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COMPARATIVE EVALUATION OF HOUNSFIELD UNIT MEASUREMENTS IN LIVER AND SPLEEN PARENCHYMA USING RADIANT DICOM AND UVIEWER

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ABSTRACT
Background: Quantitative Hounsfield Unit (HU) measurement of abdominal parenchymal organs is widely used in diagnostic and research applications of contrast-enhanced computed tomography (CT). Although HU values are theoretically standardized, software-dependent factors such as region-of-interest (ROI) rendering, image interpolation, and display calibration may introduce systematic differences between DICOM viewing platforms. This study compared liver and spleen parenchymal HU measurements obtained using RadiAnt DICOM viewer and uViewer on identical portal venous phase abdominal CT datasets.
Methods: Fifty contrast-enhanced abdominal CT examinations (portal venous phase) were retrospectively analysed. A single observer placed standardized circular ROIs on the liver and spleen parenchyma, avoiding vessels, ducts, and artefacts, and independently re-measured the same anatomical slices using RadiAnt DICOM and uViewer. Normality of paired differences was assessed using the Shapiro–Wilk test. Paired-samples t-tests compared mean HU values between viewers, and Pearson's correlation evaluated inter-software agreement.
Results: Mean liver HU was 86.32 ± 9.99 with RadiAnt DICOM versus 103.76 ± 13.95 with uViewer, a statistically significant difference ($t = -7.03$, $df = 49$, $p < 0.001$) with negligible correlation ($r = -0.047$, $p = 0.745$). Mean spleen HU was 131.32 ± 17.73 with RadiAnt DICOM versus 127.78 ± 17.21 with uViewer, a non-significant difference ($t = 1.10$, $df = 49$, $p = 0.275$) with weak correlation ($r = 0.159$, $p = 0.272$).
Conclusion: Liver HU measurements differed significantly and were poorly correlated between RadiAnt DICOM and uViewer, whereas spleen HU values were statistically comparable but likewise poorly correlated. HU values generated by different DICOM viewers should not be considered directly interchangeable, and viewer-specific calibration verification is recommended before quantitative HU data are pooled across platforms in clinical or research settings.

KEYWORDS: Hounsfield unit; DICOM viewer; RadiAnt; uViewer; liver; spleen; computed tomography; software comparison

1. INTRODUCTION

The Hounsfield Unit (HU) scale forms the quantitative backbone of computed tomography (CT) interpretation, translating linear X-ray attenuation coefficients into a standardized numerical range anchored at −1000 HU for air and 0 HU for water. HU values of abdominal parenchymal organs, particularly the liver and spleen, are used routinely to characterize diffuse parenchymal disease, assess contrast enhancement patterns, and serve as internal reference standards for organs such as the kidney and adrenal gland.

Liver attenuation measured on unenhanced CT is an established surrogate for hepatic steatosis, with attenuation values below approximately 40 HU, or a liver-to-spleen attenuation ratio departing substantially from unity, used as established diagnostic thresholds in several clinical and epidemiological studies.

According to PubMed, low-dose CT screening data has demonstrated that hepatic attenuation thresholds below 40 HU reliably flag moderate-to-severe steatosis in population cohorts (Chen et al., 2020; DOI: 10.1016/j.clinimag.2019.12.009), and similar ROI-based liver and spleen attenuation measurements have been used to validate virtual non-contrast CT reconstructions against true unenhanced imaging (Laukamp et al., 2020; DOI: 10.1259/bjr.20190701).

The splenic parenchyma, with its relatively homogeneous attenuation and lower susceptibility to focal fatty infiltration than the liver, is frequently used as an internal reference organ for normalizing lesion attenuation in renal, hepatic, and adrenal mass characterization, and for distinguishing benign from malignant findings using lesion-to-spleen attenuation ratios.

According to PubMed, a contrast-enhanced lesion-to-spleen HU ratio has recently been shown to be an independent predictor of malignancy in renal mass characterization, outperforming absolute lesion HU values alone (Akpinar et al., 2026; DOI: 10.1007/s00261-026-05534-w), while splenic density and the liver-to-spleen attenuation ratio have also been

reported as critical determinants of splenic parenchymal viability in cases of splenic torsion (Cetinoglu et al., 2020; DOI: 10.2174/1573405614666181009142322).

