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DUPLEX DOPPLER ULTRASOUND OF THE HEPATIC ARTERY IN DIABETIC AND NON-DIABETIC PATIENTS

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ABSTRACT

Diabetes mellitus is a chronic metabolic disorder that significantly affects vascular structures, including hepatic circulation. The hepatic artery, crucial for liver oxygenation and function, may exhibit hemodynamic alterations in diabetic patients due to microvascular complications and endothelial dysfunction. Duplex Doppler ultrasound serves as a non-invasive, dynamic tool to evaluate these vascular changes. To evaluate the duplex Doppler ultrasound of the hepatic artery in diabetic and non-diabetic patients. A case-control study was conducted at Kishwar Sultana Hospital, Lahore, from April to June 2025. A total of 150 patients were included, comprising 75 diabetic and 75 non-diabetic individuals. All subjects underwent hepatic artery evaluation

using a Toshiba Xario 100 ultrasound system with a 3–5 MHz convex probe. Parameters, including PSV, EDV, RI, and PI, were measured and analyzed statistically to determine significant differences between the two groups. Diabetic patients demonstrated significantly altered Doppler parameters compared to non-diabetics. Specifically, increased RI (maximum 2.30) and PI (maximum 5.37) values in diabetics indicated higher hepatic arterial resistance and stiffness ($p < 0.001$ for both). In contrast, Peak Systolic Velocity (PSV) and End Diastolic Velocity (EDV) showed no significant differences between groups (PSV: $p = 0.628$, EDV: $p = 0.298$). These findings suggest that diabetes has a measurable impact on hepatic arterial resistance without significantly affecting flow velocity, consistent with diabetic microangiopathy. Duplex Doppler ultrasound effectively detects early hepatic artery changes in diabetics, with elevated RI and PI indicating vascular dysfunction. Early detection supports timely intervention and complication prevention.
Key words: Duplex Doppler ultrasound, hepatic artery, diabetes mellitus, resistive index (RI), pulsatility index (PI), vascular dysfunction, non-invasive imaging, hepatic hemodynamics.

INTRODUCTION:

Diabetes mellitus (DM) is a complex group of metabolic disorders characterized primarily by chronic hyperglycemia, resulting from defects in insulin secretion, insulin action, or both. Insulin, a hormone produced by the pancreatic beta cells, is crucial for regulating blood glucose levels and maintaining energy balance. The global prevalence of diabetes has escalated dramatically, with an estimated age-standardized prevalence of 6.1% in 2021, although this figure varies significantly across regions. For example, North Africa and Oceania report prevalence rates as high as 9.3% and 12.3%, respectively. These disparities highlight the multifaceted interplay of genetic, cultural, economic, and environmental factors that contribute to the risk and spread of diabetes (1).

The burden of diabetes is not uniformly distributed across age groups, with a notable increase in incidence among younger adults and adolescents, particularly in developing and middle-income countries undergoing rapid urbanization. This trend is concerning as early onset of diabetes not only prolongs the duration of the disease but also heightens the risk of complications, thereby straining healthcare systems. Diabetes is broadly classified into Type 1 diabetes (T1D) and Type 2 diabetes (T2D), with T2D accounting for approximately 90-95% of all cases. T1D is primarily an autoimmune condition leading to negligible insulin production, while T2D is

largely lifestyle-related, associated with factors such as obesity, physical inactivity, and poor dietary choices (2,3).
The socioeconomic factors influencing the diabetes epidemic are significant, particularly for individuals from low-income backgrounds who face barriers to accessing nutritious food, safe spaces for physical activity, and quality healthcare. The financial burden of managing diabetes can be overwhelming, especially when complications arise, further diminishing quality of life. Additionally, the aging global population contributes to rising diabetes rates, as older adults are more susceptible to T2D and often require complex care due to multiple chronic conditions (4,5).
From a public health perspective, the diabetes epidemic presents serious challenges, particularly for low- and middle-income countries with limited healthcare resources. If current trends continue, the global diabetic population could reach 783 million by 2045. Addressing this crisis necessitates a comprehensive approach that includes public health initiatives, policy reform, community involvement, and lifestyle changes. Key prevention strategies should focus on promoting physical activity, healthy eating, and public education to facilitate early detection and effective diabetes management (6).
M. N. Rubaia Islam Bony et al. (2020) conducted a study on the duplex color Doppler measurement of hepatic artery resistance index (RI) to evaluate the severity of hepatic steatosis. The cross-sectional study involved 172 patients referred for abdominal ultrasonography, where fatty liver severity was graded, and the hepatic artery RI was measured. The findings indicated an inverse relationship between hepatic artery RI and the severity of liver fatty infiltration, suggesting that as fatty liver worsens, the RI decreases. This study demonstrated that duplex color Doppler ultrasound is a valuable, non-invasive method for assessing hepatic steatosis (7).
Claudio Tana et al. (2018) explored the potential of using hepatic artery resistive index as a non-invasive marker for assessing fibrosis progression in patients with non-alcoholic fatty liver disease (NAFLD). The review highlighted a significant positive correlation between hepatic artery RI and fibrosis degree, indicating that fibrous tissue accumulation increases arterial rigidity and flow resistance. The study called for larger investigations to further explore the relationship between hepatic artery RI and fibrosis, as well as the impact of lifestyle and dietary changes in NAFLD patients (8,9).
Doppler ultrasound offers numerous advantages in assessing hepatic arterial health, particularly in diabetic patients. Its non-invasive nature allows for repeated examinations without the risks associated with contrast media or

