|| ISSN(online): 2589-8698 || ISSN(print): 2589-868X ||

Available online on http://www.ijmbs.info

International Journal of Medical and Biomedical Studies; 2026; 10(1); 125-143

Original Research

The correlation between proportional pulse pressure and grades of left ventricular dysfunction in patients of heart failure

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Received: 19-11-2025 / Revised: 22-12-2025 / Accepted: 27-01-2026

DOI: https://doi.org/10.32553/ijmbs.v10i1.3229

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Conflict of interest: No conflict of interest

Abstract:

Background: Effective care of heart failure (HF), a leading cause of morbidity and mortality globally, depends on early detection of left ventricular (LV) systolic dysfunction. Echocardiography is difficult to get in many environments with limited resources. A straightforward bedside metric derived from blood pressure readings, proportional pulse pressure (PPP), may be a helpful marker of left ventricular systolic failure.

Objective: To assess the correlation between the degree of LV systolic dysfunction in heart failure patients and proportional pulse pressure

Methods: Patients with heart failure diagnoses participated in a clinical investigation. PPP was calculated using blood pressure readings, and LV systolic function was evaluated using echocardiography. Analysis was done on the relationship between PPP values and the degree of LV systolic dysfunction.

Results: The degree of LV systolic dysfunction was inversely correlated with PPP. More severe LV systolic function impairment was linked to lower PPP values. This implies that PPP could be a helpful marker for locating patients who have severe heart problems.

Conclusion: A non-invasive and reasonably priced indicator that is correlated with the degree of left ventricular systolic failure is proportional pulse pressure. In situations where echocardiography is not easily accessible, it can be especially useful as a first screening technique, enabling early discovery and prompt referral for more in-depth assessment and treatment. Additional extensive, multicenter research is required to confirm its clinical usefulness.

Keywords: Non-invasive, systolic dysfunction, LV, proportional pulse pressure (PPP), echocardiography

Introduction

Heart failure (HF) is a complex and prevailing cardiovascular problem which significantly decreases the life span and quality of an individual 's life. One of the main reasons contributing to HF is the left ventricular (LV) dysfunction (1). Proper assessment of the degree of LV dysfunction is crucial for early diagnosis and optimal clinical intervention. One of the new cardiovascular markers is pulse pressure (PP) the difference between systolic and diastolic blood pressure (2).. The purpose of this study is to assess the relationship between PPP and various degrees of LV dysfunction in heart failure patients

The prevalence of HF continues to rise with age. It is seen in about 1-2 percent of people between the ages of 40 and 59 and up to 12 percent of individuals over 80 years old. For a 55-year-old, the expected risk is approximately 33 percent in men and 28 in women (3). While the total number of heart failure cases is expected to rise, this increase may be tempered by greater focus on education, earlier action, and improved management of cardiovascular diseases and other related health conditions (4).

Estimates indicate that HF is likely to rise by approximately 34 percent in the coming years. Such increase poses new challenges considering the enormous burden HF places on strained health care services, coupled with high rates of comorbidity and mortality, and diminished functioning among patients (5). On the positive side, the last decade has brought important changes in the pharmacological treatment, cardiac devices, and coordination of care, which have markedly improved HF management (6).

Study Design

This investigation was an institution-based analytical cross-sectional study. It was designed to evaluate some of the clinical and hemodynamic features of the patients with heart failure in a defined hospital area.

Study Location

The study was conducted in the Department of General Medicine, Patna Medical College and Hospital, Patna, Bihar.

Study Duration

The study and data collection spanned over a period of 17 months starting from 1st December 2023 to 30th April 2025.

Sample Size

Within this time frame, a total of 50 heart failure patients were recruited and analyzed.

Study Population

The subjects were patients with heart failure who came to the outpatient medicine clinic or those who presented with acute decompensated heart failure in the emergency room and were later admitted to the general medicine wards.

Inclusion Criteria

- Patients within the age range of 18 to 75 years.
- Individuals with the clinical signs and symptoms of heart failure.
- Subjects who were willing to participate and provided written consent.

Exclusion Criteria

- Patients younger than 18 years or older than 75 years.
- Patients with pericardial diseases.
- Patients whose heart failure was secondary to pulmonary conditions.
- Patients that did not give informed consent.

Statistical analysis

Data entry was done using Microsoft Excel and analyzed through SPSS software. Descriptive and inferential statistics were calculated. A p-value of <0.05 was regarded as statistically significant in all tests.

Results

Table 4.1: Age (years)

Age Range	Count	Percentage
18.9 – 30.2	9	18.0%
30.2 – 41.4	12	24.0%
41.4 – 52.6	6	12.0%
52.6 – 63.8	11	22.0%
63.8 – 75.0	12	24.0%

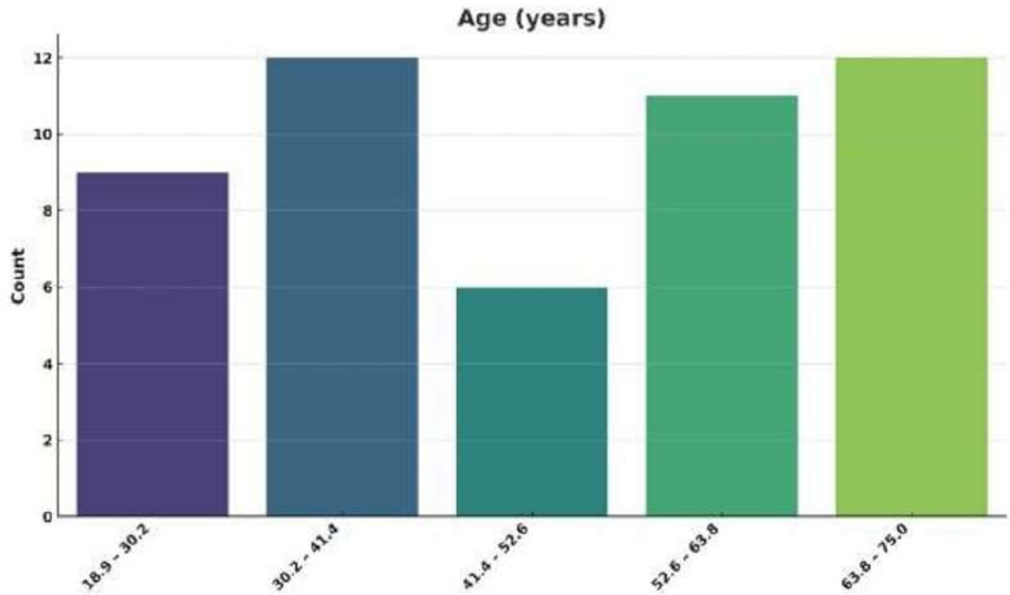

Figure 4.1: Graphical Representation of Age (years)

Table 4.2: Gender Representation

Gender	Count	Percentage
Female	34	68.0%
Male	16	32.0%

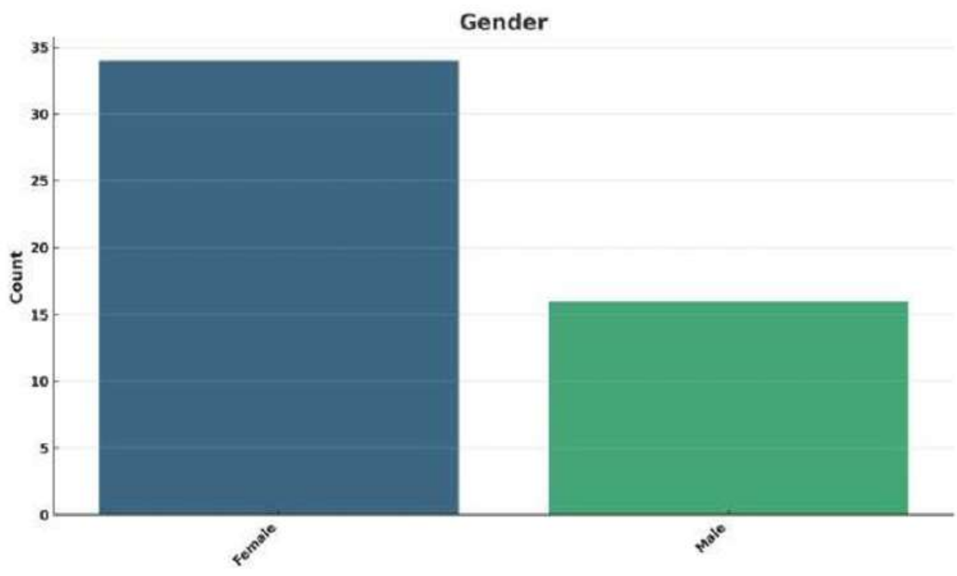

Figure 4.2: Graphical Representation of Gender

Table 4.3: Heart Rate (bpm)

