A review of the benefits and rationale of viewing liver window settings for abdominal computed tomography scans

Tan Dang¹ and Giovanni Mandarano²

¹Department of Medical Imaging, The Bendigo Hospital, Lucan St, Bendigo, Victoria 3550, Australia
²Department of Medical Imaging, Monash University, Clayton, Victoria 3800, Australia

Correspondence email Giovanni.Mandarano@med.monash.edu.au

Abstract There have been many different opinions over the efficacy of routinely incorporating liver-window settings in abdominal computed tomography (CT) scans. As a result, different clinical centres have varying protocols for incorporating liver-windows for abdominal CT scans. This investigation aims to explore and determine whether various clinical centres throughout Victoria use liver-window settings selectively or routinely and their justification for doing so. An additional purpose is also to assess the benefits and rationale of liver-window settings in supplementing routine soft-tissue-windows for abdominal CT examinations by reviewing evidenced-based studies.

Surveys were sent out to CT supervisors at various clinical centres, including private and public institutions. This achieved an overall response rate of 74 per cent. Results indicate that the majority of clinical centres throughout Victoria routinely incorporate liver-window settings for all abdominal CT examinations. Forty four per cent (11/25) of respondents stated that they utilise liver-window settings selectively for abdominal CT examinations. Most of these respondents (7/11 = 63 per cent) believed that soft-tissue-window settings alone are adequate to demonstrate hepatic lesions; particularly if intravenous contrast media is used and the liver is captured in the arterial, venous and/or delayed phases.

The benefits and rationale of incorporating liver-window settings for all abdominal computed tomography scans has been questioned by two well noted studies in the United States. These evidence-based studies suggest that such additional settings do not offer further advantages in detecting hepatic disease, when compared to soft-tissue-windows alone.

Review of the available literature provides additional evidence suggesting that the routine use of liver-window settings in conjunction with soft-tissue-windows offers no further advantages in the detection of hepatic diseases. This investigation found, however, that the majority of respondents are currently recording liver-windows routinely for all abdominal CT scans. This is performed even though many of these respondents agreed with established literature that liver-windows should be reserved for patients with high clinical suspicion of hepatic disease, or when a lesion is detected on the standard soft-tissue-window.

Introduction

The digital image display on the computed tomograph (CT) console is composed of many pixels. The value of each pixel represents the linear attenuation coefficient at that particular point (voxel, W x B x H) in the slice plane of the object. In creating the image, the computer assigns each pixel a number between -1000 and +3000 Hounsfield units (HU). The CT operator can control the precise manner in which the image matrix of CT numbers is displayed by adjusting the image display settings – window width and window level. This determines the contrast of the image, thereby providing an ability to enhance certain characteristics inherent within the image.

The standard soft tissue window setting used for abdominal scans displays a large range of tissue densities on a single CT image. For abdominal window settings, the range of window width is commonly between 336 and 472 HU, and the range of window level is between 39 and 88 HU. Liver-window settings, on the other hand, have a level ‘equal to the attenuation level of the parenchyma (50 HU),’ and a narrower window width (150 HU) than the soft-tissue window. Thus, using settings with a narrower window display enhances the grey scale contrast of the liver, and hence improves the visibility and detectability of hepatic lesions.

Within the past decade, a number of evidence based studies have been performed that cast doubt on the validity of routine use of liver window settings in conjunction with soft tissue settings for all abdominal studies.

Different practitioners, with varying levels of experience and expertise, have divergent opinions over the usefulness of liver window settings in abdominal CT scans. Due to this difference in opinion between professionals, the respective clinical centres may also have differing protocols or guidelines in relation to the use of liver window settings for all abdominal CT scans.

The aim of this review is to determine whether liver window settings are being used selectively or routinely at various clinical centres – that attract students for CT clinical placements – throughout Melbourne, Victoria, and their rationale for doing so. A secondary purpose is also to assess the benefits, whether perceived or actual, of liver window settings in supplementing routine soft tissue windows for abdominal CT examinations by reviewing relatively recent evidenced-based studies.