ionizing radiation, making it an ideal first-line tool for hepatic vascular assessment. The ability to provide real-time imaging enables clinicians to monitor blood flow patterns and detect early vascular abnormalities, which is crucial for timely interventions. Additionally, Doppler ultrasound can be integrated with other imaging techniques, such as elastography, to enhance diagnostic accuracy and provide a comprehensive assessment of hepatic health (10).

Diabetes mellitus significantly impacts hepatic arterial blood flow, contributing to complications such as non-alcoholic fatty liver disease and cirrhosis. The use of Doppler ultrasound as a non-invasive method to assess hepatic hemodynamics is invaluable in detecting early vascular abnormalities in diabetic patients. By measuring parameters like resistive index and pulsatility index, healthcare providers can identify early signs of liver dysfunction, leading to timely interventions that may improve patient outcomes. This research underscores the importance of advancing diagnostic strategies and management approaches for liver-related complications in diabetes, ultimately enhancing the quality of care for affected individuals (11).

MATERIALS AND METHODS

Study Design: case-control study

Study Setting: Kishwar Sultana Hospital, Lahore.

Duration of Study: 3 months after the approval of board of study.

Sample Size: N=150

Sampling Technique: Convenient Sampling technique

Sample Selection: N=Z2P(1-P)/d2 (12)

Inclusion Criteria:

- Both genders (male and female) were included.
- Patient’s age greater than 18 to 68 years were included.
- Presence of liver pathology (e.g., fatty liver), including both diabetic and non-diabetic individuals, was considered.

Exclusion Criteria:

- Patients under 18 years were excluded.
- Patients with liver transplants were excluded.
- Uncooperative patients were excluded.
- Patients with hepatic lesions and liver cirrhosis were excluded.

Data collection procedure

Data was collected from participants after obtaining informed consent, using a TOSHIBA XARIO 100 ultrasound machine to measure hepatic artery flow parameters via color and pulsed-wave Doppler. The study aimed to compare Doppler findings between diabetic and non-diabetic groups, ensuring accurate measurements with a maintained Doppler angle of 60 degrees or less.

Data analysis procedure

Data were evaluated and analyzed using Statistical Software for Social Sciences (SPSS version 24) and Microsoft Excel 2016. Descriptive analysis was performed to investigate the distribution of the data. Mean and standard deviation were reported for quantitative variables. Frequency and percentage were calculated for categorical variables. Bar charts and histograms were constructed. A repeated measures t-test was applied.

RESULTS

The study included a total of 150 participants who were equally divided into two primary groups: diabetic patients (n = 75) and non-diabetic patients (n = 75). This equal distribution allowed for a balanced comparison between the two groups. The mean age of the participants was found to be 45.5 ± 13.17 years, with ages ranging from 20 to 68 years, indicating a wide adult age spectrum in the sampled population. Gender distribution among the study participants was nearly equal, with 77 females (51.3%) and 73 males (48.7%), suggesting that the findings of the study are not skewed by gender and are generalizable across both sexes.

