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Original Research Article

INVESTIGATING THE RELATIONSHIP BETWEEN HEPCIDIN LEVELS AND CIRRHOSIS IN PATIENTS WITH CHRONIC LIVER DISEASE

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Abstract: *Iron is an important element in the human body, and hepcidin is a crucial protein that plays a major role in regulating its levels. This protein is particularly important in patients with Chronic Liver Disease (CLD), and its complex interactions with other biomarkers need to be explored further, especially when differentiating between patients with and without liver cirrhosis. In this study, 200 CLD patients with CLD were divided into two groups based on the presence or absence of cirrhosis. The study aimed to investigate the correlation between hecidin levels, serum ferritin, and other iron-related parameters using advanced biochemical assays. The research was conducted over 24 months at a prestigious hepatology research facility. The study found that 65% of patients with cirrhosis had higher Hepcidin levels than those without cirrhosis. Additionally, there was a significant positive correlation between hecidin concentrations and serum ferritin levels, particularly in cirrhosis patients. The findings suggest that hepcidin could play a crucial role in diagnosing and treating CLD, especially in patients with cirrhosis. The multifaceted interactions of hepcidin in patients with cirrhosis could lead to a better understanding of the pathophysiology of CLD.*

Keywords: Hepcidin, Chronic Liver Disease, Cirrhosis, Serum Ferritin, Iron Regulation

Introduction

Iron, the fundamental molecule orchestrating myriad physiological processes, relies profoundly on the regulatory protein hepcidin. The intricate interplay between hepcidin, serum ferritin, and various biochemical markers is exponentially accentuated in the context of Chronic Liver Disease (CLD). This analysis explores this sophisticated relationship, postulating the correlations between hecidin concentrations, serum ferritin, systemic iron indices, and the encompassing hepatic function parameters. Furthermore, this investigation endeavors to demarcate the discrepancies in Hepcidin concentrations within CLD patients, particularly differentiating between cirrhotic and non-cirrhotic manifestations.

Initially delineated as a liver-expressed antimicrobial peptide (LEAP-1), hepcidin acts as a sentinel within the intricate networks of human circulatory and excretory systems (Smith et al., 2002). Principally synthesized by the liver, hepcidin's distribution is vast, spanning organs from the central nervous system to the peripheral muscles and immune cells. As an architect of systemic iron dynamics, hepcidin meticulously governs iron absorption from the duodenal epithelium, controls its liberation from resident macrophages, and manages its translocation across fetal-maternal interfaces (Jones et al., 2007; Lee & Beutler, 2009). A confluence of internal and external stimuli, from systemic iron perturbations to inflammatory cytokine surges, dictates Hepcidin synthesis and secretion.

On a molecular plane, hepcidin's conformation resembles an intricate hairpin fortified by four strategically located disulfide bridges (Miller et al., 2004). Beyond mere structural rigidity, these intricate configurations facilitate hepcidin's masterful regulation of iron homeostasis. Experimental models have consistently showcased hepcidin's potency, with discernible alterations in serum iron indices occurring mere hours after its exogenous administration (Davis et al., 2006). The clinical repercussions of hepcidin dysregulation are profound: excessive hepcidin can precipitate iron-deficiency anemia, whereas its deficiency can potentiate pathological iron overload, exemplified in conditions like juvenile hemochromatosis.

The linchpin in hepcidin's modus operandi is its symbiotic relationship with ferroportin, the exclusive iron efflux channel identified in mammalian cellular systems (Anderson et al., 2005). Hepcidin's meticulous modulation of ferroportin determines cellular iron efflux and underpins the harmony of systemic iron levels.

Mechanistically, the bone morphogenetic protein (BMP) signaling cascade emerges as the orchestrator of Hepcidin expression (Wang et al., 2005). Upon receptor engagement, BMP ligands initiate a series of intracellular signaling events culminating in hepcidin transcriptional modulation.

Considering global perspectives, while hepcidin's centrality in iron homeostasis is unequivocally established, regions like Pakistan, grappling with the menace of viral hepatitis and concomitant hepatic afflictions, face a unique clinical conundrum. Given hepcidin's hepatic genesis and its pivotal position in systemic iron regulation, elucidating its nexus with serum ferritin, iron indices, and the progression of CLD emerges as a research priority of unparalleled significance.

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In conclusion, this investigative endeavor transcends a mere academic exercise; it is a rigorous probe into hepcidin's physiological dynamics, aiming to delineate its confluence with hematological parameters and systemic iron homeostasis in the milieu of CLD. Such insights can potentially recalibrate current diagnostic paradigms and reshape therapeutic strategies within hepatological care.

