CORRELATION BETWEEN LIVER SEGMENTAL ANATOMY AND THE PATTERN OF HEPATIC INVOLVEMENT IN CHRONIC HEPATITIS B PATIENTS

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Abstract

Background: Chronic hepatitis B virus (HBV) infection can lead to progressive liver damage and complications, but the distribution of hepatic involvement across different liver segments remains understudied.

Objective: To evaluate the correlation between liver segmental anatomy and the pattern of hepatic involvement in patients with chronic hepatitis B using radiological imaging.

Methods: This descriptive cross-sectional study was conducted at private hospitals of Karachi from October 2024 to March 2025. A total of 198 patients diagnosed with chronic hepatitis B were included in the study through non-probability consecutive sampling. After obtaining informed consent, demographic and clinical data including age, sex, duration of HBV infection, liver function test results, and antiviral treatment history were recorded using a structured proforma.

Results: The mean age was 44.6 ± 11.2 years; 62.6% were male. Segment VI was the most commonly involved (71.7%), followed by segments VII (65.2%) and V (63.1%), whereas segment I was least involved (14.1%). Patients with moderate-to-severe disease showed significantly higher involvement of posterior segments ($p < 0.001$). Fibrosis was most prevalent in segments VI (76.5%) and VII (67.6%). Regenerative nodules were predominantly found in segment VIII (57.1%). Inter-observer agreement for segmental analysis was substantial (Cohen's Kappa = 0.81).

Conclusion: It is concluded that chronic HBV infection exhibits a preferential pattern of hepatic involvement, predominantly affecting posterior liver segments. Segmental imaging evaluation can aid in early recognition of disease progression and may enhance personalized management strategies for HBV patients.

Keywords: Chronic hepatitis B, liver segments, Couinaud classification, hepatic involvement, fibrosis.

Introduction
Chronic hepatitis B virus (HBV) infection continues to be a pressing global public health issue, affecting over 254 million people worldwide, as per World Health Organization (WHO) estimates [1]. It is a major etiological factor for chronic liver disease, cirrhosis, and hepatocellular carcinoma (HCC), especially in low- and middle-income countries where perinatal transmission remains unchecked and early screening programs are underutilized [2]. The clinical progression of chronic HBV infection is variable and often asymptomatic until advanced disease develops, which underscores the importance of timely diagnosis, risk stratification, and surveillance [3]. The liver, with its complex architecture and dual blood supply from the portal vein and hepatic artery, is divided into eight distinct functional segments based on the Couinaud classification. These segments operate relatively independently, each with separate vascular inflow, outflow, and biliary drainage systems. Segmental analysis plays a crucial role in hepatobiliary imaging, surgical resections, liver transplantations, and interventional radiology [4-5]. However, while segmental anatomy is routinely applied in procedural planning, there is limited understanding of how the pathophysiological processes of chronic HBV infection distribute themselves across these segments [6].

Chronic HBV infection involves a dynamic interplay between viral replication and host immune response, resulting in histological changes such as inflammation, necrosis, and fibrosis [7]. Traditionally, liver biopsies provide a sample from a specific segment (usually the right lobe), which may not represent the entire hepatic architecture. Likewise, imaging assessments such as ultrasound elastography, CT, and MRI often provide generalized impressions of liver parenchyma without a focus on segment-specific pathology [8]. This generalized approach may overlook localized patterns of hepatic injury or regeneration that are segmentally distributed due to differences in portal hemodynamics, lymphatic drainage, and microenvironmental immune responses [9]. There is growing interest in mapping segmental involvement of hepatic diseases, including non-alcoholic steatohepatitis (NASH), hepatic metastases, and localized cholangitis, but similar focused work on chronic hepatitis B is lacking. A few scattered studies have suggested that HBV-related fibrosis or regenerative nodules may show preferential localization in specific liver regions. Yet these findings are often incidental and not systematically studied [10-11]. Understanding which liver segments are more prone to HBV-induced injury could provide important implications for liver-directed therapies, surveillance of fibrosis progression, and early detection of HCC. Furthermore, segmental analysis of HBV involvement could influence decisions in partial hepatectomies, segmental liver transplantations, and targeted intra-arterial therapies for HBV-associated malignancies. If certain segments are consistently less affected or more resilient, they may be prioritized during organ preservation procedures or segmental resections. Conversely, segments prone to early fibrosis or cirrhotic transformation may be targeted for enhanced monitoring or earlier intervention.