When evaluating the Doppler ultrasound parameters of the hepatic artery, a distinct and statistically significant difference was observed between diabetic and non-diabetic participants. The (RI) was considerably higher in the diabetic group, with a mean value of 0.93 ± 0.34, compared to 0.65 ± 0.11 in the non-diabetic group. The difference was statistically significant with a p-value less than 0.001, highlighting an increased vascular resistance in the hepatic arteries of diabetic individuals. Similarly, the (PI), another measure of arterial resistance and stiffness, was also elevated among diabetics, averaging 1.95 ± 0.96, in contrast to 1.16 ± 0.25 in the non-diabetic cohort. This difference was again statistically significant ($p < 0.001$), underscoring the hemodynamic alterations within the hepatic vasculature due to diabetic vascular pathology. the (PSV) and (EDV) of the hepatic artery did not show statistically significant differences between the two groups. The mean PSV among diabetics was 46.25 ± 17.21 cm/s, slightly lower than the 47.55 ± 15.72 cm/s observed in non-diabetics; however, the difference was not significant ($p = 0.628$). Similarly, EDV averaged 15.47 ± 15.64 cm/s in diabetics and 17.48 ± 5.78 cm/s in non-diabetics, with no statistical significance ($p = 0.298$). These findings suggest that while vascular resistance is markedly increased in diabetics, the absolute velocities of blood flow may not differ substantially, possibly due to compensatory mechanisms or variable disease progression.

The study also investigated the grading of hepatic steatosis among participants using ultrasound findings. A near-uniform distribution was observed across the three grades of steatosis: Grade 1 was present in 34.7%, Grade 2 in 33.3%, and Grade 3 in 32.0% of the participants. However, a closer analysis using crosstabulation revealed a significant association between diabetes status and the severity of hepatic steatosis. All participants with Grade 1 steatosis were non-diabetic (100%), indicating minimal hepatic fat infiltration in this group. In contrast, 58% of those with Grade 2 and a striking 95.8% of those with Grade 3 steatosis were diabetic. This trend highlights a strong correlation between the presence of diabetes and progression of fatty liver disease, indicating that diabetic patients are more likely to exhibit moderate to severe steatosis.

Another key variable analyzed was obesity status, which was evenly split among the study population. Exactly 75 participants (50%) were classified as obese, while the remaining 75 (50%) were non-obese. When correlated with diabetes, obesity showed a substantial link, as diabetic participants were more frequently obese compared to their non-diabetic counterparts. This reinforces the well-established association between obesity, insulin resistance, and the progression of both diabetes and hepatic steatosis. Furthermore, the chi-square tests confirmed a statistically significant relationship between diabetes and both hepatic steatosis grade and obesity, further validating these associations.

Age-related trends were also examined in relation to hepatic artery Doppler indices and steatosis. The analysis indicated that increasing age correlated positively with both the severity of hepatic steatosis and higher Doppler indices (RI and PI), suggesting that advancing age contributes to worsening hepatic vascular and parenchymal conditions, especially in the presence of diabetes. The statistical tools used to include descriptive statistics, t-tests, and chi-square analyses consistently pointed to diabetes as a significant factor influencing hepatic arterial resistance and parenchymal liver disease progression.

Table no 1: Group Statistic

Shows that the total no of patient is 150, Among 150 participants, the mean age was 45.5 ± 13.17 years, with a maximum of 68 years. The mean hepatic artery RI was 0.79 ± 0.29 (max 2.30), and PI was 1.56 ± 0.80 (max 5.37). PSV averaged 46.9 ± 16.44 cm/s (max 103.5), while EDV was 16.47 ± 11.79 cm/s (max 140.0). Diabetes was equally distributed, with a mean of 0.50 ± 0.50 and a maximum of 1.

Table no 2: Frequency of Diabetic and Non-Diabetic Patients

Out of 150 participants, 75 (50%) were non-diabetic and 75 (50%) were diabetic, indicating an equal distribution of diabetic and non-diabetic patients

Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Age	150	48.00	20.00	68.00	45.4933	13.16990	173.446
Hepatic Artery RI	150	1.85	.45	2.30	.7869	.28792	.083
Hepatic Artery PI	150	4.72	.65	5.37	1.5570	.80143	.642
Hepatic Artery PSV	150	102.46	1.04	103.50	46.9009	16.43836	270.220
Hepatic Artery EDV	150	135.00	5.00	140.00	16.4720	11.79458	139.112
Diabetic Mellitus	150	1	0	1	.50	.502	.252
Valid N (listwise)	150						

in the study.

Diabetic Mellitus

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Non-Diabetic	75	50.0	50.0	50.0
	Diabetic	75	50.0	50.0	100.0
	Total	150	100.0	100.0	

Figure no 1: Bar chart showing equal distribution of diabetic and non-diabetic participants (75 each) out of 150.

