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Original Article

Role of portal venous doppler in detecting capillary leakage among dengue patients: A cross-sectional study from a tertiary care hospital in Puducherry.

Page | 1

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Abstract

Background: Dengue fever is a globally significant arboviral disease, with India bearing a substantial disease burden. Severe forms are characterized by capillary leak syndrome (CLS), which can lead to hypovolemic shock and organ dysfunction. Aim: This study aimed to evaluate the role of portal venous doppler parameters in the early detection of CLS among dengue patients.

Methods: A cross-sectional study was conducted on 65 serologically confirmed dengue patients at a tertiary hospital in Puducherry. Demographic, clinical, and laboratory data were collected. Grayscale ultrasound and portal venous Doppler were used to assess gall bladder wall thickness, ascites, pleural effusion, and hemodynamic indices, including congestion index (CI). CLS was defined as $\geq 20\%$ hematocrit rise or ultrasonographic evidence of plasma leakage. Statistical analyses included the Chi-square test, t-test, and ROC curve analysis.

Results: The mean age was 37.7 years, with 57% of participants being male. CLS was present in 41.5%. Gall bladder wall edema (69.2%) was the most common ultrasonographic finding and was significantly associated with CLS ($p < 0.001$). Pleural effusion (47.7%) also showed significance ($p = 0.010$). Doppler evaluation revealed significantly lower portal vein velocity in CLS patients (16.6 vs 19.5 cm/s, $p = 0.013$) and higher CI (0.11 vs 0.04, $p < 0.001$). ROC analysis demonstrated high diagnostic accuracy for gall bladder wall thickness (AUC = 0.86), CSA (AUC = 0.85), and CI (AUC = 0.81).

Conclusion: Portal venous Doppler parameters, particularly CI and CSA, serve as valuable functional markers for early detection of CLS. Combined with ultrasonography, they enhance diagnostic accuracy, guide timely fluid management, and may reduce severe dengue complications.

Recommendations: Larger multicentered studies should validate these Doppler indices and establish standard cut-offs. Incorporating Doppler into triage protocols and training clinicians in bedside use could strengthen early intervention strategies in endemic areas.

Keywords: Dengue, Capillary Leak Syndrome, Ultrasonography, Portal Venous Doppler, Congestion Index

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Introduction

Dengue is one of the most important mosquito-borne viral infections in India and has been recognized for more than two centuries¹. Globally, nearly 390 million infections occur annually, with India contributing significantly. Seroprevalence studies from Puducherry highlight its regional burden⁴. The economic impact is also considerable. Severe dengue is characterized by capillary leak syndrome (CLS), leading to shock and organ dysfunction⁶⁻⁸. Endothelial dysfunction is central to its pathogenesis^{9,10}. The WHO 2009 guidelines emphasize early detection¹¹, and studies comparing the 1997 and 2009 classifications highlight better sensitivity for severe disease^{12,13}.

Ultrasonography detects structural signs of plasma leakage such as gall bladder wall edema, ascites, and pleural effusion¹⁵⁻¹⁷. Gall bladder wall thickness is an early marker^{18,19}, while effusion and ascites correlate with CLS^{20,21}. Functional Doppler monitoring adds value²², and bedside or serial ultrasound aids in assessing severity²⁴. Portal venous Doppler congestion index, first described in earlier studies²⁵, has been applied to dengue patients²³. This study evaluates the role of Doppler in the early detection of CLS among dengue patients.

Materials And Methods

This hospital-based cross-sectional study was conducted in the Department of Radiology and General Medicine at Sri Venkateshwara Medical College, Hospital & Research Centre, Puducherry, India, over 18 months (January 2023–June 2024), after obtaining approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment. Sixty-five adult

patients (>18 years) with serologically confirmed dengue infection (NS1 antigen or IgM ELISA positive) were included. Patients with chronic liver disease, portal vein thrombosis, unrelated hypoalbuminemia, or hypotension, and those with hemodynamic instability were excluded. Demographic, clinical, and laboratory data (haematocrit, platelet count, liver enzymes) were collected from case records and bedside evaluation. Grayscale ultrasonography and portal venous Doppler were performed using a standardized protocol to assess gall bladder wall thickness, ascites, pleural effusion, and hemodynamic parameters, including cross-sectional area, mean flow velocity, and congestion index. All scans were performed by a single experienced radiologist to ensure uniformity and minimize measurement bias. The sample size of 65 was determined based on the prevalence of dengue admissions and feasibility during the study period.

