New Digital Radiography Exposure Indicators and the ACR Dose Index Registry for Digital Radiography

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Disclosures

Corporate-funded research in digital radiography with:
Carestream
FujiFilm
Screen-Film versus Digital Radiography

Optical density

- Screen film ≈ exposure
- Immediate feedback to technologist and radiologist regarding technique

Grey Scale

- Digital ≠ exposure
- Processing compensates
- No feedback to technologist and radiologist regarding technique
Screen-film

Digital

Courtesy Michael Flynn, PhD
Proprietary Exposure Indicators

Provide feedback about technique adequacy
Incident radiation on x-ray plate

Carestream Formula:

\[ EI = 1000 \times \log_{10}(\text{mR}) + 2000 \]

1 mR = 2000 EI, 2 mR = 2300 EI, 0.5 mR = 1700 EI

Fuji S = 200/(mR)
Siemens EXI = \( \mu \text{Gy} \)

Overexposure common
Proprietary Exposure Indicators

As plate exposure:
- Carestream indicator: logarithmic
- Fuji indicator: linearly
- Siemens indicator: linear
Exposure reporting

Multiple exposure measures confuse radiologists and technologists
Exposure values may not be reported in PACS
Cannot access data for analysis
Difficult to assure quality
Standardized Exposure Terminology

International Electrotechnical Commission

- IEC 62494-1 standard
- Standardized nomenclature
- Standardized “dose” reporting
- Medical Imaging and Technology Alliance (MITA) has accepted standard
- FDA may recognize standard
Standardized Exposure Terminology

3 terms to learn:

• Exposure Index (EI)
• Target Exposure Index ($\text{EI}_T$)
• Deviation Index (DI)
Exposure Index (EI)

Measure of exposure in the relevant region on the receptor

Depends on

- Examination type
- Image processing
- Exposure
Exposure Index (EI)

Calibrated using standardized conditions
  • 70 kVp, 21 mm pure Aluminum (6.8 HVL)
  • (RQA-5)

Linear relationship with mAs
  • At same kVp, double mAs doubles EI

Dependent on kVp
Exposure Index - Beam Quality Response

- 70 KVP - 6.85 HVL @ 10 Microgray, EI ~1000 - (RQA-5)
- 90 KVP - 4.41 HVL @ 10 Microgray, EI ~ 800
- 70 KVP - 3.34 HVL @ 10 Microgray, EI ~ 700
- 50 KVP - 2.45 HVL @ 10 Microgray, EI ~ 500

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Target Exposure Index (EIₜ)

Reference exposure when image is “optimally” exposed

Set by

- Manufacturer
- Imaging center
Target Exposure Index ($EI_T$)

Depends on

- Detector
  - $\uparrow$ DQE  $\downarrow$ mAs yet maintain EI
- Body part
- View
- Procedure
Deviation Index (DI)

Quantifies how EI varies from EIT

\[ DI = 10 \times \log_{10} \left( \frac{EI}{EI_T} \right) \]
<table>
<thead>
<tr>
<th>Deviation Index</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>-3</td>
<td>50</td>
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<tr>
<td>-1</td>
<td>80</td>
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<tr>
<td>0</td>
<td>100</td>
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<tr>
<td>+1</td>
<td>126</td>
</tr>
<tr>
<td>+3</td>
<td>200</td>
</tr>
</tbody>
</table>
Deviation Index

It provides a feedback to technologists and radiologist

Measure of exposure adequacy only (noise)

Still must check for

- Collimation
- Motion
- Positioning
Effects of mAs on EI at fixed 60 kVp \( EI_T = 450 \)

- mAs = 1.0
  - EI = 479
  - DI = 0.3

- mAs = 2.5
  - EI = 1258
  - DI = 4.5

- mAs = 0.25
  - EI = 102
  - DI = -6.4

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Region of Interest effect on EI:
EI = 264, EI_T = 300, DI = -0.6
ROI Lungs:
$EI = 375$, $EI_T = 300$, $DI = 1.0$
ROI Abdomen:
EI = 64, EI_T = 300, DI = -6.7
ROI free-in-air:
EI = 1924, EI_T = 300, DI = 8.1
EI = 102, EI_T = 250, DI = -3.8
Acceptable image
EI = 12, $EI_T = 250$, DI = -13.2

Unacceptable image
EI = 1780, $E_{IT} = 400$, DI = 6.5
Overexposed without saturation
EI = 301, \( EI_T = 250 \), DI = 0.8
Left arm unnecessarily exposed
Patient Dose Estimate

Exposure Indicator is not patient dose!

Technique Factors

- Grid use, kVp, added filtration
- Patient positioning –AP/PA, lateral
- Age
- Organ

Dose Area Product
ACR Dose Index Registry
For Digital Radiography

Registry to collect and compare dose information across facilities
Uses DICOM SR and ACR Triad software
Establishes national benchmarks and practice patterns in dose indices
CT DIR for adults and pediatrics now running using Radlex playbook
5 centers supplying data to DIR DR
Summary

Exposure Index standard eliminates confusing vendor terminology

New exposure terminology:
- Exposure Index
- Target Exposure Index
- Deviation Index

ACR DR DIR compares data among centers
- Only 1 vendor completely compliant
- Need pediatric centers