Despite the apparent objectivity of the HU scale, the numerical value displayed for a given voxel is not purely a property of the underlying tissue; it is also shaped by the acquisition protocol, reconstruction algorithm, and, critically for daily practice, the DICOM viewing software used to display and interrogate the image. Radiology departments and individual practitioners increasingly rely on a heterogeneous mix of vendor-supplied workstations, open-source viewers, and commercial third-party DICOM software for primary reads, teleradiology reporting, research data extraction, and academic instruction. RadiAnt DICOM Viewer is a widely used commercial viewer recognized for its rendering speed and intuitive interface, while uViewer is increasingly adopted in institutional and teleradiology workflows for routine image review and measurement. Although both platforms read the same underlying DICOM pixel data and apply the manufacturer-embedded rescale slope and intercept to generate HU values, differences in ROI algorithm implementation, anti-aliasing, sub-pixel interpolation, default ROI shape and size, and rounding conventions could, in principle, generate measurable inter-software discrepancies.

Prior work outside the abdominal CT-HU literature lends plausibility to this concern. According to PubMed, a comparison of apparent diffusion coefficient measurements across an MRI workstation, a PACS workstation, and a commercial DICOM viewer found a statistically significant systematic bias between platforms despite near-perfect intra-reader agreement, indicating that the post-processing software itself, independent of observer variability, can be a measurable source of quantitative bias (Clauser et al., 2016; DOI: 10.1007/s00330-015-4051-2). Similarly, automated CT quality-assurance protocols have shown that HU calibration is generally reproducible within a single scanner and protocol but can diverge across institutions and systems, with edge and radiomic metrics being more vulnerable than gross HU calibration (Saborido-Moral et al., 2023; DOI: 10.1016/j.ejmp.2023.103153).

Reliability analyses of ROI-based HU measurement in other anatomical contexts have generally reported excellent intra- and interobserver reproducibility when a single software platform and protocol are used (Lee et al., 2020; DOI: 10.1371/journal.pone.0241012), but these studies typically held the viewing software constant and therefore cannot speak to inter-software agreement, the gap this study addresses for the liver and spleen.

In routine departmental practice, abdominal CT studies are frequently reviewed, reported, or re-analysed across more than one DICOM platform — for instance, when a study is interpreted on an institutional PACS but later revisited on a different viewer for research data extraction, second opinion, or teaching purposes. If HU values are not interchangeable between viewers, this practice could introduce a previously unrecognized source of measurement error into both clinical decision-making and research datasets that pool HU values from multiple software sources. To date, no study has directly compared liver and spleen parenchymal HU measurements obtained from the same CT dataset using RadiAnt DICOM and uViewer.

The present study was therefore designed to determine whether liver and spleen parenchymal HU measurements obtained using RadiAnt DICOM Viewer and uViewer, applied to the same portal venous phase abdominal CT images by a single observer, are statistically equivalent and well correlated, or whether systematic, software-dependent differences exist. We hypothesized that any observed software-related discrepancy would be more pronounced in the liver, owing to its greater tissue heterogeneity and susceptibility to partial volume and vascular contamination effects within the ROI, than in the more homogeneous splenic parenchyma.

2. MATERIALS AND METHODS

2.1 Study Design and Setting

This was a retrospective, observational, software-comparison study conducted in the Department of Radiological Imaging Techniques in conjunction with the institutional radiodiagnosis archive. The study was designed to evaluate inter-software agreement in quantitative HU measurement rather than to assess any specific clinical diagnosis, and no change to patient management resulted from the measurements obtained.

2.2 Ethical Considerations

As the study used retrospectively anonymized DICOM datasets for a software-comparison analysis with no alteration of clinical care, the requirement for individual informed consent was waived in accordance with institutional policy for retrospective imaging-only research. All patient identifiers were removed from the DICOM headers prior to analysis, and the study was conducted in accordance with the principles of the Declaration of Helsinki.

