KAP and MSD variation in interventional cardiology

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Medical physicist
Turku university hospital
IC procedures
- Few words on basics

KAP
- DRLs in Finland and measured EU KAP
- Dose variation and ideas what to do about it
- ICRP

Data science
- Data mining for procedure difficulty levels

Skin doses
- Gafchromic film MSDs and erythema risks in Finland
- Alert Levels
- Dose variation

Skin dose algorithms
- Skin dose estimation software and their accuracy
Interventional cardiology

- Team work between cardiologist and 2-3 nurses
- Patient is imaged during a procedure from various projections with fluoroscopy and often also cine
- Many clinical practices affect the often instantaneous choices on how and when to obtain necessary diagnostic information

Typical Finnish exposures

<table>
<thead>
<tr>
<th>Työntekijäryhmä</th>
<th>$H_{p}(10)$</th>
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<tbody>
<tr>
<td>Kardiologi</td>
<td>20</td>
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<tr>
<td>Hoitaja</td>
<td>4</td>
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Efektiivinen annos saadaan jakamalla syväanno syväanons tekijällä 50–100.
Most Dose-heavy procedures in Finland

Finnish DRLs
The median total $P_{ax}$ values (in Gy cm$^2$) for each procedure and each country. The last two columns are the 3rd quartiles (without and with weight restriction) of the data on each row. The median $P_{ax}$ values that are based on less than five data points are given in parentheses. DRL was calculated from medians with at least five data points. *Includes ablation. The 3rd quartiles in parenthesis are calculated without this values.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>BE</th>
<th>HR</th>
<th>CZ</th>
<th>FI</th>
<th>FR</th>
<th>GR</th>
<th>IR</th>
<th>LB</th>
<th>PL</th>
<th>RS</th>
<th>ES</th>
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<td>CTO</td>
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<td>137</td>
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<td>3.20</td>
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<td>2.53</td>
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<td>0.86</td>
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<td>3.2</td>
<td>4.75</td>
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<td>14.1 (11.9)</td>
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</tr>
</tbody>
</table>
Dose variation in Finland

Percutaneous Coronary Intervention

Transcatheter Aortic Valve Implantation
Dose variation in the EU
Parameters and Practices

- **Procedure difficulty**
  - Many possible parameters depending on the procedure

- **Optimization**
  - Imaging protocols
  - FL time
  - Cine
  - Collimation
  - Projections
  - Zoom
How to set difficulty levels?
Dose monitoring software

- DoseWatch, Radimetrics and many others available
- Angiospecific parameters
- Exportation of data
Procedure registries
Patient demographic data

- Weight
- Height
- Age
- Gender
Dose prediction

1) Read data
2) Split into training and test sets
3) Impute missing values
4) Scale features

Repeat 100 times with new randomisation seed

Training set

Repeat for k feature selection methods

5) Use feature selection method k

Training set

6) Select n best features

Repeat for n features

Repeat for each hyper-parameter combination

8) Obtain the best model based on validation error for prediction

Test set

9) Save final test error for feature selection method k using n features
Dose prediction
Maximum Skin Doses and Erythema Risks

- There is a risk but how big is it?
- How to communicate it?
- How to implement good practices?
Dose variation in Gafchromic Film Measurements

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<tr>
<td>N</td>
<td>87</td>
<td>50</td>
<td>41</td>
<td>10</td>
<td>14</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>Mean Gafchromic film MSD (mGy)</td>
<td>116.15</td>
<td>437.08</td>
<td>96.34</td>
<td>121.76</td>
<td>158.74</td>
<td>210.55</td>
<td>623.81</td>
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<tr>
<td>Mean KAP (Gycm²)</td>
<td>26.67</td>
<td>95.86</td>
<td>5.45</td>
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<td>7.85</td>
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<td>64.66</td>
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<td>Mean Air kerma (mGy)</td>
<td>479.63</td>
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## Dose variation in Gafchromic Film Measurements

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### Graphs

- **PCI MSD vs. KAP**
  - Equation: \( y = 5.378x + 234.56 \)
  - \( R^2 = 0.7912 \)

- **PCI MSD vs. AirKerma**
  - Equation: \( y = 0.077x + 383.63 \)
  - \( R^2 = 0.2657 \)
What causes this variation?
What causes this variation?

- Use of projections
- Patient size
- Imaging protocols
Alert Levels

• For 2 Gy MSD to be exceeded in TAVI
  • 200 000 mGycm$^2$ KAP
  • Or
  • 2 Gy air kerma
Skin dose algorithms
Rough outline on how they work

- Estimation of patient size and location
- Realtime data collection of projections and irradiations
- Estimation of entry points and summing skin doses
- DoseWatch, DoseWise, CareMonitor, Dose tracking system...
Software Comparisons

The diagram illustrates the comparison between MSD (mGy) and RPAK (mGy) for two different software systems: GE DoseWatch and Siemens CareMonitor.

For CareMonitor:
- Equation: \( y = 0.8582x + 49.811 \)
- Data points and trend line

For DoseWatch:
- Equation: \( y = 1.1092x + 7.4575 \)
- Data points and trend line
Validation?
Thank you!


