Efficacy of a liver detection algorithm for noise reduction in abdominal CT

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Authors: N. Ardley¹, K. Buchan², K. Lau¹; ¹Clayton/AU, ²Melbourne/AU
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Purpose

The recent advent of state-of-the-art CT technology has been generating great interest in the reduction of radiation dose. CT radiation dose administration is based on the ALARA (as low as reasonably achievable) principle. CT radiation dose reduction strategies include limiting scanning to the clinically relevant areas of interest and modulating scan parameters, such as the tube current. A major concern for reducing radiation dose by adjusting scan parameters is an increase in the image noise content, which can affect the diagnostic quality of images (1). Recently, CT scanning technology has concentrated on image quality enhancement at reduced radiation exposures by using iterative image reconstruction algorithms and post-reconstruction noise reduction filters which aid the preservation of the qualitative appearance of the image without a perceptible loss of anatomic structure delineation (2).

Nevertheless, optimal radiation dose to answer the clinical question is still paramount and necessary in maintaining the diagnostic quality of images. Intelligent dose modulation techniques that increase radiation dose to areas of the abdomen where there is less tissue contrast of anatomical structures may help to overcome the undesirable noise that reduces diagnostic confidence.

The Liver is commonly identified as one of the noisiest structures in an abdominal CT scan due to its inherent low contrast resolution. Liver lesions can be compromised because of the image noise associated with radiation dose reduction strategy [1]. This study determines the efficacy of a liver detection algorithm (which enables the liver to be dose managed independently of the rest of the abdomen by altering the way the dose is distributed) and the effect it has on image noise.
Methods and Materials

Patients:

40 consecutive patients of all ages and genders presenting for a standard portal venous phase abdominal CT scan were scanned with a traditional abdominal CT protocol. This traditional protocol employed a standard dose modulation technique. A subsequent 40 consecutive patients of all ages and genders presenting for a standard portal venous phase abdominal CT scan were scanned with a protocol utilizing a liver detection algorithm.

CT Scanning:

The CT studies were undertaken using a 128-MDCT scanner (Ingenuity, Philips Healthcare, Cleveland, USA). Both groups of patients utilised identical baseline scanning protocols that included 100kV and identical iterative reconstruction settings. The variations from the baseline protocol in the Liver detection algorithm group were the method of dose modulation selected and the use of a liver detection algorithm. The dose modulation method varied by modulating differently from the baseline protocol such that the modulation profile did not reach the same peak values in the Z direction of scanning. The liver detection algorithm automatically placed a location line at the most superior aspect of the liver as detected from the initial Surview images. It then placed a second location line at a default offset length of 15cms inferior to this point. If required the imaging technologist could vary the position of each location line on the Surview images to define the liver extent (see Figure 1). This defined liver region allowed the liver to be treated as a separate region of the abdomen for dose prescription such that it independently received more dose than the rest of the abdomen.

Analysis:

Doses administered from the helical acquisition for each patient were recorded and compared. Each CT study was de-identified and blindly reviewed by a medical imaging technologist. Comparison of Hounsfield Units (HU) and standard deviation (SD) were made and averaged across the two data sets by placing an identical sized Region of Interest (ROI) in the left lobe of liver, right lobe of liver, spleen, psoas muscle and bladder.
**Fig. 1:** Liver Detection Algorithm: These two PA surviev images demonstrate the location lines which define the region for dose adjustment. On the right an example shows the liver region area shaded in yellow.

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Results

All images for both data samples were of diagnostic quality. Average HU and SD data for each region assessed for each group of patients can be seen in Table 1. The average HU in each region is comparable as seen graphically in Figure 2, whilst the significant differences in SD is demonstrated graphically in Figure 3.

The average SD in the right lobe of the liver reduced by 10.1%, in the left lobe of liver by 15.61% and the mid spleen by 15.83%. These anatomical areas are within the region where the dose has increased due to the liver detection algorithm. The average SD also reduced in the psoas muscle and bladder by 2.73% and 1.71% respectively.

The mean Dose Length Product (DLP) for the traditional Abdominal CT protocol was 426.10mGy/cm with an average CTDI\textsubscript{vol} (CT Dose Index) of 7.855mGy. The mean DLP for the Abdominal CT protocol employing the liver detection algorithm was 402.19mGy/cm with an average CTDI\textsubscript{vol} of 7.7mGy. The average DLP when using the liver detection algorithm reduced by a factor of 5.94% (see Figure 4) which corresponds to a 0.359mSv reduction where a k factor of 0.015 was used.
# Average Hounsfield Units and Standard Deviation Data

<table>
<thead>
<tr>
<th></th>
<th>Rt Lobe Liver</th>
<th>Lt Lobe Liver</th>
<th>Spleen</th>
<th>Psoas Muscle</th>
<th>Bladder</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>HU</td>
<td>SD</td>
<td>HU</td>
<td>SD</td>
<td>HU</td>
</tr>
<tr>
<td>Traditional Method</td>
<td>99.6</td>
<td>11.98</td>
<td>104.55</td>
<td>12.46</td>
<td>117.72</td>
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<tr>
<td>Liver Detection Algorithm Method</td>
<td>100.63</td>
<td>10.77</td>
<td>102.49</td>
<td>10.515</td>
<td>112.65</td>
</tr>
</tbody>
</table>

**Table 1**: Average Hounsfield Units and Standard Deviation Data

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**Fig. 2**: Average Hounsfield Units: Traditional Method vs. Liver Detection Algorithm

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Fig. 3: Average Standard Deviation: Traditional Method vs. Liver Detection Algorithm

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Fig. 4: Dose Comparison: Traditional Method vs. Liver Detection Algorithm

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Conclusion

The new liver detection algorithm reduces the SD significantly in the liver region defined yet the overall dose administered reduces due to the change in the modulation technique. The findings of reduced noise in the liver region, and an almost equivocal noise level in the remaining parts of the abdomen when compared between samples, have determined that this technique be used in standard clinical practice since there is no dose penalty.
References


Personal Information

Nicholas Ardley, BRadMedImag (HONS)
CT Supervisor
Monash Medical Centre
Southern Health
Melbourne, Australia

Kevin Buchan, DCR(R), GDVET
Clinical Science
CT Business Unit
Philips Healthcare

Dr Kenneth K Lau MBBS, FRANZCR
Director of CT
Southern Health
Melbourne
Australia