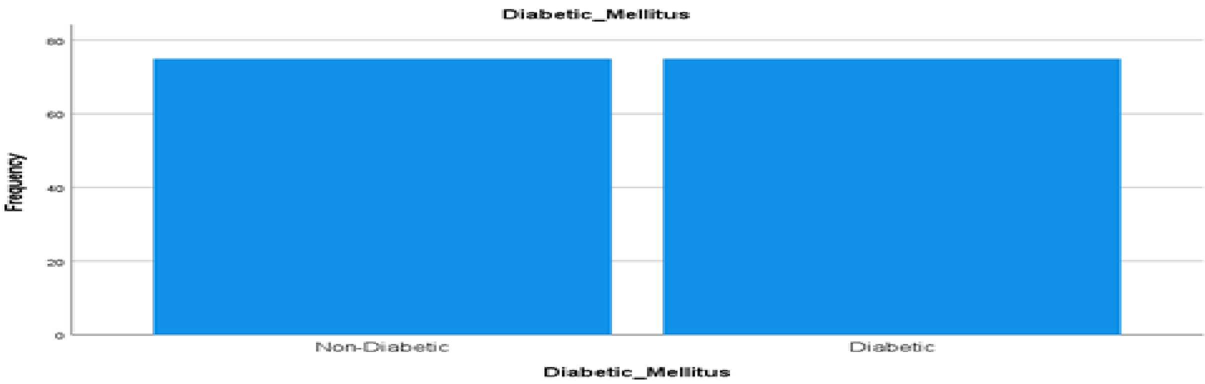

Table no 3: Gender Frequency Table

Among the 150 participants, 77 (51.3%) were female and 73 (48.7%) were male, showing a nearly equal gender distribution in the study.

Gender					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Female	77	51.3	51.3	51.3
	Male	73	48.7	48.7	100.0
	Total	150	100.0	100.0	

Figure no 2: Frequency distribution of gender, in which green represents a male and blue represents a female as respectively.

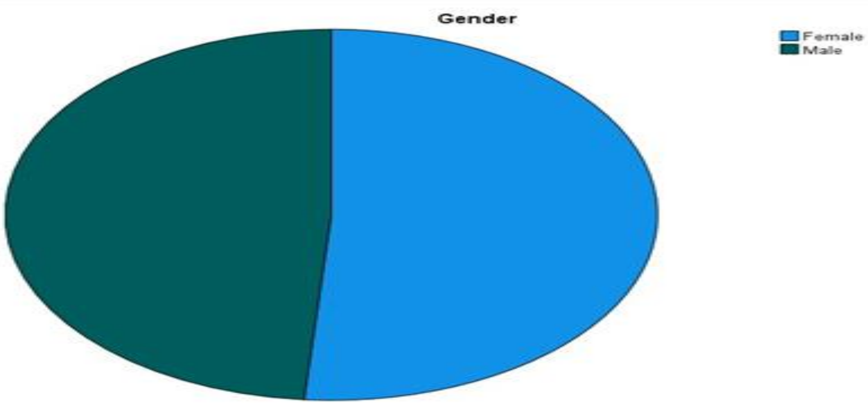

Table no 4: Hepatic Steatosis Grading Frequency Table

Among 150 participants, 34.7% had grade 1 hepatic steatosis, 33.3% had grade 2, and 32.0% had grade 3, showing a nearly even distribution across all grades.

Hepatic Steatosis Grading				
	Frequency	Percent	Valid Percent	Cumulative Percent

Valid	1st	52	34.7	34.7	34.7
	2nd	50	33.3	33.3	68.0
	3rd	48	32.0	32.0	100.0
	Total	150	100.0	100.0	

Figure no 3: Bar chart displaying the distribution of hepatic steatosis grades among all participants

