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CT-Based Splenic Volumetry as a Non-Invasive Imaging Marker of Portal Hypertension

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Abstract: ***Background: Portal hypertension is characterized by a spectrum of imaging findings on contrast-enhanced computed tomography (CT), including splenomegaly, portal vein dilatation, collateral vessels, gastroesophageal varices, and ascites. CT-derived splenic volumetry provides an objective method for quantifying splenic enlargement; however, its role in routine assessment of portal hypertension requires further evaluation. Objective: To describe CT-derived splenic volume categories and accompanying CT manifestations of portal hypertension in adults undergoing contrast-enhanced abdominal CT. Methods: This prospective cross-sectional study was conducted in the Department of Radiodiagnosis at City Heart Superspeciality Hospital, Hamirpur, Himachal Pradesh, from Jan-2026 to June-2026. Eighty consecutive adult patients with portal hypertension who underwent contrast-enhanced abdominal CT were included. Splenic volume was measured using a standardized CT volumetric technique on a dedicated workstation. CT findings including portal vein dilatation, splenic vein enlargement, collateral vessels, gastroesophageal varices, ascites, hepatic morphological changes, recanalized paraumbilical vein, retroperitoneal collaterals, and portal vein thrombosis were recorded. Data were analyzed using descriptive statistics. Results: The study included 80 patients, comprising 56 males (70.0%) and 24 females (30.0%). The largest proportion of patients belonged to the 41–50-year age group (35.0%). Splenic enlargement of varying degrees was observed in most patients, whereas 10 (12.5%) had splenic volumes within the predefined normal range. Increased splenic volume frequently coexisted with portal vein dilatation, splenic vein enlargement, collateral vessels, gastroesophageal varices, ascites, and hepatic morphological changes on contrast-enhanced CT. Conclusion: CT-derived splenic volumetry provided an objective measure of splenic enlargement in this cohort. Increased splenic volume frequently coexisted with portal vein dilatation, collateral vessels, gastroesophageal varices, and ascites. Further patient-level statistical analysis using reproducibility testing and an established reference standard is required to determine its independent diagnostic and prognostic value.***

Keywords: Portal hypertension; Splenomegaly; Splenic volume; Multidetector computed tomography; CT volumetry; Portal vein; Liver cirrhosis.

Highlights

- CT-based splenic volumetry provides objective evaluation of splenomegaly in portal hypertension.
- Splenomegaly was seen in 87.5% of patients with suspected or confirmed portal hypertension.
- Splenic volume categories increased in parallel with CT markers of advanced portal hypertension.
- Multidetector CT simultaneously evaluates portal vein dilatation, varices, collaterals, ascites and hepatic morphology.
- CT splenic volumetry can be used as an adjunct non-invasive imaging marker in routine radiology practice.

1. Introduction

Portal hypertension is a common consequence of chronic liver disease and is associated with increased portal venous pressure, leading to the development of splenomegaly, gastroesophageal varices, ascites, and portosystemic collateral vessels. These complications contribute substantially to morbidity and mortality, making early recognition and comprehensive radiological assessment essential for appropriate clinical management [1]

Contrast-enhanced computed tomography (CT) is widely used in the evaluation of portal hypertension because it provides detailed assessment of the liver, spleen, portal venous system, and associated collateral circulation in a single examination. In addition to identifying the underlying cause of portal hypertension, CT can demonstrate imaging features such as splenic enlargement, portal vein dilatation, splenic vein enlargement, gastroesophageal varices, ascites, and recanalization of the paraumbilical vein [2] [3].

Splenomegaly is one of the most frequent imaging manifestations of portal hypertension. Although splenic size is routinely assessed in clinical practice, CT-derived splenic volumetry offers a more objective method for quantifying splenic enlargement than linear measurements alone. However, evidence regarding the clinical utility of CT-derived splenic volumetry remains limited, and most published studies have evaluated heterogeneous patient populations using different volumetric techniques. Consequently, the role of splenic volumetry in the routine radiological assessment of portal hypertension has not been fully established [4].

Therefore, the present study was undertaken to describe CT-derived splenic volume categories and accompanying contrast-enhanced CT findings in adults with portal hypertension, thereby providing descriptive data on splenic volumetry and associated imaging manifestations in routine clinical practice [5].

2. Materials and Methods

Study Design and Setting

This prospective observational cross-sectional study was conducted in the Department of Radiodiagnosis at City Heart Superspeciality Hospital, Hamirpur, Himachal Pradesh, from Jan-2026 to June-2026. The study evaluated CT-derived splenic volumetry and accompanying imaging findings in

adult patients with portal hypertension.