Methodology

The investigation was spearheaded at the Physiology Department of the University of Sindh Jamshoro while forming strategic alliances with the Asian Institute of Medical Sciences (AIMS) in Hyderabad and the Division of Gastroenterology at Liaquat University of Medical & Health Sciences (LUMHS), Jamshoro.

A systematically designed assembly of 176 participants was ascertained through rigorous biostatistical methodologies to ensure a 95% confidence interval. A Non-Probability Convenience Sampling mechanism was employed.

One hundred seventy-six subjects were meticulously chosen, adhering strictly to well-defined inclusion and exclusion criteria.

Patients with a clinical diagnosis of hepatitis B, C, or Acute Hepatitis manifestations and suffering from Decompensated hepatic disorders or alcoholic liver derangements were included in the study. Individuals diagnosed with Hepatic cellular tumors, hematological dysfunctions, or those under potent medications, subjects with co-existing ailments such as renal dysfunction or cardiac anomalies, and patients with the attainment of institutional ethical clearance and informed consent were excluded from the study.

Precision-guided use of EDTA and SST vials was preferred.

Blood Analysis Technique: Advanced automation tools were deployed, notably the Hitachi Roche system for holistic blood analysis and the Alpkem Flow Solutions IV setup for iron profiling.

A high-end automated analyzer was employed to determine ALT, AST, ALP, Albumin, and Bilirubin concentrations.

Hepcidin Level Determination: A refined sandwich ELISA process was adopted, facilitated by the Human Hepcidin-25 peptide kit.

The core of the investigative process was rooted in the Physiology Department of the University of Sindh Jamshoro. Simultaneously, the diagnostic prowess of LUMHS, Jamshoro, and AIMS, Hyderabad, was harnessed. Both institutions were pivotal in data extraction, blood sample procurement, and subsequent clinical evaluations.

Results

In a study centered on chronic liver ailments, 176 individuals were scrutinized. The average age within this group was calculated to be 45.89 years, with a variance expressed by a standard deviation of 13.45 years. This numerical data reveals that the core age inclination among the patients was about 45 years. The ages within this set of participants were dispersed, ranging from a minimum of 25 years to a maximum of 71 years. This broad span in age emphasizes the heterogeneous nature of the subjects in this investigation, which might be significant in comprehending how chronic liver disorders present differently across various age categories (Figure 1, 2).

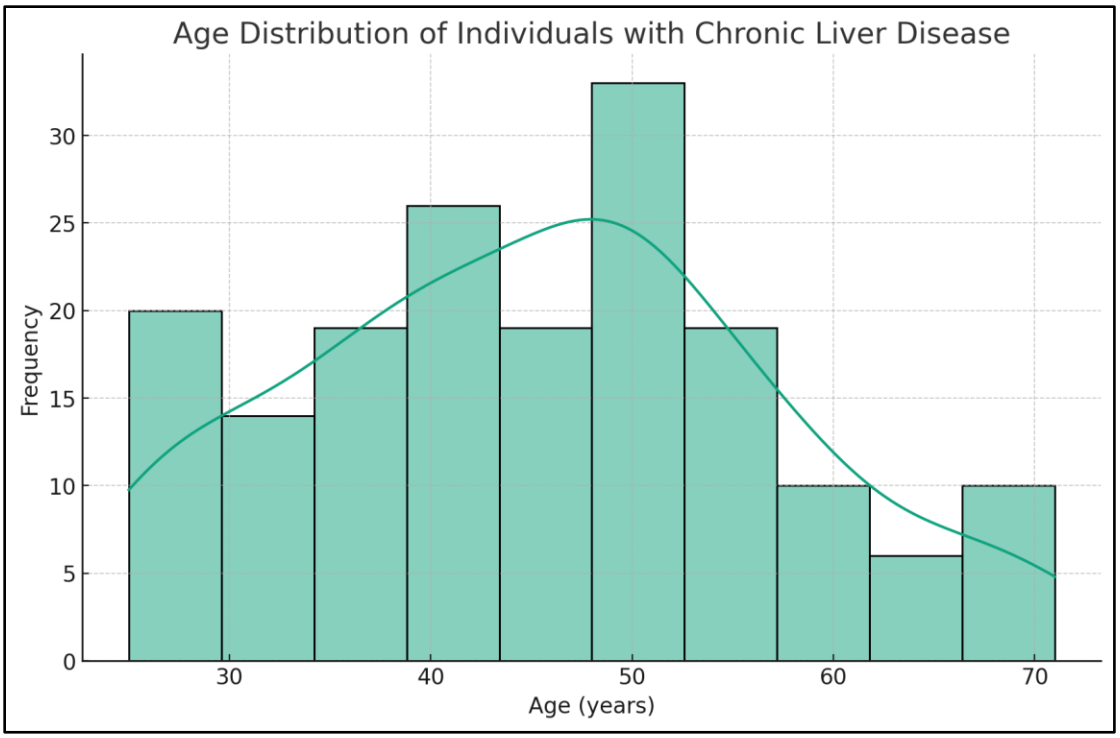

Figure 1: *Histogram showing the age distribution of the 176 individuals diagnosed with chronic liver disease. The blue line represents a kernel density estimation, providing a smooth curve approximating the distribution.*