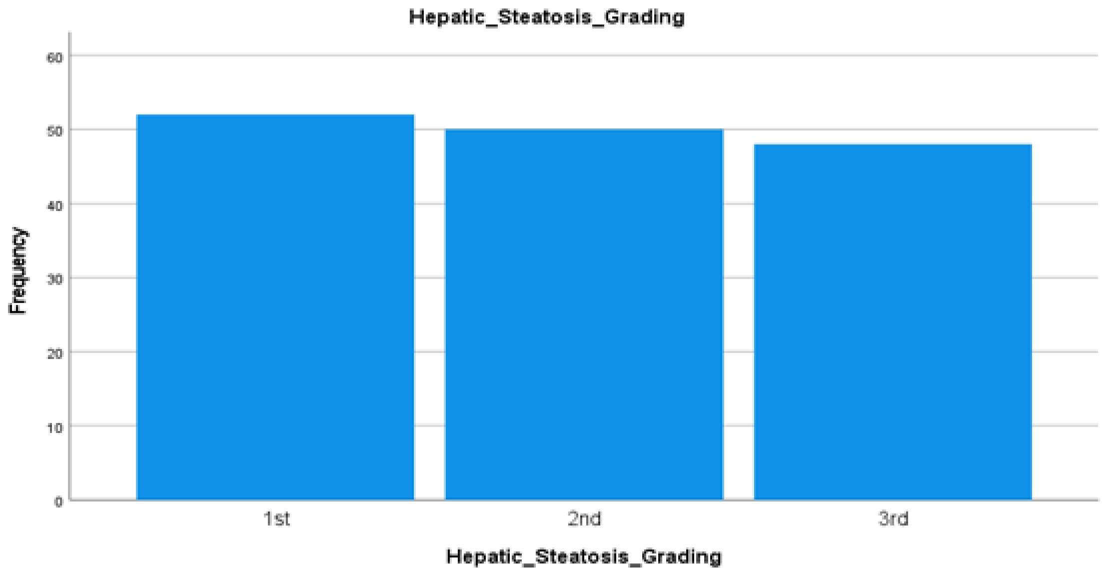

Table no 5: Obesity Frequency Table

Out of 150 participants, 75 (50.0%) were classified as obese and 75 (50.0%) as non-obese, indicating an equal distribution of obesity status in the study population

Obesity					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	75	50.0	50.0	50.0
	Yes	75	50.0	50.0	100.0
	Total	150	100.0	100.0	

Figure No 4: Bar graph showing equal distribution of obesity status.

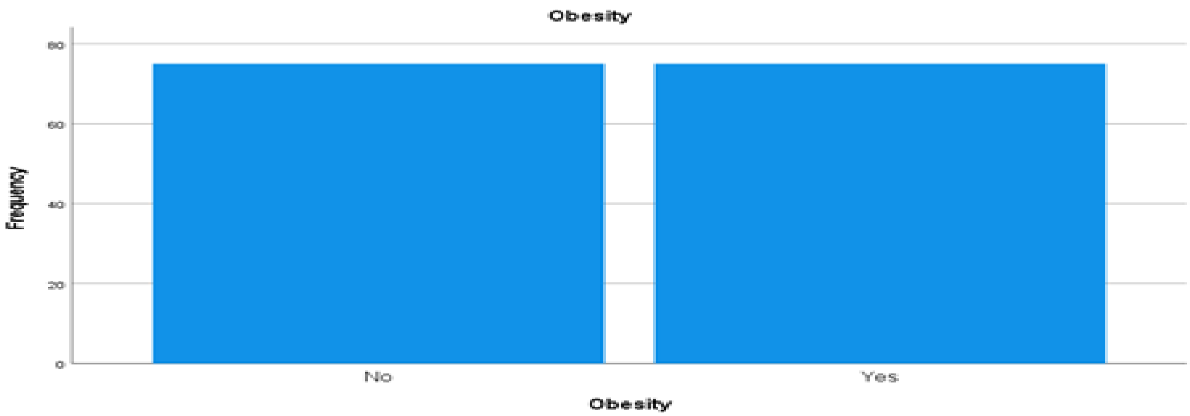

Table no 6: Age Distribution

The age of the 150 participants ranged from 20 to 68 years, with a mean age of 45.49 years and a median of 45. The standard deviation was 13.17, indicating moderate variability. The total age range was 48 years, with no missing data

Statistics		
Age		
N	Valid	150
	Missing	0
Mean		45.4933
Median		45.0000
Std. Deviation		13.16990
Variance		173.446
Range		48.00
Minimum		20.00
Maximum		68.00