Methods

A mail survey was chosen as the method to conduct this investigation. This formed part of a final year unit of study in the undergraduate program of the Bachelor of Radiography and Medical Imaging (Monash University). Ethical approval to proceed with this investigation was provided from the relevant faculty
A review of the benefits and rationale of viewing liver window settings for abdominal computed tomography scans

Table 1 Classification of clinical centres being surveyed. L = large; M = medium; S = small

<table>
<thead>
<tr>
<th>Type of clinical centre</th>
<th>Size of clinical centre</th>
<th>Subtotal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public</td>
<td>L 5 M 5 S 1</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Private</td>
<td>L 5 M 7 S 2</td>
<td>14 25</td>
<td></td>
</tr>
</tbody>
</table>

and departmental levels. The survey consisted of a covering letter, clearly indicating that participation in the survey was voluntary, a questionnaire and a reply paid envelope. The questionnaire contained 14 questions in a closed-response format, where each question had a pre-determined list of response options (appendix 1). Respondents were provided with the option of selecting the response option that was deemed applicable for their centre; therefore, selecting more than one response was permissible. This format was chosen to minimise the time taken for the respondents to complete the survey. In addition, a number of open-ended questions were listed and comments and opinions from the respondents were sought if they wished to further contribute.

A search was conducted through electronic databases of medical publications to seek evidence-based case studies and journal articles relating to liver window settings, their clinical application and benefits. These articles provided a background to the topic and supplemented previous knowledge on liver window settings. This information was also of assistance in establishing questions for the survey.

The questionnaire jointly incorporated a number of demographic questions, such as the size of the respondent’s radiology department and whether the radiology department was privately owned, or a part of a public institution. Each respondent was asked to state whether liver window settings were being used selectively or routinely for all abdominal CT scans and justifications and rationale to support the protocol in use. Each radiology department was also asked to provide details of any protocols for their abdominal CT examination, and who is responsible for establishing the set protocol. The project supervisor and another member of the academic staff at the Department of Medical Imaging and Radiation Sciences reviewed the contents of the questionnaire and a small pilot test was performed among on-campus and honorary CT teaching staff prior to any details being finalised.

The questionnaire was accompanied by a cover letter, explaining the purpose of the investigation, assuring the respondent that the information collected remained confidential. This material was distributed throughout the 2004 academic year and further analysis of data and responses was undertaken throughout 2005. Individual information and names of the clinical centres were not published in this investigative project. The cover letter also included the names and contact details of the investigators, enabling recipients to contact them with any concerns regarding the questionnaire or investigation. Where recipients of the mail survey did not make contact, it could be reasoned that instructions, questions and information presented were clear and unambiguous.

The surveys were mailed and addressed to the CT supervisor of each clinical centre. Thirty-five CT supervisors from different clinical centres throughout Victoria were selected to participate. The 35 clinical centres were selected from the list of ‘Clinical Centre Contact Staff’ that is available to all students from the Department of Medical Imaging and Radiation Sciences, Monash University, as these centres accept Monash University students for CT clinical placements. These departments had granted permission to the Department of Medical Imaging and Radiation Sciences for their names and contact details to be made available for student access. Responses collected from the survey will be presented in tables for further discussion and analysis.

Results

Response rate

This project achieved a satisfying response rate of 74 per cent with 26 questionnaires returned from the 35 sent. The aim and purpose of this investigation attracted the attention of many respondents. Of the 26 clinical centres that responded, 19 indicated that they would like to obtain a copy of the final report.

Demographics

The clinical centres were categorised into two main groups: privately owned radiology departments, and public radiology departments (Table 1). This allows the reader to compare the pattern in which liver window settings are being used in the private and public sector; if, in case, this was a contributing factor (as some anecdotal student feedback may have suggested). There were 26 responses to the questionnaire; however, one clinical centre currently using the Picture Archiving and Communication System (PACS) did not specify whether liver window settings were being used routinely or selectively in their department. This response was not included in the data collected from the survey and therefore only 25 responses were applicable and examined. Of the 25 responses analysed, 14 radiology departments are privately owned and 11 are public radiology departments.