Heart Rate Range	Count	Percentage
59.9 – 71.8	13	26.0%
71.8 – 83.6	10	20.0%
83.6 – 95.4	8	16.0%
95.4 – 107.2	10	20.0%
107.2 – 119.0	9	18.0%

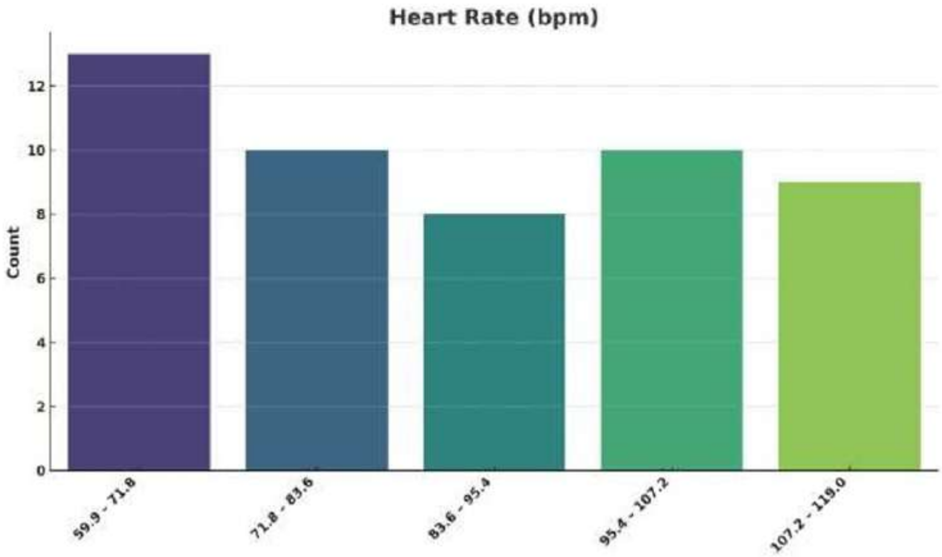

Figure 4.3: Graphical Representation of Heart Rate (bpm)

Table 4.4: SBP (Systolic Blood Pressure)

SBP Range (mmHg)	Count	Percentage
86.8 – 111.6	9	18.0%
111.6 – 136.4	10	20.0%
136.4 – 161.2	13	26.0%
161.2 – 186.0	14	28.0%
186.0 – 210.8	4	8.0%

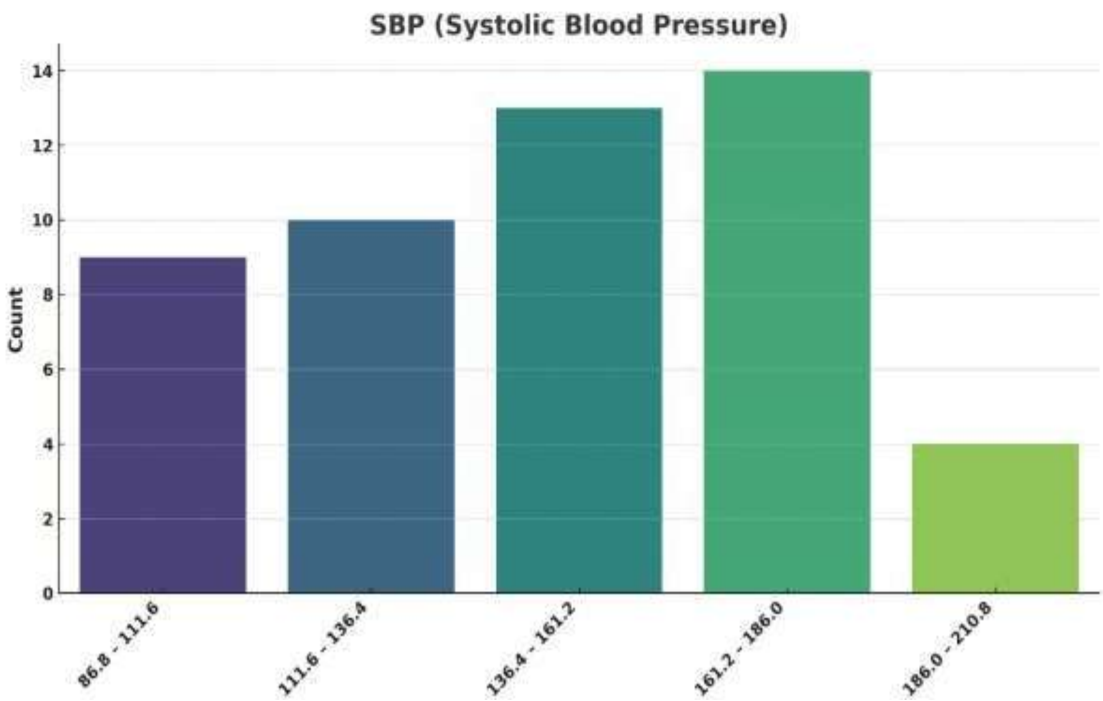

Figure 4.4: Graphical Representation of SBP (Systolic Blood Pressure)

Table 4.5: Ejection Fraction (%)

EF Range (%)	Count	Percentage
20.2 – 28.6	14	28.0%
28.6 – 37.0	7	14.0%
37.0 – 45.4	6	12.0%
45.4 – 53.8	12	24.0%
53.8 – 62.2	11	22.0%

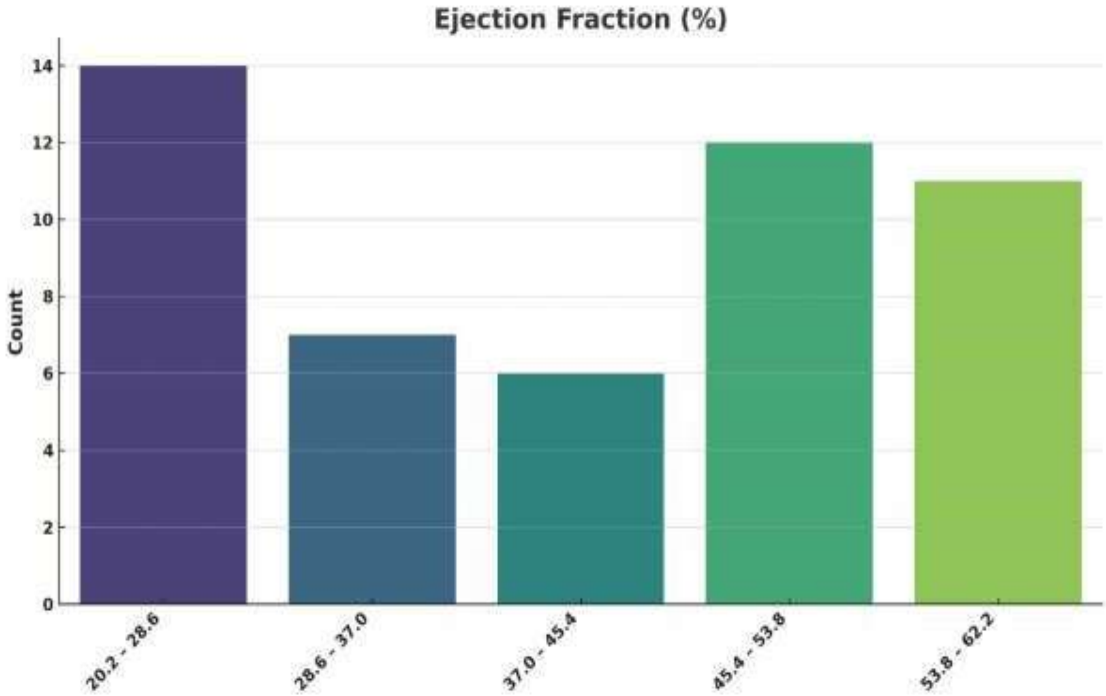

Figure 4.5: Graphical Representation of Ejection Fraction (%)

