Minimizing Medically Unwarranted CT Scans

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The big issue with CT doses

- The individual radiation risks from CT are small, but almost certainly non zero, so if a CT scan is medically justified, the benefit / risk ratio for any individual will typically be very large.

- But ~¼ of all CTs may be clinically unjustified (~20 million /yr in the US), and here the benefit /risk ratio will not be large.

- For these clinically unjustified CT scans, even though the individual radiation risk will still be very small, when multiplied by a large (and increasing) number of individuals (~20 million/yr in the US), the potential exists to produce a significant long-term public health concern.

- We need to minimize medically unwarranted CT scans – a hard task.
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## Typical organ doses from single diagnostic x ray examinations

<table>
<thead>
<tr>
<th>Examination</th>
<th>Relevant organ</th>
<th>Relevant organ dose (mGy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental x ray</td>
<td>Brain</td>
<td>0.005</td>
</tr>
<tr>
<td>PA Chest x ray</td>
<td>Lung</td>
<td>0.01</td>
</tr>
<tr>
<td>Lateral chest x ray</td>
<td>Lung</td>
<td>0.15</td>
</tr>
<tr>
<td>Screening mammogram</td>
<td>Breast</td>
<td>3</td>
</tr>
<tr>
<td>Adult abdominal CT (200 mAs)</td>
<td>Stomach</td>
<td>11</td>
</tr>
<tr>
<td>Adult head CT (200 mAs)</td>
<td>Brain</td>
<td>13</td>
</tr>
<tr>
<td>Child abdominal CT (50 / 200 mAs)</td>
<td>Stomach</td>
<td>8 / 30</td>
</tr>
<tr>
<td>Child head CT (100 / 200 mAs)</td>
<td>Brain</td>
<td>18 / 35</td>
</tr>
</tbody>
</table>
Taking onto account

* Machine variability,
* Usage variability,
* Age variability,
* Scans done with and without contrast
* Multiple scans

the relevant organ dose range for CT is

5 - 100 mSv
Low dose radiation risks

Hiroshima and Nagasaki

5-100 mSv
## Number of solid cancers in A-bomb survivors exposed to doses from 5-100 mSv

### Small but statistically significant increase in risk

<table>
<thead>
<tr>
<th>Study population (5-100 mSv)</th>
<th>Total solid cancers observed</th>
<th>Solid cancers expected (controls)</th>
<th>Radiation-related excess solid cancers</th>
<th>Cancer incidence (1958-98)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4,406</td>
<td></td>
<td>27,789</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4,325</td>
<td></td>
<td></td>
</tr>
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</tbody>
</table>

Preston *et al* 2007
There is also an increasing realization that lifetime cancer risks due to radiation exposure in middle age may be larger than we thought.
There is also an increasing realization that lifetime cancer risks due to radiation exposure in middle age may be larger than we thought.
Estimating the radiation-induced cancer risks from CT exams

- Direct epidemiology on people who received CT scans
- Risk estimation based on organ doses
Estimated % lifetime attributable cancer mortality risk, as a function of age at exam, for a single CT exam

- Adult: 200 mAs
- Pediatric Abdomen: 50 mAs
- Pediatric Head: 100 mAs
There is no question that CT has revolutionized medical practice...has made it possible to examine a variety of abnormalities in the abdomen and thorax in a manner not previously possible. This development permits a remarkable insight into the study of human disease \textit{in vivo}.
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Blunt abdominal trauma in children: impact of CT on operative and nonoperative management.

The value of routine follow-up imaging in pediatric blunt liver trauma.

Should helical CT scanning of the thoracic cavity replace the conventional chest x-ray as a primary assessment tool in pediatric trauma? An efficacy and cost analysis.

Routinely repeated computed tomography after blunt head trauma: does it benefit patients?

Utility of serial computed tomography imaging in pediatric patients with head trauma.

Utility of computed tomography and selected MR sequences in the diagnostics of patients with partial epileptic attacks.