Data were analysed using SPSS version 23.0. Chi-square test and independent t-test were applied, and Receiver Operating Characteristic (ROC) curve analysis was performed to determine diagnostic accuracy. A p-value < 0.05 was considered statistically significant.

Results

A total of 65 serologically confirmed dengue patients were included in this hospital-based cross-sectional study. The results are summarized under key analytical findings.

Prevalence of Capillary Leak Syndrome

Capillary leak syndrome (CLS) was identified in 27 (41.5%) participants, while 38 (58.5%) showed no evidence of CLS.



Table 1: Association Between Ultrasonographic and Doppler Findings with CLS

Parameter	CLS Present (n=27)	CLS Absent (n=38)	χ^2 / t value	p-value	Interpretation
Gall bladder wall edema	27 (100%)	18 (47%)	$\chi^2 = 28.51$	<0.001	Strongly associated with CLS
Pleural effusion	18 (58.1%)	13 (34.2%)	$\chi^2 = 6.70$	0.010	Significantly associated with CLS
Ascites	13 (44.8%)	16 (42.1%)	$\chi^2 = 0.23$	0.629	Not significant
Hepatomegaly	8 (30.8%)	18 (47.4%)	$\chi^2 = 2.05$	0.150	Not significant
Splenomegaly	10 (45.5%)	12 (31.6%)	$\chi^2 = 0.21$	0.647	Not significant
Flow direction (hepatojugular)	1 (3.7%)	1 (2.6%)	Fisher's exact	1.000	Not significant

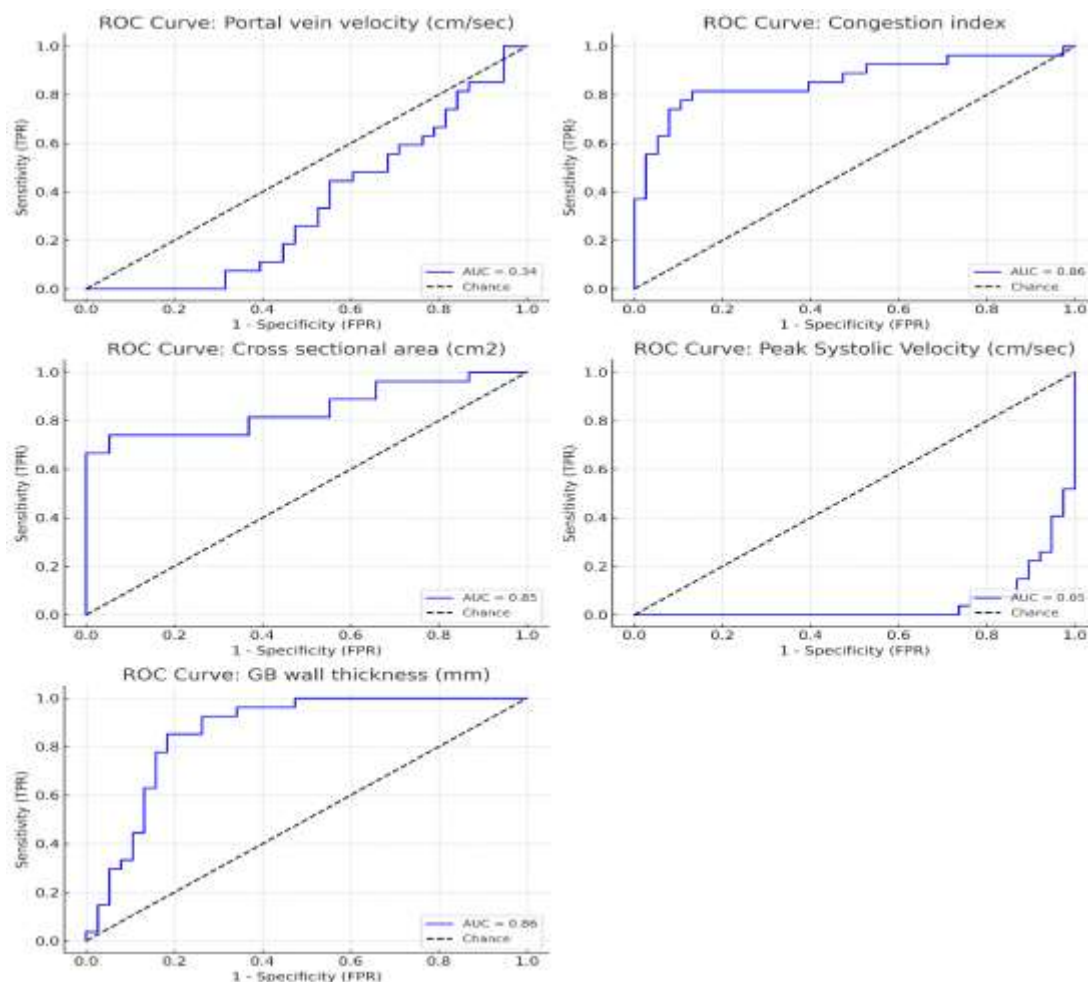
Gall bladder wall edema and pleural effusion were the only ultrasonographic parameters significantly associated with CLS ($p < 0.05$).

