Use of lead shielding for adult chest CT

Dose measurements and patient & radiographer experiences

The Leeds Teaching Hospitals NHS Trust


International Survey

- An online survey of CT Radiographers:
  - Do you use lead shielding during pregnancy?
  - Do you find it heavy or light?
  - How well does it fit the patient?
  - Do you have any work related back problems?
  - Do patients complain about the weight of the shielding?

- 390 completed responses (543 total)
  - 117 from Australia, 114 from UK, 110 from North America, 41 from Europe, 8 others

- Thank you for your assistance!
Do you use lead shielding?
## Use of shielding

<table>
<thead>
<tr>
<th>Region</th>
<th>Using lead shielding (%)</th>
<th>Using shielding on both sides of patient (%)</th>
<th>Using shielding as per recommendations (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>73.7</td>
<td>90.1</td>
<td>66.4</td>
</tr>
<tr>
<td>North America</td>
<td>94.5</td>
<td>98.1</td>
<td>92.8</td>
</tr>
<tr>
<td>Europe</td>
<td>46.3</td>
<td>89.5</td>
<td>41.5</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>73.6</td>
<td>88.2</td>
<td>64.9</td>
</tr>
</tbody>
</table>
Moving and handling

How would you rate the weight of the lead shielding?

- UK
- N. America
- Europe
- Rest of the world

Percentage

- Positive
- Indifferent
- Negative
Moving and handling

Is the lead shielding easy or difficult to manoeuvre?

Percentage

- Positive
- Indifferent
- Negative

UK
N. America
Europe
Rest of the world
Radiographers back problems

Have you suffered from occupationally related back problems?

- UK
- N. America
- Europe
- Rest of the world

<table>
<thead>
<tr>
<th>Region</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>70.0</td>
<td>80.0</td>
</tr>
<tr>
<td>Rest of the world</td>
<td>90.0</td>
<td>90.0</td>
</tr>
</tbody>
</table>
How well does the shielding fit?

How well does the shielding fit the patient?

- UK
- North America
- Europe
- Rest of the world

Percentage

- Positive
- Indifferent
- Negative
Complaints about weight

Have any patients complained about the weight of the shielding?
Summary responses

- “The lead shielding fit is more difficult closer to the end of the pregnancy, trying to get the lead to stay on the abdomen and not to slide into the anatomy to be covered is difficult.”

- “If the patient is very big I may have to use three aprons to completely circumvent the patient.”

- “It is difficult to eliminate the gap at the sides and sometimes an additional apron is used which increases the weight on the abdomen.”
The need for something new...

“Big patients are very difficult to get the shielding all the way around. There is nothing specifically designed for pregnant people.”
ShieldAll™
Comparative study

- 35 volunteers
  - ‘Patient’ & radiographer
- Simulated pregnancy
- Compare Pb aprons and ShieldAll
  - Weight
  - Manoeuvrability
  - Fit to patient shape
  - Perception of protection
Radiographer

Were the products easy or difficult to manoeuvre?

How would you rate the weight of the product in terms of moving and handling?

Was it easy or difficult to position the product on the patient?

How well did the product fit the pregnant patient?
How would you rate the products in terms of weight?

- Lead Aprons
- ShieldAll

How would you rate the products in terms of the fit to your shape?

- Lead Aprons
- ShieldAll

How well did you feel that the product protected your abdomen?
## Comparative study - results

### From the radiographer perspective

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Indifferent</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead aprons</td>
<td>27%</td>
<td>22%</td>
<td>51%</td>
</tr>
<tr>
<td>ShieldAll</td>
<td>83%</td>
<td>15%</td>
<td>2%</td>
</tr>
</tbody>
</table>

### From the patient perspective

<table>
<thead>
<tr>
<th></th>
<th>Positive</th>
<th>Indifferent</th>
<th>Negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead aprons</td>
<td>17%</td>
<td>28%</td>
<td>55%</td>
</tr>
<tr>
<td>ShieldAll</td>
<td>72%</td>
<td>20%</td>
<td>8%</td>
</tr>
</tbody>
</table>
A volunteer’s response

“The lead coat was very bulky and could maybe seem unprofessional and slap dash to a patient who is in late pregnancy with the added worries of having to have a CT scan, whereas the [ShieldAll] seemed more catered and suitable to the CT scan table and was much lighter and in my opinion would provide much more protection to the foetus.”
Focus groups: summary

“… the [ShieldAll] was unanimously preferred over the lead coat, both from a patient perspective and an administering radiographer.”
Dose saving for non-pregnant patients

- Scanned chest of anthropomorphic male phantom
- Abdomen & pelvis contained TLDs for dose measurement
- Three sets of scans:
  - No lead
  - Lead aprons
  - ShieldAll
Dose calculations

● Calculated point doses and average dose per slice
● Match organ and dose measurement positions for shielded organs → organ doses
● Bone surface (skin & bone marrow)
  ● Organ fraction per phantom slice
  ● Bone surface dose per phantom slice
  ● Weighted for percentage in shielded region
Average dose per slice

No statistically significant difference between lead aprons and ShieldAll data sets ($p=0.4990$)
Dose distributions

- No lead
- Lead aprons
- ShieldAll
  - Map of dose scattered outside scan volume
  - Dose savings greatest at periphery of phantom
  - Successfully eliminating external scatter
## Organ dose savings

<table>
<thead>
<tr>
<th>Organ/Tissue</th>
<th>Tissue weighting factor (ICRP 103)</th>
<th>Dose saving (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone Marrow (Red)</td>
<td>0.12</td>
<td>16.6</td>
</tr>
<tr>
<td>Bone Surface</td>
<td>0.01</td>
<td>9.5</td>
</tr>
<tr>
<td>Colon</td>
<td>0.12</td>
<td>33.2</td>
</tr>
<tr>
<td>Kidneys</td>
<td>Remainder</td>
<td>3.7</td>
</tr>
<tr>
<td>Lymph Nodes</td>
<td>Remainder</td>
<td>35.0</td>
</tr>
<tr>
<td>Muscle</td>
<td>Remainder</td>
<td>35.0</td>
</tr>
<tr>
<td>Ovaries</td>
<td>0.08</td>
<td>24.9</td>
</tr>
<tr>
<td>Prostate</td>
<td>Remainder</td>
<td>59.0</td>
</tr>
<tr>
<td>Skin Surface</td>
<td>0.01</td>
<td>9.3</td>
</tr>
<tr>
<td>Small Intestine</td>
<td>Remainder</td>
<td>3.8</td>
</tr>
<tr>
<td>Testes</td>
<td>0.08</td>
<td>71.7</td>
</tr>
<tr>
<td>Urinary Bladder</td>
<td>0.04</td>
<td>40.9</td>
</tr>
<tr>
<td>Uterus</td>
<td>Remainder</td>
<td>35.4</td>
</tr>
</tbody>
</table>
Dose savings summary

- Up to 72% reduction in dose to specific organs
- 4% reduction in effective dose
  - Over and above dose savings from protocol optimisation (e.g. lowering mA)
- Large reduction in collective dose
- Thus large reduction in collective risk
USA case study

- CT delivers ~50% of medical collective effective dose (~70 million scans in 2007)

- ~4100 cancers/year due to chest CT

- Reduced to ~3900 by use of shielding
Conclusions

- Lead shielding still not universally used for pregnant patients
- ShieldAll approved by ‘pregnant patients’ and radiographers
- Yields significant organ, effective and collective dose savings
  - Over and above conventional optimisation
  - Associated reduction in collective risk
- Recommend use on all patients undergoing CT scans, especially pregnant patients and paediatrics
Acknowledgments

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