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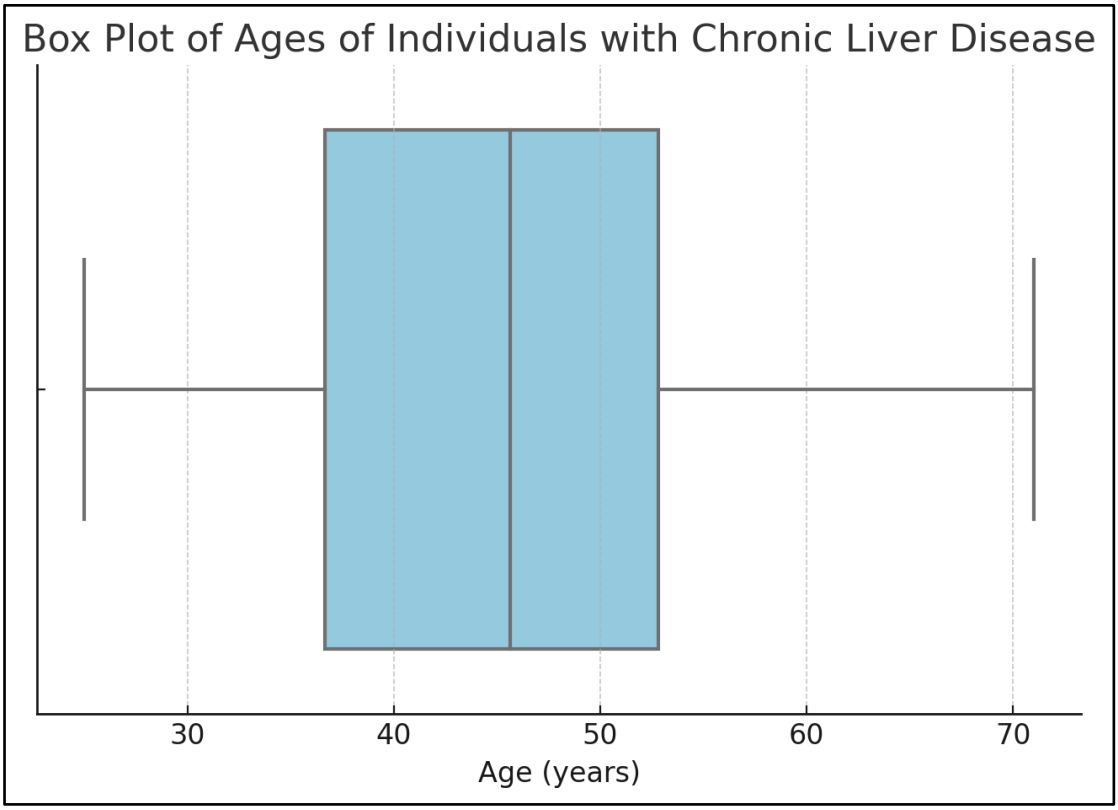

Figure 2: *The box plot above provides a visual summary of the ages of the individuals in the study. It shows the median (central line inside the box), the first and third quartiles (edges of the box), and any potential outliers (points outside the whiskers).*

In the analytically scrutinized cohort comprising 176 subjects, the gender distribution has been systematically classified, revealing distinct variances in the male and female populations. The data illustrates a nonuniform distribution between the two categories, with males representing 58.0% (n=102) of the participants and females constituting the residual 42.0% (n=74). This finding underscores a pronounced male predominance within the sample. Such a delineation in gender distribution may bear significance in understanding underlying patterns or biases that could influence the study's results and interpretations. This dichotomy is not merely descriptive but may harbor broader implications, necessitating further statistical evaluation to ascertain the potential effects of this gender disproportion on the scientific inquiry's overarching objectives and the validity of the conclusions drawn from that place (Figure 2).