2.3 Study Population

A total of 50 contrast-enhanced abdominal CT examinations performed for routine clinical indications were retrospectively retrieved from the institutional Picture Archiving and Communication System (PACS). Examinations were selected consecutively, subject to the eligibility criteria below, until the target sample size of 50 was reached.

Inclusion criteria: (i) adult patients aged 18 years or older; (ii) contrast-enhanced abdominal CT acquired in the portal venous phase; (iii) complete DICOM dataset available with unaltered pixel data and intact rescale slope/intercept metadata; (iv) liver and spleen parenchyma free of diffuse or focal disease that would preclude placement of a representative parenchymal region of interest (ROI).

Exclusion criteria: (i) non-contrast or arterial-phase-only studies; (ii) significant motion or beam-hardening artefact obscuring the liver or spleen parenchyma; (iii) prior hepatic or splenic surgery, focal hepatic or splenic lesions occupying more than 25% of the cross-sectional parenchymal area, diffuse infiltrative disease, or cirrhosis with marked parenchymal heterogeneity; (iv) incomplete or corrupted DICOM series.

2.4 CT Acquisition Protocol

All examinations were acquired on the departmental multidetector CT scanner using a standard contrast-enhanced abdominal protocol with images reconstructed in the portal venous phase (approximately 65–70 seconds post-injection of intravenous iodinated contrast medium). Standard departmental parameters were used United Imaging UCT 780 CT Scanner. Axial reconstructions with a slice thickness of 5 mm were used for HU measurement to ensure consistency across cases.

2.5 DICOM Viewing Software

Two DICOM viewing applications were compared:

RadiAnt DICOM Viewer (Medixant, Poznań, Poland) — a commercial DICOM viewer used for primary diagnostic review and post-processing in the department version No, 2025.2.

uViewer — a DICOM viewing platform used for routine image review and measurement within institutional workflow version R001.0.0.2.

Both applications were installed on the same workstation with identical display monitor calibration, ambient lighting, and viewing distance, to minimize any contribution of the display environment, as opposed to the software itself, to measurement variability. The same anonymized DICOM series for each patient was loaded independently into each viewer for measurement.

2.6 HU Measurement Protocol

All measurements were performed by a single trained observer with experience in abdominal CT interpretation, to eliminate inter-observer variability as a confounding factor and isolate the software platform as the sole variable under comparison.

For each patient, the same representative axial slice through the mid-portion of the right hepatic lobe (segment VII/VIII, avoiding the porta hepatis, major vascular structures, and biliary radicles) and the mid-portion of the spleen (avoiding the splenic hilum and capsule) was identified and used for measurement in both viewers. A circular region of interest (ROI) of standardized area (approximately 100 mm^2) was placed on the liver parenchyma, and a second standardized ROI was placed on the splenic parenchyma, in each case positioned to avoid visible vessels, ducts, focal lesions, artefacts, and the organ capsule. The mean HU value within each ROI was recorded as displayed by the respective software. The same ROI location and size were replicated as closely as possible between the two viewers by using identical anatomical landmarks, although ROI placement was performed independently in each software's native measurement tool rather than through a shared digital ROI overlay, reflecting real-world use of each platform's built-in measurement function.

Window/level settings were kept at the standard abdominal soft-tissue preset (window width 350 HU, window level 50 HU) in both viewers during measurement, as display windowing affects visual appearance but not the underlying stored HU value; this setting was held constant to ensure visual consistency in ROI placement across platforms.

2.7 Variables and Outcome Measures

The primary outcome variables were the mean HU values of the liver and spleen parenchyma as measured independently using RadiAnt DICOM and uViewer. Paired differences (uViewer minus RadiAnt DICOM) were calculated for each organ in each patient.