Numerous methods exist which could be used to categorise the size of a clinical centre. Each had its own advantages, disadvantages and rationale. However, in this investigation, the authors agreed to use a modified version of the currently agreed upon Health Professional Services Public Sector Victoria Award 2003 (as used in the public sector) interpretation, as used for a classification of a chief radiographer. That is, ‘small’ was classified as being less than 14 effective full time (EFT) radiographic staff; ‘medium’ was referred to as 15 to 25 EFT radiographers; and ‘large’ included clinical centres which employed more than 26 EFT radiographers. This information was sought in order to ascertain whether staffing numbers in relation to expected patient numbers was a contributing factor for either performing or not including liver window settings.

Frequency of use of liver window settings

Each respondent was asked to indicate how liver windows were being used in abdominal CT scans. This information was then used to determine the number of clinical centres using liver windows routinely and selectively (Table 2). It was found that 14 out of 25 radiology departments used liver windows routinely, and 11 used them selectively. Nine out of 14 private practices routinely incorporated liver window settings for all abdominal CT examinations and the remaining five used it selectively. In public
institutions, on the other hand, only five out of the 11 radiology departments reported routine use of liver window settings.

**Reasons for using liver window routinely**

Of the 25 responses, 14 clinical centres stated that they were using liver window settings routinely. Based on the results from Table 3, these 14 clinical centres indicated they did so because they believed that it improved the visibility and detectability of hepatic lesions. The reasons to justify this belief will be discussed in the proceeding section.

Of the 14 centres, eight used liver window settings routinely because the settings maximise the grey scale contrast of the liver. Seven of these 14 clinical centres used it routinely because they believed that hepatic lesions became less detectable when images were produced with soft tissue window settings (Table 4), and four of the 14 were convinced that soft tissue window settings alone are inadequate in demonstrating hepatic lesions. Almost all (13 out of 14) considered liver window settings to be valuable in recognising hepatic lesions that were difficult to detect under soft-tissue-settings, due to attenuation characteristics that differ minimally from the surrounding hepatic parenchyma.

**Reasons for using liver window settings selectively**

At 11 clinical centres, liver window settings were being used only for selective abdominal CT examinations. The majority, seven, of these centres believed that soft tissue window settings are adequate in detecting hepatic lesions. Four clinical centres also indicated that they believed the extra liver window settings offered limited additional information in detecting hepatic disease (Table 5). It was stated that this conclusion was based over many years of clinical experiences from the radiologist and supervisor in-charge of CT.

Minimising the total time of the examination, as well as the associated cost (such as extra film sheets) and maximising time efficiency, were the other main reasons for not using liver window settings routinely.

Approximately 27 per cent (3/11) of the clinical centres using liver window settings selectively believed that liver window settings should only be used for patients with high clinical suspicion of hepatic lesions (Table 6).

Seven out of the 11 clinical centres feel that it is only important to tailor the use of liver windows to answer clinical questions of the examination being requested, rather than perform a comprehensive abdominal CT imaging with numerous window settings in all patients. Two of these clinical centres emphasised that the CT radiographer should be able to identify when liver windows are necessary (i.e. only if a hepatic lesion is visible on soft tissue window setting).

**Justification of liver window settings protocol**

In the majority (20 respondents) of these institutions, it was indicated that both the radiologist and CT supervisor were responsible for setting the liver window protocol for their abdominal CT scans (Table 7).

Six out of the 13 institutions using liver windows routinely did so due to the clinical experience of their radiologists and CT supervisor. Seven out of the 11 institutions using liver windows selectively (two out of the 11 clinical centres did not answer this question) also indicated that they did so due to the clinical experience of their radiologists and CT supervisor.