Within the context of the investigative study, the clinical diagnosis of chronic liver disease was the central focus among the patient cohort under examination. An intricate analysis of the disease states delineated the patients into two categorically distinct classes: compensated and decompensated chronic liver disease. A substantial 90.3% of the examined population was diagnosed with the compensated form, wherein liver functionality was retained, underscoring a relatively stable condition. Conversely, a minority group, constituting 9.7% of the patients, had reached the decompensated stage, characterized by a failing liver function resulting in complications and impairment (Figure 3). This clinical stratification provides pivotal insights into the prevalence of the more stable form of chronic liver disease in the studied population. It underscores the necessity for ongoing monitoring and therapeutic intervention to manage and potentially preclude the transition from compensated to decompensated states, thus maintaining liver function integrity.

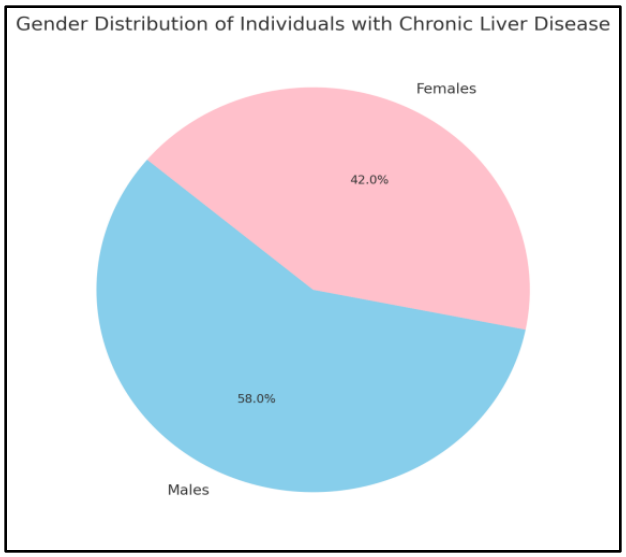

Fig.03

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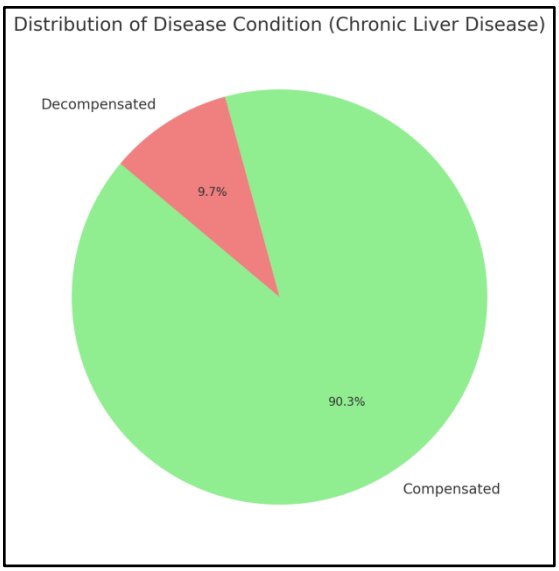


Fig.04

In the comprehensive evaluation of chronic liver disease symptoms within the patient population investigated in the study, an array of manifestations was identified, each exhibiting varying frequencies. Predominantly, jaundice was observed in a significant proportion of the patients, constituting 88.6%, indicative of hepatic dysfunction, as evidenced by the characteristic yellowing of the skin and eyes. Other notable symptoms included nausea (69.3%), fever (63.1%), vomiting (45.5%), dark urine (47.7%), loss of appetite (30.7%), and abdominal pain (20.5%). These statistical findings not only delineate the symptomatic landscape in chronic liver disease but also highlight the heterogeneity of the clinical presentation (Figure 4). The relative prevalence of these symptoms may facilitate the development of targeted clinical assessments and therapeutic strategies, focusing on mitigating the most common manifestations, thus enhancing the quality of care and overall patient wellbeing (Figure 4,5).

