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Original Research Paper

Analysis of Window Width and Window Level Variation on Anatomical Information of Abdominal CT scan in Cases of Intra-Abdominal Mass Using Siemens 16 Slice Device

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Abstract

Background: Optimal adjustment of window width (WW) and window level (WL) is essential for improving anatomical visualization on abdominal CT scans in patients with intra-abdominal masses. **Objective:** To analyze the effects of different WW and WL settings on abdominal CT images and determine the optimal values for evaluating intra-abdominal mass cases. **Methods:** This quantitative observational study analyzed abdominal CT scans from six patients with radiologist-confirmed intra-abdominal masses. Images were reconstructed using different WW and WL combinations, and three experienced observers independently assessed the resulting anatomical information to identify the most appropriate image settings. **Results:** Significant differences were observed in the anatomical information produced by the various WW and WL settings. The combination of WW 300 HU and WL 60 HU provided superior visualization of abdominal anatomical structures and lesion characteristics compared with the other settings evaluated. These parameters consistently yielded clearer image contrast and improved diagnostic interpretation across the observers. **Conclusion:** Variations in WW and WL significantly influence the diagnostic quality of abdominal CT images in patients with intra-abdominal masses. A setting of WW 300 HU and WL 60 HU is recommended as the optimal protocol for enhancing anatomical visualization and supporting accurate radiological assessment in routine clinical practice.

Keywords: Abdominal CT scan; Intra-Abdominal Mass; Window Width; Window Level.

Introduction

Computed Tomography Scanning (CT scan), also known as Computed Axial Tomography (CAT scan), is a medical imaging technology that uses X-rays and computer-based reconstruction to produce cross-sectional images of the human body. Unlike conventional radiography, which mainly differentiates bone, soft tissue, and air in a superimposed projection, CT provides tomographic images with better anatomical detail, including visualization of blood vessels, muscular soft tissue, parenchymal organs, and other internal structures. Another important advantage of CT is its ability to display body sections without significant overlap from different anatomical structures. CT scanning was first introduced through the pioneering work of Godfrey Hounsfield and was subsequently developed into one of the most important diagnostic imaging modalities in modern radiology.[1,2]

A tumor is an abnormal growth of body tissue resulting from uncontrolled proliferation of cells. The term neoplasm is often used synonymously with tumor, although tumors may be benign, malignant, or have uncertain malignant potential. Cancer refers to a malignant neoplasm characterized by uncontrolled growth, invasion, and potential spread to other tissues. Under normal physiological conditions, new cells replace older or damaged cells in a regulated manner; however, tumors develop when the balance between cell proliferation and cell death is disrupted. This abnormal growth may form a solid or fluid-filled mass and may cause clinical manifestations depending on its location and biological behavior.[3]

One anatomical region frequently affected by tumors is the abdomen. An intra-abdominal tumor or mass is an abnormal growth within the abdominal cavity that may resemble normal tissue structurally but does not perform normal physiological functions. Its growth may place pressure on abdominal organs and interfere with normal organ activity. Intra-abdominal masses may cause abdominal swelling, changes in abdominal contour, discomfort, pain, or bloating. Clinically, abdominal masses are often described according to location, including the right upper, left upper, right lower, and left lower quadrants. They may also be described in relation to the epigastric and periumbilical regions, which are important anatomical landmarks for localizing pathology.[4,5]

In diagnosing intra-abdominal tumors, clinicians usually use several diagnostic approaches to determine the nature, location, extent, and possible malignancy of the mass. Multi-Slice Computed Tomography (MSCT) is one of the most useful imaging modalities for evaluating intra-abdominal abnormalities because it provides high-resolution axial images and multiplanar reconstruction. Abdominal MSCT can help identify the organ of origin, tumor margins, vascular involvement, relationship to adjacent structures, and the presence of complications. Patient preparation may include negative oral contrast such as water to distend the stomach and small bowel and to reduce artifacts during image interpretation and post-processing. In pancreatic and other abdominal mass evaluations, arterial and portal venous phases are often selected according to the expected vascularity and clinical question.[6,7]

Abdominal MSCT examinations may use positive or negative contrast media. Each type has specific characteristics, advantages, and limitations depending on the clinical indication. Plain water as negative oral contrast can improve visualization of the gastric and small-intestinal walls, making wall thickening or mural tumors easier to identify compared with some positive contrast agents. Conversely, positive contrast may be more useful for certain gastrointestinal tract evaluations, particularly when luminal delineation is required. Selection of contrast type and route must therefore be adjusted to the diagnostic purpose, patient condition, and departmental protocol.[8]