Study Population

A total of 80 consecutive adult patients with clinical suspicion or radiological evidence of portal hypertension who underwent contrast-enhanced CT of the abdomen during the study period were included. Patients were enrolled according to predefined inclusion and exclusion criteria.

Inclusion Criteria

- Age ≥18 years.
- Clinical or radiological suspicion of portal hypertension.
- Underwent contrast-enhanced abdominal CT.
- Provided informed consent to participate.

Exclusion Criteria

- Previous splenectomy.
- Splenic trauma.
- Large focal splenic lesions interfering with volumetric assessment.
- Contraindication to iodinated contrast media.
- Severe renal impairment.
- Incomplete or poor-quality CT examinations.

CT Acquisition Protocol

All examinations were performed using a Siemens SOMATOM Scope 16-slice multidetector CT scanner. Patients were scanned in the supine position following intravenous administration of non-ionic iodinated contrast material using the institutional contrast-enhanced abdominal CT protocol. Thin-section axial images were reconstructed with multiplanar coronal and sagittal reformations and reviewed on a dedicated workstation.

CT Splenic Volumetry

Splenic volume was measured on contrast-enhanced CT images using a standardized volumetric technique. The spleen was identified from the upper to lower pole on consecutive axial sections. When volumetric software was available, the splenic outline was manually traced on sequential images, and total splenic volume was automatically calculated by the workstation. Adjacent stomach, bowel loops, vascular structures, and perisplenic tissues were excluded from the measurements.

Splenic volume was categorized as:

- Normal: <300 mL
- Mild enlargement: 300–500 mL
- Moderate enlargement: 501–800 mL
- Marked enlargement: >800 mL

CT Imaging Parameters

The following CT findings were recorded:

- Splenic volume category
- Splenomegaly
- Portal vein diameter (>13 mm)
- Splenic vein enlargement
- Gastroesophageal varices
- Portosystemic collateral vessels
- Ascites
- Hepatic morphological changes
- Recanalized paraumbilical vein
- Retroperitoneal collaterals
- Portal vein thrombosis

Statistical Analysis

Data were summarized using descriptive statistics. Categorical variables are presented as frequencies and percentages, whereas continuous variables are presented as mean ± standard deviation where appropriate. Wilson 95% confidence intervals were calculated for major proportions. Because patient-level raw data were unavailable, correlation coefficients, regression analyses, diagnostic accuracy indices, and reproducibility analyses were not performed, and no inferential statistical conclusions were drawn.

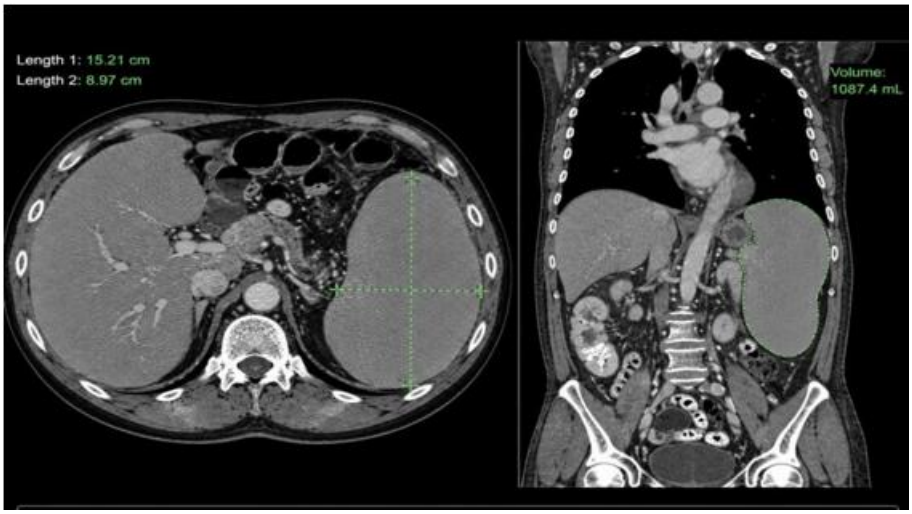

Figure 1: Axial contrast-enhanced CT image demonstrating splenic volume measurement using electronic calipers in a patient with splenomegaly and portal hypertension