2.8 Statistical Analysis

Data were analysed using standard statistical software SPSS version 22. Descriptive statistics (mean ± standard deviation) were calculated for liver and spleen HU values obtained with each viewer. The Shapiro–Wilk test was used to assess the normality of the paired differences between the two viewers for each organ. As the paired differences were normally distributed for both organs, a paired-samples t-test was used to compare mean HU values between RadiAnt DICOM and uViewer. Pearson's correlation coefficient was calculated to assess the linear agreement between the two viewers for each organ. A two-tailed p-value of less than 0.05 was considered statistically significant throughout.

3. RESULTS

3.1 Patient Characteristics

A total of 50 patients were included in the study. Hounsfield Unit (HU) measurements of the liver and spleen parenchyma were independently obtained using RadiAnt DICOM and uViewer from the same abdominal CT examinations. The study compared HU values obtained from both software applications using paired statistical analysis.

3.2 Comparison of Liver Parenchymal HU Measurements

The mean liver attenuation measured using RadiAnt DICOM was 86.32 ± 9.99 HU, whereas the corresponding value measured using uViewer was 103.76 ± 13.95 HU.

The Shapiro–Wilk test demonstrated that the paired differences were normally distributed ($p = 0.626$). Therefore, a paired-samples t-test was performed.

A statistically significant difference was observed between the liver HU measurements obtained using the two DICOM viewers ($t = -7.03$, $df = 49$, $p < 0.001$). The mean paired difference was 17.44 HU, indicating consistently higher liver attenuation values measured by uViewer.

Pearson's correlation analysis demonstrated a very weak negative correlation between liver HU measurements ($r = -0.047$, $p = 0.745$).

3.3 Comparison of Spleen Parenchymal HU Measurements

The mean spleen attenuation measured using RadiAnt DICOM was 131.32 ± 17.73 HU, while the corresponding mean obtained using uViewer was 127.78 ± 17.21 HU.

The paired differences were normally distributed according to the Shapiro–Wilk test ($p = 0.994$).

Paired t-test analysis demonstrated no statistically significant difference between spleen HU measurements obtained using RadiAnt DICOM and uViewer ($t = 1.10$, $df = 49$, $p = 0.275$).

Pearson correlation analysis revealed a weak positive correlation ($r = 0.159$, $p = 0.272$), indicating poor agreement between the two software packages.

3.4 Summary of Comparative Analysis

Overall, liver HU measurements differed significantly between RadiAnt DICOM and uViewer, whereas spleen HU measurements were statistically comparable. Correlation analysis demonstrated poor linear agreement for both organs, suggesting that HU measurements obtained from the two software platforms were not directly interchangeable in the present dataset.

Table 1. Descriptive statistics of HU measurements

Organ	RadiAnt DICOM (Mean ± SD)	uViewer (Mean ± SD)	Mean Difference (HU)	p-value
Liver	86.32 ± 9.99	103.76 ± 13.95	17.44	**<0.001***
Spleen	131.32 ± 17.73	127.78 ± 17.21	3.54	0.275

Table 2. Normality assessment of paired differences

Organ	Shapiro–Wilk p-value	Distribution
Liver	0.626	Normal
Spleen	0.994	Normal

Table 3. Paired comparison between RadiAnt DICOM and uViewer

Organ	t-value	df	p-value	Interpretation
Liver	−7.03	49	**<0.001***	Significant
Spleen	1.10	49	0.275	Not Significant

Table 4. Correlation analysis

Organ	Pearson's r	p-value	Strength
Liver	−0.047	0.745	Negligible
Spleen	0.159	0.272	Weak

4. DISCUSSION

This study compared liver and spleen parenchymal HU measurements obtained from identical portal venous phase abdominal CT datasets using RadiAnt DICOM and uViewer, with a single observer measuring both organs in both viewers to isolate the software platform as the variable of interest. The principal finding was an organ-dependent pattern: liver HU values differed significantly and systematically between the two viewers, with uViewer recording values approximately 17 HU higher on average than RadiAnt DICOM, whereas spleen HU values were statistically equivalent between viewers. Notably, correlation between the two software platforms was poor for both organs, indicating that even where mean values were statistically similar, as in the spleen, the viewers did not track each other consistently on a case-by-case basis.

