Validation of a large scale audit technique for CT dose optimisation

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13th CT Users Group
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Overview

• Introduction
  – RIS, dose audits and DRLs
• Method
  – Dosalyzer© and data filtering
  – The 3rd UK CT Survey
• Results & Discussion
  – A comparison of the large scale audit with the 3rd UK CT Survey data
• Dosalyzer© in action – a practical example
  – CT Head optimisation (Toshiba Aquillion 64 slice)
• Conclusions
Introduction

• It is a requirement of IR(ME)R that we perform dose audits for the purposes of optimisation and checking protocols against DRLs (national and local).

• The traditional ‘paper-based’ audit exercise is time-consuming and very limited in scope (~20 standard (70 kg) patients per room per examination).

• The Radiology Information System (RIS) should contain dose information already – so why not use this?

• Is this sounding familiar?...
Large Scale CT Dose Audit Through Radiology Information Systems (RIS)

P Charnock¹, A Pike¹

¹ Integrated Radiological Services Limited, Liverpool, England

Paul Charnock - Scientific Officer, IRS ltd
CT Users Group Meeting, Hammersmith Hospital, London. October 2010
Patient dose audit using RIS data

- In principle there are many advantages to using the RIS data for patient dose audit
  - Much bigger sample size (e.g. 3400 head CT scans from RIS compared with 20 for the 3rd UK CT Survey)
  - Lessens the burden on often very busy CT departments
  - Much quicker and easier to analyse data
  - Allows routine and long-term monitoring of patient dose and CT protocol changes
  - Readily available local dose data, including the rarer examination types e.g. IR(ME)R incidents, ethics, etc.
The concerns…

• As was raised at last year's meeting, there are potential problems:
  – Incorrect data entry
  – Zeroes and blank entries
  – Multiple exposures assigned to a single exam (linked to zeroes and blanks)
  – Non-standard practice
  – ‘Abnormal’ patients e.g. bariatric

• The results of the dose audit will only be as good as the quality of the data that goes into it!
The ‘Hull’ solution – Data entry

• Talk to the Radiographers
  – Establish what the problems are with data entry, and come up with mutually agreeable solutions
  – Establish what the examination names mean e.g. what’s the difference between a CT chest and a CT chest with contrast? Are they all unique?

• Simple adaptations to the RIS (Radcentre)
  – Flags were added to identify multiple and ‘abnormal’ exposures e.g. non-standard practice, bariatric patients, etc

• Training, training & training
  – Make sure all Radiographers know how important it is to enter data correctly, and when to use the multiple/abnormal flags
The ‘Hull’ solution - Dosalyzer©

- Data is extracted from the RIS in .csv format and uploaded onto a central database every month
- Individual systems, date ranges, examination types (codes) and age groups can be analysed
- Filters can be applied to the data to remove blanks, zeroes and multiple/abnormal exposures (as identified by the Radiographers)
- An additional ‘outlier’ filter can also be applied using sliders on the dose distribution to set the limits for analysis (exclude anything ridiculous)
- Summary dose statistics are then produced, which are exported to Excel for further analysis
### DRL Dosalyzer

**Analysis Dates**
- From: 01 Jul 2010
- To: 31 Jul 2011

**Analysis Options**
- Site: HRI (KCT)
- Room: HRI CT RM1
- Exam: CT CHEST WITH CONTRAST
- Age Range: 16 to 100

**Select Filters**
- Remove 0
- Remove Blanks
- Remove Abnormal Exposures
- Remove Outliers

**View Analysis Results**
- Min Samples: 1

<table>
<thead>
<tr>
<th>ExamName</th>
<th>RoomName</th>
<th>ExamMonth</th>
<th>NumSamples</th>
<th>NDRL</th>
<th>AverageD (Gy/cm²)</th>
<th>MedianD (Gy/cm²)</th>
<th>SEM</th>
<th>MinDose (Gy/cm²)</th>
<th>MaxDose (Gy/cm²)</th>
<th>Standard</th>
<th>Quartiles</th>
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<td>CT CHEST WITH CONTRAST</td>
<td>HRI CT RM1</td>
<td>January</td>
<td>51</td>
<td>80</td>
<td>634.91</td>
<td>574.00</td>
<td>70.07</td>
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<td>2172.00</td>
<td>459.96</td>
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<td>1019.00</td>
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<td>HRI CT RM1</td>
<td>March</td>
<td>76</td>
<td>80</td>
<td>692.50</td>
<td>710.00</td>
<td>60.36</td>
<td>160.00</td>
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<td>671.54</td>
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<td>77.50</td>
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<td>652.85</td>
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<td>62.53</td>
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<td>596.00</td>
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<td>73.71</td>
<td>286.70</td>
<td>2098.00</td>
<td>434.90</td>
<td>463.00</td>
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</table>
Method - Dosalyzer©