Table 2: Doppler Parameters and CLS

Doppler Parameter	CLS Present (Mean $\pm$ SD)	CLS Absent (Mean $\pm$ SD)	t-value	p-value	Interpretation
Portal vein velocity (cm/s)	16.6 $\pm$ 3.0	19.5 $\pm$ 5.3	2.54	0.013	Lower in CLS
Congestion index	0.11 $\pm$ 0.03	0.04 $\pm$ 0.01	5.12	<0.001	Higher in CLS
Cross-sectional area (cm ²)	1.6 $\pm$ 0.5	1.2 $\pm$ 0.4	4.87	<0.001	Significantly greater in CLS
GB wall thickness (mm)	7.8 $\pm$ 1.2	5.3 $\pm$ 3.9	3.91	<0.001	Strong association
Peak systolic velocity (cm/s)	22.2 $\pm$ 4.9	22.0 $\pm$ 7.8	0.13	0.895	Not significant

Doppler parameters — portal vein velocity, congestion index, cross-sectional area, and GB wall thickness — were significantly associated with CLS ($p < 0.05$).

Figure 1: Receiver Operating Characteristic (ROC) Analysis



The present analysis highlights that capillary leak syndrome (CLS) occurred in approximately 41.5% of dengue patients. Among ultrasonographic markers, gall bladder wall edema and pleural effusion were the strongest indicators of plasma leakage.

On Doppler assessment, reduced portal vein velocity, increased congestion index, and enlarged cross-sectional area of the portal vein were significantly associated with CLS, confirming venous hemodynamic compromise during leakage.