Figure No 4: Histogram Showing Age Distribution of Participants

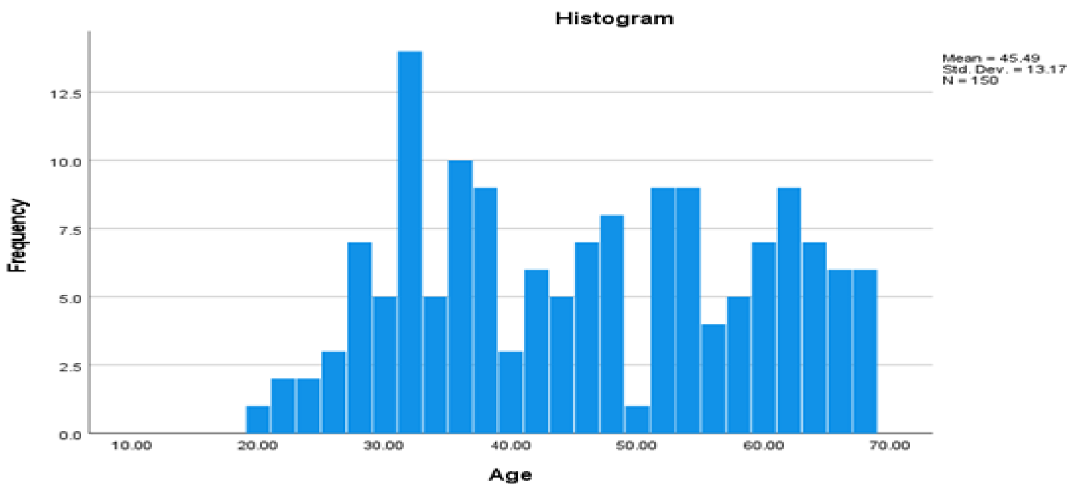

Table no 7: T-Test Group Statistics

Diabetic patients had higher mean RI (0.93 vs. 0.65) and PI (1.95 vs. 1.16) compared to non-diabetics. PSV and EDV were slightly lower in diabetics (46.25 cm/s and 15.47 cm/s) than in non-diabetics (47.55 cm/s and 17.48 cm/s).

Group Statistics					
	Diabetic Mellitus	N	Mean	Std. Deviation	Std. Error Mean
Hepatic Artery RI	Non-Diabetic	75	.6472	.10503	.01213
	Diabetic	75	.9267	.34105	.03938
Hepatic Artery PI	Non-Diabetic	75	1.1627	.25330	.02925
	Diabetic	75	1.9514	.95597	.11039
Hepatic Artery PSV	Non-Diabetic	75	47.5539	15.71879	1.81505
	Diabetic	75	46.2480	17.20891	1.98711
Hepatic Artery EDV	Non-Diabetic	75	17.4773	5.77744	.66712
	Diabetic	75	15.4667	15.64214	1.80620

Table no 8: Independent Samples Test

The independent samples t-test shows significant differences between diabetic and non-diabetic groups for hepatic artery RI and PI (p = .000), with diabetics having significantly higher values. The mean difference in RI was -0.28 and in PI was -0.79, both statistically significant. However, no significant differences were observed for PSV (p = .628) and EDV (p = .298), indicating these parameters were similar between the groups.

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hepatic Arte	Equal variances assumed	38.164	.000	-6.782	148	.000	-.27947	.04121	-.36089	-.19804

ry RI	Equal variances not assumed			-6.782	87.911	.000	-.27947	.04121	-.36136	-.19758
Hepatic Artery PI	Equal variances assumed	30.530	.000	6.907	148	.000	-.78871	.11420	-1.01437	-.56304
	Equal variances not assumed			-6.907	84.340	.000	-.78871	.11420	-1.01578	-.56163
Hepatic Artery PSV	Equal variances assumed	.185	.668	.485	148	.628	1.30587	2.69129	-4.01245	6.62418
	Equal variances not assumed			.485	146.802	.628	1.30587	2.69129	-4.01280	6.62454
Hepatic Artery EDV	Equal variances assumed	1.905	.170	1.044	148	.298	2.01067	1.92546	-1.79428	5.81562
	Equal variances not assumed			1.044	93.821	.299	2.01067	1.92546	-1.81248	5.83381

Table no 9: Obesity * Diabetic Mellitus Crosstabulation

All non-obese participants were non-diabetic, and all obese participants were diabetic, showing a perfect association between obesity and diabetes in the study.