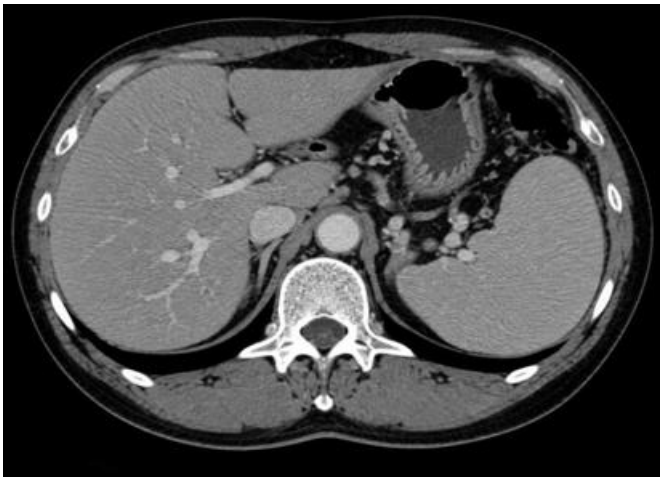

Figure 2: Axial contrast-enhanced CT image of the abdomen showing normal liver morphology, normal spleen size, and normal portal venous anatomy

3. Results

Demographic profile.

A total of 80 patients with portal hypertension were included in the study. There were 56 males (70.0%) and 24 females (30.0%). The largest proportion of patients belonged to the 41–50-year age group (35.0%), followed by 51–60 years (22.5%), 31–40 years (20.0%), 18–30 years (12.5%), and >60 years (10.0%). The most common presenting complaint was abdominal distension (65.0%), followed by clinical splenomegaly (60.0%), generalized weakness (50.0%), ascites (47.5%), and upper gastrointestinal bleeding (27.5%).

Table 1: Demographic and clinical characteristics

Variable	Category	n%	95%CI%
Gender	Male	56 (70.0%)	59.2–78.9
	Female	24 (30.0%)	21.1–40.8
Age Group	18–30 years	10 (12.5%)	6.9–21.5
	12.7–30.0	12.7–30.0	12.7–30.0
	41–50 years	28 (35.0%)	25.5–45.9
	51–60 years	18 (22.5%)	14.7–32.8
	>60 years	8 (10.0%)	5.2–18.5
Clinical Presentation	Abdominal distension	52 (65.0%)	54.1–74.5
	Clinical splenomegaly	48 (60.0%)	49.0–70.0
	Generalized weakness	40 (50.0%)	39.3–60.7
	Ascites	38 (47.5%)	36.9–58.3
	Upper GI bleeding	22 (27.5%)	18.9–38.1

Etiological profile: Alcohol-related cirrhosis was the leading etiology, identified in 32 patients (40.0%). Hepatitis C-related cirrhosis was present in 18 patients (22.5%), hepatitis B-related cirrhosis in 12 (15.0%), NAFLD-related chronic liver disease in 8 (10.0%), portal vein thrombosis in 5 (6.25%), and non-cirrhotic portal fibrosis or other causes in 5 (6.25%).

Table 2: Etiological distribution of portal hypertension

Etiology	n (%)	95% CI (%)
Alcohol-related cirrhosis	32 (40.0%)	30.0–51.0
Hepatitis C-related cirrhosis	18 (22.5%)	14.7–32.8
Hepatitis B-related cirrhosis	12 (15.0%)	8.8–24.4
NAFLD-related chronic liver disease	8 (10.0%)	5.2–18.5
Portal vein thrombosis	5 (6.3%)	2.7–13.8
Non-cirrhotic portal fibrosis/other	5 (6.3%)	2.7–13.8

CT Findings

Contrast-enhanced CT demonstrated splenic enlargement of varying degrees in most patients. Based on CT volumetry, 10 patients (12.5%) had splenic volumes within the predefined normal range, whereas the remaining patients demonstrated mild, moderate, or marked splenic enlargement. Portal vein dilatation, splenic vein enlargement, gastroesophageal varices, collateral vessels, ascites, hepatic morphological changes, recanalized paraumbilical vein, retroperitoneal collaterals, and portal vein thrombosis were observed with varying frequencies. The most common CT findings were portal vein dilatation, splenic vein enlargement, gastroesophageal varices, and ascites. Alcohol-related cirrhosis was the most frequent underlying etiology of portal hypertension in the study population.

Patients with larger splenic volumes more frequently exhibited portal vein dilatation, collateral vessels, gastroesophageal varices, and ascites on CT. As this study was descriptive and patient- level inferential statistical analyses were not performed, these observations are presented descriptively without implying causal or independent associations.