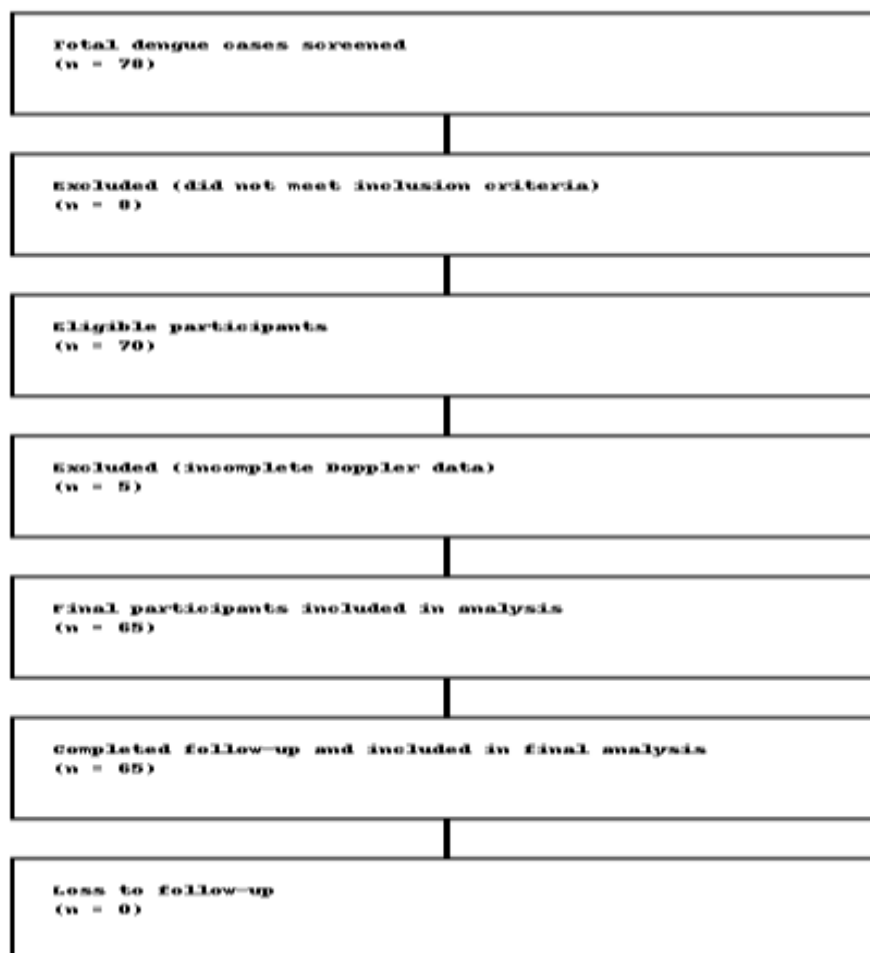
ROC analysis further established gall bladder wall thickness, cross-sectional area, and congestion index as reliable diagnostic parameters with excellent predictive accuracy (AUC > 0.80). Conversely, portal vein velocity and peak systolic velocity showed poor discriminatory value.

These findings collectively underscore the complementary role of grayscale ultrasonography and portal venous Doppler in the early non-invasive identification of capillary leak in dengue.



Participant flow:

Page | 5



A total of 78 serologically confirmed dengue patients were screened during the study period. Of these, 8 were excluded due to not meeting the inclusion criteria (4 with chronic liver disease, 2 with portal vein thrombosis, and 2 declined consent). Seventy participants were eligible; 5 were excluded due to incomplete Doppler data, resulting in a final analytical sample of 65 patients. All 65 underwent complete ultrasonography and Doppler evaluation with no loss to follow-up.

Discussion

In this hospital-based cross-sectional study of 65 serologically confirmed dengue patients, capillary leak syndrome (CLS) was identified in 41.5%. This finding aligns with prior Indian studies reporting plasma leakage in 30–45% of hospitalized dengue cases (1, 3, 5, 7). CLS is a hallmark of severe dengue, resulting from immune-mediated endothelial dysfunction and increased vascular permeability (8–10).



Gall bladder wall edema was observed in all CLS-positive patients and in 47% of those without CLS, making it the most sensitive ultrasonographic marker of plasma leakage ($p < 0.001$). Similar findings have been reported where gall bladder wall thickening (GBWT) served as an early and reliable indicator of severe dengue (15–18). A GBWT greater than 3 mm has been correlated with early plasma leakage and disease severity (18, 19). The universal presence of GBWT among CLS patients in the present study reinforces its diagnostic significance in detecting early vascular leak.

Pleural effusion was significantly associated with CLS in 58.1% of patients ($p = 0.010$), consistent with prior studies that identified pleural effusion and ascites as imaging markers of plasma leakage in dengue (19–21). In contrast, ascites, hepatomegaly, and splenomegaly were not significantly associated, suggesting that these features appear later in the course of illness.