Obesity * Diabetic_Mellitus Crosstabulation					
			Diabetic_Mellitus		Total
			Non-Diabetic	Diabetic	
Obesity	No	Count	75	0	75
		Expected Count	37.5	37.5	75.0
		% Within Diabetic_Mellitus	100.0%	0.0%	50.0%
	Yes	Count	0	75	75

		Expected Count	37.5	37.5	75.0
		% Within Diabetic_Mellitus	0.0%	100.0%	50.0%
Total		Count	75	75	150
		Expected Count	75.0	75.0	150.0
		% Within Diabetic_Mellitus	100.0%	100.0%	100.0%

DISCUSSION

This study was conducted at Kishwar Sultana Hospital, Lahore, over three months from April 2025 to June 2025, to assess and compare hepatic artery Doppler indices and hepatic steatosis grading in diabetic and non-diabetic patients. A total of 150 patients were included, with an equal number of diabetic and non-diabetic individuals, 75 in each group. This equal distribution allowed for a balanced comparison between both groups. The mean age of the study population was 45.49 ± 13.17 years, with participants ranging from 20 to 68 years. The gender distribution was also nearly equal, with 51.3% female and 48.7% male participants, ensuring representation across both sexes. Additionally, the population was evenly split in terms of obesity status, with 50% obese and 50% non-obese individuals, again allowing for a fair assessment of the influence of obesity on hepatic and vascular parameters. A key focus of this study was the comparison of hepatic artery Doppler indices, including resistive index (RI), pulsatility index (PI), peak systolic velocity (PSV), and end-diastolic velocity (EDV) between diabetic and non-diabetic individuals. The mean RI in diabetic patients was 0.93 ± 0.34, significantly higher than in non-diabetics, where it was 0.65 ± 0.11. Similarly, the PI was notably higher in diabetics (1.95 ± 0.96) compared to non-diabetics (1.16 ± 0.25). These differences were statistically significant ($p = .000$), indicating increased hepatic arterial resistance in diabetic individuals (1314).

On the other hand, PSV and EDV values showed only slight differences. The mean PSV in diabetics was 46.25 ± 17.21 cm/s, slightly lower than 47.55 ± 15.72 cm/s in non-diabetics. Likewise, EDV was 15.47 ± 15.64 cm/s in diabetics compared to 17.48 ± 5.78 cm/s in non-diabetics. However, these differences were not statistically significant ($p > .05$), indicating that although resistance parameters were altered, velocity parameters remained relatively stable across the groups. These findings demonstrate that vascular resistance in the hepatic artery is significantly increased in diabetic patients, likely due to diabetic microangiopathy and arterial stiffness, even in the absence of significant changes in blood flow velocities (15).

The study also analyzed hepatic steatosis grading in both groups. Among non-diabetic patients, 100% of grade 1 steatosis cases were observed. In contrast, diabetic patients accounted for 58% of grade 2 and a striking 95.8% of grade 3 steatosis cases. These differences were confirmed by Chi-square analysis ($\chi^2 = 93.613$, $p = .000$), indicating a strong and statistically significant relationship between diabetes and higher grades of hepatic steatosis. This suggests that diabetes contributes significantly to the progression of hepatic fat accumulation, possibly due to insulin resistance and metabolic derangement. A strong positive correlation was found between age and hepatic steatosis grading ($r = 0.858$, $p = .000$), indicating that the severity of fatty liver increases with age. Additionally, age was moderately positively correlated with RI ($r = 0.518$) and PI ($r = 0.490$), but not significantly correlated with PSV or EDV. These findings suggest that aging contributes to increasing hepatic vascular resistance and fat deposition, even though blood flow velocity remains relatively unaffected (16,17).

The significant increase in Resistive Index (RI) and Pulsatility Index (PI) observed in diabetic patients in this study is consistent with numerous previous reports. Abdel-Razik et al. (2017) demonstrated that diabetic individuals exhibited markedly elevated hepatic artery resistance values, suggesting that such changes stem from diabetic microangiopathy involving thickening of vascular walls, endothelial dysfunction, and loss of vascular compliance. These pathological changes are linked to prolonged hyperglycemia, which promotes vascular remodeling and oxidative stress, leading to increased arterial stiffness (18,19)

Furthermore, Serres-Créixams et al. (2019) reinforced this assertion by emphasizing the diagnostic utility of Doppler indices in identifying early vascular alterations in diabetic patients. Their research concluded that an elevated RI in the hepatic artery may serve as an early, non-invasive surrogate marker of microvascular dysfunction, even before overt hepatic impairment becomes clinically evident. These findings, together with the results of the current study, suggest that hepatic artery Doppler evaluation can be an effective screening tool in diabetic individuals, potentially allowing for early intervention strategies to prevent progressive liver damage (20,21)