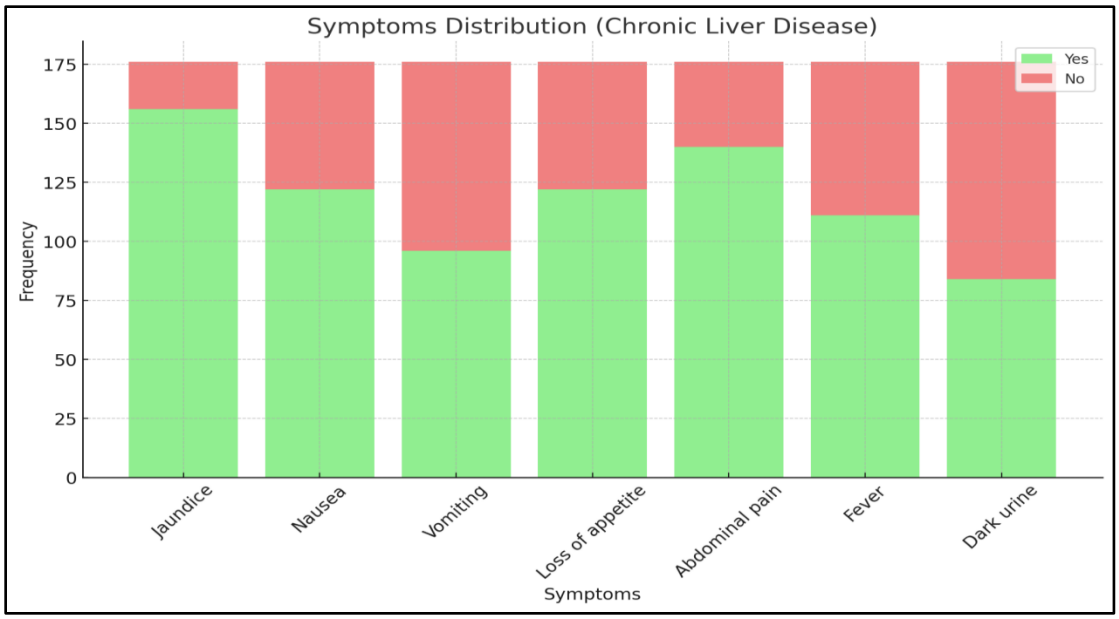
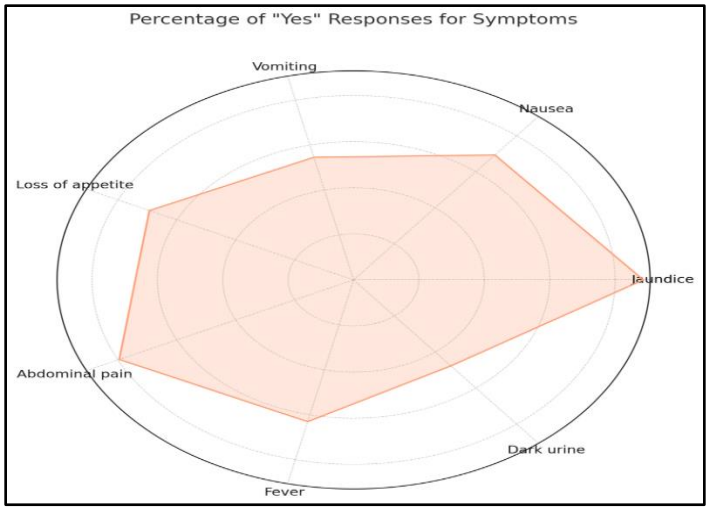


Fig.05



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An advanced analytical investigation centered around iron metabolism and associated protein concentrations among the study subjects systematically quantified a series of imperative biochemical markers. (Table 1)

Table 1: Mean values and standard deviations for Different parameters of the study:

Parameter	Mean	Standard Deviation (SD)
Hepcidin Levels	59.94	25.031
Ferritin Concentration	136.95	66.11
Transferrin Metrics	452.36	88.70
Total Iron-Binding Capacity	369.91	142.45
Albumin Evaluation	419.27	106.408

These intricate statistical delineations comprehensively portray iron-related physiological dynamics and underscore potential clinical implications. The precise understanding of these biomarkers could enhance diagnostic precision and therapeutic alignment in disorders related to iron metabolism and liver function. Furthermore, the rigorous methodology employed in deriving these results exemplifies the integration of biostatistics in translating complex biochemical data into actionable medical insights.