Abdominal MSCT protocols may include several acquisition phases. A non-enhanced CT (NECT) phase can be used before contrast administration to detect calcification, hemorrhage, or baseline tissue density. An early arterial phase may be acquired approximately 15–20 seconds after injection, while a late arterial phase may be obtained at about 35–40 seconds. The hepatic or portal venous phase is generally acquired around 70–80 seconds after contrast injection, whereas delayed imaging may be performed several minutes later when clinically indicated. Proper phase selection is important because lesion conspicuity depends on the enhancement pattern of the mass and the surrounding normal tissue.[9,10]

Although CT provides important diagnostic information, it also delivers a higher radiation dose than many other radiological examinations. Abdominal and pelvic CT examinations contribute substantially to medical radiation exposure because they cover a relatively large anatomical region and may involve multiphase acquisitions. Therefore, protocol optimization is essential to maintain diagnostic image quality while minimizing unnecessary radiation exposure. This principle is consistent with radiological protection practices that emphasize justification, optimization, and dose reduction whenever possible.[11,12]

The anatomical information obtained from abdominal CT scans is strongly influenced by image quality. Important factors affecting image quality include spatial resolution, contrast resolution, image noise, and artifacts. Spatial resolution determines the ability to distinguish small structures, while contrast resolution determines the ability to differentiate tissues with small differences in attenuation. Noise can obscure fine anatomical detail, and artifacts may mimic or conceal pathology. Among the parameters that directly influence contrast appearance and visual interpretation are window width (WW) and window level (WL).[13,14]

Window width refers to the range of CT numbers displayed as shades of gray on the monitor. A wider WW displays a broader range of attenuation values but produces lower image contrast, whereas a narrower WW increases contrast but may obscure structures outside the selected range. Window level represents the midpoint of the displayed gray-scale range and determines overall image brightness. Selecting an appropriate combination of WW and WL is essential because inappropriate settings may make organ boundaries less distinct or reduce lesion conspicuity, particularly in soft-tissue abdominal imaging.[15,16]

CT values are expressed in Hounsfield units (HU), with water defined as 0 HU, air approximately -1000 HU, and dense bone commonly around +1000 HU or higher. Other tissues fall within this range depending on their X-ray attenuation characteristics. The CT image displayed on a monitor is therefore a gray-scale representation of digital attenuation data. Windowing, also known as gray-level mapping, transforms the original CT number data into a visible image by assigning selected HU ranges to shades of gray. Proper windowing allows radiologists to focus on the attenuation range most relevant to the organ or lesion being evaluated.[17,18]

For soft-tissue evaluation on CT, WW values of approximately 250–600 HU are frequently used because this range helps distinguish abdominal organs such as the liver, pancreas, spleen, kidneys, bowel wall, and muscles. Soft-tissue densities commonly cluster within a relatively narrow HU range; therefore, an appropriate soft-tissue window can improve the visibility of organ margins and pathological masses. By adjusting WW and WL, radiologists can enhance anatomical detail, improve contrast between normal and abnormal structures, and obtain images that are more suitable for diagnostic interpretation.[19,20]

The midpoint of the displayed gray-scale range is the WL, while the width of the displayed range is the WW. These parameters work together to determine how CT attenuation values are converted into image brightness and contrast. Determining the most optimal WW and WL values is particularly important in abdominal examinations involving intra-abdominal masses because subtle differences between mass tissue and adjacent organs may affect detectability and diagnostic confidence. This study was therefore conducted to identify the optimal WW and WL combination for axial abdominal CT images in cases of intra-abdominal masses.[21]

Materials and Methods

Study Design

This study used a quantitative observational design by assessing abdominal CT scan images in cases of intra-abdominal masses that had been confirmed by a radiologist. The study was conducted in the Radiology Department of Dr.

H. Yuliddin Away Regional General Hospital, Tapaktuan, in January 2025. The main focus of the study was the comparison of anatomical information obtained from variations in WW and WL values on reconstructed axial CT images.[21]

Sample

The subjects of this study were six patients who underwent abdominal multislice computed tomography (MSCT) examinations for intra-abdominal mass cases using a Siemens 16-slice CT scanner. Image reconstruction was performed by varying the WW and WL settings in order to compare the quality of anatomical information produced by each setting.[19,21]

Patients with confirmed intra-abdominal masses who provided written informed consent were included in the study. Those who declined or withdrew consent at any stage were excluded. These criteria ensured ethical compliance and the availability of complete imaging data for analysis.