The role of brain computed tomography in evaluating children with new onset of seizures in the emergency department.

The utility of neuroimaging in the evaluation of children with migraine or chronic daily headache who have normal neurological examinations.
Some common scenarios where there is evidence that CT usage could potentially be reduced, without compromising patient care:

- CT for renal colic
- CT for minor head trauma
- CT for abdominal pain
- CT for abdominal and chest trauma
- CT angiography for pulmonary embolus
The ALARA concept in pediatric CT intelligent dose reduction

The Society for Pediatric Radiology organized this multidisciplinary conference on August 18–19, 2001, for clarification of the radiation issues pertaining to pediatric CT. It was made possible by an unrestricted grant from General Electric Medical Systems.

2001 Straw Poll of Pediatric Radiologists:
“30% of CT scans are not clinically necessary”
What proportion of CT scans could potentially be avoided?

There are many studies of the proportion of CT scans that could be avoided if high-sensitivity CT decision guidelines are applied.
What proportion of CT scans could potentially be avoided?

<table>
<thead>
<tr>
<th>Decision Guideline</th>
<th>% of CT scans that could be avoided</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scandinavian</td>
<td>50</td>
</tr>
<tr>
<td>Nexus-II</td>
<td>44</td>
</tr>
<tr>
<td>New Orleans</td>
<td>31</td>
</tr>
<tr>
<td>WFNS</td>
<td>45</td>
</tr>
<tr>
<td>Canadian CT Head Rule</td>
<td>45</td>
</tr>
</tbody>
</table>

Retrospective analysis of decision guidelines for CT scanning of mild traumatic brain injury

Glasgow coma scale 14-15, Stein et al 2009
Decision rules for diagnosing pediatric appendicitis

- **Equivocal symptoms**
  - **CT** +
  - Appendectomy

- **CT**
  - 100%

- **Ultrasound**
  - 70%

- **Low Risk**
  - In patient observation

- **Medium risk**
  - Ultrasound
  - CT
  - Appendectomy

- **High Risk**
  - (e.g. Alvarado scoring system)

- **43% CT**

*Based on Garcia Pena 2004*
Many sets of decisions rules exist, some good, some not so good
Inappropriate CT prescriptions rates:
Department of Radiology, Oulu University Hospital
based on EC Referral Guidelines

<table>
<thead>
<tr>
<th>CT Exam</th>
<th>Percent inappropriate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lumbar &amp; central spine</td>
<td>77</td>
</tr>
<tr>
<td>Head</td>
<td>36</td>
</tr>
<tr>
<td>Abdomen / upper abdomen</td>
<td>37</td>
</tr>
<tr>
<td>Nasal sinus</td>
<td>20</td>
</tr>
<tr>
<td>Cervical spine</td>
<td>3</td>
</tr>
<tr>
<td>Trauma</td>
<td>0</td>
</tr>
<tr>
<td><strong>All CT exams</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

Oikarinen et al 2009
Inappropriate CT prescriptions rates: Primary care physicians….

based on ACR Appropriateness Criteria

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<th>Percent inappropriate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head / brain</td>
<td>62</td>
</tr>
<tr>
<td>Maxillofacial</td>
<td>36</td>
</tr>
<tr>
<td>Spine</td>
<td>53</td>
</tr>
<tr>
<td>Chest</td>
<td>12</td>
</tr>
<tr>
<td>Chest/abdomen/pelvis</td>
<td>30</td>
</tr>
<tr>
<td>Abdomen / pelvis</td>
<td>18</td>
</tr>
<tr>
<td>Miscellaneous + angiography</td>
<td>21</td>
</tr>
<tr>
<td><strong>All CT exams</strong></td>
<td><strong>27</strong></td>
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</tbody>
</table>

Lehnert and Bree 2010
Potential Impact of the American College of Radiology Appropriateness Criteria on CT for Trauma

Johnathan L. Hadley¹
John Agola¹
Ping Wong¹,²

Received January 10, 2005; accepted after revision February 22, 2005.
¹Department of Radiology, Eastern Virginia Medical School, 4720 Brompton Dr., Virginia Beach, VA 23456.