Table 4.6: Symptoms Present

Value	Count	Percentage
Yes	33	66.0%
No	17	34.0%

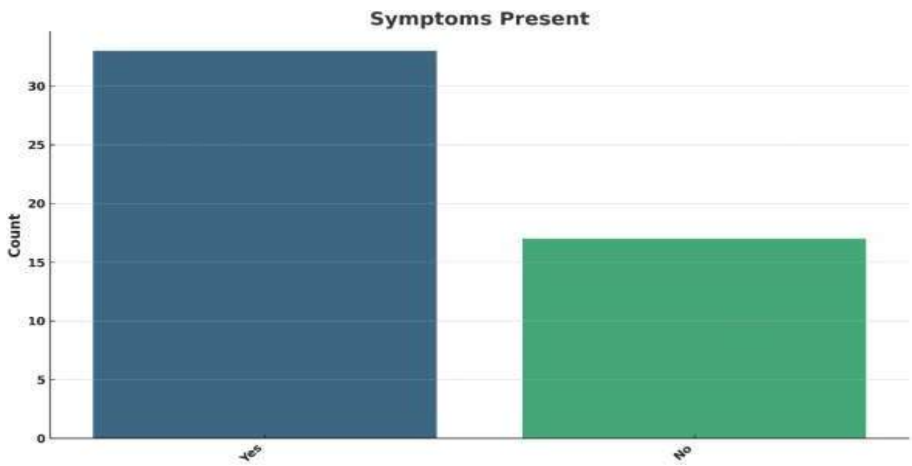

Figure 4.6: Graphical Representation of Symptoms Present

Table 4.7: History of Hypertension

Value	Count	Percentage
No	30	60.0%
Yes	20	40.0%

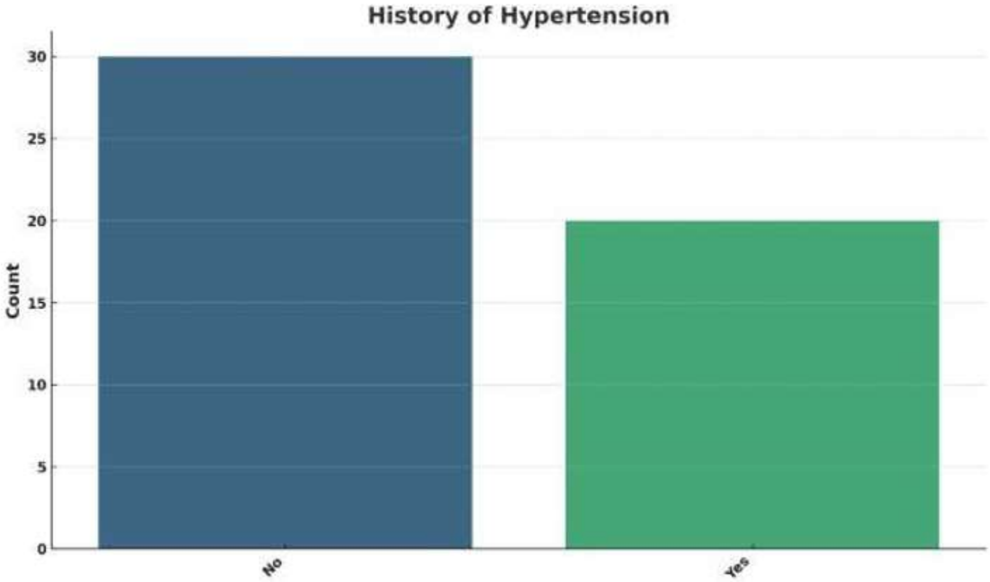

Figure 4.7: Graphical Representation of History of Hypertension

Table 4.8: History of Diabetes

Value	Count	Percentage
No	30	60.0%
Yes	20	40.0%

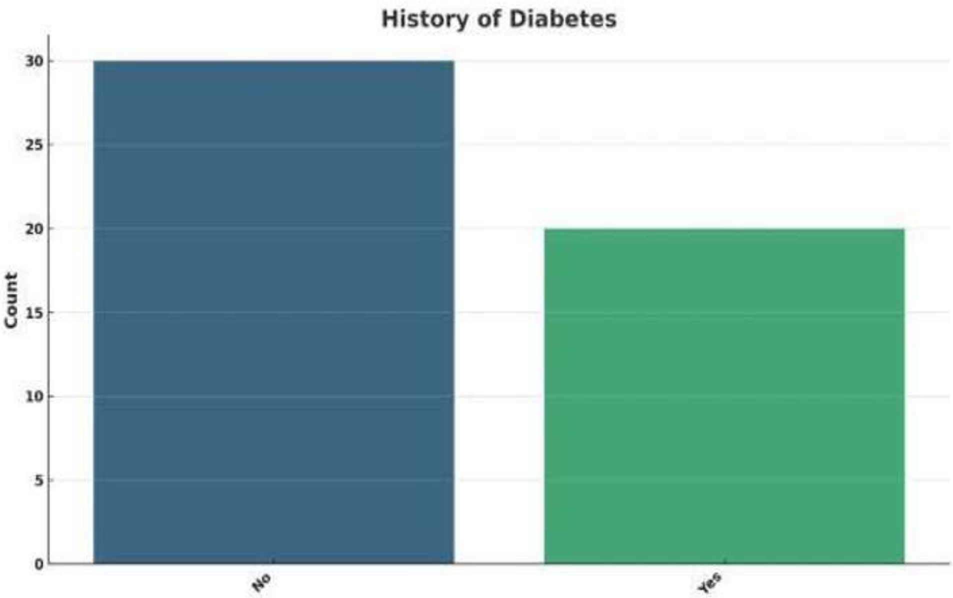

Figure 4.8: Graphical Representation of History of Diabetes

Table 4.9: Smoking History

Value	Count	Percentage
No	36	72.0%
Yes	14	28.0%

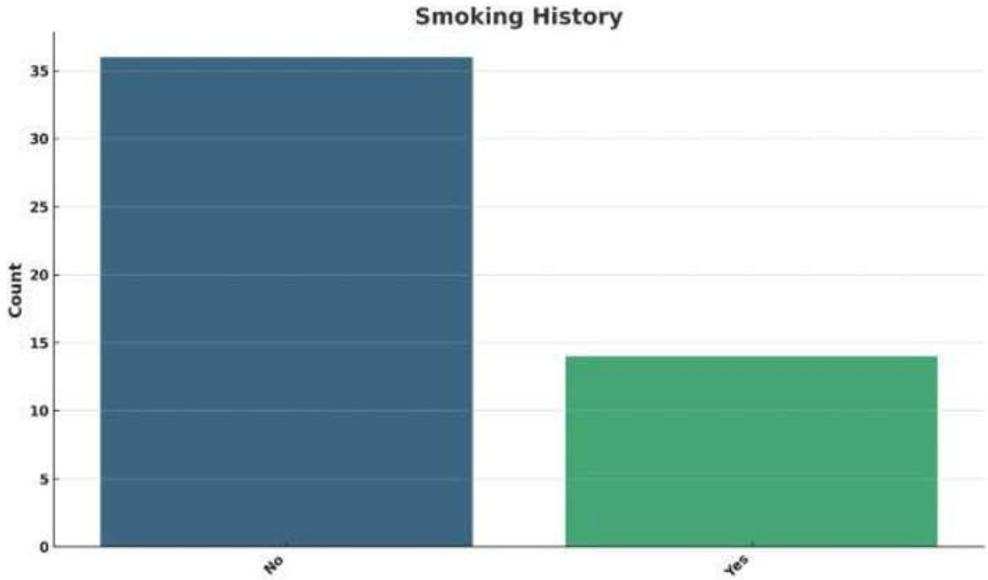

Figure 4.9: Graphical Representation of Smoking History

Table 4.10: Current Medications

Medication	Count	Percentage
ACE Inhibitors	15	30.0%
Diuretics	14	28.0%
Beta Blockers	11	22.0%
None	10	20.0%