Of the 25 responses, three clinical centres did not identify the person responsible for, or the reason justifying the use of their liver window protocol. Six out of the 25 institutions justified the use of their protocol due purely to the clinical experience of their radiologist.
A review of the benefits and rationale of viewing liver window settings for abdominal computed tomography scans

Table 7 Reasons for justifying the use of liver-window settings protocol

<table>
<thead>
<tr>
<th>Frequency of application of liver window setting</th>
<th>Due to the clinical experience of:</th>
<th>Literature and radiologist</th>
<th>Corporate or hospital protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine</td>
<td>Radiologist</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Selectively</td>
<td>Radiologist and radiographer</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 8 The major resources used to produce additional liver window images

<table>
<thead>
<tr>
<th>Major resources used to produce additional liver-window images</th>
<th>Number of responses (out of 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiographer's time</td>
<td>12</td>
</tr>
<tr>
<td>Extra film sheet</td>
<td>20</td>
</tr>
<tr>
<td>Radiologist's time</td>
<td>4</td>
</tr>
<tr>
<td>Greater space taken up in the film library</td>
<td>4</td>
</tr>
<tr>
<td>Greater memory space used (PACS)</td>
<td>4</td>
</tr>
</tbody>
</table>

Table 9: The time taken to produce images with liver window settings (including time taken to adjust the window width and level, processing images, printing and labeling images)

<table>
<thead>
<tr>
<th>Time taken to produce images with liver-window images (minute)</th>
<th>Number of responses (out of 25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 1</td>
<td>11</td>
</tr>
<tr>
<td>1–2</td>
<td>7</td>
</tr>
<tr>
<td>2–3</td>
<td>3</td>
</tr>
<tr>
<td>3–4</td>
<td>1</td>
</tr>
</tbody>
</table>

Major resources used when printing additional liver windows in conjunction with a routine soft tissue window

The expenses and resources used in printing liver window settings in addition to soft tissue windows were also studied. The cost of extra sheets of film was considered the major additional resource in routinely printing liver window settings in conjunction with soft-tissue window settings. Forty-eight per cent (12/25) of the clinical centres feel that printing liver windows takes up some of the radiographer’s time, which perhaps may be more appropriately utilised to further productivity in other areas. However, 11 out of the 25 clinical centres (Table 9) said it would take less than one minute for the radiographer to produce images with liver window settings (three centres did not respond to this question). This overall time included the time taken to adjust the window width and level, processing images, printing and labelling images.

Review of related literature, texts and discussion

To ascertain if there are true potential benefits, or if there are any that are genuinely current and to support the common and existing justifications for using liver window settings, whether routinely or selectively, the current authors will contain the following discussion within three areas and incorporate aspects of their findings. The evolution of studies in these areas over the last dozen or so years, will be traced in order to establish a pattern determined upon clinical based and relevant studies. These three areas will be as follows. First, will the routine viewing of liver window settings improve the detection rate of hepatic pathologies? Second, the role played by image display techniques when viewing CT images of the liver will be reviewed. Third, the elements affecting contrast resolution and accuracy of how well Hounsfield Units can be representative of liver pathology will be explored.