• Summary dose statistics were generated for CT heads, chests, hi-res chests, CTPAs, abdo/pelvis, C-spines and virtual colonoscopies for up to four CT scanners (three Philips, one Toshiba)
• 6 month period between July 2010 and December 2010
• Only adult exposures considered (age range set between 16 and 150)
• All blanks, zeroes and multiple/abnormal exposures were filtered out of the data set
Method – 3rd UK CT Survey

- This data was taken as the ‘gold-standard’
  - It will be the basis for future revisions of national DRLs?
- Data was acquired for 20 patients per examination per room
- The data collection was complete in just a few days for the most frequent exams (very much a snap-shot of doses compared with Dosalyzer©), and up to a month for the less frequent
- Mean DLPs and SEMs determined from data
- The patient dimensions of the patients in this study suggested no particularly large or small patients were included (standard patient?)
Results – CT Head

- Large scale RIS audit - mean dose
- 3rd UK CT Survey method (Hull data)
- NDRL (2003)

<table>
<thead>
<tr>
<th>Room</th>
<th>DLP (mGy.cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHH CT RM1</td>
<td></td>
</tr>
<tr>
<td>CHH CT RM2</td>
<td></td>
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<tr>
<td>HRI CT RM1</td>
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<td>HRI CT RM2</td>
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Hull and East Yorkshire Hospitals
NHS Trust
Results

• Overall, good level of agreement between RIS audit and 3rd UK CT survey data for all examinations considered
  – Generally (but not always) agree within the limits of the error bars ($2 \times \text{SEM}$)

• Encouraging given the difference in sample size (3400 c.f. 20) and date range
  – Month-to-month variations can be quite significant…
Month-to-month variations
CT chest with contrast

- CHH CT RM1
- CHH CT RM2
- HRI CT RM1
- HRI CT RM2

DLP (mGy cm)

July
August
September
October
November
December

Month
Month-to-month variations

- **HRI CT RM1**
  - November = 920 mGy cm (N = 47)
  - December = 710 mGy cm (N = 30)

- Whilst not necessarily statistically significant (large error bars), these variations may result in unrepresentative doses being determined.

- This may be particularly problematic when setting local DRLs.

- However, one trend that has been noted is that the mean dose from RIS is almost always higher than that determined from the 3rd UK CT Survey…
RIS dose distributions

- The dose histograms generated from the RIS data are clearly asymmetric, with an appreciable ‘tail’ extending to the high dose region
  - Due to larger/obese and/or tall (longer scan length) patients i.e. not standard patient
- Hence, the mean dose is skewed to higher values…
Mean versus median dose
All examinations

- Mean
- Linear (Mean)
- Median
- Linear (Median)

y = 1.08x
R² = 0.88

y = 0.99x
R² = 0.89
Mean versus median dose

• On average, the **mean** dose is 8% higher than that determined from the 3rd UK CT Survey

• The **median** dose is a much better indicator of standard patient dose (on average 1% lower)
  – It will more closely match the peak of the dose distributions and is not skewed significantly by the long high dose ‘tail’

• Only one point does not agree with the 3rd UK CT survey data when the error bars are considered
Dose reporting using RIS data

• The following process is being implemented within the Hull and East Yorkshire Hospitals Trust for routine (quarterly) dose audits:
  – The mean dose is reported as an indicator of overall population dose. This will include obese/tall patients (i.e. non-standard)
  – The median dose is reported to indicate the dose to the ‘standard’ patient, and for comparison with DRLs
  – Local DRLs will be set as the mean of the room median doses (i.e. not mean of the room means)
Dosalyzer© in action
A practical example

• CT head exposures on Toshiba scanner above NDRL
  – Median DLP = 1163 ± 11 mGy cm c.f. 930 mGy cm
• Helical protocol using SureExposure AEC system
• Adjusted the noise standard deviation from 2.0 to 2.3
  – Expected ~30% reduction in dose, with a ~15% increase in noise
Dosalyzer© in action

A practical example

Noise standard deviation changed second week in March
Dosalyzer© in action

A practical example

• For the three months following adjustment, consistent dose of 870 mGy cm (now easily below the NDRL)

• 25% dose reduction with no concerns raised over image quality

• Further reductions possible?...
Conclusions

• RIS data can be used for CT dose audits
• It is particularly efficient compared with the ‘traditional’ technique, and allows more routine and long term monitoring of patient doses
• However, caution must be taken to not remove the role of the Radiographer completely
  – As IR(ME)R operators, they have a responsibility to ensure all exposures are optimised
  – They may identify clinical issues that are not obvious from the data present in the RIS system
  – The extra information they *may* provide can reveal more about clinical protocols
    • Individual doses for multiple sequence exams e.g. CT chest c.f. CT chest with contrast
Acknowledgements

• The CT Radiographers at Castle Hill Hospital and Hull Royal Infirmary for collecting the 3rd UK CT Survey data
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