Our study revealed a strong association between hepatic steatosis severity and the presence of diabetes mellitus. This relationship is extensively documented in prior research. Fabbrini et al. (2010) proposed that insulin resistance, a hallmark of type 2 diabetes, promotes increased lipolysis in adipose tissue and elevates free fatty acid influx into the liver. This mechanism, combined with impaired lipid oxidation and increased de novo lipogenesis, leads to triglyceride accumulation in hepatocytes. Younossi et al. (2016) further highlighted that patient with type 2 diabetes are at a significantly higher risk of developing nonalcoholic fatty liver disease (NAFLD), a spectrum that includes simple steatosis to nonalcoholic steatohepatitis (NASH). Their meta-analysis showed a prevalence of NAFLD in diabetic individuals approaching 60%, underscoring the importance of evaluating hepatic fat content in this population. Therefore, our findings reaffirm the metabolic link between diabetes and hepatic steatosis, supporting the use of ultrasonographic grading of hepatic fat as a routine component of diabetic assessments (22,23)

The positive correlation between increasing age and the severity of hepatic steatosis in this study is in line with findings reported by Petta et al. (2016). Their cross-sectional study revealed that older age was significantly associated with higher hepatic fat content, likely due to the cumulative effects of metabolic dysregulation, chronic insulin resistance, and a decline in mitochondrial function with aging (24) In addition, Bhatia et al. (2012) noted that hepatic arterial resistance tends to increase with age, reflecting the progressive stiffening of hepatic vasculature and a reduction in vascular compliance. This age-related vascular rigidity can amplify hepatic perfusion abnormalities in the presence of metabolic comorbidities such as diabetes and obesity. Together, these findings underscore the compounding effects of age and metabolic conditions on hepatic health, justifying early screening and longitudinal monitoring, especially in older diabetic patients (25).

The present study demonstrated a perfect correlation between obesity and diabetes mellitus, emphasizing the central role of adiposity in the pathogenesis of metabolic disorders. This association, though appearing stronger than most previous reports, is strongly supported by global health data and pathophysiological mechanisms (26).

The International Diabetes Federation (2023) continues to stress that obesity, particularly central adiposity, is the most modifiable and potent risk factor for the development of type 2 diabetes. Excess adipose tissue promotes chronic systemic inflammation, insulin resistance, and altered adipokine secretion, all of which contribute to beta-cell dysfunction and hyperglycemia. Reaven (2005) introduced the concept of Syndrome X or metabolic syndrome, in which obesity plays a central role in a cluster of conditions including insulin resistance, hypertension, and dyslipidemia all major contributors to both hepatic steatosis and diabetes (27,28)

In contrast to RI and PI, the Peak Systolic Velocity (PSV) and End-Diastolic Velocity (EDV) of the hepatic artery in diabetics were found to be only slightly lower and statistically non-significant. This finding aligns with the study by Park et al. (2013), who noted that while diabetics showed early microvascular changes in resistance indices, velocity parameters such as PSV and EDV remained largely unaffected in the initial stages. Their research suggested that changes in velocity indices are more likely to manifest in advanced diabetic liver disease or in the presence of significant steatosis or fibrosis. This pattern reflects the compensatory hemodynamic mechanisms that maintain hepatic perfusion despite increased resistance, until decompensation occurs. Thus, the stability of PSV and EDV in our study may indicate that most diabetic participants were at early or moderate stages of hepatic involvement, further validating the use of RI and PI as more sensitive indicators for early detection (29,30)

CONCLUSION

Duplex Doppler ultrasound has proven to be an effective and non-invasive method for detecting hemodynamic changes in the hepatic artery of diabetic patients. The findings of elevated resistive index (RI) and pulsatility index (PI) are indicative of increased vascular resistance, which suggests early signs of diabetic vascular involvement. These changes can serve as critical markers for the onset of hepatic complications associated with diabetes, such as non-alcoholic fatty liver disease and cirrhosis. By enabling timely assessment of hepatic arterial health, Duplex Doppler ultrasound can facilitate early intervention strategies aimed at preventing the progression of liver-related complications in diabetic individuals. Furthermore, its ability to provide real-time imaging and quantitative flow measurements enhances its utility in clinical practice, allowing healthcare providers to monitor disease progression and treatment efficacy effectively. Incorporating Duplex Doppler ultrasound into routine clinical evaluations for diabetic patients may improve overall management strategies, ultimately leading to better patient outcomes. As the prevalence of diabetes continues to rise globally, the importance of early detection and management of its complications cannot be overstated. Thus, this non-invasive tool represents a valuable asset in the comprehensive care of patients with diabetes, contributing to improved quality of life and reduced healthcare burdens associated with advanced liver disease.

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