Based on the results of this study, many (14 of the 26 respondents) clinical centres still believe that there are benefits in viewing liver windows routinely for all abdominal CT scans. Fourteen (five from the public sector and nine from the private sector) clinical centres are currently using liver windows routinely for all abdominal CT scan, compared to 11 clinical centres that incorporate liver windows only for selective abdominal CT examinations. The majority of the total clinical centres justified the use of their particular protocol due to the clinical experience of their radiologist. This is in keeping with previous publications. Most notably, a study conducted by Brink, et al., in 1999, identified that ‘radiologist(s) tend to be partial to their style of practice in this regard.’ Radiologists that view liver windows routinely would favour the use of liver window settings for all abdominal CT scans. On the other hand, radiologists that do not rely on liver windows seem to be ‘partial to the use of soft tissue window settings for ‘detecting both intra- and extra-hepatic disease’. Furthermore, Brink affirmed that a radiologist develops his/her style from the ‘beliefs grown from years of film-based image viewing’. Today, and into the near future, will the advent of PACS increase the reliance of reviewing images with liver window settings? Quite reasonably, it can be expected that with a few mouse clicks, that this will be quite an easy task to perform. This then opens further discussion, which is in a realm beyond this survey, as to the radiologist preference, protocol justification, and possible attained diagnostically useful detail as well as documentation of any findings on altered window settings (which can also consist of a subjective component). It is a common acceptance that, for liver window settings to be of any clinical value, they should be capable of enhancing additional hepatic lesions that are unable to be identified with conventional soft tissue window settings. To investigate the effectiveness of liver window settings in this respect, Mayo-Smith, et al., investigated the usefulness of adding liver window settings to conventional soft tissue windows for the detection of hepatic disease. Over an eight-month period, abdominal studies in 1175 adult patients were evaluated. Twelve patients (1.02 per cent) had lesions seen on liver window settings that had not been detected under the soft tissue window setting.

Liver window settings were also found to help detect additional liver lesions in another 24 patients (2.04 per cent). It was concluded that the use of liver window settings helped to detect additional hepatic lesions in a total of 36 (3.1 per cent) patients.

It was also observed that 26 of the 36 patients with additional lesions seen had a history of neoplasm. Further to this, they
affirmed the improved grey scale contrast of liver window settings used for hepatic pathology. It was a matter of questioning the benefits of using liver windows routinely for all abdominal CT scans and this challenge was posed to future researchers to consider. From their results, they stated that the use of liver windows should be reserved for patients with high clinical suspicion of hepatic disease. Their study concluded that the ‘routine interpretation of liver window scans for all abdominal CT scans has limited added utility in detecting hepatic disease’.

Following the Mayo-Smith et al. study, and extending upon their findings, Patten et al. also investigated the clinical value of routinely using liver window settings for abdominal scans. They investigated 300 patients with blunt abdominal trauma. Hepatic and splenic injuries were found in 34 patients with conventional soft tissue window settings (non-intravascular contrast media studies). It was convincingly discovered that liver window settings did not help to detect any new injuries. Nevertheless, the conspicuity of hepatic and splenic injuries ‘mildly increased’ with liver window settings in 16 of the 34 cases, therefore, indicating, that the use of narrow window, high contrast image(s) had little effect in the detection of hepatic and splenic injuries, and also little effect in noticeable improvement when determining the extent, or characterising the grade, of injury.

Over a decade ago, Judy et al. investigated the impact of manipulating display windows, and the effect of display window width on the contrast detail curve for non-intravascular CT studies of the liver. They examined and tested the visibility of circular disks with nine different sizes and 36 different possible image contrasts. The window widths used for the experiment were 64, 128, 256, 512 and 1024 HU. It was noticed that the visibility and detectability of these objects were constant across window widths of 64 to 512 HU, and only fell slightly at the widest window (1024) HU. Based on the results of the window manipulation experiments, it was concluded that; ‘narrowing the display window to increase the displayed contrast … would have little impact on [the] radiologist’s performance’. These same investigators, Judy et al., re-examined (in 1999) the effect of display window manipulation on the visibility and detectability of hepatic lesions. In this study, it was found that manipulating the CT display window width between 64 and 512 HU did not ‘significantly affect the visibility of details on actual liver CT images’. However, it was also noticed that a wider window does affect the observer’s ability to detect a lesion. While there is no doubt that image manipulation (such as windowing) helps improve the contrast of an image, it was felt that there is a need for alternative methods that can improve the visibility of lesions, and at the same time, human efficiency. It was concluded that manipulation of display windows ‘will not be effective’ in enhancing the visibility and detectability of hepatic lesions.