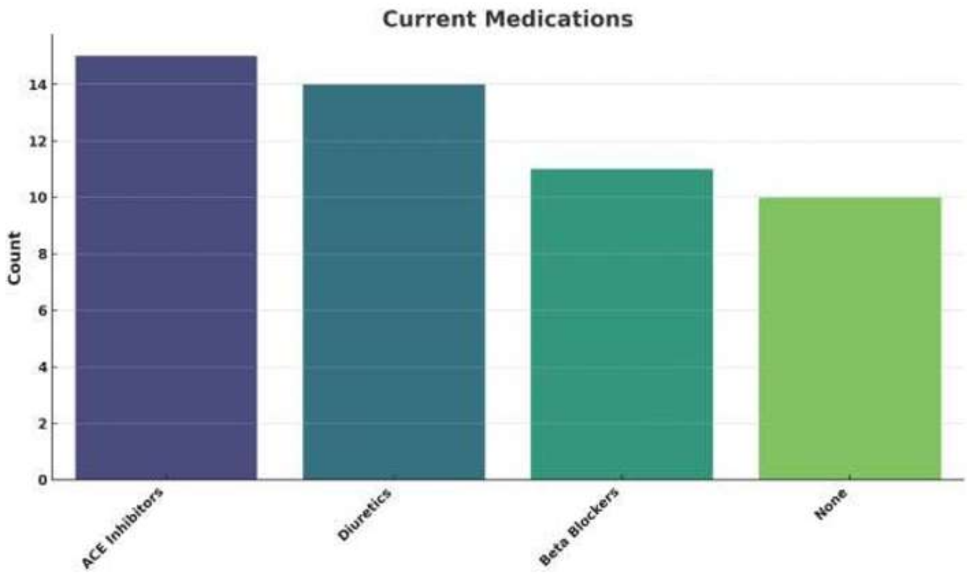

Figure 4.10: Graphical Representation of Current Medications

Table 4.11: ECG Findings

ECG Finding	Count	Percentage
Arrhythmia	13	26.0%
LVH	13	26.0%
Normal	13	26.0%
ST Depression	11	22.0%

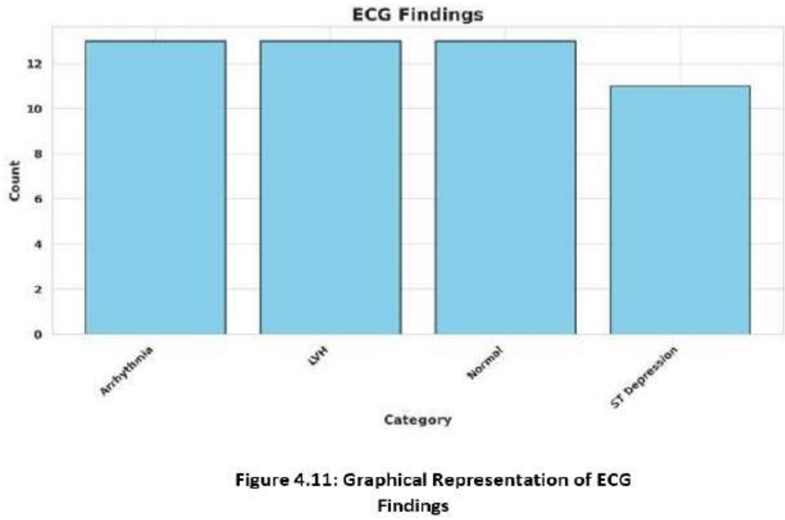

Figure 4.11: Graphical Representation of ECG Findings

Table 4.12: Echocardiogram Findings

Echo Finding	Count	Percentage
Normal	18	36.0%
Hypertrophic LV	12	24.0%
Reduced EF	10	20.0%
Dilated LV	10	20.0%