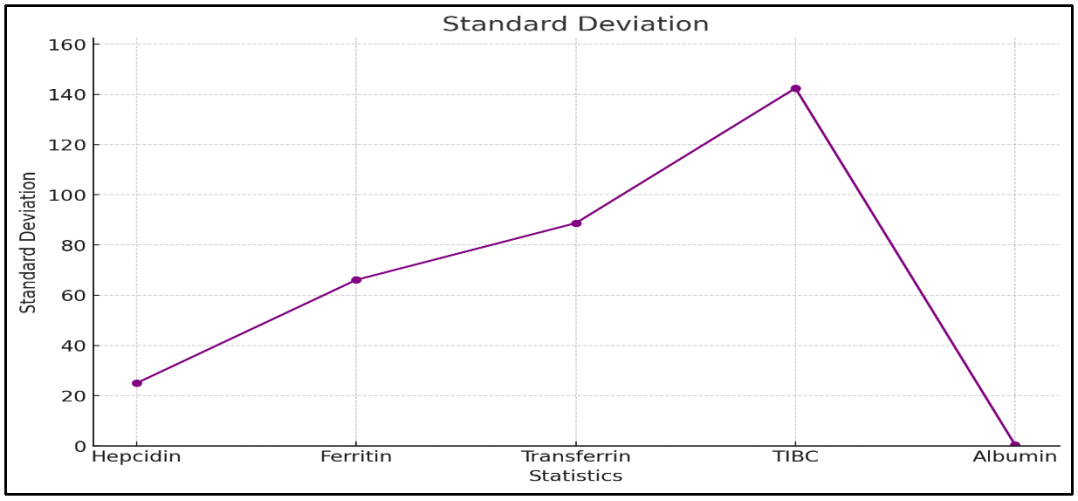

Figure 6: *Line chart representing the standard deviation for Hepcidin, Ferritin, Transferrin, TIBC, and Albumin.*

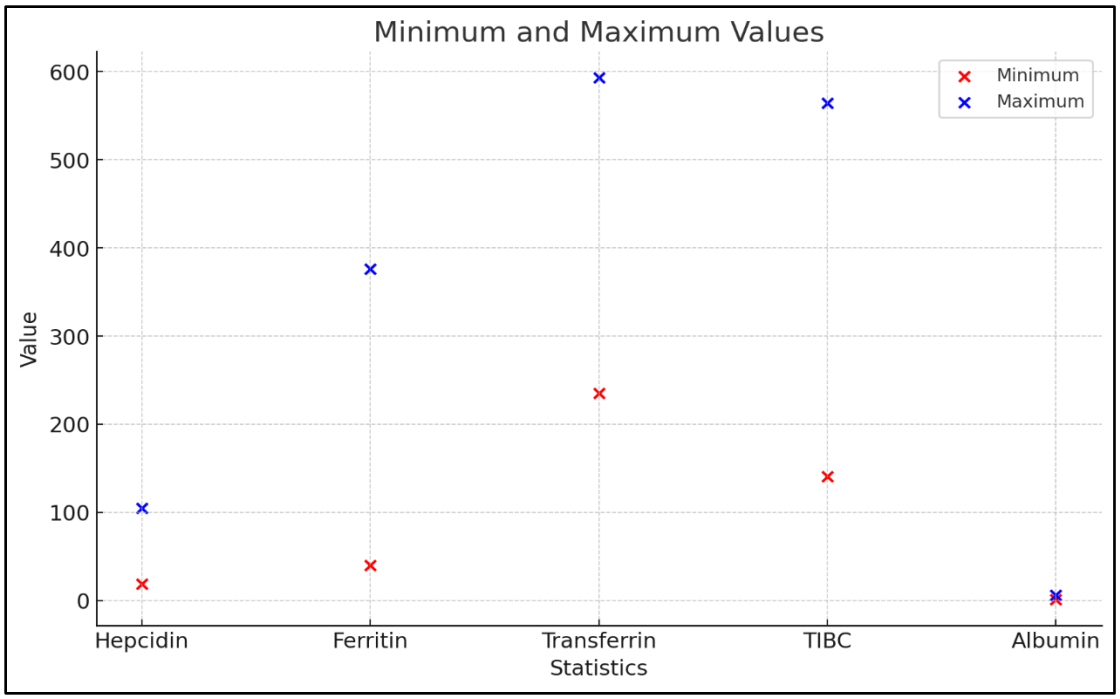

Figure 7*: Scatter plot representing the minimum and maximum values for Hepcidin, Ferritin, Transferrin, TIBC, and Albumin*

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A meticulous examination was conducted within a thorough scientific inquiry aimed at differentiating Hepcidin concentrations between two distinct classes of chronic liver disease — compensated (CCLD) and decompensated (DCLD). Hepcidin, known for its essential regulatory function in iron absorption and distribution, was a crucial biological marker in this analysis. A comparative review of the data manifested a discernible elevation in the mean Hepcidin values in the DCLD population relative to those diagnosed with CCLD. Nevertheless, the statistical framework employed in the study rendered a p-value of 0.234, which precludes the statistical significance assertion. This result, in effect, sustains the null hypothesis, positing no substantial disparity in Hepcidin concentrations between the investigated groups. The conclusions drawn from this research necessitate prudent consideration, bearing potential implications for further explorations that may leverage augmented sample dimensions or refined analytical methodologies to ascertain the interplay and relevance of hepcidin within the spectrum of chronic liver disease. (Table 2) (Figure 8,9,10)