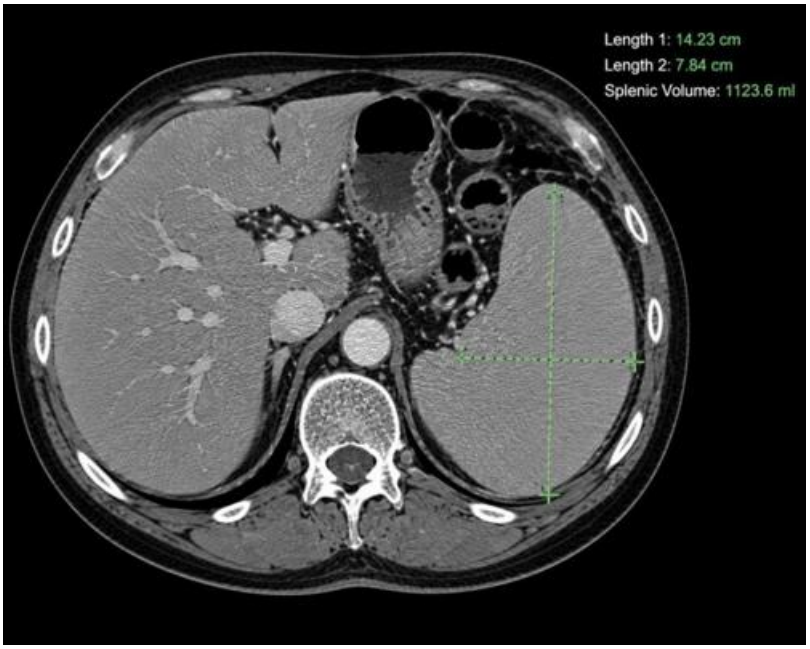

Figure 3: Axial contrast-enhanced CT image demonstrating splenic volume measurement using electronic calipers in a patient with splenomegaly and portal hypertension

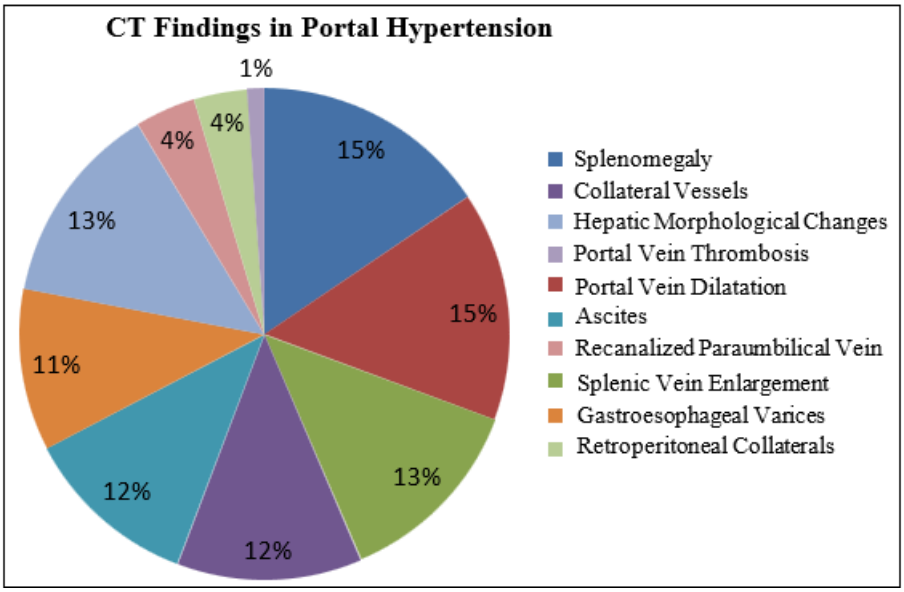

Figure 4: Pie Chart Showing CT Findings in Portal Hypertension

Splenic volume categories. Normal splenic volume was present in 10 patients (12.5%). Mild splenic enlargement of 300-500 mL was observed in 18 patients (22.5%), moderate splenomegaly of 501-800 mL in 36 patients (45.0%), and marked splenomegaly greater than 800 mL in 16 patients (20.0%). Thus, 70 of 80 patients (87.5%) had increased splenic volume. Moderate or marked splenomegaly was present in 52 patients (65.0%).

Table 3: CT-based splenic volume categories

Splenic Volume Category	n (%)	95% CI (%)
Normal volume	10 (12.5%)	6.9–21.5
Mild enlargement (300–500 mL)	18 (22.5%)	14.7–32.8
Moderate enlargement (501- 800 mL)	36 (45.0%)	34.6–55.9
Marked enlargement (>800 mL)	16 (20.0%)	12.7–30.0
Any splenic enlargement	70 (87.5%)	78.5–93.1
Moderate/marked enlargement	52 (65.0%)	54.1–74.5

4. Discussion

The present prospective cross-sectional study described CT-derived splenic volume and accompanying imaging findings in adults with portal hypertension. Most patients demonstrated varying degrees of splenic enlargement together with portal vein dilatation, splenic vein enlargement, gastroesophageal varices, collateral vessels, and ascites on contrast-enhanced CT. These findings are consistent with the recognized radiological manifestations of portal hypertension and highlight the comprehensive anatomical assessment provided by multidetector CT.