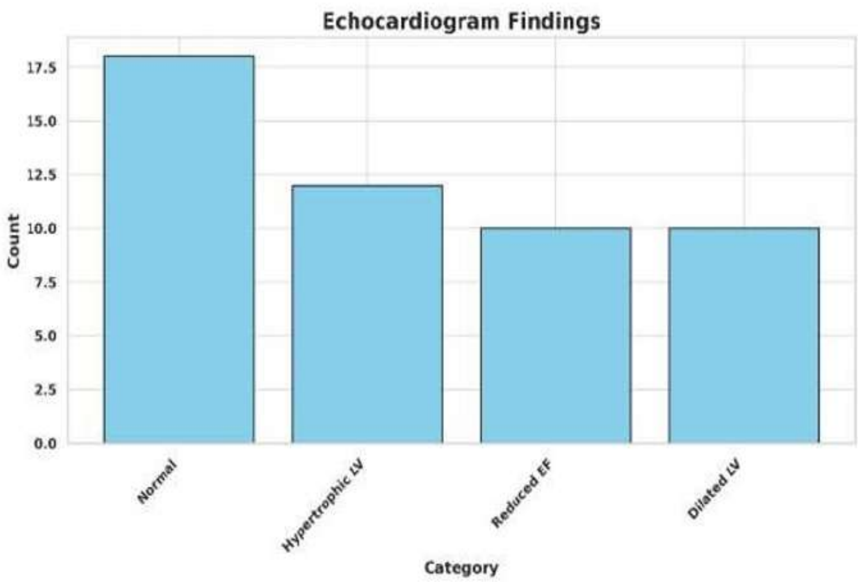

Figure 4.12: Graphical Representation of Echocardiogram Findings

Table 4.13: Patient Consent

Consent	Count	Percentage
Yes	50	100.0%

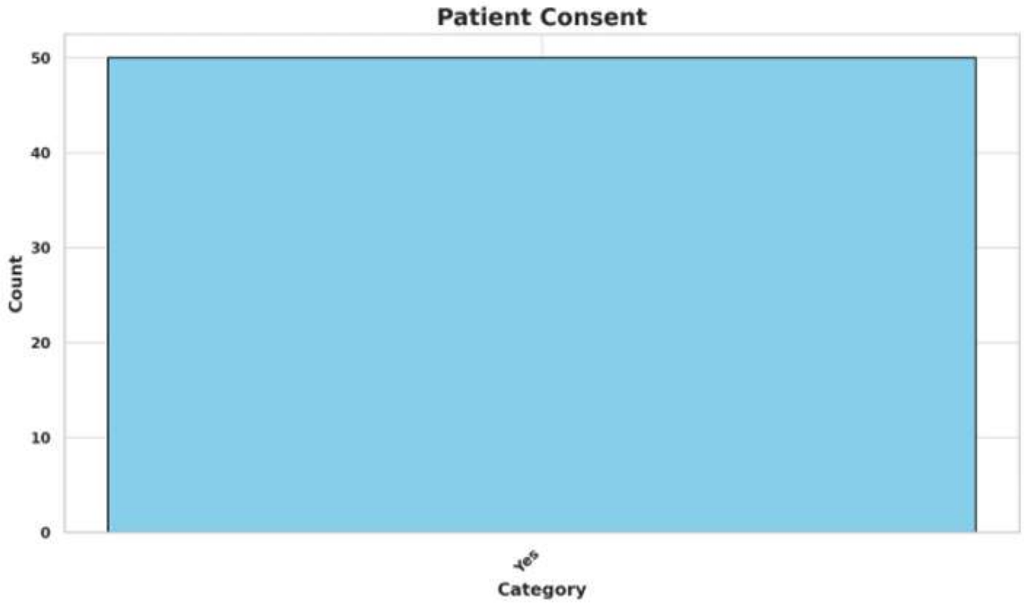

Figure 4.13: Graphical Representation of Patient Consent

Table 4.14: Family History

Family History	Count	Percentage
No	31	62.0%
Yes	19	38.0%

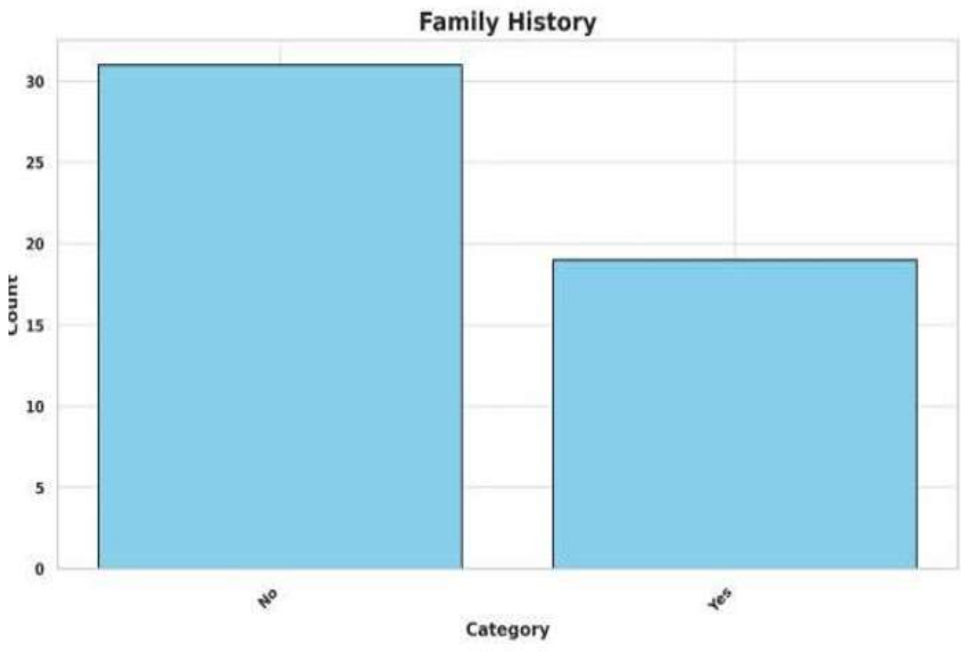

Figure 4.14: Graphical Representation of Family History

Table 4.15: Duration (Years)

Duration Range (Years)	Count	Percentage
0.98 – 4.8	8	16.0%
4.8 – 8.6	13	26.0%
8.6 – 12.4	9	18.0%
12.4 – 16.2	7	14.0%
16.2 – 20.0	13	26.0%

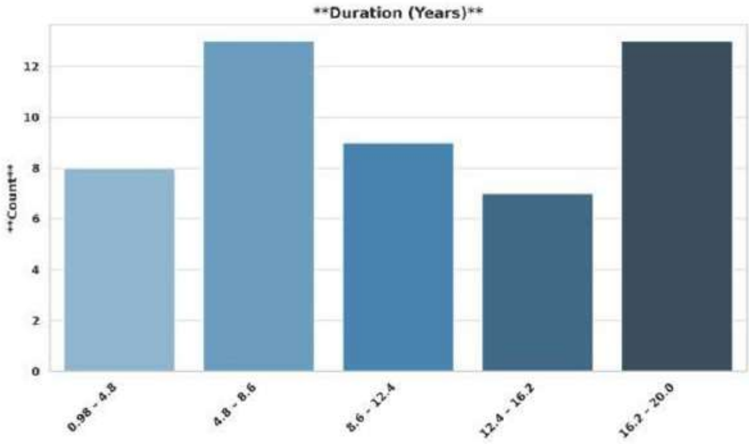

Figure 4.15: Graphical Representation of Duration (Years)

Table 4.16: Pulse Pressure

Range (mmHg)	Count	Percentage
-6.1 – 13.6	9	18.0%
13.6 – 33.2	7	14.0%
33.2 – 52.8	7	14.0%
52.8 – 72.4	23	46.0%
72.4 – 92.0	4	8.0%

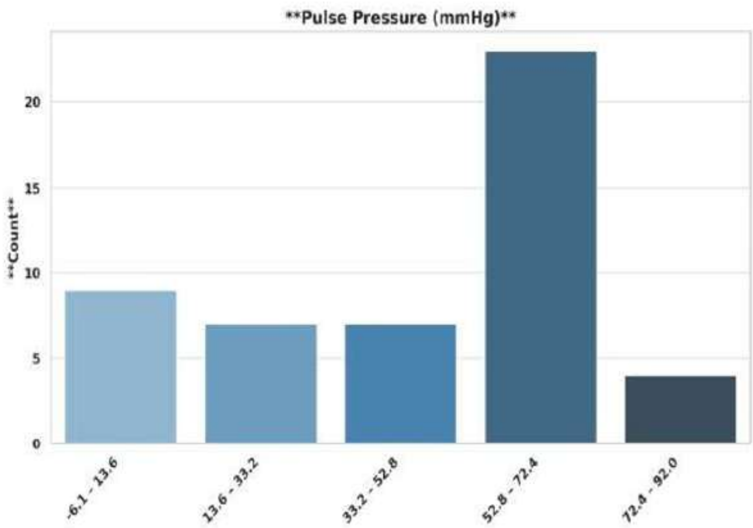

Figure 4.16: Graphical Representation of Pulse Pressure

Table 4.17: Jugular Venous Pressure (cm H_2O)

JVP (cm H_2O)	Count	Percentage
5	4	8.0%
6	12	24.0%
7	9	18.0%
8	10	20.0%
9	9	18.0%
10	6	12.0%

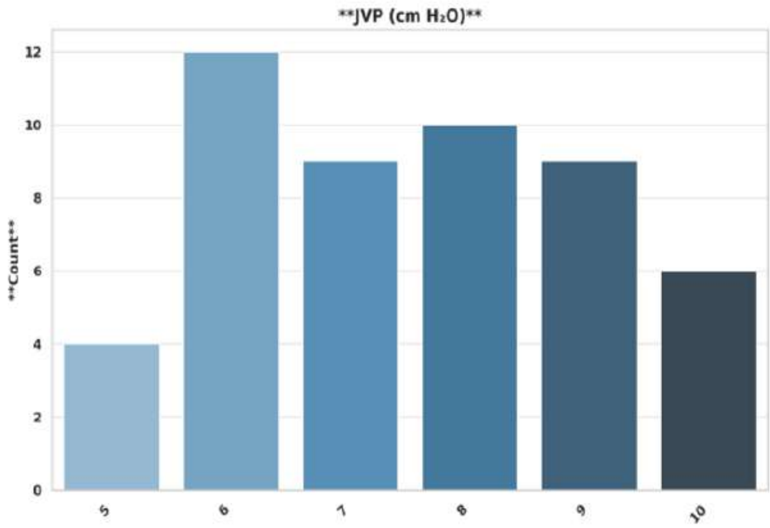

Figure 4.17: Graphical Representation of Jugular Venous Pressure (cm H_2O)

Table 4.18: B/I Pedal Edema

Value	Count	Percentage
No	33	66.0%
Yes	17	34.0%

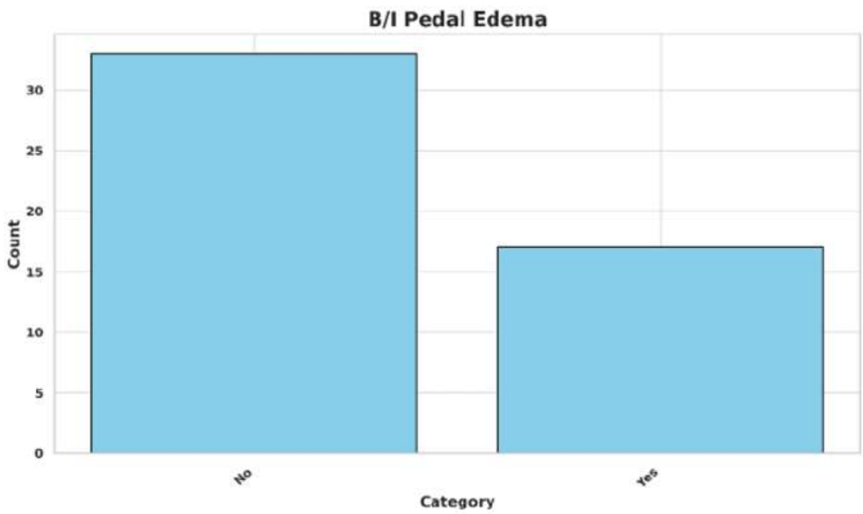

Figure 4.18: Graphical Representation of B/I Pedal Edema

Table 4.19: Hemoglobin (g/dL)

Range (g/dL)	Count	Percentage
12.1 – 13.3	10	20.0%
13.3 – 14.5	8	16.0%
14.5 – 15.6	7	14.0%
15.6 – 16.8	9	18.0%
16.8 – 18.0	16	32.0%