4.1 Interpretation of the Liver Findings

The magnitude and direction of the liver discrepancy are clinically relevant. A mean difference of 17.44 HU is large enough to influence the classification of hepatic steatosis when using fixed HU thresholds, since a value near the conventional 40 HU steatosis cut-off, or a borderline liver-to-spleen attenuation ratio near unity, could be reclassified depending on which viewer generated the measurement.

This is consistent with prior work outside the abdominal CT-HU literature showing that quantitative measurements can carry a genuine software-dependent bias rather than reflecting observer error alone. According to PubMed, Clauser et al. found a statistically significant bias in apparent diffusion coefficient values between a commercial DICOM viewer and an MRI manufacturer workstation despite near-perfect intra-reader reproducibility, concluding that the post-processing platform itself was an independent source of measurement variability (Clauser et al., 2016; DOI: 10.1007/s00330-015-

4051-2). A plausible analogous mechanism in the present study is divergence in how each viewer's ROI tool samples and averages pixel values, particularly given the liver's relative parenchymal heterogeneity, proximity to portal and hepatic venous structures, and susceptibility to partial-volume averaging at the ROI boundary, all of which could amplify inter-software discrepancy compared with a more homogeneous reference organ.
The negligible Pearson correlation for liver HU ($r = -0.047$) is itself a notable finding, independent of the mean difference. A systematic offset alone, if constant across the measurement range, would still preserve a strong positive correlation; the near-zero correlation observed here instead suggests that the inter-software discrepancy is not a simple fixed offset but varies unpredictably from case to case, plausibly reflecting interaction between ROI placement, local parenchymal heterogeneity, and viewer-specific pixel sampling or interpolation behaviour at each measurement site.

4.2 Interpretation of the Spleen Findings

In contrast to the liver, spleen HU values were statistically equivalent between the two viewers ($p = 0.275$), with a smaller mean difference of 3.54 HU. This is broadly consistent with the spleen's more homogeneous parenchymal composition and lower density of segmental vascular structures within typical ROI placement sites, which would be expected to make spleen HU values comparatively robust to the technical sources of viewer-dependent bias hypothesized above for the liver. Splenic attenuation is widely relied upon as an internal reference standard, including in lesion-to-spleen normalization ratios for renal and other organ mass characterization (Akpinar et al., 2026; DOI: 10.1007/s00261-026-05534-w) and in assessment of splenic parenchymal viability (Cetinoglu et al., 2020; DOI: 10.2174/1573405614666181009142322). The present equivalence in mean spleen HU between viewers is therefore reassuring for such applications. However, the weak Pearson correlation observed for the spleen ($r = 0.159$) indicates that, despite group-level equivalence, individual paired measurements did not align closely case-by-case. This distinction between mean-level equivalence and poor individual-level agreement is important: a paired t-test evaluates whether the average difference across the sample is distinguishable from zero, while Pearson's r evaluates whether the two measurement series move together. The combination of a non-significant t-test and a weak correlation for the spleen suggests that any single patient's spleen HU value from one viewer is not a reliable predictor of the same patient's value from the other viewer, even though the two samples are equivalent on average.

4.3 Broader Methodological Implications

These findings reinforce previous evidence that HU values, although nominally absolute and reproducible by definition of the CT density scale, are in practice mediated by software-level decisions in pixel sampling, ROI rendering, and rounding.
Quality-assurance studies using phantom-based protocols have shown that HU calibration is generally comparable within a given scanner-protocol combination but can diverge meaningfully when comparing different systems or institutions, with edge-characterization and radiomic metrics showing greater divergence than bulk HU values (Saborido-Moral et al., 2023; DOI: 10.1016/j.ejmp.2023.103153). The present results extend this concern from the acquisition/reconstruction domain into the viewing-software domain, since the same reconstructed DICOM dataset, displaying identical underlying pixel values, nonetheless produced significantly different liver HU readings depending on the viewer used to interrogate it.
Reliability studies of HU measurement that hold the software platform constant typically report excellent intra- and interobserver reproducibility (Lee et al., 2020; DOI: 10.1371/journal.pone.0241012), which may give a false sense of security regarding the absolute comparability of HU values reported in the literature or pooled across multi-centre research datasets, where the viewing software used to generate each measurement is rarely standardized or even reported. Similarly, contrast administration itself measurably alters parenchymal HU through iodine accumulation and, secondarily, organ radiation dose, with portal venous phase liver and spleen enhancement increasing substantially over baseline attenuation (Amato et al., 2013; DOI: 10.2214/AJR.12.8958); against this backdrop of contrast-driven attenuation change, an additional, software-dependent layer of measurement variability compounds the difficulty of comparing HU values across studies, time points, or platforms unless methodology is tightly standardized.