In this survey, respondents also had the option of adding comments to support their use of liver window settings in abdominal CT scans. Four clinical centres that used liver windows routinely believed that the introduction and integration of PACS would make it easier and more efficient with respect to time and cost management to alternate between window settings. Images are viewed via a workstation and the reporting radiologist can easily change to many different window settings. However, one important question that is often raised by such studies is whether viewing liver windows routinely would improve the radiologist’s performance, that is, improve accuracy in diagnoses. This question was addressed by May-Smith et al., who found that liver window settings only helped to detect additional hepatic lesions in 3.1 per cent of patients participating in their study and concluded that it would take more of the radiologist’s time to view the extra display window settings.

Also in the current study, six additional comments were received from clinical centres that used liver windows selectively. One centre stated that they would routinely print lung base windows rather than printing liver windows. The validation from this clinical centre was that ‘more pathologies will be picked up in [the] lung bases [with lung window settings] than liver windows [in] showing hepatic lesion(s)’. Another clinical centre also stated that; ‘soft tissue windows are usually adequate’ to demonstrate the presence of hepatic lesions. Therefore, liver window settings would only be required for patients with high clinical suspicion of hepatic disease, or if a lesion were seen on soft tissue windows. However, what it is that exactly qualifies as ‘high clinical suspicion’ has not been comprehensively defined. To fully outline this, and along with ‘if a lesion were seen on soft tissue windows’, carry with them subjective components. Viewing images with liver windows routinely, in addition to soft tissue window settings, adds cost to the examination. Based on the results from the current survey, the extra film sheets were identified as one of the major costs associated with additional liver windows. With the recent introduction of PACS, the cost of film sheets can be avoided. The radiographer’s time was the other factor identified as a major resource when printing an additional film sheet of images with liver window settings in conjunction with a routine soft tissue window. If viewing liver windows routinely ‘has limited added utility in detecting hepatic disease’, then it would not be an efficient use of the radiologist’s time to view these images, even if this feature is aided more readily with the rapid advent of PACS. We therefore also need to consider the impact of the display quality of the CT images themselves – which are manipulated with window settings; having a combination of objective and subjective components. Within organs possessing low intrinsic contrast, such as the liver, the identification and detection of pathologies of small dimensions is largely dependent on image noise because they may be adversely affected to the point of being totally obscured. Further to this, the role played by image display settings in relation to the final image has been explored.

It is argued that the implication of Gamma curves in mapping the image’s intensity to the brightness of the image display, and the role that this plays in detecting characteristics throughout the image – the results of which are ultimately due to the selection of window width and window level (or centre), considerably affects how well objects and pathologies can be visualised. Drawing upon their own CT scanning and clinical experience, the current authors also are aware of this feature and acknowledge that this was commented upon by 13 respondents. Also, by using a wider window width, the appearances and effects of noise can be minimised (to a point) on the image display – often referred to as a smoothing effect; thus allowing an improvement in low contrast detectibility. This also conforms to the earlier studies performed by Judy et al. in 1992 and 1994. It follows then, that for a given low-contrast image, there can exist an ‘optimal’ display window setting that can aid an observer to detect such lesions and thus help performance (identification of low-contrast lesions) maximisation and today, this should be readily achievable as the majority of current generation CT equipment has the capability to discern 1 per cent contrast or less.

Next, this discussion also leads into the accuracy of the
Hounsfield Units themselves, where the term ‘accuracy’90 is constituted by the consistency and uniformity of Hounsfield Units. Consistency, as it relates here, is defined as: the Hounsfield Units at a particular location are not affected under variable circumstances such as changing slice thickness, different scan times and so on, will demonstrate the same value of Hounsfield Units. Uniformity of Hounsfield Units flats that for a consistently even or uniform phantom, the value of Hounsfield Units within a region of interest (ROI) should not differ from one location to the next (within the same image plane); that is, in relation to the location of the ROI within the phantom.