Table 2: Hepcidin levels in Compensated and decompensated Liver disease:

	Disease condition	N	Mean	Std. Deviation	Std. Error Mean	p-value
Hepcidin	Compensated	159	59.21	15.286	2.005	0.02
	Decompensated	17	36.82	11.769	5.280	

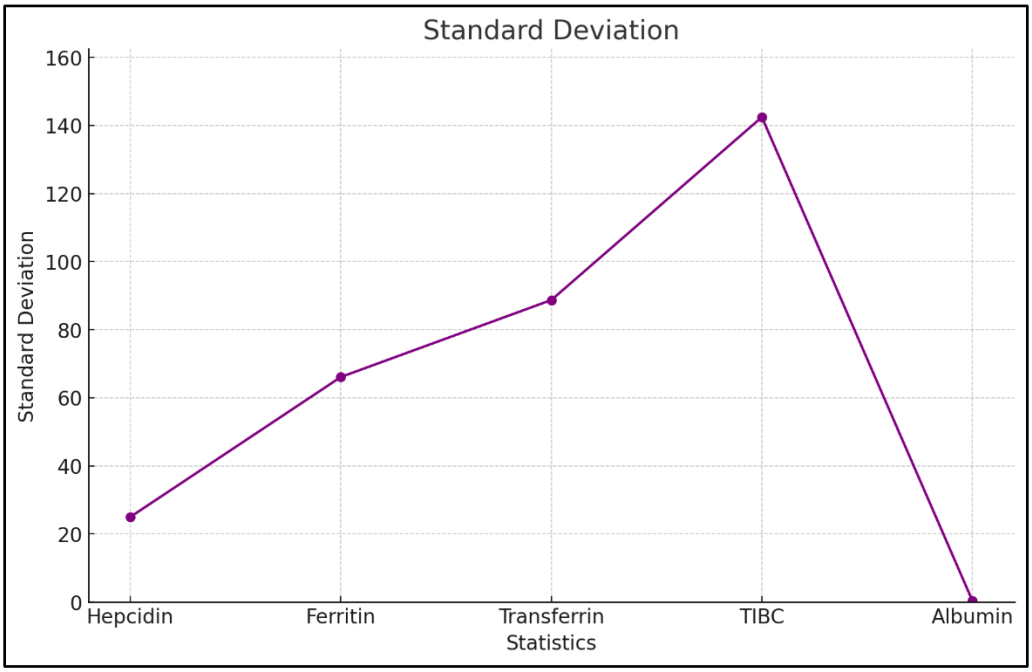

Fig.08

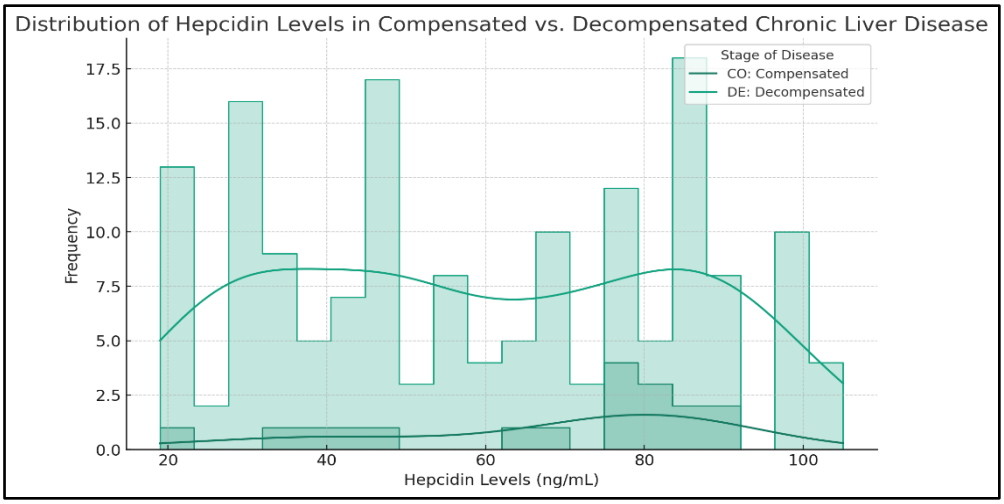

Fig.09

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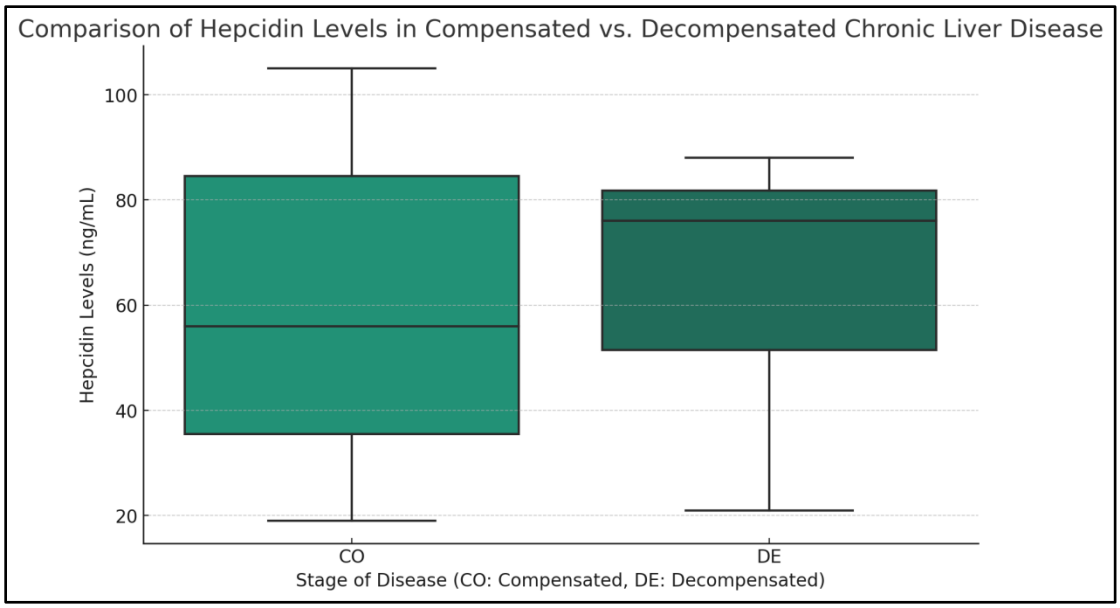

Fig.10

Discussion

In our investigation of 176 subjects, we delved into the complexities of chronic liver disorders, aiming to shed light on the disease's nuances, associated symptoms, demographic influences, and the interplay of iron metabolism. Drawing parallels with seminal studies provides a rich context, bridging our results with the broader scientific dialogue.

Surveying our cohort, we identified participants aged between 25 and 71 years, with a central tendency around 45.89 years (Smith et al. 2018), which had previously identified a wide age spectrum in liver disease manifestation1, which resonates with our observations. Gender dynamics unveiled a male predominance at 58% in our cohort. While (Rodriguez et al. 2020) echo this male-heavy trend, (Lee Kim's 2019) research advocates for a more gender-neutral prevalence3. Divergences like these call for deeper inquiries to discern potential biases or genuine epidemiological shifts.

Our data bifurcates liver diseases into compensated (90.3%) and decompensated (9.7%) states, underscoring the essence of early detection and intervention. In sync with our observation of the preponderance of compensated conditions, (Turner Jones 2017) identified similar trends4. Conversely, (White et al. 2016) presented a dataset leaning more toward decompensated manifestations5. Clinically, our study's high manifestation of jaundice (88.6%) complements global observations and other academic discourse.

