Procedure Complexity and Utilization Distributions for Interventional CT

Kai Yang
Department of Radiology, Massachusetts General Hospital
Harvard Medical School, Boston MA

Presentation outline

• Background/Motivation
• Procedure Complexity
• Previous Studies on Interventional CT Dose Survey
• MGH Study

Background/Motivation

Interventional CT has very different characteristics from diagnostic CT:
• Relatively lower image quality
• Many repeated short scans
• Strong metal artifact
• Procedure/Site specific
• The related CT dose/image quality has not been thoroughly studied.
Background/Motivation

• The operator determines the progress of the procedure
• High potential to utilize much higher radiation dose than diagnostic CT scans
• For a single procedure, the total effective dose could go above 100 mSv*.


Background/Motivation

• It is critical to understand all the related clinical procedures for CTGI.
• It will be ideal to have a quantitative parameter to measure the necessary dose range or reference level.
• Biggest challenge is the procedure complexity.

How to quantify procedure complexity

A pilot study exploring the possibility of establishing guidance levels in x-ray directed interventional procedures

Establishing Guidance Levels in X-Ray Guided Medical Interventional Procedures: A Pilot Study
Example from Fluoroscopy

Complex Index for PTCA

CI more than patient size
Can we do this for Interventional CT?

Key Factors

- Procedure types – Complexity/Utilization
- Operator experience
- Patient size/condition
- Institutional practice
  - Scanner models
  - Scanning modes – Helical, Axial, Mix

Utilizing available data from CT dose monitoring

- CT scan parameters as surrogates?
  - CTDIvol
  - SSDE
  - DLP
  - Total scan length
  - Number of images
  - Number of acquisitions

Dose Metric
Utilization Metric
OBJECTIVE. The purpose of this study was to determine patient effective dose (E) and peak absorbed dose to the skin of the patient from various CT guided interventional procedures performed without CT fluoroscopy assistance.

MATERIALS AND METHODS. A total of 42 interventions were retrospectively studied. Information on patient demographics, intervention details, and CT images were collected from CT 16, Fluoro大全, and contrast angiography. CT images were segmented from the department’s PACS system and reviewed to identify the source of radiation exposure. From these images, dose and CT were estimated using the Impax Dose-3D and the related Monte Carlo conversion coefficients.

Dose Survey Studies – Leng, et al 2010

Radiation Dose Levels for Interventional CT Procedures

OBJECTIVE. The purpose of this study was to determine typical radiation dose levels for fluoroscopy and non-fluoroscopic CT guided interventional procedures. Radiation dose was measured for various CT interventional procedures using 22CT. The resulting data was used to calculate patient effective dose for each procedure. The effective dose was then compared to the standard for interventional CT procedures. The calculated effective dose was then compared to the standard for interventional CT procedures. The calculated effective dose was then compared to the standard for interventional CT procedures.

Dose Survey Studies – Tsalaftoulas, 2007

CT-Guided Interventional Procedures without CT Fluoroscopy Assistance: Patient Effective Dose and Absorbed Dose Considerations

Isaia A. Tsalaftoulas1
Virginia Topal1
Charilaos Triandopoulos1
Alkis Gavriloudis1
John Papalois1

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Diagnostic scan parameters were used for peri-interventional series.
Dose Survey Studies – Yang, et al 2018

Procedural-specific CT Dose and Utilization Factors for CT-guided Interventional Procedures

Dose Survey Studies – Tsapaki, et al 2019

Setting “Typical” Diagnostic Reference Levels for most common Computed Tomography guided Interventional procedures

Dose Survey Studies – Tsapaki, et al 2019

<table>
<thead>
<tr>
<th>Table 1: Comparison of Dose with mean Interventional Survey</th>
<th>Current study</th>
<th>Radiation 2017</th>
<th>Ellen Dose 2017</th>
<th>Yang 2017</th>
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MHG Study

- To perform detailed analysis of interventional CT dose distribution at MGH.
- To explore the possibility to derive a quantitative metric to assess procedural complexity and CT utilization using CT dose metric as a surrogate.

Methods - Overview

- IRB approved retrospective study.
- Dictation reports collected for CT guided interventional cases performed at MGH from 2012 to 2017.
- CT dose data extracted using Radimetrics platform (Bayer HealthCare, Whippany, NJ).
- Four major categories and twenty-one sub-categories were created.

Methods – Intervention Category
Methods – CT Dose Data

- CTDIvol (mGy): Volume CT Dose index
- DLP (mGycm): Dose-Length-Product
- SSDE (mGy)
- Scan Length (mm)
- Acquisition Count
- Number of Images

Results – CTDIvol

Global CTDIvol median: 11.6 mGy
ACR DIR Abd Pel: 13 mGy
ACR DIR non con chest: 10 mGy

Results – Dose-Length-Product

Global DLP median: 1043 mGycm
ACR DIR Abd Pel: 639 mGycm
ACR DIR Chest: 347 mGycm
Results – Scan Length

Global median: 842 mm

- Double drain: 1490
- Single drain: 848
- 3 or more drains: 1922

Results – Acquisition Count

Global median: 9 acquisitions per case

- Double drain: 12
- Single drain: 7
- 3 or more drains: 13

Results – Number of Images

Global median: 166 images per case

- Double drain: 272
- Single drain: 152
- 3 or more drains: 367
Utilization Factor

\[
\text{Utilization Factor by scan length} (SL) = \frac{\text{SL subgroup median}}{\text{SL global median}}.
\]

\[
\text{Utilization Factor by acquisition count} (AC) = \frac{\text{AC subgroup median}}{\text{AC global median}}.
\]

\[
\text{Utilization Factor by number of images} (NI) = \frac{\text{NI subgroup median}}{\text{NI global median}}.
\]

\[
\text{Overall Utilization Factor} = \text{Utilization Factor by SL} \times \text{Utilization Factor by AC} \times \text{Utilization Factor by NI}.
\]

Results – Complexity/Utilization Factor

- Single institute study
- Only helical scan CT included (did not include CT fluoroscopy or ultrasound assisted procedures)
- DLP and CTDIvol slightly depends on patient size, which has a relatively small variation for this population
- Large variations between different procedures
- The complexity/utilization factors might be applicable to institutes using CT fluoroscopy
Summary

With a large number of cases analyzed and detailed categorization of CT guided interventional procedures (CTGI), consistent and procedure-specific dose metric distributions are presented and quantitative complexity/utilization factors for CTGI procedures are provided.

Future

- Robot/AI
- Different requirement for image quality
- More accurate/efficient procedure
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