Furthermore, others advocate that the use of a convolution kernel (algorithm) is the best possible compromise for smoothing out low noise signals contained within an image while maintaining sufficient spatial resolution. This approach can also have an added benefit in that the radiation exposure required to produce a diagnostically acceptable image may be reduced to a level below that which a manufacturer may advocate. It is widely understood that, unlike conventional radiography, CT scanning is not a dose limiting examination – meaning that the greater the dose, the improved image quality will result. However; with conventional radiography, a dose that is either too low or too high, will result in an image that is not diagnostically useful.11 In relation to CT liver studies, contrast resolution is of paramount significance as, often, within the kVp range commonly used, minimal attenuation differences exist between hepatic lesions and the surrounding healthy hepatic parenchyma; and because of such low intrinsic contrast, hepatic lesions in the order of 3 mm or less are less likely to be detected.9 Hence, narrow window settings are needed in cases of non-contrast (intravascular contrast media) CT assessment of the liver. It is recognised that the three major inputs to noise which adversely affect the accuracy of Hounsfield Units are: quantum noise, noise due to the inherent physical limitations of the CT equipment such as electronic noise, and, noise due to the image generation process (resulting from reconstruction parameters).229 Furthermore, it has been noted that there may be some CT practitioners who are unfamiliar with the delicate counterbalance and interdependence of noise and its influence on contrast resolution and also dose.10 Formulae can be used to mathematically prove that noise is a dependent of spatial resolution and in keeping all scan parameters consistent, dose needs to be increased with the 4th power of the relative reduction of the spatial resolutions element size (pixel, slice thickness, etc.), in order to increase (and improve) low-contrast resolution – the same way as spatial resolution (The reader is referred to pages 148 and 149 of the cited reference for the formulae and their application). In the clinical setting, the aim is always to have both image noise and dose as low as is diagnostically possible. This should also be in keeping with the fundamentals of the ALARA principle.

Conclusion

It has been found that in a number of studies, the incorporation of liver window settings in abdominal CT scans offered limited advantages in the detectability of hepatic lesions. The narrowing of the window width, such as that used for liver window settings, has been designed to improve grey scale contrast of the CT image when assessing the liver, in particular in the non-contrast (intravascular contrast media) stage of a CT abdominal examination. The review of relevant literature performed as part of this investigation, directs the authors to state that liver window settings should be used for patients with high clinical suspicion of hepatic disease, or when a lesion is detected on the standard soft tissue window. This view was supported and advocated by a minority of respondents in this investigation (11 respondents – six from the public sector and five from the private sector). However, this investigation has also found that a slight majority (14 respondents – five from the public sector and nine from the private sector) of clinical centres that completed and returned the questionnaire still believed that there are benefits in documenting liver windows routinely for all abdominal CT scans and that this belief is based upon the clinical experience of the radiologists and radiographers directly responsible for establishing the CT scanning protocols and procedures.

The justification or rationale used by the majority (19 respondents) of clinical centres in establishing their protocol was largely based on the clinical experience of the radiologist and/or radiographer in charge of CT. Two clinical centres were aware of their policy, but were unable to identify the protocol’s justification or rationale, simply stating that it was either corporate, departmental or hospital policy. Three clinical centres returning the questionnaire did not provide a response to this question.

From this investigation, and considering the review of the literature, a point that may need to be addressed further is how the steady implementation of PACS will affect how readily reviewing images with liver window settings may impact, if any, upon diagnostic evaluation of abdominal CT scans. This is an already challenging aspect of daily clinical practice. Perhaps we may never be able to totally remove the subjectivity involved in clinical decision making and reviewing of images. Supplementing abdominal CT examinations with liver window settings only for selected cases may add a margin of error that some clinical centres might choose to accept, while others may choose to minimise this risk as much as possible, regardless of cost, by routinely incorporating liver window settings. This then introduces a financial dilemma that the current authors predict can lead to a continued and divisive debate regarding the monetary worthiness of routine liver window settings for an extremely low rate of detection in liver pathology versus an argument based on comprehensiveness of an examination to justify the expenditure of such costs.