Data Collection Technique

The data obtained consisted of primary and secondary data, including abdominal CT scan images of intra-abdominal mass cases and interview results from respondents.

Data Analysis Technique

The collected data were analyzed to assess the level of agreement or reliability among radiologists' observations of abdominal CT images using Cohen's Kappa test. Kappa analysis was used because it measures agreement beyond chance and is commonly applied in observer-based image interpretation studies. After the data distribution was found to be non-normal, the Friedman test was used to determine whether there were statistically significant differences in anatomical imaging information across the repeated WW and WL variations.[22,23]

The confidence level, also known as the level of significance, was set at $\alpha = 0.05$. The mean rank value from the Friedman test was used to determine which WW and WL variation produced the best anatomical information. H0 was rejected when $\rho < 0.05$, indicating that there was a statistically significant difference in anatomical information among the abdominal CT scan images reconstructed using different WW and WL settings.[24,25]

Ethical Consideration

This study adhered to the ethical principles of health research, including informed consent, confidentiality, beneficence, and respect for participants. All participants provided voluntary informed consent before enrollment, and patient confidentiality was maintained using coded identifiers. The study involved no additional invasive procedures beyond the routine abdominal CT examination, ensuring participants' safety and comfort throughout the research process.

Results

A total of six patients who underwent abdominal CT examinations at the Radiology Department of Dr. H. Yuliddin Away Regional General Hospital, Tapaktuan, were included in this study. All participants met the predefined inclusion criteria established by the researchers and were eligible for image evaluation and analysis.

Figure 1. Siemens 16-Slice CT Scan Modality.

Patient Preparation

Preparation for abdominal CT examination may vary slightly among imaging centers or according to the radiologist's preference. The use of CT equipment requires a specific protocol before the patient's examination schedule. Preparation for abdominal scanning begins the night before the CT examination. If the examination is scheduled in the morning, the patient eats a low-fiber meal the previous evening and begins fasting at midnight, approximately 8–10 hours before the examination. If the examination is scheduled in the afternoon, the patient may have a low-fiber breakfast and then fast for 8–10 hours until the examination. The patient must also be properly managed after the last meal and during the fasting period before the examination.[21]

Examination Technique

The patient was positioned supine on the examination table with the feet close to the gantry. The arms were raised above the head whenever possible to minimize beam-hardening artifacts and improve image quality. Patients were instructed to remain still and perform breath-holding during image acquisition to reduce motion artifacts and ensure optimal visualization of the abdominal structures.

For object positioning, the patient was adjusted so that the body's mid-sagittal plane (MSP) was aligned with the longitudinal indicator light and the mid-coronal plane (MCP) was aligned with the horizontal indicator light. The hands were placed above the head. To reduce motion artifacts, the patient's position was supported using foam pads and a special strap. A pad was placed under the patient's knees to reduce pressure on the back, improve comfort, and minimize movement. The patient was given instructions regarding breathing techniques before the examination.[19,21]

Examination Process

The abdominal examination is not as extensive as a routine examination. With CT technology, radiology personnel can consider using thin slices to support image quality when scanning the desired area.[19,21]

For a non-intravenous contrast abdominal study, the first image produced is a coronal view of the abdomen. From this image, the protocol determines whether the patient's MSP is centered along the long axis of the examination table. The range of axial images should extend from the iliac crest to the pubic symphysis. The technologist selects a wide field of view (FOV) to include the entire pelvis. Axial slices do not require gantry angulation and must be perpendicular to the patient's MSP.

