Radiation Reduction using 80 kV and 100 kV protocols for CT Pulmonary Angiography

Resident Clinical Audit Project
Canadian Association of Radiologists 77th annual meeting, April 24-27, 2014

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Background

- Radiation exposure from medical imaging is making headlines both within the medical community and in mainstream media.
Background

- Radiation exposure from medical imaging is a concern within the medical community and is also making headlines in mainstream media.
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Many people unaware of radiation risk from CT scans

BY GENEVRA PITTMAN
NEW YORK Thu Jan 3, 2013 4:32pm EST

Generic color switch tied to not taking pills
Little change in overtreatment at doctors’ offices
Novartis says trial results back Tazigna drug
Should breast cancer patients skip the pre-op

(Reuters Health) - One-third of people getting a CT scan didn’t know the test exposed their body to radiation, in a new study from a single U.S. medical center.

Researchers found the majority of patients also underestimated the amount of radiation delivered by a CT scan, and just one in 20 believed the scan would increase their chance of ever getting cancer.
Clinical Audit Project: Canadian Association of Radiologists 77th Annual Scientific Meeting, April 24-27, 2014

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How Much Do CT Scans Increase the Risk of Cancer?

Researchers reevaluate the safety of radiation used in medical imaging.

Jun 18, 2013 | By Carina Storrs

Ever since physicians started regularly ordering CT (computed tomography) scans four decades ago, researchers have worried that the medical imaging procedure could increase a patient’s risk of developing cancer. CT scanners bombard the human body with x-ray beams, which can damage DNA and create mutations that spur cells to grow into tumors.

Doctors have always assumed, however, that the benefits outweigh the risks. The x-rays, which rotate around the head, chest or abdomen, are said to enhance cancer detection.

But recent studies have raised questions about whether the benefits outweigh the risks. Scientific American recently explored the topic.

The analysis found that in the United States, CT scans are the source of the highest body radiation exposure, accounting for 40% of the average person’s total exposure. The study also noted that CT scans aren’t reserved for cancer patients: many scans are done in the general population, with roughly one in three people in the United States getting a CT scan.

St. Michael’s
Inspired Care. Inspiring Science.
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Ever since physicians started ordering CT (computerized tomography) scans four decades ago, research has shown that the medical imaging procedure increases a patient's risk of developing cancer. CT scanners bombard the human body with x-ray beams, which can damage DNA and create mutations that spur cells to grow into tumors.

Doctors have always assumed, however, that the benefits outweigh the risks. The x-rays, which rotate around the head, chest or abdomen, can help diagnose and treat diseases. But now, with rising concerns about cancer and radiation exposure, some experts are questioning the wisdom of routine imaging.

"We are slowly irradiating ourselves to death," said Dr. Rita F. Redberg, a cardiologist at the University of California, San Francisco, in a commentary article published last Friday in the New York Times.

That's the conclusion — and warning — that cardiologist Dr. Rita F. Redberg and radiologist Dr. Adrea S. Smith-Bindman, both of the University of California, San Francisco, make in a commentary article published last Friday in the New York Times.
Patients are demanding dose-reduction and it’s our job to provide it.
Background

• Acute pulmonary embolism (PE) requires prompt diagnosis and therapy. The mainstay of PE diagnosis is the CT pulmonary angiography (CTPA).\(^1\)

• Since CTPA is being utilized with increasing frequency, the Department of Medical Imaging at St. Michael’s Hospital has sought to improve its protocols to reduce radiation as much as possible.

• Studies have shown that lower-voltage protocols for CT pulmonary angiography reduce the radiation dose.\(^2\text{-}7\)
Background

• Patient anatomy, dimension and body morphology affect radiation dose. Published studies have reported and/or controlled for:
  – Height$^{2,3,4}$
  – Weight$^{2,3,4}$
  – BMI$^{2,3,4}$
  – Chest AP diameter$^{3,4}$
  – Chest cross-sectional area$^{4}$
  – Perpendicular distance from skin to anterior ribs$^{2}$

• However, other body composition factors are much more difficult to control for.

• No studies to date have quantified low-voltage CTPA dose reduction using internal controls to account for intrapatient factors.

* References provided at end.
Aim of Audit

• To evaluate the intrapatient dose reduction with lower-voltage CTPA at our institution since introducing new protocols on April 1, 2013.