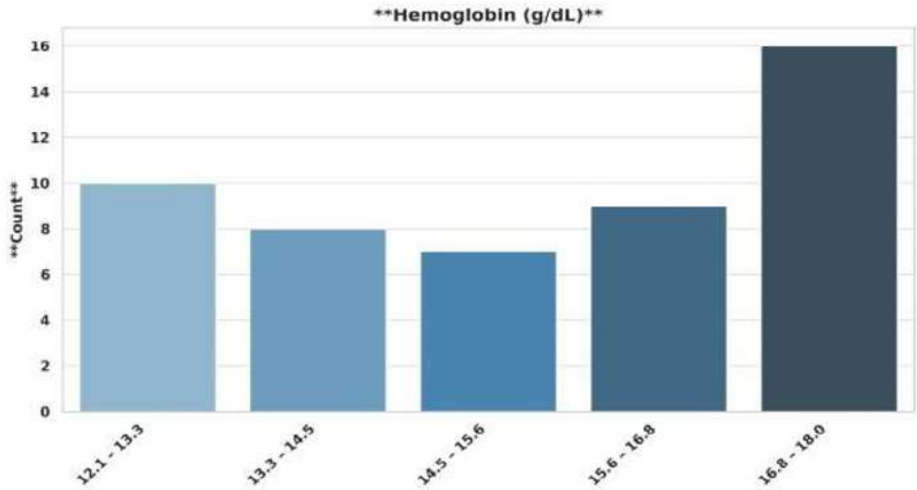

Figure 4.19: Graphical Representation of Hemoglobin (g/dL)

Table 4.20: WBC (cells/µL)

Range (cells/µL)	Count	Percentage
4144 – 5521	8	16.0%
5521 – 6890	5	10.0%
6890 – 8260	17	34.0%
8260 – 9630	9	18.0%
9630 – 11000	11	22.0%

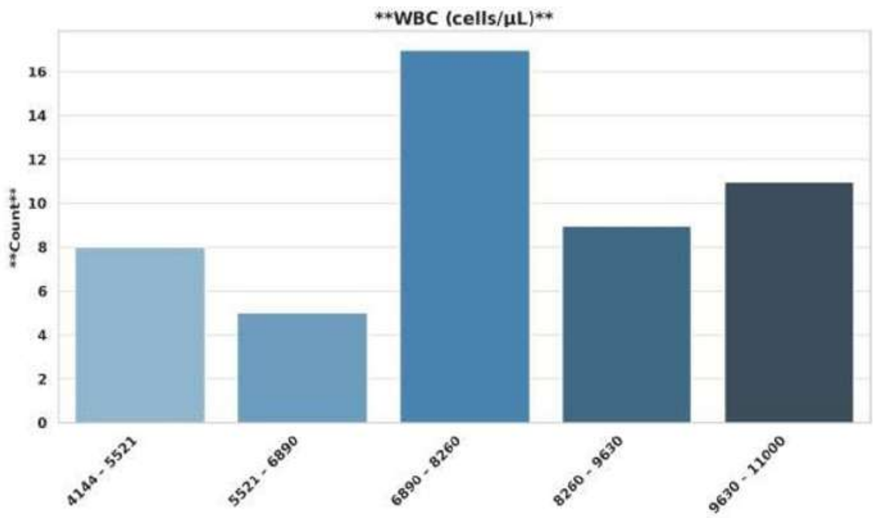

Figure 4.20: Graphical Representation of WBC (cells/µL)

Table 4.21: Platelets (cells/µL)

Range (cells/µL)	Count	Percentage
151236 – 210822	8	16.0%
210822 – 270112	18	36.0%
270112 – 329401	6	12.0%
329401 – 388691	9	18.0%
388691 – 447980	9	18.0%

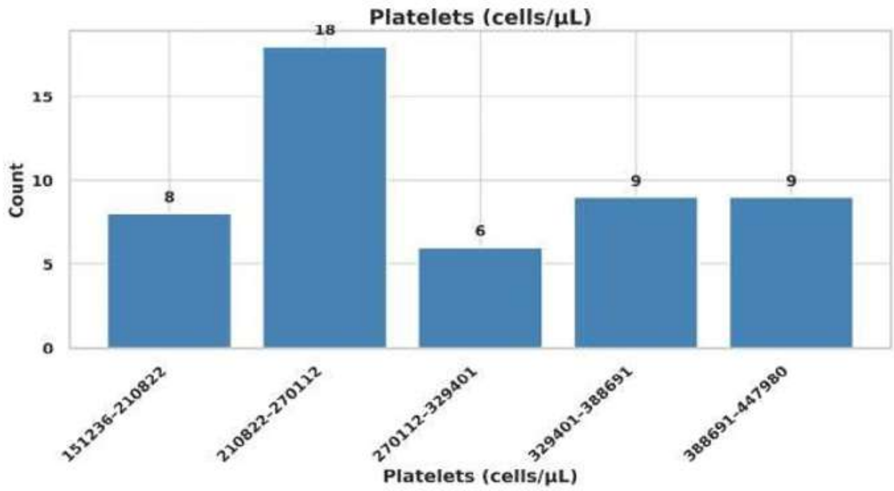

Figure 4.21: Graphical Representation of Platelets (cells/µL)

Table 4.22: Creatinine (mg/dL)

Range (mg/dL)	Count	Percentage
0.61 – 0.75	10	20.0%
0.75 – 0.88	13	26.0%
0.88 – 1.02	6	12.0%
1.02 – 1.15	11	22.0%
1.15 – 1.29	10	20.0%

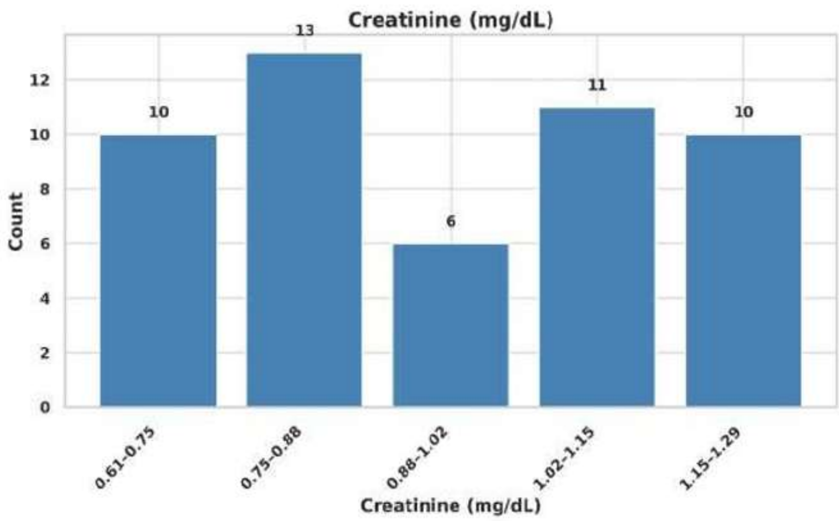

Figure 4.22: Graphical Representation of Creatinine (mg/dL)

Table 4.23: Urea (mg/dL)

Range (mg/dL)	Count	Percentage
15.0 – 22.0	8	16.0%
22.0 – 29.0	12	24.0%
29.0 – 36.0	6	12.0%
36.0 – 43.0	13	26.0%
43.0 – 50.0	11	22.0%

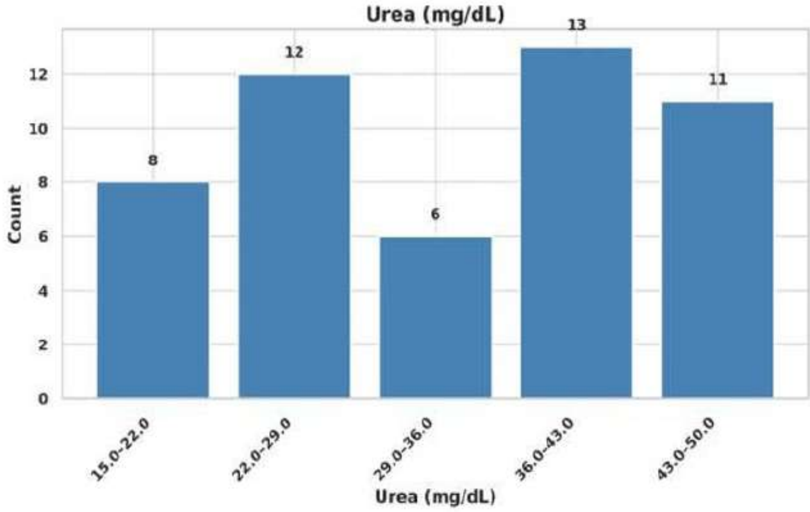

Figure 4.23: Graphical Representation of Urea (mg/dL)