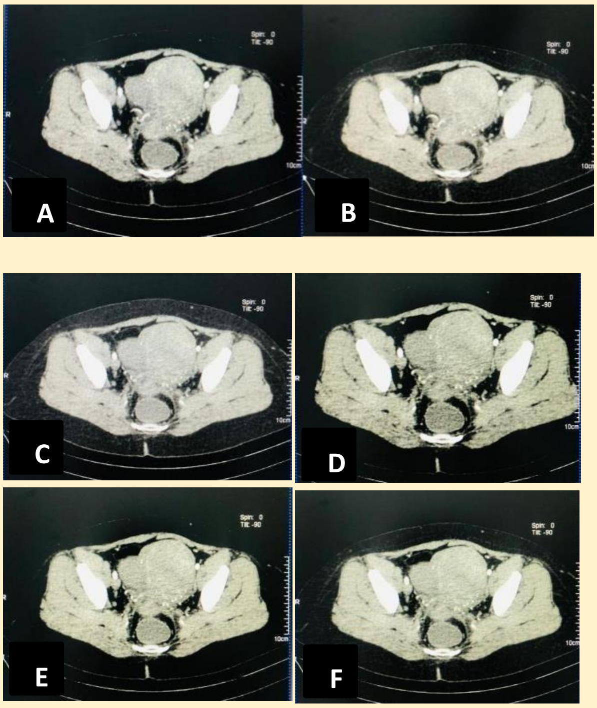

Figure 2. *Reconstructed images with WW and WL variations: A. WW 250 and WL 30; B. WW 300 and WL 30; C. WW 350 and WL 30; D. WW 250 and WL 60; E. WW 300 and WL 60; F. WW 350 and WL 60.*

In intravenous contrast studies of the abdomen, 100–150 ml of contrast medium is administered at an injection rate of approximately 1.5–2.0 ml/second. This process accommodates rapid spiral imaging. Abdominal images are usually obtained after a delay following injection. The delay time depends on the anatomy of interest. For example, to demonstrate bladder conditions, the delay time may take several minutes after intravenous injection. The radiographer must pay attention to the appropriate flow rate in the intravenous contrast protocol before image acquisition. After injection and the appropriate waiting period for the intravenous contrast medium, the second part of the scanning procedure begins. The scanning procedure extends from the iliac crest to the pubic symphysis.[7,8,21]

Patient Characteristics

The study sample consisted of six patients aged 46 to 55 years whose abdominal CT scan images were reconstructed for intra-abdominal mass cases. Based on Table 1, the patient characteristics by age showed that two patients were in the 46–50-year age group and four patients were in the 51–55-year age group.

Table 1. Sample characteristics based on age.

Age	Frequency	Percentage (%)
46 - 50	2	33.3%
51 - 55	4	66.7%
Total	**6**	**100%**

From the abdominal CT examinations of six patients with intra-abdominal mass cases, image reconstruction was performed on axial slices using WW variations of 250 HU, 300 HU, and 350 HU, and WL variations of 30 HU and 60 HU.

The reconstructed abdominal CT images were independently evaluated by three radiology professionals with a minimum of five years of clinical experience. For each of the six patients, six image reconstructions were generated using different combinations of window width (WW) and window level (WL) settings to assess their impact on anatomical visualization. The evaluated image settings were: (1) WW 250/WL 30, (2) WW 300/WL 30, (3) WW 350/WL 30, (4) WW 250/WL 60, (5) WW 300/WL 60, and (6) WW 350/WL 60. Each image was labeled according to its corresponding WW and WL combination to facilitate systematic comparison and observer assessment.

Three radiology specialists then observed the images. All images were labeled with the number of the first, second, third, fourth, fifth, and sixth patient, along with the corresponding WW and WL variation. A clearer example can be seen in Figure 2.

Respondent Characteristics

The three study respondents were radiology specialists with experience in interpreting abdominal CT scan images.

After the respondents evaluated the abdominal organ images, the researchers modified the WW and WL variations on selected slices based on the intra-abdominal masses from the six patients.

Description of Study Results Based on the Percentage of Respondents' Answers. After the three respondents provided assessments on the research forms, the results were recapitulated in tables to obtain the average value for each WW and WL variation. Examples of the percentages from respondents 1, 2, and 3 are shown in Table 2.

Table 2. Percentage of abdominal CT scan images in intra-abdominal mass cases with WW and WL variations

Total score from the three respondents				
No	***WW/WL***	**Score**		
		1	**2**	**3**
1	250/30	5	6	7
2	300/30	3	5	9
3	350/30	4	6	7
4	250/60	4	7	7
5	300/60	1	5	12
6	350/60	3	6	10

The image quality assessment was performed using a three-point scoring system based on the clarity of anatomical visualization. A score of 3 indicated that the observed organ was clearly visible with well-defined boundaries, 2 indicated that the organ was identifiable but with less distinct margins, and 1 indicated poor visualization with unclear boundaries. Three experienced radiology observers independently evaluated all reconstructed images. The total scores for the different WW and WL combinations ranged from 7 to 12, demonstrating variations in image quality across the tested settings. Among all parameter combinations, WW 300 HU and WL 60 HU achieved the highest total score of 12, indicating superior visualization of abdominal anatomical structures and lesion margins. These findings suggest that this parameter combination provides optimal image contrast and diagnostic quality for evaluating intra-abdominal mass cases on abdominal CT examinations.