• Audit period: April 1 – December 31, 2013
Methodology

• Retrospective analysis of patients who underwent CTPA at:
  – 80 kV (for BMI < 23 kg/m²)
  – 100 kV   (for BMI 23-30 kg/m²)
  – 120 kV   (standard)

• Radiation dose data from Radimetrics eXposure™ dose tracking software
Methodology

• Two analyses:

  – **Global statistics** for each of the groups were calculated on ICRP-103 effective doses

  – **Sub-analysis** on radiation dose reduction:
    • If a patient undergoing 80 kV or 100 kV CTPA had previously also undergone 120 kV CTPA (Jan. 2010 to Dec. 2013), they were included in a sub-analysis on radiation dose reduction.
    • Paired t-test statistics were used.
      – Radiation dose at 80 kV vs. 120 kV
      – Radiation dose at 100 kV vs. 120 kV
Results

619 CTPA studies
(April 1 to December 31, 2013)

65 CTPA at 80 kV

10 studies with previous 120 kV CTPA

127 CTPA at 100 kV

20 studies with previous 120 kV CTPA

427 CTPA at 120 kV
Patient Demographics

- **80 kV**
  - 21 males, 44 females (n = 65)
  - Average age: 59 years (20–91 years)

- **100 kV**
  - 63 males, 64 females (n = 127)
  - Average age: 58 years (17–100 years)

- **120 kV**
  - 235 males, 192 females (n = 427)
  - Average age: 57 years (17–93 years)
Patient Demographics

Patients who had both 80 kV and 120 kV studies:
• 5 males, 5 females (n = 10)
• Average age: 59 years (33-87 years)

Patients who had both 100 kV and 120 kV studies:
• 11 males, 9 females (n = 20)
• Average age: 58 years (31-73 years)
Results (Global Statistics)

Radiation Doses for CTPA at 80 kV, 100 kV, and 120 kV

- 80 kV: 2.9 mSv (n = 65)
- 100 kV: 5.2 mSv (n = 127)
- 120 kV: 10.8 mSv (n = 427)
Results (Sub-analysis)

Radiation Dose Reduction

80 kV
(n = 10)
46%

Radiation Dose Reduction

100 kV
(n = 20)
38%
Results (Sub-analysis)

Radiation Dose Reduction

80 kV
(n = 10)

Radiation Dose Reduction

100 kV
(n = 20)

2.6 mSv
(95% CI: 1.6-3.6 mSv)

3.2 mSv
(95% CI: 2.1-4.2 mSv)
Limitations

• In this analysis, we made the following assumptions:

  – The patient’s body morphology (height, weight, BMI, composition, etc.) remained unchanged between scans

  – There was no significant difference in the scan length (z-axis) between low-voltage CTPA studies and standard-voltage CTPA studies
Conclusions

• Performing CTPA at lower peak-kilovoltage offers significant dose reductions for the patients who meet the protocol criteria.
Next Steps

- Continue data collection
- Assess image and diagnostic quality of the studies obtained
- A letter informing the radiologists and CT technologists of the audit's findings was circulated in order to increase the number of lower voltage studies performed on patients who meet the protocol criteria.
- The results of this audit was presented to Joint Radiology and Emergency Department rounds.
- A follow-up audit will be performed in a year's time to track progress.
References

Acknowledgements

- Faculty supervisors:
  - Dr. Bruce Gray
  - Dr. Djeven Deva

- We would like to acknowledge the support and cooperation of the CT technologists at St. Michael’s Hospital during the audit period.
AUDIT TEMPLATE

TARGET
Radiation Reduction using 80 kV and 100 kV protocols for CT Pulmonary Angiography (CTPA)

PURPOSE
The use of CTPA studies to investigate pulmonary embolism (PE) has been increasing in recent years. The goal of this audit is to quantify the reduction in radiation dose with low-dose protocols using internal controls.

METHODOLOGY
Retrospectively analyze all patients who have undergone CTPA (80kV, 100kV, 120kV) over a given time frame. Determine the radiation dose parameters (ICRP-103 effective dose and tissue-specific dose) for each CTPA study using Radiometrics eXposure™ radiation dose tracking software. A data collection form is attached.

Calculate the mean dose and standard deviation for each of these patient groups. For patients who have undergone both low voltage CTPA (80kV or 100kV) and standard CTPA at 120 kV, perform a paired t-test analysis on the dose data.

RESOURCES USED
Radiometrics eXposure™ (radiation dose tracking software)
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<th>No.</th>
<th>Unique Study ID (not MRN)</th>
<th>Gender</th>
<th>Age at Exam</th>
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<th>BMI [kg/m^2]</th>
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<th>mAs</th>
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