Use of the deviation index (DI) for quality control in digital radiography

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Disclosures

• None

Contributors to AAPM TG 232

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• Eric Gingold (RFSC chair, now IPC chair)
• Behrang Amini and Patrick O'Keefe (radiologists)
The infamous Table 2

Good intentions

But perhaps flawed logic
But perhaps flawed logic
Review and replace

**Charge**: To investigate the current state of practice for CR/DR Exposure and Deviation Indices based on AAPM TG 116 and IEC-62494, for the purpose of establishing achievable goals (reference levels) and action levels in digital radiography.
Methods

- Solicited data for 9 body parts and views for adult and pediatric digital radiography from 10 sites
  - Abdomen: AP/KUB, Upright, Decubitus
  - Chest: PA, AP, Lateral, Decubitus
  - Pelvis: AP
  - Extremity: without multiple views on same image
- Institutional Review Board/Quality Improvement Assessment Board approvals
- DI calculated from EI and EI
- Minimal pre-processing of data
- -9.9 ≤ DI ≤ +9.9
- 505,930 exposures analyzed

Methods

- Analysis was performed in aggregate and stratified by
  - Patient type
  - Adult vs. pediatric
  - Exposure control method
  - Manual vs. AEC
  - Image receptor technology
  - Scanned pixel vs. fixed pixel
  - Practice setting
  - Academic Hospital vs. Community Hospital
What we learned about the state of practice

We know where we're going but we don't know where we are...

EI_f varied widely among participating sites

Many DI fell outside TG-116 significant action limits
Mean DI was often not equal to 0.0

No single site was the best at everything
Use of AEC resulted in a narrower DI distribution

The table below shows the DI distribution by exposure control method and technology for EI values before and after the application of AEC. The table includes columns for different technologies, exposure control methods, and EI values, with mean and standard deviation provided for each category.

DI distribution was not reliably correlated with EI.

The scatter plot demonstrates the relationship between DI and EI for AP chest images. The correlation coefficient is r = -0.072 with a p-value of 0.790, indicating no significant correlation between DI and EI.
DI distribution was not reliably correlated with $E_1_T$.

**PA chest**

$r = 0.830$

$p < 0.001$

**Lat chest**

$r = 0.640$

$p = 0.014$

**KUB abdomen**

$r = 0.351$

$p = 0.183$
How can we use this information for quality control?

Well isn’t that neat! What do you use it for?

1. Review your DI data.
- Mean DI should equal 0.0
  - EI, configured properly
  - Equipment calibrated properly
  - Equipment used properly (process)
- Compare your DI distribution to the data in TG-232
  - Most importantly, the standard deviation of the DI

Best and worst case SD(DI) – all sites – adult

<table>
<thead>
<tr>
<th>Body part</th>
<th>View</th>
<th>Site with the smaller standard deviation of the DI</th>
<th>Site with the largest standard deviation of the DI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of exams</td>
<td>Standard deviation of DI</td>
<td>Number of exams</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Head</td>
<td>Front Oblique</td>
<td>115</td>
<td>1401</td>
</tr>
<tr>
<td></td>
<td>Frontal</td>
<td>115</td>
<td>1401</td>
</tr>
<tr>
<td></td>
<td>AP</td>
<td>115</td>
<td>1401</td>
</tr>
<tr>
<td></td>
<td>PA</td>
<td>115</td>
<td>1401</td>
</tr>
<tr>
<td></td>
<td>Lateral</td>
<td>115</td>
<td>1401</td>
</tr>
<tr>
<td>-----------</td>
<td>------------------</td>
<td>--------------------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Pelvic</td>
<td>Superior Ectopic</td>
<td>1230</td>
<td>1620</td>
</tr>
<tr>
<td></td>
<td>Lower Ectopic</td>
<td>1230</td>
<td>1620</td>
</tr>
<tr>
<td></td>
<td>Upper Ectopic</td>
<td>1230</td>
<td>1620</td>
</tr>
</tbody>
</table>

*Number of examinations from site was at least 10% of the total number of examinations from all sites insufficient sample size data provided in Appendix A for reference*
2. Review your EI\_T values.

- Mean DI should equal 0.0
- Remember, the EI is an **indicator**
- Stick around for the next talk

3. Adjust your DI limits.

- DI limits should consider
  - Body part and view
  - Practice setting, including characteristics of radiologists
  - Image receptor technology
  - Image processing algorithm
  - VOI identification method
- A tiered review process should be triggered when DI limits are exceeded
Tiered review process

Table 14. Recommended action limits and associated actions for the deviation index (DI).

<table>
<thead>
<tr>
<th>DI Limit</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3</td>
<td>Provide action</td>
</tr>
<tr>
<td>≤ 3</td>
<td>For periodic review, daily number of occurrences for periodic review.</td>
</tr>
<tr>
<td>≤ 1.5</td>
<td>See noted in Figure 5.</td>
</tr>
</tbody>
</table>

4. Repeat
Needs to make the DI more useful

- Utilities for configuring global EI, values for broad categories
- The ability to set DI limits at any level of granularity, from a single universal set of limits to limits by individual body parts and views
- Both of the above may be accomplished by allowing upload of EI, values and DI limits in a specified file format
- Utilities for easily filtering and downloading EI, values, EI data, and DI data, preferably over the network
- An optional overlay of the identified VOI on the FOR PROCESSING image data

In the end

- It's time that we used the data that are available to us
- To drive quality control and quality improvement
- The FDA should mandate that the IEC EI and DI be reported by all digital radiography systems in the US
- State regulatory agencies should mandate that sites have a QA program for their radiography operation and log and review the DI and EI