Review of options for cabin dosimetry & operation

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Review of options for cabin dosimetry & operation

- Different centres have differing lamp replacement policies
- More centres using internal detectors to control patient dose for TL01 phototherapy to account for gradual reduction in tube output with treatment hours

Aims of study

- Assess the influence of cold and hot spots on lamp replacement policy
- Investigate how patient position could affect detector reading and hence patient dose
- Investigate the contribution of lamp banks to the overall irradiance
Decline in Cabin Output with time

30 – 40% reduction in cabin irradiance over 200 h
Mean lamp lifetime ±1sd = 470 ± 170h
Influence of cold/hot spots

- Lamps failure produces an area of low irradiance – a ‘cold spot’
- Defined as the magnitude of the irradiance in a quadrant where the tube has failed compared to a normal quadrant
- Similarly for a ‘hot spot’
- Historical data from West of Scotland automated UV dosimetry system\textsuperscript{1,2} interrogated for various TI01 cabin types

\textsuperscript{1} - Currie GD et al. 2001 An automated dosimetry system for testing whole-body ultraviolet phototherapy cabinets \textit{Physics in medicine and biology} \textbf{46} 333-45

\textsuperscript{2} - Evans AL et al. 2002 Instrument for scanning the angular variation of irradiance in ultraviolet phototherapy cabinets \textit{Journal of Medical Engineering & Technology} \textbf{26(3)}126-31
Automated UV Dosimetry System

- System to take 800 measurements of irradiance around 360° rotation
- Collimated detector to give indication of output from individual lamps (radiant intensity)

![Diagram of Automated UV Dosimetry System]

- Radiometer
- Collimated detector
- Stepper motor in base
- Controlled by LAPTOP
Automated UV calibration system

Dual detector head

Rotation achieved using stepper motor controlled by integrated circuits
Influence of cold/hot spots (a)

UV 7001 – 40 tubes

1 out centre: 10%
2 adjacent: 18%

1 out corner: 7%
2 adjacent: 13%

Hot spot: 4 - 5% 1 tube replacement
Influence of cold/hot spots (b)

UV 1000 – 26 lamps
Integral 20-25% reduction towards hinges due to cabin geometry

1 tube out centre: 7-10%
1-2 tubes out hinge: 30-40%
3 lamps out: 55%

Failure of 3 lamps in one quadrant
Influence of cold/hot spots (c)

UV 7001k – 13 tubes
30% reduction if one tube out
15% increase for replacement tube

Also UV 5000 – 24 tubes
12% reduction if one tube out
6-7% increase for replacement tube

Failure of 1 lamp and its replacement
Influence of cold/hot spots

- % irradiance variation of cold spots ~ double that of hot spots
- More significant for cabins with fewer lamps & dependent on cabin geometry
- Modern cabins – localised erythema unlikely due to variation in irradiance (order of 10%)
- Older dual lamp cabins or smaller cabins – lamp failures should be dealt with promptly (order of 30%)
Study of Internal detectors

- Ti01 cabins only
- 3 different types of cabin
- Developed a phantom with reflectance approximately the same as skin
  (Phantom: 5% ± 8%, Skin 4 – 7%)
- Allowed cabin warm-up to stabilise output
- Moved phantom in Anterior Posterior (AP) & Lateral directions, controlled from outside cabin during single run
<table>
<thead>
<tr>
<th>Unit</th>
<th>Nº Tubes</th>
<th>Internal Detector Type</th>
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</thead>
<tbody>
<tr>
<td><strong>Waldmann UV 7001</strong></td>
<td>40</td>
<td>Double detector&lt;br&gt;Facing side banks&lt;br&gt;Knee height</td>
</tr>
<tr>
<td><strong>Waldmann UV 5000</strong></td>
<td>24</td>
<td>Single detector&lt;br&gt;Facing Patient right&lt;br&gt;Knee height</td>
</tr>
<tr>
<td><strong>Cosmedico GP 42</strong></td>
<td>Dual UVA/TL01&lt;br&gt;21 TI01 lamps</td>
<td>Double detector&lt;br&gt;Facing 2 banks to Patient Right&lt;br&gt;Above head height</td>
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</tbody>
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Detector configurations

- Dual Detector 7001
- Single detector 5000
- UV 5000/7001
- Cosmedico GP42
Bank dependency

- Whole lamp banks covered and resulting internal detector reading recorded
- Relative dependency calculated as a percentage
- Measured dependency from door bank negligible

UV 7001 - Dual Detectors
Bank dependency

**UV 5000 - Single Detector**

- 14%
- 32%
- 20%
- 34%

**Cosmedico GP42 - Dual Detector**

- 14%
- 56%
- 12%
- 34%
Variation in irradiance

Patient position Vs. relative irradiance (lateral direction)
## Results

<table>
<thead>
<tr>
<th>Centre Offset [cm]</th>
<th>% Dose Discrepancy</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>UV 7001</td>
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<tr>
<td></td>
<td>AP</td>
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<tr>
<td>-10</td>
<td>-2</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
</tr>
</tbody>
</table>
Results

- Few % difference between standard & large patients
- Single detector system outliers ±60% (for ±10-20cm offset)
- However, UV 5000 cannot be used with internal detector control
- Newer Waldmann UV 5001 has single internal detector with calibration performed without patient in cabin
- Results in a 15% patient attenuation coefficient dose discrepancy
- Cosmedico GP42 outliers ±10-15% for taller patients (for ±10-20cm offset)
Results

- Two bank dependency for Cosmedico GP42 (56%)  
- If a single tube out on these banks, results in a 9 – 10% reduction in detected cabin irradiance, compared to ~3% for other banks  
- However, actual reduction in overall cabin irradiance will be ~5%
Conclusions

- Whole batch & single lamp replacement policies are considered equally acceptable provided there is a robust system to identify & replace failed lamps.
- However, batch replacement will also have periods of failed tubes → cold spots.
- Waldmann 7001 cabin internal detector readings only varies by ±5% with patient position.
- Waldman 5000 cabin readings varies by 50% with patient position, but not used to control treatment.
- Cosmedico GP42 cabin readings vary by ±5% with patient position, but one lamp failure can change reading by 10%.
Acknowledgements

- Stuart MacCalman & Graeme Phanco
  Health Physics Service

- Cameron Hosie
  Lanarkshire Acute Hospitals NHS Trust