risk for cancer from radiation exposure proceeds in a linear fashion irrespective of the dose, without a threshold.

Will you discourage having the examination?

Informing Parents About CT Radiation Exposure in Children: It's OK to Tell Them

David B. Larson[1,2]
Scott B. Rader[1,2]
Howard P. Forman[3]
Laura Z. Fenton[1,2]

OBJECTIVE. The purpose of our study was to determine how parents' understanding of and willingness to allow their children to undergo CT change after receiving information regarding radiation dose and risk.

MATERIALS AND METHODS. One hundred parents of children undergoing nonemergent CT studies at a tertiary-care children's hospital were surveyed before and after reading an informational handout describing radiation risk. Parental knowledge of whether CT uses radiation or increases lifetime risk of cancer was assessed, as was willingness to permit their child to undergo both a CT examination that their child's doctor recommended and one for which their doctor thought observation might be equally effective.

RESULTS. Of the 100 parents who were surveyed, 66% believed CT uses radiation before reading the handout, versus 99% afterward ($p < 0.01$). Before reading the handout, 13% believed CT increases the lifetime risk of cancer, versus 86% afterward ($p < 0.01$). After reading the handout, parents became less willing to have their child undergo CT given a hypothetic situation in which their doctor believed that either CT or observation would be equally effective ($p < 0.01$), but their willingness to have their child undergo CT recommended by their doctor did not significantly change. After reading the handout, 62% of parents reported no change in level of concern. No parent refused or requested to defer CT after reading the handout.

CONCLUSION. A brief informational handout can improve parental understanding of the potential increased risk of cancer related to pediatric CT without causing parents to refuse studies recommended by the referring physician.

Keywords: CT, pediatric imaging, radiation

DOI:10.2214/AJR.07.2248

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[2]Department of Radiology, University of Colorado Health Sciences Center, 4200 E Ninth Ave., Denver, CO 80262. Address correspondence to D. B. Larson (david.larson@uchsc.edu).

[3]Department of Diagnostic Radiology, Yale School of Medicine, New Haven, CT.

AJR 2007; 189:271–275

0361–803X/07/1892–271

Utilization of CT continues to steadily increase in the pediatric population [1–3]. Although CT examinations make up approximately 11% of the number of radiologic procedures, radiation from CT delivers approximately 70% of the medically related radiation dose to the general U.S. population [4].

Even small doses of radiation may pose an increased risk of cancer [5–7], and children are thought to be at increased risk compared with adults [2, 8–10]. However, the risk remains theoretic and has generated considerable attention and controversy in both the medical literature and the lay press [11–13]. Regardless, because of the potential risk, established as-low-as-reasonably-achievable (ALARA) principles have been the standard in the radiology community for many years and are especially applicable in the case of pediatric CT [14].

The U.S. Food and Drug Administration (FDA) has outlined a three-pronged strategy to minimize avoidable pediatric CT radiation dose: optimize CT settings for pediatric patients, minimize multiple phases in contrast-enhanced studies, and minimize inappropriate CT referrals [15]. The first two elements rely almost completely on imaging professionals, whereas the third element relies more heavily on referring clinicians. Studies have shown that clinicians usually underestimate CT-related radiation dose and associated risk of cancer [16, 17]. Furthermore, some experts believe that as many as 30% of all pediatric CT examinations are unlikely to benefit the individual or could be easily and effectively replaced by a nonionizing imaging technique [18]. Acting on these findings, at least one institution has shown that educating clinicians can help stem the increase in CT referrals [3].

Patients also generally have a poor understanding of the radiation dose and risk associated with CT [16]. Some experts believe that parents may contribute to the increasing demand for CT as they seek rapid diagnosis without understanding the potential risks [4].

TABLE 1: Reported Change in Understanding of Risks

No. (%) of Parents	Response
28 (28)	I already knew this before visiting my child's doctor.
13 (13)	My child's doctor explained all of this to me.
30 (30)	My child's doctor explained some risks to me, but this information made it more clear.
29 (29)	All of this was new to me—my child's doctor did not explain any of it.
100	Total

TABLE 2: Willingness to Allow Child to Undergo CT Before and After Reading Handout

No. (%) of Parents Before	No. (%) of Parents After	Response
67 (67)	57 (58)	Willing to allow CT, no concerns
32 (32)	40 (40)	Willing to allow CT, some concerns
1 (1)	2 (2)	Willing to allow CT, strong concerns
0	0	Unwilling to allow CT
100	99	Total

"NO"

Larson et al AJR 2007; 189

From: Sent: 2016 1:2
To: Donald Frush, M.D.
Cc:
Subject: Thank You for Your Reply!