Table 4.24: ALT (U/L)

Range (U/L)	Count	Percentage
7.0 – 16.6	11	22.0%
16.6 – 26.2	11	22.0%
26.2 – 35.8	11	22.0%
35.8 – 45.4	8	16.0%
45.4 – 55.0	9	18.0%

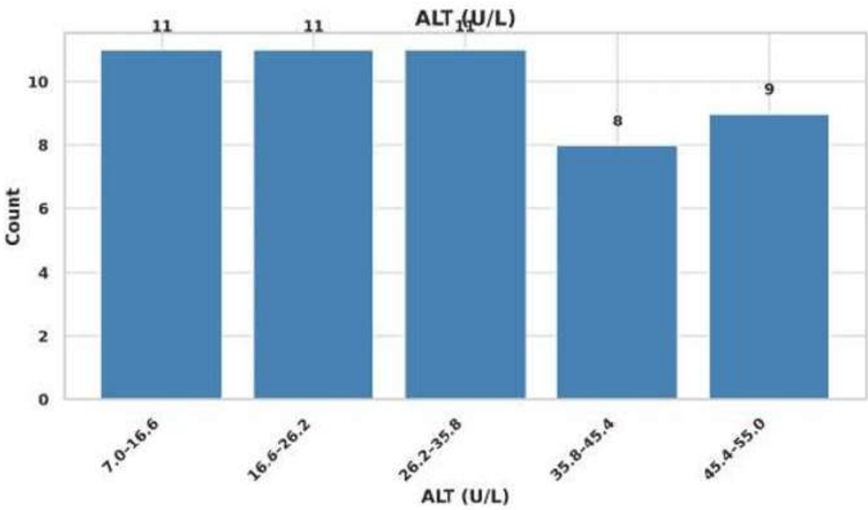

Figure 4.24: Graphical Representation of ALT (U/L)

Table 4.25: AST (U/L)

Range (U/L)	Count	Percentage
10.0 – 16.0	8	16.0%
16.0 – 22.0	16	32.0%
22.0 – 28.0	10	20.0%
28.0 – 34.0	7	14.0%
34.0 – 40.0	9	18.0%

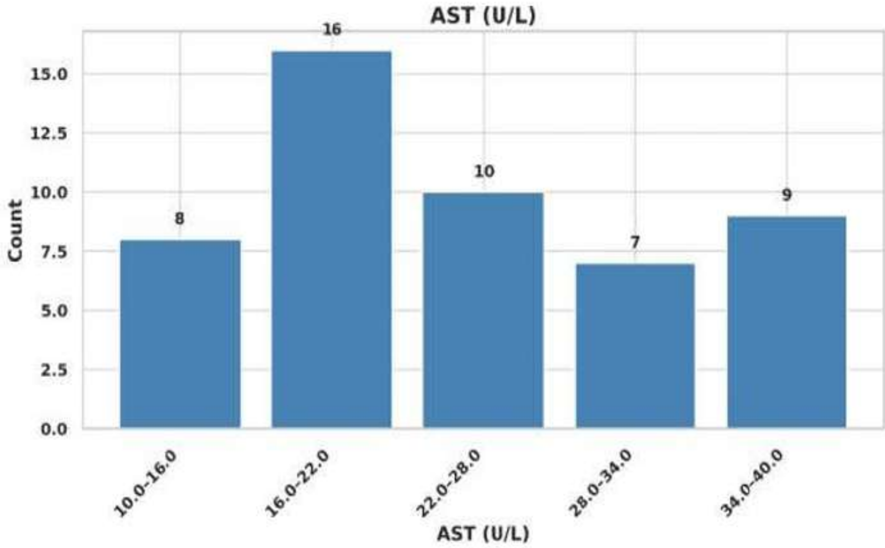

Figure 4.25: Graphical Representation of AST (U/L)

Table 4.26: Bilirubin (mg/dL)

Range (mg/dL)	Count	Percentage
0.109 – 0.326	9	18.0%
0.326 – 0.542	5	10.0%
0.542 – 0.758	9	18.0%
0.758 – 0.974	18	36.0%
0.974 – 1.19	9	18.0%

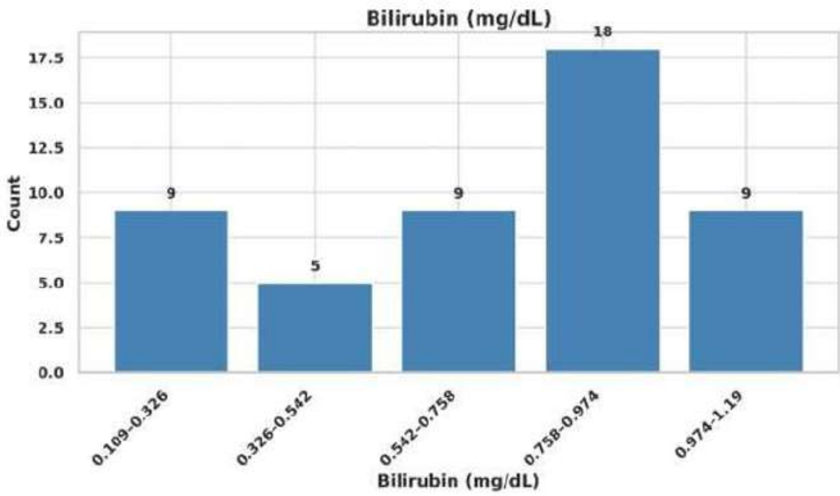

Figure 4.26: Graphical Representation of Bilirubin (mg/dL)

Table 4.27: Proportional Pulse Pressure (%)

Range (%)	Count	Percentage
-6.565 – 6.56	6	12.0%
6.56 – 19.62	6	12.0%
19.62 – 32.68	4	8.0%
32.68 – 45.74	20	40.0%
45.74 – 58.8	14	28.0%

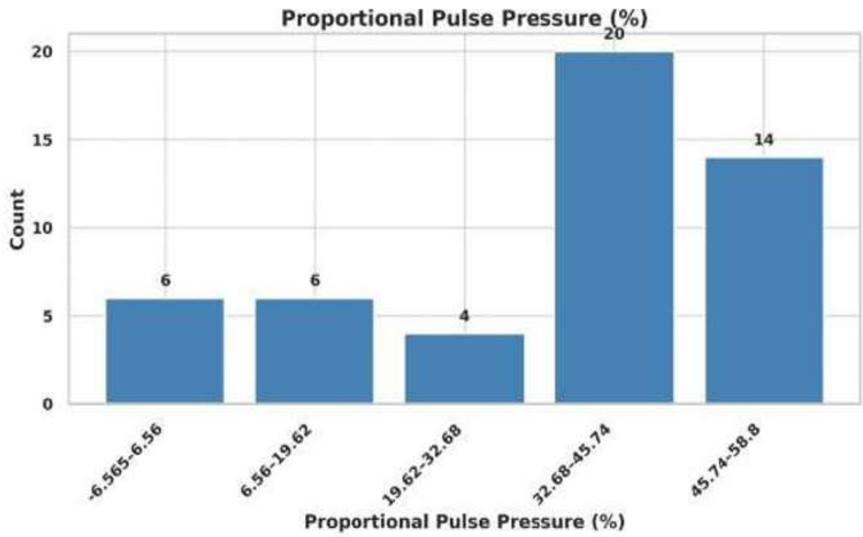

Figure 4.27: Graphical Representation of Proportional Pulse Pressure (%)

Table 4.28: LV Dysfunction Grade

Grade	Count	Percentage
Grade I (Impaired Relaxation)	13	26.0%
Grade 0 (Normal)	11	22.0%
Grade III (Restrictive)	10	20.0%
Grade II (Pseudonormal)	8	16.0%
Grade IV (Irreversibly Restrictive)	8	16.0%