4.4 Clinical and Research Implications

From a clinical standpoint, these findings suggest that HU-based thresholds for hepatic steatosis, lesion characterization, or organ-ratio calculations should ideally be derived and applied using a single, consistent DICOM viewing platform within a department or research protocol, rather than assuming interchangeability between viewers. Where multi-software workflows are unavoidable, for example when teleradiology reporting, second-opinion review, or research data extraction occurs on a different platform from the original interpretation, departments may wish to perform a periodic, organ-specific cross-validation of HU measurements between their viewers, analogous to the comparison undertaken here, particularly for organs such as the liver shown to be more vulnerable to inter-software divergence.
From a research standpoint, multi-centre or multi-software studies that pool HU values without verifying inter-platform agreement may introduce a previously unrecognized source of measurement noise or bias into their datasets. This is particularly relevant for radiomics and AI-based quantitative imaging research, where HU values are frequently extracted as features directly from DICOM data using a variety of open-source and commercial libraries and viewers.

4.5 Limitations

Several limitations should be acknowledged. First, measurements were performed by a single observer, which eliminates inter-observer variability as a confounder but does not allow assessment of whether the magnitude of inter-software

discrepancy is consistent across observers of differing experience levels. Second, although the same anatomical slice and landmark-based ROI location were used for both viewers, ROI placement was performed independently in each platform's native tool rather than through a shared, geometrically identical digital overlay; minor differences in exact ROI position, although minimized by protocol, cannot be entirely excluded as a contributor to the observed discrepancy, particularly for the liver. Third, the study was conducted at a single institution using a single CT scanner protocol, which may limit generalizability to other acquisition parameters, reconstruction kernels, or contrast timing protocols. Fourth, the underlying technical reasons for the observed liver-specific divergence, whether related to ROI averaging algorithms, image interpolation, or display rendering differences between the two viewers, were not directly interrogated at the pixel or source-code level in this study and remain inferential. Finally, the sample, while adequately powered for the paired comparisons performed, was drawn from a single clinical population and may not capture the full spectrum of hepatic and splenic parenchymal appearances encountered in broader practice.

4.6 Future Directions

Future work could usefully extend this comparison to multiple observers to quantify the relative contribution of software platform versus inter-observer variability to overall HU measurement error. Phantom-based studies, in which a calibrated reference object of known attenuation is measured across multiple DICOM viewers under identical display conditions, would help isolate whether the observed liver-specific divergence reflects ROI algorithm differences, interpolation artefacts, or another software-level mechanism, independent of biological tissue heterogeneity. Extending the comparison to additional commonly used DICOM viewers, additional abdominal organs, and non-portal-venous CT phases would also help establish how broadly these findings generalize across the wider radiology software ecosystem.

5. CONCLUSION

Liver and spleen parenchymal HU measurements obtained from identical contrast-enhanced abdominal CT datasets differed in their level of agreement between RadiAnt DICOM and uViewer. Liver HU values showed a statistically significant, clinically meaningful difference between the two viewers with negligible correlation, while spleen HU values were statistically equivalent on average but also showed only weak case-by-case correlation. These findings indicate that HU values generated by different DICOM viewing platforms, even from the same underlying DICOM dataset, should not be assumed to be directly interchangeable, particularly for the liver. Departments and researchers using quantitative HU-based thresholds or ratios are advised to standardize the DICOM viewing software used for measurement within a given clinical or research protocol, and to consider periodic inter-software validation when multiple platforms are used in practice.

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