Doppler assessment revealed significantly reduced portal vein velocity and increased congestion index (CI) and cross-sectional area (CSA) in patients with CLS. These findings indicate venous hemodynamic compromise due to plasma leakage and increased intra-abdominal pressure. Previous research has shown similar Doppler alterations in severe dengue, where elevated CI and enlarged CSA were associated with early vascular leakage (22, 23). CI, defined as the ratio of portal vein CSA to mean velocity, reflects hepatic venous congestion (25). The present findings, therefore, support CI and CSA as functional Doppler markers for early detection of CLS.

Receiver Operating Characteristic (ROC) analysis in this study demonstrated high diagnostic accuracy for GBWT (AUC = 0.86), CSA (AUC = 0.85), and CI (AUC = 0.81), which is consistent with prior work reporting comparable predictive performance of ultrasound parameters for severe dengue (19, 22). Combining grayscale ultrasonography with Doppler thus enhances diagnostic precision compared to individual modalities.

The observed ultrasonographic and Doppler changes correspond with the underlying pathophysiological process of endothelial activation and cytokine-mediated vascular leakage (8–10). Such functional imaging correlates can help identify patients at risk of

CLS even before hematocrit elevation or overt hemodynamic instability.

The study supports the integration of ultrasound and Doppler assessment into dengue management protocols for early, non-invasive recognition of plasma leakage, as recommended by WHO guidelines (11, 12). In endemic areas with limited laboratory access, bedside Doppler evaluation can provide real-time insights for timely fluid resuscitation and monitoring.

This study is limited by its single-center design and modest sample size. Serial Doppler follow-up was not performed, which could provide insight into temporal changes in venous flow parameters. Future multicentric studies are needed to validate these Doppler indices and establish standardized cut-off values for predicting CLS (23, 24).

Generalizability

The findings of this single-center study may be generalizable to similar tertiary care hospitals in dengue endemic regions. Doppler is operator-dependent and influenced by hydration and position. Serial monitoring was not performed, limiting temporal insights. Furthermore, the lack of longitudinal follow-up limited this ability to assess Doppler changes over the course of illness. The exclusion of pediatric patients also narrows the generalizability of the study findings. However, further validation through multicentric and larger cohort studies is necessary for broader external applicability.

Conclusion

Portal venous Doppler, especially CI and CSA, provides a reliable, non-invasive method for early detection of CLS in dengue. When combined with grayscale ultrasonography, it enhances diagnostic accuracy and supports timely clinical management. These findings reinforce the role of imaging as a cornerstone in dengue evaluation. Future adoption of Doppler-based indices in clinical settings could transform the early detection and management of severe cases.



Recommendations

Future multicenter studies should validate Doppler indices in larger cohorts. Standard cut-off values should be established. Serial monitoring and bedside use by trained physicians may improve early detection in endemic regions. Additionally, integration of Doppler into triage protocols in endemic regions could significantly aid early intervention. Collaboration between clinicians and radiologists is essential for maximizing the potential of these tools in routine practice.

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Conflict of interest

The authors declare that there is no conflict of interest.

Ethical Clearance

The study was conducted after obtaining approval from the Institutional Ethical Committee of Sri Venkateshwaraa Medical College, Hospital & Research Centre, Puducherry.

List Of Abbreviations

CLS – Capillary Leak Syndrome
CI – Congestion Index
CSA – Cross-sectional Area
AUC – Area Under Curve
USG – Ultrasonography
ROC – Receiver Operating Characteristics
GB – Gall Bladder

Author Contributions

Dr Hemalatha Kannane: Study conception, data collection, ultrasonographic analysis, manuscript drafting.

Dr. Nirmal Kumar Gopalakrishnan: Supervision, validation, and critical review.

Dr. Dhivagar Kannane: Methodological input, data interpretation, and discussion review.

Dr. Kamalnath Krishnasamy: Statistical analysis, figure preparation, and data support.

Data Availability

The datasets analyzed during this study are available from the corresponding author upon reasonable request.

Author Biographies

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Original Article

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Page | 9

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