

ORIGINAL ARTICLE

Prognostic Significance of Inferior Vena Caval Diameter in Patients with Chronic Heart Failure

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Abstract

Background: Heart failure is a major public health problem with rising prevalence and accounts for a substantial number of OPD and emergency visits. Despite advances in pharmacotherapy and various devices being added to the armamentarium in managing heart failure the mortality continue to remain high. Therefore, we seek to find an easy bedside tool for risk stratification and prognostication of patients suffering from chronic heart failure for identifying patients with high risk and tailoring appropriate therapy for better outcome.

Methods: Consecutive patients, clinically diagnosed as heart failure supported by objective evidence of cardiac dysfunction: either a LVEF < 45% or LA dilatation, or both was studied to find out the etiologies, symptoms and signs, derangement of laboratory parameters and echocardiographic findings including IVC diameter and was followed up for six months at monthly intervals.

Results: A prospective observational study was performed on 62 patients. Majority of heart failure occurred in the age group of 51 to 60 years. Acute coronary events, infections, arrhythmias were the commonest precipitating factors. An increase in LVIDD, LA diameter, LA volume index was significantly associated with increase in mortality ($p=0.002$, $p=0.034$, $p=0.011$ respectively). An increase in IVC diameter was found to be significantly associated with increased mortality ($P=0.001$)

Conclusion: In a country with limited resources like India, inferior vena caval diameter, as a surrogate marker of congestion, may prove to be a cost effective way in predicting and prognosticating patients with heart failure.

Introduction

Heart failure is a growing problem with over 20 million people affected worldwide with an estimated prevalence of 2 % in developed nations, rising with age and affects 6-10% of people over age 65 with males affected more than females.¹

The estimated prevalence of HF in India due to coronary artery disease, hypertension, obesity, diabetes and Rheumatic Heart Disease (RHD) alone in 2000 ranged from 1.3 million to 4.6 million, with an annual incidence ranging from 491 600 to 1.8 million. Both estimates are projected to rise and does not account for other important causes of HF such as alcoholic, familial, hypertrophic and idiopathic dilated

cardiomyopathies, pericardial disease and endomyocardial fibrosis.²

Previous studies found inferior vena cava ultrasound to be a rapid, reliable means for identification of CHF in the acutely dyspnoeic patient.³

The aim of our study was to assess the relation between inferior vena cava (IVC) diameter, clinical variables, and outcome regarding number of emergency visits, hospitalization and mortality in patients with chronic heart failure (CHF).

Methods

The study was an observational, descriptive longitudinal study conducted in the Department of Cardiology, R.G. Kar Medical College and Hospital, Kolkata. All patients attending OPD and Indoor of Department of Cardiology, R.G. Kar Medical College and Hospital during the period of data collection, clinically diagnosed as Heart Failure supported by objective evidence of cardiac dysfunction: either a LVEF < 45% or LA dilatation (> 4 cm diameter in the parasternal long axis), or combination of both, and gave informed consent constituted the study population. A total of 62 patients were included in the study. Purposive sampling was done and all the 62 subjects, was prospectively recruited for the study during the stipulated time period and followed up for 6 months.

A detailed history, general survey and physical examination with especial emphasis on the cardiovascular system were performed. Routine blood examination and echocardiography was performed to note for chamber dimensions, regional wall motion abnormalities, left atrial volume index, ejection fraction, valvular regurgitations and IVC diameter and its respiratory variations. Other echocardiographic abnormalities, if any, were also noted. The mean IVC diameter was considered in the study.

The patients were followed up every month for 6 months including emergency visits and hospital readmissions. At each visit the complaints, if any, was noted, detailed general survey and physical examination was performed the medications reviewed. The routine

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Table 1: Distribution of study subjects by their age and sex

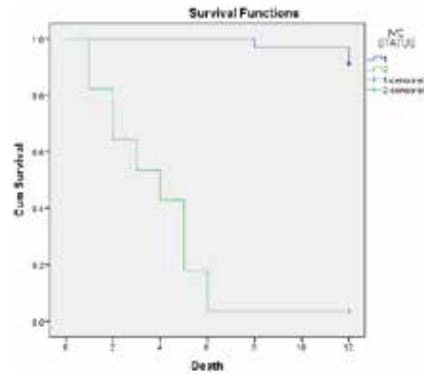
Age in years	Patients		Total No. (%)
	Male No. (%)	Female No. (%)	
21-30	0	1.6	1.6
31-40	8.1	1.6	9.7
41-50	16.1	9.7	25.8
51-60	11.3	16.1	27.4
61-70	9.7	11.3	21
71-80	8.1	6.4	14.5
Total	53.3	46.7	100

blood parameters were repeated and echocardiography performed. The medications were optimised if necessary. Patients requiring emergency visits and hospital readmissions were followed up closely. Only those patients who could be followed up for 6 months or those who expired during the study period were included. Patients who were lost to follow-up were excluded. The data collected was summarised. The results were then analysed in Microsoft Excel (2016), R and IBM-SPSS (v20). Survival analysis including Kaplan Meier, Log Rank (Mantel Cox), log survival distribution function, Hazard Function, Receiver-operating Characteristic curves and Cox Regression models were used and the sensitivity, specificity and level of significance (p value) of the parameters studied were calculated.