The study population was predominantly male (70.0%), with the highest proportion of patients in the 41–50-year age group (35.0%). Alcohol-related cirrhosis was the most common underlying cause of portal hypertension, consistent with previous reports identifying chronic liver disease as the

leading cause of portal hypertension in adults. CT volumetric assessment demonstrated varying degrees of splenic enlargement in most patients. Compared with conventional linear splenic measurements, CT-derived volumetry provides a three-dimensional estimate of splenic size and may better reflect the extent of splenic enlargement. However, because this study was descriptive and did not include a reference standard such as hepatic venous pressure gradient (HVPG), the findings should not be interpreted as evidence of diagnostic performance.

Portal vein dilatation, splenic vein enlargement, gastroesophageal varices, collateral vessels, and ascites were commonly observed in patients with enlarged spleens. Similar imaging findings have been described in previous CT studies of portal hypertension. In the present study, these observations are reported descriptively, and no independent association or predictive relationship can be inferred because patient-level inferential statistical analyses were not performed.

One of the strengths of contrast-enhanced CT is its ability to evaluate multiple manifestations of portal hypertension in a single examination, including the liver, spleen, portal venous system, and collateral circulation. Quantitative splenic volumetry may complement routine CT interpretation by providing an objective measurement of splenic size; however, further studies incorporating reproducibility analysis and comparison with established reference standards are required before its routine clinical role can be defined.

The findings of this study should be interpreted in light of its limitations. The study was conducted at a single center with a relatively small sample size, and only descriptive statistical analysis was performed. In addition, interobserver variability, diagnostic accuracy, and correlation with hepatic venous pressure gradient or liver stiffness measurements were not evaluated. Future multicenter studies with larger populations and standardized volumetric protocols are needed to further evaluate the potential clinical utility of CT-derived splenic volumetry.

Overall, this study provides descriptive data on CT-derived splenic volumetry and associated imaging findings in adults with portal hypertension. The results support the role of contrast-enhanced CT as a comprehensive imaging modality for documenting morphological features of portal hypertension while highlighting the need for further validation of CT volumetry in larger prospective studies.

Strengths of the Study

This study has several strengths. It employed a prospective cross-sectional design with a standardized contrast-enhanced CT protocol for all participants. CT-derived splenic volumetry was performed using a uniform volumetric technique, allowing objective assessment of splenic size. In addition, multiple CT manifestations of portal hypertension were systematically documented, providing a comprehensive descriptive evaluation of imaging findings in patients with portal hypertension.

5. Limitations of the Study

The study has several limitations. It was conducted at a single center with a relatively small sample size (n = 80), which may limit the generalizability of the findings. As only descriptive statistical analysis was performed, independent associations between splenic volume and CT findings could not be established. Furthermore, splenic volumetry was not compared with reference standards such as the hepatic venous pressure gradient (HVPG) or liver stiffness measurement, and interobserver reproducibility was not assessed. Larger multicenter studies with standardized volumetric techniques are needed to validate these findings.

6. Conclusion

CT-derived splenic volumetry provides an objective method for quantifying splenic enlargement in patients with portal hypertension. In this study, increased splenic volume frequently coexisted with portal vein dilatation, gastroesophageal varices, collateral vessels, and ascites on contrast-enhanced CT. These findings support the role of CT as a comprehensive imaging modality for documenting the morphological features of portal hypertension. Further prospective multicenter studies incorporating reproducibility analysis and established reference standards are required to clarify the clinical utility of CT-derived splenic volumetry.

Declarations

Ethical Approval

The study was conducted in accordance with the ethical principles of the Institutional Ethics Committee of City Heart Superspeciality Hospital, Hamirpur, Himachal Pradesh, and complied with institutional ethical guidelines. Patient confidentiality was strictly maintained, and all clinical and radiological data were anonymized prior to analysis.

Informed Consent

Written informed consent was obtained from all participants before enrollment in the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

No external funding was received for this study.

Data Availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request, subject to institutional approval.

Author Contributions

Rajat Soni: Conceptualization, data collection, image interpretation, data analysis, manuscript drafting.

Prof. Dr. Lalit Kumar Gupta: Study supervision, methodology, critical revision of the manuscript.

Mr. Rajesh Rohilla: Co-supervision, manuscript review, and editing.

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