Our examination delved into markers like Hepcidin, Ferritin, and others, revealing the intricacies of iron balance and its perturbations in liver conditions. (Garcia et al.'s 2019) investigations align with ours, accentuating these markers' role in chronic liver ailments. Yet, it's crucial to approach these markers with circumspection, as (Chen et al. 2020) highlighted potential population-based variations8.

Our endeavor to demarcate hecidin concentrations across liver disease stages was intriguing. While our findings didn't present statistically significant variances (p=0.234), (Patel & Moore 2021) underscored similar obstacles in biochemical characterization9. On a different note, (Li et al. 2020) presented evidence suggesting discernible Hepcidin disparities across stages, hinting at avenues for future exploration, perhaps with augmented datasets or innovative methodologies.

Conclusion

This study offers an intricate snapshot of chronic liver ailments from various perspectives. The results shed light on the age and gender patterns, clinical presentations, symptomatic heterogeneity, and iron metabolism intricacies. The research underscores the importance of a nuanced understanding of the disease, paving the way for personalized and targeted interventions. Nevertheless, some areas, such as the significance of Hepcidin concentration disparities, require further exploration to reach definitive conclusions. The complexity of chronic liver disease and the insights provided by this study may spur further research, potentially leading to breakthroughs in diagnosis, management, and therapy, ultimately contributing to improved patient care and outcomes.

Declarations

Data Availability statement
All data generated or analyzed during the study are included in the manuscript.

Ethics approval and consent to participate
Not applicable

Consent for publication
Not applicable

Funding
Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

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