Results

In the study population 33 patients were male and 29 were female. A total of 17 patients were in the age range of 51 to 60 years, followed by 16 patients in the age range of 41 to 50 years. Thus, in this study, the incidence of heart failure increases with advancing age, peaking in the age group of 51 – 60 yrs., and then decreasing over time.

Infection precipitating an acute coronary syndrome was the dominant cause of heart failure at the time of first presentation, followed by infection and acute coronary syndrome alone. The other precipitating causes included infections with arrhythmias. 34 patients were known diabetics, 31 were hypertensive and 3 had RHD (Rheumatic Heart Disease). 20 patients had past history NSTEMI-ACS (Non-ST Elevation – Acute Coronary Syndrome), 6 had STEMI (ST-Elevation Myocardial Infarction), 5 CSA (Chronic Stable Angina), 3 patients had undergone PTCA (Percutaneous Transluminal



Patients with a IVC diameter of more than 21 mm (green line) had a significantly higher mortality than those with a IVC diameter of < 21 mm (blue line).

Fig 1: Kaplan Meier survival analysis: Survival function at 1 year

Coronary Angioplasty) and 1 CABG (Coronary Artery Bypass Grafting). 4 patients had hypothyroidism, 2 hyperthyroidism, 6 had COPD (Chronic Obstructive Pulmonary Disease), 2 had asthma and 2 CKD (Chronic Kidney Disease). One patient had peripartum cardiomyopathy. Majority of the male patients were smokers (n=25). The other common addictions were chewing tobacco (n=8) and alcohol (n=7). Among the patients in the study 36 patients were overweight, 24 had normal weight and 2 were obese.

The mean IVC diameter in the study population was 21.33 mm with a standard deviation of 2.22 mm at the time of presentation. Survival analysis showed that an increased IVC diameter was associated with significantly increased mortality from heart failure (p=0.001). Patients with a IVC diameter of more than 21 mm (green line) had a significantly higher mortality than those with a IVC diameter of < 21 mm (blue line) (Figure 1).

The area under curve for Left Ventricular Internal Diameter in Diastole (LVIDD) was 0.0726 (0.6 to 0.85 at 95% CI), LA diameter 0.94 (0.89 to 1.00 at 95% CI), LA volume Index 0.93 (0.87 to 1.00 at 95% CI) and that of IVC diameter was 0.992 (0.87 to 1.00 at 95% CI (Figure 2).

The area under curve for Left Ventricular Ejection Fraction (LVEF) was 0.909 (0.83 to 0.98 at 95% CI) whereas that of TAPSE was 0.901 (0.82 to 0.99 at 95% CI) (Figure 3).

By 5 months 23 patients died of which 5 patients died at 1 month, 5 at 2 months, 3 at 3 months, 3 at 4 months,

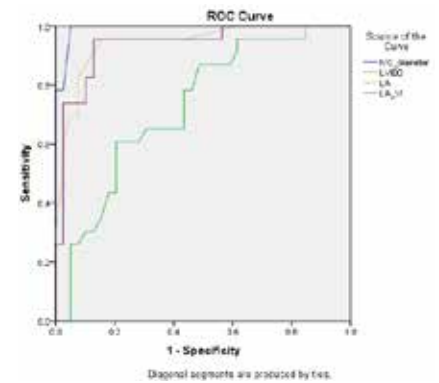


Fig. 2: Receiver-operating characteristic curves comparing the Echocardiographic parameters of LVIDD, LA diameter, Left atrial volume index and IVC diameter at 6 months for cardiovascular death

7 at 5 months and 4 patients after 6 months.

Cox regression analysis of patients suffering from heart failure who had to make a unscheduled OPD visit or required readmission for ACS, infections and arrhythmias had an increased IVC diameter had a significantly increased event rate (p = 0.019 for ACS, p = 0.004 for infections and p = 0.047 for arrhythmias) than those with a lesser IVC diameter.

Log rank survival analysis showed that a decreased haemoglobin and albumin level was associated with significantly increased mortality in patients with heart failure (p= 0.007 and 0.028 respectively). Log rank survival analysis showed that increased serum creatinine, bilirubin, cholesterol was associated with a significantly increased risk of events (p= 0.004 for bilirubin, p = 0.028 for bilirubin, p = 0.043).

Discussion

The study demonstrates a male preponderance in patients with heart failure. The incidence of heart failure peaked in the age range of 51 – 60 years, and then gradually decreasing with passing years due to increased death rate. Acute coronary events, infections, arrhythmias were the commonest precipitating factors for the first visit with heart failure. A vast majority of the patients were smokers or addicted to tobacco. 61.3% of the study population was either overweight or obese.