OBJECTIVE. The purpose of our study was to identify the current imaging utilization patterns at a level I trauma center, the radiation dose and financial costs of this imaging, and what impact, if any, the American College of Radiology (ACR) appropriateness criteria might have on these factors.

MATERIALS AND METHODS. Two hundred trauma patients were retrospectively chosen for inclusion in the study. Patients were selected on the basis of receiving any form of ionizing radiation within the first 3 hr of arrival at an academic level I trauma center. Exclusion criteria included an absence of imaging, patients transferred from outside institutions with previously acquired imaging studies, and patients who first underwent surgery and subsequently...

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200 trauma patients studied, who had some radiation imaging

• 169 had CT scans
• Total number of CTs: 660
• Cost $837,000

Had ACR Appropriateness Criteria been applied.....

• 44% of CTs would not have been carried out
• None of the major injuries would have been excluded from CT imaging
• 11 minor injuries, none of which required follow up, would have been excluded from CT imaging
• 39% decrease in cost
Percent of Emergency Room Visits that Involve a CT (US data)

Percent of ED visits involving CT

Year


Percent of visits with CT

2.8 3.2 3.5 4.1 4.7 5.3 6.0 6.8 7.5 8.9 10.7 11.6 13.9
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We need to minimize medically unwarranted CT scans – a hard task.
CT scanners / million population

From OECD Health Data, 2007

Number of CT scans / yr

USA: 80 million (0.25 / caput)
Japan: 50 million (0.4 / caput)
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A significant fraction of CT scans (at least $\frac{1}{4}$) could practically be replaced by alternate approaches, or need not be performed at all, without compromising patient care.

- Targeting this “one quarter” is a very hard task
- Physicians are subject to significant pressures
  - Throughput
  - Legal
  - Economic
  - From patients

Clinical Decision Rules
Many sets of decisions rules exist, some good, some not so good.

EUROPEAN COMMISSION

RADIATION PROTECTION 118

Update Mars 2008

Referral Guidelines For Imaging

Guidelines for Healthcare Professionals who prescribe Imaging Investigations involving Ionising Radiation

Final Report to the European Commission for Grant Agreement SUBV99/134996

University Court of the University of Aberdeen
Professor Gillian Needham and Professor Jeremy Grimshaw

Directorate-General for Energy and Transport
Directorate H — Nuclear Energy
Unit H.1 — Radiation Protection
2007
Do physicians actually use decision rules in making imaging decisions?

- **What is your primary information resource in making imaging decisions for your patients?**

![Bar chart showing the percentage of primary information resources for physicians.]

- ACR Appropriateness Criteria
- Fellow colleague
- Recent CME
- PubMed
- Personal experience
- Pocket Medicine
- MD Consult
- Google
- UpToDate
- Journal
- Radiologist

Bautista et al 2009
Towards increased utilization of CT decision rules

1) Promote increased awareness of radiation issues

2) Incorporate decision rules into a computerized radiology order entry system
Let's *image gently* when we care for kids! The *image gently* Campaign is an initiative of the Alliance for Radiation Safety in Pediatric Imaging. The campaign goal is to change practice by increasing awareness of the opportunities to lower radiation dose in the imaging of children.

ONE SIZE DOES NOT FIT ALL...

There's no question: CT helps us save kids' lives!

