Analysis of the last decade of out-of-hours CT: How have things changed

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Purpose

Since introducing CT into clinical practice in the 1970's, it has rapidly transformed the management of patients. Acting as an alternative to standard radiographs and ultrasound, examinations using CT have become an indispensable, sometimes life-saving tool, with ever increasing applications. Driving this rapid growth is the ability that CT has not only to timely triage patients for surgery but to identify and diagnose numerous conditions with high accuracy.

The growth of CT is also due to its ever-increasing clinical applications and technological advances coupled with widespread access and availability. There has been rapid technological developments including the introduction of helical and multi-detector scanners which decrease motion artefacts, acquire volumetric data in a short time with great anatomic coverage and generate isotropic data sets which facilitate the 3D reconstruction of anatomical areas. Due to its high diagnostic accuracy CT is now the mainstay for diagnosis of many acute presentations such as pulmonary emboli and renal calculi. With greater speed compared to MRI sedation can often be avoided particularly in the paediatric population. These advantages have led to the rapid increase in the utilisation of CT in both adults and children.

Furthermore there is a significant cost burden associated with any delays in patient management. Many Irish hospitals have developed acute assessment medical units with the aim of accelerating patient treatment and discharge. The pressure to reduce the length of inpatient stays has also drastically increased the daily CT requests and the radiology workload to meet hospital deadlines. Early CT imaging has been shown to reduce hospital stay as well as allowing the safe discharge of patients from the emergency department without requiring admission. This has meant that not only has there been a demand for CT during the radiology department working hours but also during on-call hours.

This study focused on weekend on-call hours as this represents the time when imaging performed should be justified by acute clinical necessity because the outcome of imaging may determine further acute management. This is also the time when the radiology department has lowest staffing levels. Ever growing numbers of CT scans are requested during routine working hours and to facilitate this work load on many days of the week the radiology department has to extend the hours during which these scans are performed. This makes it difficult to decipher which scans were requested and performed during weekday on-call hours. Choosing the study period of weekend on-call hours avoids this, ensuring all scans are both ordered and performed during our institutes' out-of-hours imaging service.
Against this background new clinical programmes are being introduced to try to facilitate the increasing requirements for CT imaging. On the horizon is a proposed introduction of an extended working day from 8am to 8pm coupled with a seven over seven working schedule including weekends as routine. Prior to this we recognised the need to retrospectively assess the data at our institution focusing on CT utilisation during weekend on-call hours for a ten-year period, from 2001-2010.
Methods and Materials

In this retrospective cross-sectional analysis the trend in diagnostic CT imaging was assessed over a ten year period from January 2001- December 2010 for both adult and paediatric patient populations. Our facility is a 625-bed university-affiliated tertiary care hospital, housing the national urology service and regional orthopaedic trauma unit. Our institute provides an adult and paediatric emergency department service. The study population included all adult and paediatric patients, both inpatients and those attending the emergency department, who underwent CT imaging during weekend on-call hours. Retrieved electronic data obtained from the hospital Radiology Information System (RIS) included the type of study performed and the source of request, whether it was from inpatient services or emergency department. The total number of CT scans per year for the ten-year period was calculated. CT imaging was grouped into eight categories by anatomical region (brain, abdomen, pelvis, spine, thorax, other, facial bones and joints). The data was described in relation to both temporal trends and patient location.
Results

In the ten-year period from 2001 to 2010, a total of 8530 CT examinations were performed during weekend on-call hours. This consisted of 8076 adult CT scans and 454 paediatric CT examinations. The emergency department accounted for a total of 52.6% of referrals, compared to 47.4% for the inpatient group. During this decade there was an overall 210.7% increase in weekend on-call CT imaging performed. Although the absolute number of paediatric CT scans performed was less than that of the adult population the overall ten-year rate of growth was 234.6% which was slightly larger than that of the adult population of 209.3%.

Results were subdivided into eight CT categories and the overall ten year total of each category of examination is displayed below (Table 1). The number of CT examination per year is displayed for the five most commonly performed CT examinations and these results are displayed below also (Table 2 and Table 3).