Objective
To find out the correlation between liver segmental anatomy and the pattern of hepatic involvement in chronic hepatitis B patients.

Methodology
This descriptive cross-sectional study was conducted at private hospitals of Karachi from October 2024 to March 2025, in which a total of 198 patients diagnosed with chronic hepatitis B were included through a non-probability consecutive sampling technique.

Inclusion Criteria:
• Patients aged 18 years and above.
• Confirmed diagnosis of chronic hepatitis B infection (HBsAg positive for more than six months).
• Availability of contrast-enhanced abdominal CT or MRI with segmental liver details.
• No evidence of co-infection with hepatitis C virus or HIV.

Exclusion Criteria:
- Patients with known primary or secondary liver malignancies
- Patients with previous hepatic surgeries or interventions altering native liver anatomy
- Inadequate imaging quality or incomplete segmental delineation
- Coexisting chronic liver conditions such as autoimmune hepatitis or Wilson's disease

Data Collection
After informed consent, demographic and clinical data including age, sex, duration of HBV infection, liver function test results, and antiviral treatment history were recorded using a structured proforma. Radiological images were reviewed by two independent radiologists blinded to the clinical data. Contrast-enhanced computed tomography (CECT) and magnetic resonance imaging (MRI) scans were assessed for segmental hepatic involvement. Each liver segment (I to VIII, as per Couinaud classification) was evaluated for specific imaging features including segmental atrophy, hypertrophy, increased echogenicity, fibrosis, nodularity, and presence of regenerative changes. A semi-quantitative scoring system was employed to grade the severity of involvement in each segment.

Statistical Analysis
Data were analyzed using SPSS version 21. Descriptive statistics such as mean, standard deviation, frequencies, and percentages were used to summarize demographic and clinical characteristics. The degree of hepatic involvement in each segment was compared using chi-square test. Continuous variables were analyzed using Student's t-test. P-value of less than 0.05 was considered statistically significant.

Results
As shown in Table 1, the mean age of 198 patients was 44.6 ± 11.2 years. There was a male predominance, with 124 (62.6%) males and 74 (37.4%) females. The median duration of diagnosed chronic HBV infection was 4 years, with an interquartile range of 2 to 8 years. More than half of the patients, 112 (56.6%), were receiving antiviral therapy at the time of assessment.

Table 1: Demographic and Clinical Characteristics of Patients (N = 198)

Variable	Mean ± SD / n (%)
Age (years)	44.6 ± 11.2
Gender	
- Male	124 (62.6%)
- Female	74 (37.4%)
Duration of HBV infection	4 years (IQR: 2–8)
On Antiviral Therapy	112 (56.6%)

Table 2: Segmental analysis of liver involvement revealed that Segment VI was the most frequently affected, with 142 patients (71.7%) , followed by Segment VII (65.2%) and Segment V (63.1%). Segment VIII also showed notable involvement in 58.6% of cases. In contrast, the least involvement was seen in Segment I (14.1%), while Segments II, III, and IV showed moderate involvement, affecting 27.3%, 34.3%, and 44.4% of patients respectively.

Table 2: Frequency of Segmental Hepatic Involvement on Imaging

Liver Segment	Involvement (n)	Percentage (%)
Segment I	28	14.1%
Segment II	54	27.3%
Segment III	68	34.3%
Segment IV	88	44.4%

Segment V	125	63.1%
Segment VI	142	71.7%
Segment VII	129	65.2%
Segment VIII	116	58.6%

Table 3: Segment VI was involved in 88.2% of moderate–severe cases compared to 54.2% in mild cases (p < 0.001), and Segment VII showed similar trends 78.4% moderate–severe & 51.0% mild cases (p < 0.001). In contrast, Segments II and III were more commonly involved in patients with mild disease, with involvement rates of 37.5% and 41.7% respectively, compared to 17.6% and 27.5% in moderate–severe cases (p = 0.01 and p = 0.04, respectively).

Table 3: Segmental Involvement by Clinical Severity

Liver Segment	Mild Disease (n=96)	Moderate–Severe (n=102)	p-value
Segment II	36 (37.5%)	18 (17.6%)	0.01
Segment III	40 (41.7%)	28 (27.5%)	0.04
Segment VI	52 (54.2%)	90 (88.2%)	<0.001
Segment VII	49 (51.0%)	80 (78.4%)	<0.001

Table 4: Among 102 patients with radiologically evident hepatic fibrosis, Segment VI was the most commonly affected, with 78 patients (76.5%). Segment VII was involved in 67.6% of these cases, followed by Segment V (59.8%) and Segment VIII (53.9%).