But, when we image, radiation matters.
* Children are more sensitive to radiation
* What we do now, lasts their lifetimes

So, when we image, let's *image gently*
* More is often not better
* When CT is the right thing to do:
  * Child size the kVp and mA
  * One scan (single phase) is often enough
  * Scan only the indicated area

Let's *image gently*...
Towards increased utilization of CT decision rules

1) Promote increased awareness of radiation issues

2) Incorporate decision rules into a computerized radiology order entry system
MGH Radiology Order-Entry and Decision-Support System

Patient Name: TEST, IGNORE  
MRN: 0000006  
Ordering Physician: 

Proceed with Order  
Cancel Exam

Head CT has low utility for the clinical indications provided

9 8 7 6 5 4 3 2 1
Indicated 7-9  
Marginal 4-6  
Low Utility 1-3

Options:
- Proceed with exam
- Cancel or select new exam
- Change indications and resubmit

Alternate procedures to consider:
MR  PET  CTA  MRA
8 8 1 1

At least one box MUST be selected from either of the following groups

SIGNS / SYMPTOMS
- Acromegaly
- Speech changes (or Aphasia), new or progressive
- Concussion mild or moderate acute, no neurological deficit
- Coordination changes, new or progressive
- Dementia
- Head injury mild or moderate acute, no neurological deficit
- Headache
- Hyperprolactinemia
- Pain in face
- Weakness- right side / left side / both
- Acute visual deficit (other than photophobia and aura)
- Syncope/fainting
- Signs of meningeal irritation (such as stiff neck)
- Amenorrhea
- Abnormal gait (Ataxia)
- Seizures new or progressive
- Cranial nerve palsy (specify):
- Dizziness
- Head injury moderate or severe acute, stable
- Hearing changes
- Mental Status change (after trauma)
- Sensation loss
- TIA with transient neurological disturbance
- Mass or lump
- Vision changes
- Signs of increased intracranial pressure (such as fundoscopic exam)
Does putting decision support into order entry help?

Virginia Mason, Seattle
Should decision support be made mandatory?

Radiation Exposure From Medical Imaging
Time to Regulate?

David J. Brenner, PhD
Hedvig Hricak, MD

The average radiation dose to which persons in the United States are exposed has doubled over the past 30 years.\(^1\,^2\) Although the average dose from natural background sources has not changed, the average radiation dose from medical imaging has increased more than 6-fold.\(^1\,^2\) Medical imaging now contributes about 50% of the overall radiation dose to the US population, compared with about 15% in 1980.\(^2\)

The largest contributor to this dramatic increase in population radiation exposure is medical imaging. Although it is impossible to imagine contemporary medicine without modern medical imaging, there are serious issues of quality control, training, and, particularly of overutilization that can best be addressed through national legislation. In fact, radiation exposure from medical radiographic imaging is comparatively unregulated; this is in striking contrast to radiation exposure in occupational settings, which is stringently regulated despite it contributing a far smaller population exposure.

The current US situation is that quality control and quality assurance for x-ray machines and facilities are the responsibility of individual states, and a variety of different standards and rules are in place: accreditation programs...
COUNCIL DIRECTIVE 97/43/EURATOM

of 30 June 1997

on health protection of individuals against the dangers of ionizing radiation in relation to medical exposure, and repealing Directive 84/466/Euratom

Article 6

Procedures

1. Written protocols for every type of standard radiological practice shall be established for each equipment.

2. Member States shall ensure that recommendations concerning referral criteria for medical exposure, including radiation doses, are available to the prescribers of medical exposure.
Conclusions

I: Are CT risks real?

- The suggestion is that CT doses will produce a small increase in individual cancer risk. Is this
  a) Based fairly directly on epidemiological evidence?
  or
  b) “Extrapolated from high radiation dose exposures studied in the Atomic Bomb experience”?

- The typical organ dose range for CT (5 to 100 mSv) is the same dose range for which there is a statistically significant epidemiological evidence of increased risk

- That being said, we await the results of the ongoing CT epidemiological studies....
Conclusions

II. The individual risks are very small

• When a CT scan is clinically warranted, the benefit will by far outweigh any possible individual radiation risk

• (though of course we can and should continue to lower doses per scan)
Conclusions

III. Reducing clinically unwarranted CT scans

• The main concern is really about the population exposure from the roughly ¼ of CT scans that may not be clinically warranted
Conclusions

IV. Reducing doses per scan is hard but doable; reducing unwarranted CT scans is harder
In fond memory of Elaine Ron