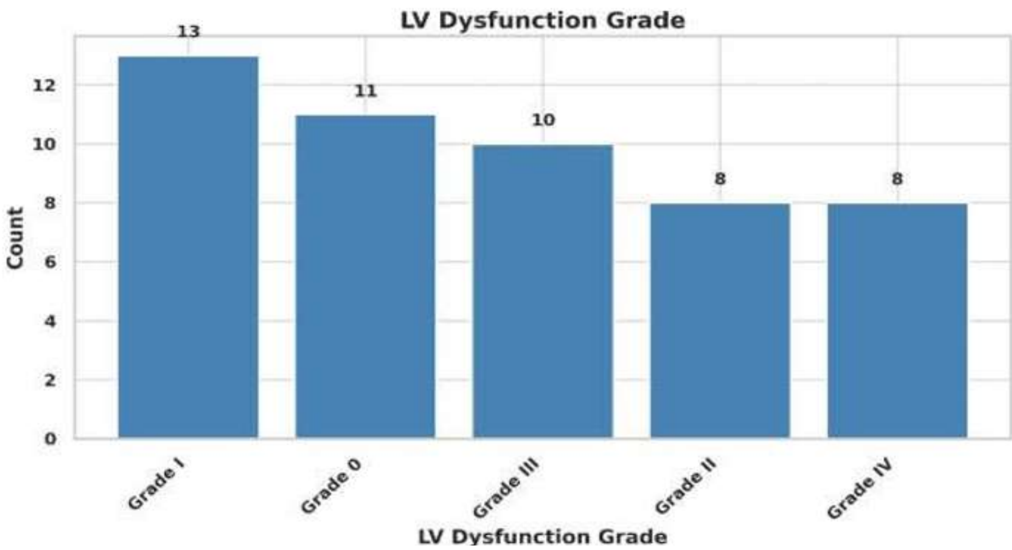

Figure 4.28: Graphical Representation of LV Dysfunction Grade

Table 4.29: PPP vs LV Dysfunction Grade (Count Table)

LV Dysfunction Grade	<10	10–20	20–30	30–40	40–50	50+
Grade 0 (Normal)	2	1	1	0	5	2
Grade I (Impaired Relaxation)	1	1	2	3	6	0
Grade II (Pseudonormal)	1	0	0	3	4	0
Grade III (Restrictive)	2	2	1	1	2	2
Grade IV (Irreversibly Restrictive)	2	0	0	0	3	3
p-value = 0.012						

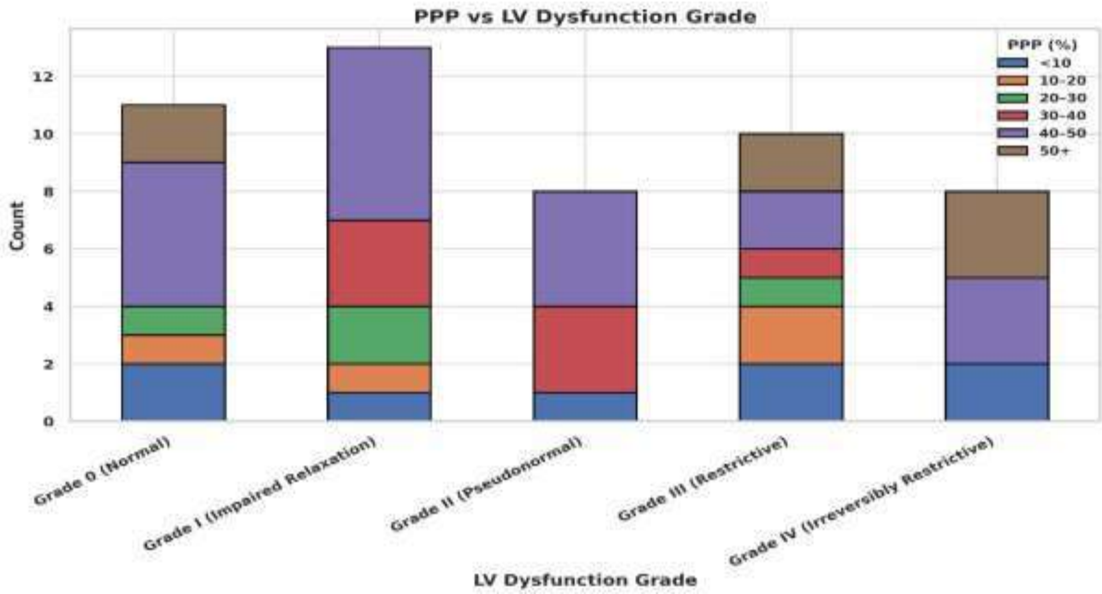

Figure 4.29: Graphical Representation of Figure PPP vs LV Dysfunction Grade (Count Table)

Discussion

Investigating the correlation between proportional pulse pressure (PPP) and the degree of left ventricular (LV) dysfunction in patients with heart failure (HF) was the main goal of this study. PPP's clinical utility as a non-invasive, hemodynamic marker of cardiac functional decline was supported by the data collection and analysis, which showed a significant inverse relationship between PPP and left ventricular ejection fraction (LVEF) (7).

Significantly lower mean pulse pressures were observed in patients with more advanced LV systolic dysfunction; this pattern is consistent with previous findings by Echouffo-Tcheugui et al. (2016) (2). Their research highlighted the relevance of low pulse pressure in the progression from latent LV dysfunction to symptomatic HF and found it to be a good indicator of reduced stroke volume. This physiological explanation is still in line with our findings, which support the diagnostic use of PPP by showing that a constricted PP is a result of a decreased stroke volume in damaged hearts.

The findings are similarly consistent with other study (8), who demonstrated that the interaction of arterial stiffness and systemic vascular resistance causes both wider and narrowed pulse pressure variations in HF patients. The focus on proportional pulse pressure (PPP), which is determined as the ratio of PP to systolic blood pressure, takes baseline hemodynamic variability into account and provides a more precise measure of ventricular performance than their more general use of absolute pulse pressure. Because of this adjustment, PPP may be a more reliable indicator across different BP ranges (9).

The study population's epidemiological features mostly mirror those reported by Groenewegen et al. (2020) (4), who highlighted the rising incidence of heart failure in the elderly, which is frequently made worse by co-occurring ischemic heart disease and hypertension. In line with previous researchs (10), which emphasized the critical role that persistent hypertension plays in causing and exacerbating LV systolic dysfunction, our group likewise showed a significant rate of hypertension (11).

Standard echocardiographic cut-offs for ejection fraction were used to stratify patients into mild, moderate, and severe LV dysfunction, following accepted recommendations akin to those put forth by Maddox et al. in the 2024 ACC Expert Consensus Document (12). The findings support the notion that PPP decreases in proportion to the severity of systolic dysfunction. There is a high correlation between LV dysfunction grades and proportional pulse pressure, as indicated by the statistically significant p-value (0.012). Given that decreased ventricular contractility reduces stroke volume and modifies vascular compliance, this link makes physiological sense (13).

Although our study did not differentiate between different subtypes of cardiomyopathy, previous research has demonstrated that the hemodynamic implications of dilated and hypertrophic cardiomyopathies differ, with both conditions having different effects on pressure parameters (8). These results imply that PPP might be used as a more comprehensive indicator of ventricular mechanical problems, expanding its use beyond simple ejection fraction analysis. Wang et al. (2003) (14), who promoted the early diagnosis of subclinical cardiac dysfunction using readily available diagnostic markers, also endorse the practical use of PPP as a screening and prognostic tool. The findings support this strategy, confirming that PPP which is generated from routine blood pressure readings offers an affordable and practical choice for preliminary assessment, especially in environments with restricted access to sophisticated imaging (15).

Conclusion

This study shows that the degree of left ventricular (LV) systolic dysfunction in heart failure patients is inversely correlated with proportional pulse pressure (PPP). PPP exhibits potential as a useful tool for early identification, severity assessment, and monitoring of heart failure because it is a straightforward, non-invasive, and economical measure. PPP can be used as an initial screening signal to identify patients at risk of severe cardiac dysfunction and enable prompt referral for additional investigation in areas with limited resources where echocardiography may not be easily accessible. To confirm these results and investigate the incorporation of PPP into standard clinical decision-making for better heart failure management, bigger, multi-center populations are required for future research.

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