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Original Article

Bed-side inferior vena cava diameter and mean arterial pressure predict long-term mortality in hospitalized patients with heart failure: 36 months of follow-up

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ABSTRACT

Background: In discharged patients with heart failure (HF), diverse conditions can intervene to worsen outcome. We would investigate whether such factors present on hospital admission can affect long-term mortality in subjects hospitalized for acute HF.

Methods: One hundred twenty-three consecutive patients hospitalized for acute HF (mean age 74.8 years; 57% female) were recruited and followed for 36 months after hospitalization.

Results: At multivariate Cox model, only inferior vena cava (IVC) diameter and mean arterial pressure (MAP) registered bed-side on admission, resulted, after correction for all confounders factors, the sole factors significantly associated with a higher risk of all-cause mortality in long-term (HR 1.06, $p = 0.0057$; HR 0.97, $p = 0.0218$; respectively). Study population was subdivided according to median values of IVC diameter (23 mm) and MAP (93.3 mm Hg). The Kaplan–Meier curve showed that HF patients with both IVC ≥ 23 mm and MAP <93.3 mm Hg on admission had reduced probability of survival free from all-cause death (log rank $p = 0.0070$ and log rank $p = 0.0028$, respectively).

Conclusions: In patients hospitalized for acute HF, IVC diameter, measured by hand-carried ultrasound (HCU), and MAP detected on admission are strong predictors of long-term all-cause mortality. The data suggest the need for a careful clinical-therapeutic surveillance on these patients during the post-discharge period. IVC diameter and MAP can be utilized as parameters to stratify prognosis on admission and to be supervised during follow-up.

1. Introduction

Heart failure (HF) is a major public health problem currently responsible for a considerable number of deaths and hospitalizations. Despite modern therapeutic advances, HF mortality remains still high in the community with 50% of people who die within 5 years from diagnosis [1]. Therefore, survival improvements require a better understanding of the factors that may adversely impact outcome at identifying which patients are candidates to a strict clinical–therapeutic follow-up. Many factors, including intrinsic those related to cardiac disease and such comorbidities, must be taken into account to assess their real impact on outcome [2]. In this study, we would investigate what factors present on hospital admission, may influence long-term mortality in a real cohort of patients discharged as diagnosis of acute HF.

2. Methods

2.1. Patient population

Between January 2012 and December 2012, consecutive patients admitted with acute HF to Department of Internal Medicine at University Hospital of Palermo and discharged alive were prospectively enrolled. Written informed consent was obtained and the study was approved by the local institutional review board. The investigation was conducted according to the Declaration of Helsinki. Eligibility criteria on admission included the following: symptoms of HF according to the criteria commonly accepted in the literature [3]; NYHA functional classes III or IV, with an acute exacerbation of symptoms of at least 1 class; evidence of systolic or diastolic dysfunction by echocardiography. Exclusion criteria included acute myocardial infarction or myocardial infarction within 3 months, unstable angina, pulmonary embolism, pneumonia,

Abbreviations: BUN, Blood urea nitrogen; DBP, Diastolic blood pressure; HF, Heart failure; GFR, Glomerular filtration rate; IVC, Inferior vena cava; LVEF, Left ventricular ejection fraction; MAP, Mean arterial pressure; NYHA, New York Heart Association; SBP, Systolic blood pressure.

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or other severe pulmonary disease, end-stage renal disease specified as a glomerular filtration rate (GFR) < 15 mL per minute per 1.73 m^2 for three months or more, neoplastic diseases.

At admission, all patients underwent medical history questionnaire, clinic visit, laboratory tests, and mean arterial pressure which was calculated using the formula [(systolic blood pressure) + (2 diastolic blood pressure)]/3.

In all patients, a bed-side evaluation of inferior vena cava (IVC) diameter, to rapidly estimate volume status, was performed at admission by an expert sonographer with a previous training in echocardiography, using a multi-functional hand-carried ultrasound (HCU) (machine S6, SonoScape, China). IVC images were obtained from an anterior trans-abdominal, sub-costal approach, using an abdominal convex probe (3–5 Mhz). The transverse diameter of the IVC was measured anterior to posterior at 2.0 cm from the IVC right atrial junction with the use of electronic callipers. Measurements were taken using M-mode at maximum diameter during expiration [4].

Within the first 72 h from hospitalization, patients underwent a complete echocardiogram.

2.2. Comorbidities evaluation

Standard criteria were used for demographic variables, medical history, and clinical examination. Specifically, patients were diagnosed as having a history of hypertension, if they had evidence of systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg or if they received any antihypertensive medication at time of hospital admission. Diabetes mellitus (DM) was specified as fasting serum glucose ≥126 mg/dl or serum glucose ≥200 mg/dl at 2 h following a 75 g oral glucose tolerance test or use of antidiabetic therapy. Smoking status was defined as current use. Chronic kidney disease was specified as a glomerular filtration rate (GFR) < 60 mL per minute per 1.73 m^2 according to the four-variable MDRD formula: 186.3 × creatinine–1.154 × age–0.203 × 1.212 (if black) × 0.742 (if female) [5], for 3 months or more with or without kidney damage; or GFR ≥60 mL per minute per 1.73 m^2 according to the four-variable MDRD formula, for 3 months or more, with kidney damage. Anaemia was specified as haemoglobin <13 g/dl in woman and <12 g/dl in man. Metabolic syndrome (MetS) was defined as having a cluster of at least 3 of the following characteristics: elevated fasting glucose ≥100 mg/dL or taking medications for elevated glucose; abdominal obesity, given as waist circumference: males >102 cm, females >88 cm; elevated triglycerides ≥150 mg/dL; reduced HDL-C (high-density lipoprotein cholesterol) < 40 mg/dL in males, and <50 mg/dL in females; elevated blood systolic (≥130 mmHg) and/or diastolic (≥85 mmHg) pressure or antihypertensive drug treatment in a patient with a history of hypertension. History of atherosclerosis was defined as documented presence of atherosclerotic plaques in aorta or in the supra-aortic, coronary or legs' arteries.