<table>
<thead>
<tr>
<th>CT Examination</th>
<th>Ten Year total for adult CT</th>
<th>Ten year total for paediatric CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain</td>
<td>3673</td>
<td>271</td>
</tr>
<tr>
<td>Abdomen</td>
<td>1670</td>
<td>55</td>
</tr>
<tr>
<td>Pelvis</td>
<td>1326</td>
<td>43</td>
</tr>
<tr>
<td>Spine</td>
<td>527</td>
<td>33</td>
</tr>
<tr>
<td>Thorax</td>
<td>488</td>
<td>28</td>
</tr>
<tr>
<td>Facial Bones</td>
<td>119</td>
<td>20</td>
</tr>
<tr>
<td>Joints</td>
<td>70</td>
<td>2</td>
</tr>
<tr>
<td>Other</td>
<td>203</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 1. Ten year total per category of CT examination

<table>
<thead>
<tr>
<th>Year</th>
<th>CT Brain</th>
<th>CT Abdomen</th>
<th>CT Pelvis</th>
<th>CT Thorax</th>
<th>CT Spine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>24</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2002</td>
<td>13</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>
Table 2. Number of CT examinations per year for the five most commonly performed paediatric CT examinations

<table>
<thead>
<tr>
<th>Year</th>
<th>CT Brain</th>
<th>CT Abdomen</th>
<th>CT Pelvis</th>
<th>CT Thorax</th>
<th>CT Spine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>33</td>
<td>6</td>
<td>2</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>2004</td>
<td>27</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>2005</td>
<td>19</td>
<td>8</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2006</td>
<td>34</td>
<td>9</td>
<td>8</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>2007</td>
<td>28</td>
<td>8</td>
<td>8</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>20</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>2009</td>
<td>21</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>2010</td>
<td>52</td>
<td>9</td>
<td>7</td>
<td>4</td>
<td>11</td>
</tr>
</tbody>
</table>

Table 3. Number of CT examinations per year for the five most commonly performed adult examinations

<table>
<thead>
<tr>
<th>Year</th>
<th>CT Brain</th>
<th>CT Abdomen</th>
<th>CT Pelvis</th>
<th>CT Thorax</th>
<th>CT Spine</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>257</td>
<td>82</td>
<td>26</td>
<td>12</td>
<td>38</td>
</tr>
<tr>
<td>2002</td>
<td>230</td>
<td>109</td>
<td>79</td>
<td>31</td>
<td>47</td>
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<tr>
<td>2003</td>
<td>329</td>
<td>178</td>
<td>131</td>
<td>41</td>
<td>68</td>
</tr>
<tr>
<td>2004</td>
<td>317</td>
<td>145</td>
<td>119</td>
<td>36</td>
<td>55</td>
</tr>
<tr>
<td>2005</td>
<td>283</td>
<td>155</td>
<td>137</td>
<td>36</td>
<td>43</td>
</tr>
<tr>
<td>2006</td>
<td>331</td>
<td>163</td>
<td>156</td>
<td>50</td>
<td>39</td>
</tr>
<tr>
<td>2007</td>
<td>372</td>
<td>143</td>
<td>132</td>
<td>42</td>
<td>50</td>
</tr>
<tr>
<td>2008</td>
<td>422</td>
<td>172</td>
<td>167</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>2009</td>
<td>504</td>
<td>214</td>
<td>178</td>
<td>75</td>
<td>67</td>
</tr>
<tr>
<td>2010</td>
<td>628</td>
<td>229</td>
<td>201</td>
<td>120</td>
<td>82</td>
</tr>
</tbody>
</table>

The trends in each CT modality are displayed graphically below (Figures 1, 2, 5 and 6). For each year over the decade of our study CT brain dominated and shows a substantial increase from 2001-2010.
Fig. 1: Yearly trends in paediatric CT on-call imaging

References: Dr Sinéad Culleton department of Radiology AMNCH
Although the annual number of CT studies performed was generally increasing across all anatomical areas, the highest numbers of scans performed over the study period were observed in CT brain imaging. This was the most common type of CT examination performed accounting for 45% of adult examinations and almost 60% of paediatric imaging. Growth was consistent in both adult and paediatric patients, accounting for an overall total of 3673 and 271 CT brain examinations performed, respectively during the decade. There was an overall exponential increase in the growth of CT brain imaging (Figure 3).
Fig. 3: Exponential increase in adult CT brain imaging

References: Dr Sinéad Culleton department of Radiology AMNCH
The remaining CT studies changed over time in keeping with this increase in demand for CT brain imaging. With only 12 scans performed in 2001 during the weekend on-call hours compared to 120 in 2010, a ten-fold increase was observed for thoracic CT studies. This growth was not seen in paediatric chest imaging with only 28 scans performed during the study period. CT adult abdominal imaging also showed a substantial rise and a 224.4% increase was seen, rising from 82 scans in 2001 to 266 in 2010. Only 55 paediatric CT scans were performed in total. Likewise adult CT pelvis studies showed a similar increase from an annual total of 26 in 2001 to 201 in 2010, a 673.0% increase. Again the number of paediatric CT pelvic imaging remained small and only 43 were performed over the decade of study.
Fig. 5: Ten year total of adult weekend on-call CT examinations