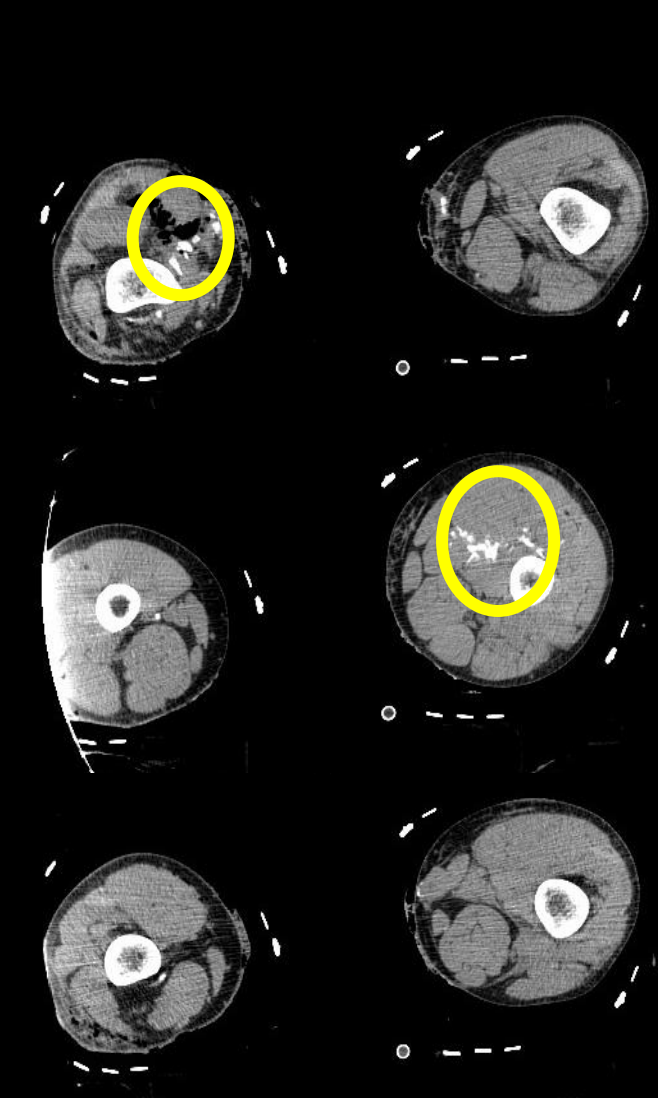
Dear Dr. Frush,

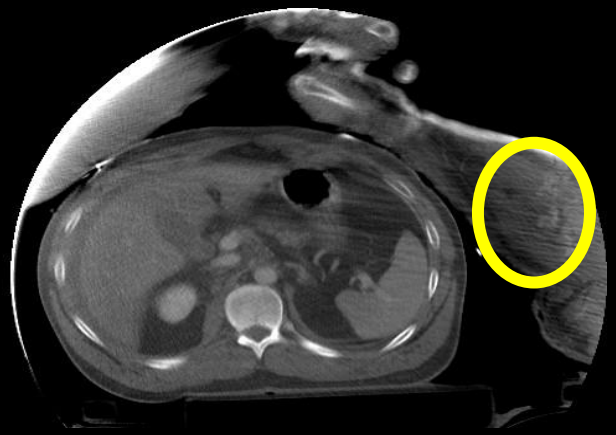
Thank you kindly for taking time out of your week to reply back to me on this issue. Our family's fears are allayed. Moreover, this experience and Image Gently have raised our awareness and clarified radiation in general amidst much online confusion.

Thank you very much again. Please have a blessed weekend yourself, sir.

Appreciatively,

Really? Benefit Risk Balance?





Conclusions

- **CT is invaluable**
- **Understand your audience**
- **Content *and delivery* must be considered**