2.3. Follow-up and clinical endpoint

After discharge, patients were treated by their primary physicians. Survival status was assessed by telephone contact with patients, family members, and patients' physicians, and also verified by hospital charts. The endpoint of the present study was defined as all-causes death occurred during the 36 months of follow-up.

3. Statistical analysis

Data were collected with a predefined pro-forma. Continuous variables were summarized as mean ± standard deviation and categorical variables as frequency and percentage. Associations between variables and outcome during 36 months follow-up were assessed with univariate and multivariate Cox proportional hazards models. Hazard ratio (HR) and 95% CI were calculated for the strength of association and adjusted for the potential confounders. Receiver-operating characteristic (ROC) curves were used to compare the independent predictors of mortality. Median values of the independent predictors of mortality were used to subdivide patient population in subgroups. Simple and multiple linear regression model were used to identify variables associated with independent predictors of mortality. In the bivariate analysis, survival curves and rates were estimated by the Kaplan–Meier method and compared using the log rank test. A p value < 0.05 was considered statistically significant. Statistical analyses were performed using MedCalc software (Version 14.12, Belgium).

4. Results

A total of 179 patients (pts) were recruited. 56 patients were lost during follow-up and were not included in the analysis. One hundred twenty-three patients were analysed and their clinical end laboratory features are reported in Table 1. The mean age was 74.8 years and 57% of the population (70 pts) was female. Fifty-one per cent (63 pts) had a left ventricular ejection fraction (LVEF) ≥ 50%, 61.8% (76 pts) was in NYHA class III on admission, and 90% (111 pts) in NYHA class II on

Table 1
Medical history, demographic, laboratory, and clinical characteristics of the study population (heart failure patients) to admission in our hospital.

Characteristics		HF patients n.123
Males	n (%)	53 (43%)
Mean age		74 ± 9.9
Atrial fibrillation	n (%)	75 (60.9%)
Central obesity •	n (%)	60 (48.8%)
Chronic kidney disease	n (%)	73 (59.3%)
Chronic obstructive pulmonary disease	n (%)	60 (48.8%)
Chronic ischemic heart disease	n (%)	66 (53.6%)
Current smoking	n (%)	43 (34.9%)
DBP	mmHg	73 ± 13
Diabetes	n (%)	74 (60.2%)
History of atherosclerosis	n (%)	74 (60.2%)
Hypertension	n (%)	109 (88.6%)
Ischemic cerebrovascular disease	n (%)	39 (31.7%)
IVC diameter	(mm)	23.6 ± 5.8
MAP	mmHg	92.6 ± 14
Mean LVEF	%	46.7 ± 14
Metabolic syndrome	n (%)	65 (52.8%)
NYHA class III	n (%)	47 (38.2%)
NYHA class IV	n (%)	76 (61.8%)
Preserved* LVEF	n (%)	63 (51%)
Valve disease	n (%)	117 (95%)
SBP	mmHg	131 ± 22
BUN	(mg/dl)	38 ± 24
Creatinine	(mg/dl)	1.57 ± 0.89
GFR	ml/min/1.73 m^2	49 ± 26
Haemoglobin	(g/dl)	11.5 ± 2
HDL-C	(mg/dl)	46 ± 23
Serum potassium level	(mEq/l)	4.4 ± 0.74
LDL-C	(mg/dl)	76 ± 29
Serum sodium level	(mEq/l)	138 ± 5
Triglycerides	(mg/dl)	96 ± 48
Total-cholesterol	(mg/dl)	136 ± 37
ACEIs	n (%)	42 (33.3%)
Aldosterone antagonists	n (%)	15 (12%)
Antiaggregants	n (%)	54 (44%)
Anticoagulants	n (%)	45 (36.6%)
ARBs	n (%)	34 (27.6%)
β-blockers	n (%)	59 (48%)
Digoxin	n (%)	22 (17,8%)
Furosemide	n (%)	108 (87.8%)
Average dose of furosemide	mg	174 ± 170
Statins	n (%)	50 (40.6%)

Abbreviations and acronyms: ACEIs = angiotensin-converting enzyme inhibitors; ARBs = angiotensin receptors blockers; BUN = blood urea nitrogen; Central obesity • = waist circumference ≥ 102 cm in man and ≥88 cm in woman; DBP = diastolic blood pressure; HDL-C = high-density lipoprotein cholesterol; GFR = glomerular filtration rate; IVC = inferior vena cava; LDL-C = low-density lipoprotein cholesterol; LVEF = left ventricular ejection fraction; MAP = mean arterial pressure; NYHA = New York Heart Association; SBP: systolic blood pressure; T-C = total cholesterol; *preserved LVEF = LVEF ≥ 50%.