References: Dr Sinéad Culleton department of Radiology AMNNCH
Fig. 6: Ten year total of paediatric weekend on-call CT examinations

References: Dr Sinéad Culleton department of Radiology AMNCH
**Fig. 1**: Yearly trends in paediatric CT on-call imaging

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Fig. 2: Yearly trends in adult CT on-call imaging

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**Fig. 3:** Exponential increase in adult CT brain imaging

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Fig. 4: Relative proportions of adult and paediatric CT brain imaging

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**Fig. 5:** Ten year total of adult weekend on-call CT examinations

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Fig. 6: Ten year total of paediatric weekend on-call CT examinations

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Conclusion

CT utilisation has been growing steadily worldwide. According to the 2006 report of the United Scientific Committee on the Effects of Atomic Radiation, the average frequency of CT examinations in developed countries increased yearly from 6.1 per 1,000 population in the 1970s to 48 per 1,000 population in the period between 1991 to 1996. Statistics from the US and UK indicate a 20-fold and 12-fold increase, respectively in CT usage over the past two decades, with per caput CT usage in the US being about five times that in the UK. Furthermore one US study concluded that the total radiology work load is increasing by 8% annually and that the number of radiologists in practice is estimated to increase by approximately 1.5% annually leaving radiologists faced with managing a rapidly increasing work load.

This growing worldwide trend was reflected throughout this study. CT brain demonstrated an exponential rise. A survey of paediatric CT practices in Germany between 2005 and 2006 found that 50% of paediatric CT examinations were of the brain, similar to our findings. CT brain imaging also transformed the management of stroke and this may in part, account for the trend observed in our institution. Furthermore headache accounts for a large number of emergency department visits. CT imaging of emergency headache has become widespread leading to increased demand for brain imaging. Physicians need to strictly follow the existing guidelines and justify the use of CT in patients presenting with headache in the emergency department.

Changing clinical practices worldwide may also represent, in part, increased growth in CT examinations at our institution. In the UK a significant increase in CT is postulated to be in part due to the use of CT as a primary tool for pre-surgical diagnosis of acute appendicitis. This may have influenced the three-fold rise at our institute in abdominal CT imaging. The ten-fold observed increase in thoracic CT may reflect changes in imaging for pulmonary embolism. One US study demonstrated increased trends in thoracic imaging over a decade with an increase in the ratio of CTs for pulmonary embolism per patient coupled with a decrease in the ratio of pulmonary angiograms and V/Q scans. It observed that CT is replacing more traditional techniques for diagnosing pulmonary embolism.

This study has some limitations. Due to restrictive criteria of weekend on-call hours, selected for reasons previously mentioned, perhaps only the “tip of the iceberg” of CT on-call imaging is represented. Furthermore information relating to the indications for out-of-hours CT imaging was not consistently available and our data was not adjusted for disease severity. However it was not the purpose of this study to evaluate the
appropriateness of imaging practices or to determine which factors affect utilisation of imaging studies. We assessed trends only and did not analyse imaging patterns for specific clinical indications.

CT is not without health-related risks which may include contrast-induced nephropathy and allergic reactions to iodinated contrast agents. In the longer-term there is growing concern over radiation induced secondary malignancies. A linear dose-response relationship exists between exposure to ionising radiation and the development of certain neoplasms. In many emergency scenarios, CT is the appropriate choice given its availability and speed, but undoubtedly a significant proportion of scenarios exist where equally effective alternatives exist. Studies suggest that up to one-third of CT imaging may fall into this category. Physicians are requesting increasing volumes of CT scans and should bear in mind the benefit-to-risk ratio when imaging patients.

Overall, our data shows that utilisation of CT during weekend on-call hours increased three-fold over the past decade. CT brain was the most common examination. This growth can be attributed various factors such as ageing populations, advances and availability of technology and increasing dependance on medical imaging. CT demand shows little sign of abating and is likely to continue to grow as technology progresses and as new clinical applications emerge. It is hoped that this study and other similar studies will promote ongoing dialogue among radiologists, emergency room staff and other physicians, and indeed the public to slow the increase in CT usage and CT doses, without compromising patient care.
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