The higher risk for AMI in South Asians in their younger age is largely determined by the higher levels of risk

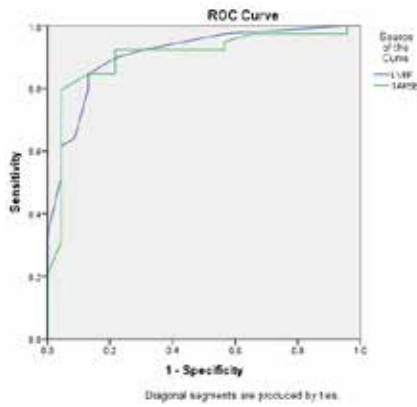


Fig. 3: Receiver-operating characteristic curves comparing LVEF and TAPSE as predictors of prognosis at 6 months for survival

factors and the nine conventional risk factors (abnormal lipids, smoking, hypertension, diabetes, abdominal obesity, psychosocial factors, consumption of fruits and vegetables, alcohol and regular physical activity) collectively explain 86 per cent of the AMI risk in south Asians. Regular alcohol consumption is not protective for AMI in south Asians.⁴

The Kaplan Meier survival function at 1 year show significant divergence in the plot between those having a IVC diameter of <21mm and those having a IVC diameter of >21 mm respectively. The ROC curve of the echocardiographic parameters show that IVC diameter is exquisitely sensitive in predicting future cardiac events (AUC 0.992).

Pellicori et al (2013) found a strong relation between IVC diameter and plasma NT-proBNP levels and that, IVC diameter was a strong predictor of prognosis, providing information similar to NT-proBNP (widely considered to be one of the most robust prognostic markers in patients with HF). The IVC diameter was found to be related to many features of congestion, including clinical signs, decreasing albumin, and renal and hepatic dysfunction.⁵

Infections, acute coronary events, arrhythmias and angina were the most frequent causes of hospital readmissions or emergency visits. Cox regression analysis showed that IVC diameter can predict and prognosticate patients with heart failure suffering from common precipitating factors necessitating rehospitalisation / emergency hospital visits like acute coronary events,

infections, angina or arrhythmias.

Worsening HF as the sole reason for readmission was reported most often.⁶ Hospitalization for HF (HHF) patients have a very high post-discharge mortality and rehospitalisation rate that has not improved in the last 2 decades despite all the available therapies. In-hospital mortality for HHF is 2% to 7%, but as high as 20% in patients with severe renal impairment and/or low systolic blood pressure (representing 2% to 5% of all HHF patients).⁷ Precipitants for HHF include cardiac factors such as myocardial ischemia, atrial fibrillation, and uncontrolled hypertension; non-cardiac factors, such as exacerbation of COPD and infections, patient-related factors, such as medication nonadherence etc.⁷

LVIDD and Left ventricular end diastolic volume was increased in 52% and 87% of patients respectively. The left atrial diameter and left atrial volume index was increased in 18% and 29% of the patients respectively. TAPSE was found to be impaired in 72.6% of patients. An increase in LVIDD, LA diameter, LA volume index (LAVi) was significantly associated with increase in mortality ($p=0.002$, $p=0.034$, $p=0.011$ respectively). A decline in LVEF or TAPSE was found to be associated with significantly increased mortality ($p=0.01$ and $P=0.039$ respectively).

In our study, progressive decline in renal function as evidenced by rising serum creatinine levels portends a bad outcome ($p=0.004$). Development of hypoalbuminemia and anaemia during the follow-up period carried a significantly high mortality risk ($p = 0.007$ and 0.005 respectively). Analysis of the ROC curves showed anaemia and hypoalbuminemia had a fairly high sensitivity for predicting future cardiac events. Development or progression of hyperbilirubinemia during the follow-up period carried a significantly high mortality risk ($p=0.028$). High Cholesterol levels were associated with only a modest increase in risk of mortality. Analysis of the ROC curves showed serum creatinine and bilirubin levels had a high sensitivity for predicting future cardiac events.

Thus IVC diameter could predict survival in patients with heart failure suffering from common precipitating factors necessitating rehospitalisation / emergency hospital visits like acute

coronary events, infections, angina or arrhythmias.

Conclusions

The peak incidence of heart failure occurs at an earlier age in our study population. Majority of patients with heart failure suffer from diabetes, hypertension or ischemic heart disease. Inferior vena caval diameter measured by echocardiography can be considered as a surrogate marker for congestion and an increase IVC diameter is associated with significantly high mortality. The ROC curve show that IVC diameter measured by echocardiography is exquisitely sensitive in predicting future cardiac events in patients with heart failure.

Among the other echocardiographic parameters changes in LVIDD, LA diameter, left atrial volume index, TAPSE and ejection fraction are also useful in predicting future cardiac events in patients with heart failure. Progressive decline in renal or liver function portend to a worse prognosis. Amongst the blood parameters, a rise in serum creatinine or total bilirubin levels was significantly associated with increased mortality as was the decline in albumin and haemoglobin levels. The common causes of hospital readmissions or emergency visits include infections, acute coronary events, arrhythmias or angina. IVC diameter can predict and prognosticate patients with chronic heart failure suffering from these common precipitating factors. Thus in a country with limited resources like India, inferior vena caval diameter, as a surrogate marker of congestion, may prove to be a cost effective way in predicting and prognosticating patients with chronic heart failure.

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