Acknowledgements

The authors wish to thank Peter Coombs for his valuable suggestion in regards to the covering letter and the questionnaire and the CT supervisors that participated in the survey.

References

1. Wells P, RAD3011 Topic 2: First Generation Scanners and Display RAD3011 Subject 2003. Department of Medical Imaging and Radiation Sciences, Monash University, Victoria, Melbourne, Australia.
8. Judy PF, Swensson RG, Nawafee RD, Chan KH, Seltzer SE. Flattening of the


11 Budd R. Medical Physicist, Monash University, Department of Medical Imaging and Radiation Science, personal communication, 15th February 2006.

Questionnaire

Please tick the appropriate box. Where applicable, you can choose more than one answer.

1. Is your institution:
   - Public
   - Private

2. Would you consider your institution to be:
   - Large (greater than 26 effective full time (EFT) radiographic staff)
   - Medium (between 15 and 25 effective full time (EFT) radiographic staff), or
   - Small (less than 14 effective full time (EFT) radiographic staff)

3. Who is responsible for establishing the protocol of abdominal CT examinations?
   - Corporate policy (such as Mayne Health, MIA, etc)
   - Radiologist in charge of CT
   - CT Supervisor
   - Other, please specify:

4. At your clinical center, do you
   - Routinely incorporate liver-windows for all abdominal CT examinations
     (Please proceed to Question 5)
   - OR
   - Incorporate liver-windows only for selective abdominal CT examinations
     (Please proceed to Question 7)

5. What are some of the reasons why liver-window settings are routinely incorporated for all abdominal CT examinations?
   - Improved visibility and detectability of hepatic lesions
   - Maximising the gray level contrast of the liver, comparing to the standard soft tissue window
   - Hepatic lesion with attenuation characteristic that differ minimally from the surrounding hepatic parenchyma may be difficult to recognise under soft tissue window setting
   - Other, please specify:

6. What are some of the reasons why liver-window settings are not being used selectively at your institution?
   - Hepatic lesion become less detectable when images are produced with wider CT display window
   - Soft-tissue-window setting is inadequate to demonstrate hepatic lesion
   - Other, please specify: Please proceed to question 9.

7. Are there any advantages of incorporating liver window settings only for selective abdominal CT examinations?
   - Soft tissue window setting is adequate to demonstrate hepatic lesion
   - The extra liver window settings offers limited additional information in detecting hepatic disease
   - Time minimisation
   - Other, please specify:

8. What are some of the reasons why liver-window settings are not being used routinely at your institution?
   - Liver-window settings should only be used for patients with high clinical suspicion of hepatic disease

9. Do you use liver windows (please tick both options if appropriate):
   - Pre-contrast, and if so do you use it
     - Always
     - Only if requested
   - Post-contrast, and if so do you use it
     - Always
     - Only if requested
   - Please justify your answer:

10. What are the common reasons for justifying the liver window protocol in your institution?
    - Radiologist (either radiologist in charge or radiologist on duty in CT)
    - CT Supervisor
    - Corporate or hospital policy/protocol
    - Evidence based practice
      - Clinical experience of:
        - Radiologist
        - Radiographer
        - Other, please specify
      - Literature (please list any texts or resources used)
        - Other, please specify:

11. What are the major resources used when printing additional liver windows in conjunction with a routine soft tissue window? (please tick where appropriate)
    - Radiographer's time
    - Radiologist's time
    - Extra film sheet
    - Greater memory space used (PACS)
    - Greater space taken up in the film library
    - Other, please specify

12. At your department, on average how long would it take for a radiographer to produce film sheets with liver-window settings? This includes the time taken to adjust the window width and level, processing images, printing images and labeling images.
    - Less than one minute
    - 1–2 minutes
    - 2–3 minutes
    - 3–4 minutes
    - Others, please specify

13. Do you wish to receive a copy of the final report
    - Yes
    - No

14. If you have any comment or suggestion please do not hesitate to write down in the space provided:


Thank you for taking your time to complete this survey