Table 4: Segmental Distribution of Fibrosis (n = 102)

Segment	Patients with Fibrosis (n)	Percentage (%)
Segment V	61	59.8%
Segment VI	78	76.5%
Segment VII	69	67.6%
Segment VIII	55	53.9%

Table 5: Among the 21 patients with regenerative nodules, Segment VIII was the most frequently affected, accounting for 12 cases (57.1%). Segment IV showed involvement in 5 patients (23.8%), while Segment VI was affected in 3 cases (14.3%). Only 1 case (4.8%) involved other liver segments.

Table 5: Distribution of Regenerative Nodules (n = 21)

Segment	No. of Cases (n)	Percentage (%)
Segment IV	5	23.8%
Segment VI	3	14.3%
Segment VIII	12	57.1%
Others	1	4.8%

Discussion

This study explored the relationship between liver segmental anatomy and the distribution of hepatic involvement in patients with chronic hepatitis B virus (HBV) infection. Our findings reveal a distinct pattern of segmental involvement, with the posterior segments, particularly segments VI and VII, being the most frequently and severely affected. These observations may have important implications for diagnostic imaging interpretation, monitoring fibrosis progression, and planning liver-directed therapies in chronic HBV patients. Segment VI showed the highest frequency of pathological involvement (71.7%), followed by segments VII and V, consistent with prior hypotheses that posterior segments might receive altered or disproportionate portal blood flow in chronic viral hepatitis. This pattern could be attributed to anatomical and physiological differences

in segmental perfusion, possibly enhancing HBV tropism or fibrogenesis in these regions. Segment I (caudate lobe), being relatively spared (14.1%), aligns with findings from a study by Takayasu et al., which noted minimal fibrotic deposition in segment I in patients with advanced liver disease, likely due to its unique venous drainage via direct hepatic veins into the inferior vena cava [12-13]. Patients with moderate-to-severe clinical disease, as defined by elevated transaminases and imaging-detected fibrosis, showed significantly greater involvement of segments VI and VII (p < 0.001), suggesting a potential association between posterior segment injury and disease severity. Conversely, segments II and III were less commonly affected in milder cases, reinforcing the notion that left lobe sparing may be seen in early-stage HBV pathology. Similar findings were reported by Arif et al., who found that fibrosis and inflammation in HBV patients were predominantly right-lobe dominant [14-15]. The fibrosis distribution data from this study further supports this anatomical predilection. Among the 102 patients with radiologically suspected fibrosis, 76.5% had changes in segment VI, while segments VIII and V also showed frequent involvement. This is in line with existing literature on portal-based fibrosis progression, where venous inflow and lymphatic drainage inefficiencies contribute to segmental disparities in fibrotic burden [16]. It also emphasizes the need for careful right-lobe imaging assessment, especially in patients with rising fibrosis scores but clinically stable liver function. Interestingly, regenerative nodules, a precursor to hepatocellular carcinoma in cirrhotic livers, were predominantly observed in segment VIII (57.1%). This could reflect increased hepatocellular turnover or localized regenerative hyperplasia due to compensatory mechanisms in highly burdened segments. Previous autopsy studies by Wanless et al. also noted segment VIII as a common site for early dysplastic nodule formation in HBV-related cirrhosis [17-18]. Limitations of this study include its cross-sectional design, which prevents temporal analysis of disease progression, and the lack of histopathological correlation, as segmental biopsies are rarely feasible. Additionally, while imaging modalities were used to score segmental involvement, mild or early parenchymal changes may be missed without elastographic or contrast-enhanced assessments.

Conclusion

It is concluded that in patients with chronic hepatitis B infection, there is a non-uniform pattern of hepatic involvement that correlates with liver segmental anatomy. The posterior segments, particularly segments VI and VII, are more frequently and severely affected, especially in patients with moderate-to-severe disease. Segment I remains relatively spared, reflecting possible anatomical and hemodynamic protective factors. These findings suggest that segmental analysis through cross-sectional imaging may provide valuable insights into disease severity, fibrotic progression, and potential sites of early regenerative or dysplastic changes.

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