Cohen's Kappa Test Results

After the questionnaires assessing agreement among respondents' perceptions were collected, Cohen's Kappa test was performed for the three radiology specialists.

The Kappa values showed consistency among respondents, with the following results: 0.843 between respondents 1 and 3, 0.811 between respondents 1 and 2, and 0.876 between respondents 2 and 3.

A p-value of 0.001 (< 0.05) indicated agreement in perception when assessing anatomical information on abdominal computed tomography (CT) images in intra-abdominal mass cases. Therefore, this study discusses the results from one respondent. The Friedman test was conducted to examine differences in anatomical information on abdominal computed tomography (CT) images in intra-abdominal mass cases. The results were based on ordinal and paired data, as presented in Table 3.

Table 3. Friedman test results of WW and WL variations on anatomical information from abdominal CT scans in intra-abdominal mass cases.

Window width and window level variation	Mean rank **Mean rank**	P-value **P-value**	Description **Description**
250/30	2.14		
300/30	3.18		
350/30	2.14	0.001 0.001	Significant difference
250/60	2.14		
300/60	5.24		
350/60	3.86		

Based on the Friedman test results, the significance value was p = 0.001 ($p < 0.05$). This means that H_0 was rejected and H_a was accepted, indicating that image information differed significantly across the WW and WL variations. The post-ranking analysis demonstrated that the selection of WW and WL parameters substantially influenced the quality of anatomical visualization in abdominal CT images. WW 300 HU and WL 60 HU produced the highest mean rank (5.24), followed by WW 350 HU and WL 60 HU (3.86), WW 300 HU and WL 30 HU (3.18), and the remaining three variations, each with a mean rank of 2.14. The Friedman test across all evaluated organs was performed to determine differences in anatomical information obtained from abdominal computed tomography (CT) images of patients with intra-abdominal masses after applying the various WW and WL settings.

Discussion

The Friedman test results showed significant differences in image data among the WW and WL variations; therefore, H0 was rejected and Ha was accepted. These differences can also be observed overall across the various WW and WL settings. WW represents the range of gray levels displayed on the monitor and is a series of CT values used to produce a gray-scale display. WW affects image contrast: the larger the WW used, the lower the image contrast. Meanwhile, WL affects the brightness level of the image; the image becomes brighter when a higher WL value is used. The purpose of windowing is to produce a more diagnostically useful image by changing the display through adjustments to window width and window level, thereby modifying image contrast.[15,16,18]

The most optimal WW and WL variation for abdominal examination in cases of intra-abdominal masses was determined from the Friedman test results. The best value was WW 300 HU and WL 60 HU, with a mean rank of 5.24. Although this value does not represent the widest WW range, the WL value of 60 HU produced the best image intensity and anatomical information in this study. This finding supports the principle that optimal abdominal soft-tissue visualization requires balanced contrast and brightness rather than the widest possible window.[19,20,24,25]

WW affects image contrast: the higher the WW, the lower the visible contrast. Reduced contrast can make anatomical images more difficult to interpret because organ boundaries become less clearly defined. Therefore, the selection of WW and WL should be adapted to the structure being evaluated, the clinical indication, and the need to distinguish the intra-abdominal mass from surrounding soft tissues.[13,15,16]

Conclusion

There were differences in anatomical information on abdominal CT scans for intra-abdominal mass cases across the various WW and WL settings. The middle-setting variations evaluated were WW 250 HU and WL 30 HU, WW 300 HU and WL 30 HU, WW 350 HU and WL 30 HU, WW 250 HU and WL 60 HU, WW 300 HU and WL 60 HU, and WW 350 HU and WL 60 HU. The most optimal variation for this examination was WW 300 HU and WL 60 HU on axial slices. For abdominal CT scan examinations in intra-abdominal mass cases that require high-quality reconstruction and optimal anatomical image information, it is recommended to use a middle setting with WW 300 HU and WL 60 HU.

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Conflict of Interest Statement

The author(s) declare no commercial, financial, or personal conflicts of interest related to this research. All authors approved the final manuscript and consented to its publication in *Healthy Tadulako Journal*.

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