International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.12 No.02, pp 58-63, 2019

Correlation of Proportional Pulse Pressure and Cardiac Index in Patients with Acute Heart Failure in Emergency Department of Adam Malik Hospital

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Abstract : Background: Clinical condition and physical examination are the most important things to diagnose heart failure. The importance of a physical examination to assess decreased cardiac output and cardiac index has been reduced as a result of the development of sophisticated diagnostic tools. Nowadays, cardiac output can be measured using transthoracic echocardiography. However, echocardiography is not easily available particularly in rural area in Indonesia. Therefore, an easier and more applicable examination through a simple physical examination is needed to assess cardiac index and cardiac output in acute heart failure.

Methods: This is a cross sectional study of 44 acute heart failure patients in emergency department Adam Malik Hospital since April 2018 until September 2018. A routine physical examination, especially blood pressure, was carried out on all patients, then echocardiography was performed to measure stroke volume, cardiac output, and cardiac index. Pearson and spearman was performed to analyze the correlation of porportional pulse pressure and cardiac index.

Results: There was positive correlation between PPP and CI ($r=0.846$, $p<0.001$). Proportional pulse pressure also correlated with CO ($r=0.777$, $p<0.001$), EF ($r=0.608$, $p<0.001$), and SVR ($r= -0.337$, $p=0.025$). The cut off value of PPP < 27.4% was 95.5% sensitive and 90.1% specific to identify patients with CI <2.2.

Conclusion : There was a strong correlation between proportional pulse pressure and cardiac index in patients with acute heart failure.

Keyword : proportional pulse pressure, cardiac index, acute heart failure.

Introduction

Acute heart failure is one of a health issue with high mortality and morbidity.[1] The American Heart Association / American College of Cardiology defines heart failure as a clinical syndrome caused by all structural and functional disorders of the heart that interfere with the ventricular ability to fill or pump blood. This guideline highlights that clinical condition is important to diagnose acute heart failure.[2] In present time the focus in management of acute heart failure has changed from only evaluate clinical symptoms to evaluate hemodynamic performance including cardiac output, ejection fraction, and left ventricular volume. An

DOI= http://dx.doi.org/10.20902/IJCTR.2019.120208

objective, accurate and easy parameters to assess hemodynamic functions needed for evaluation and management of heart failure.[3]

The importance of a physical examination to assess hemodynamic has been decreased as a result of the development of sophisticated diagnostic tools, even though physical examination can provide an adequate information about hemodynamic.[4] Some non-invasive and less invasive methods have been developed in decades to measure cardiac index. One of them is transthoracic echocardiography that can measure cardiac output and cardiac index values. But currently not all health centre particularly in rural area has full diagnostic tools such as echocardiography. An easier and more applicable examination is needed to assess the value of cardiac output and cardiac index in acute heart failure patient.

Therefore the main objective of this study is to find out whether there is a relationship between proportional pulse pressure (PPP) and cardiac index (CI) in acute heart failure, so that it can be applied as a simple physical examination not only for diagnosis but also for the selection and evaluation of therapy.

Methods

This is a cross sectional study to identify the correlation of proportional pulse pressure and cardiac index. We study 44 acute heart failure patients in Emergency Department Adam Malik Hospital since April 2018 until September 2019. The inclusion criteria was acute heart failure patients. Patients with arrhythmia, valvular heart disease, congenital heart disease, poor echo window, and incomplete data was excluded.

We performed routine physical examination and vital signs measurement to all patients. We also took body height and weight data from all patients. The proportional pulse pressure is derived from blood pressure value. That is pulse pressure divided by systolic blood pressure in percentage. We performed bedside echocardiography to assess hemodynamic parameters. We measured stroke volume using left ventricular outflow tract (LVOT) diameter from parasternal axis view and using pulsed wave Doppler to assess velocity time integral (VTI) of the left ventricular outflow tract from apical five chamber view. Stroke volume was the multiplication between the value of LVOT area and LVOT VTI. Cardiac output value derived from stroke volume and heart rate. By comparing cardiac output with body surface area, we obtain the cardiac index value. Echocardiography examinations were performed using Medison Accuvix V 10 and Vivid S6 GE. The study protocol was approved by the local ethics committee.

All data were analyzed using SPSS software, version 19. The categorical variable is presented with the number or frequency (n) and percentage (%). The numerical variables are assigned with mean (mean) and standard deviation values for normally distributed data. Normality test in numerical variables of all subjects using one sample Saphyro Wilk with n<50. Cut off point of numerical data was obtained from ROC. Comparison between dependent variable and independent variable was assessed by Pearson or Spearman test. Statistical data analyzed using statistical software, $p < 0.05$ is considered to be statistically significant.

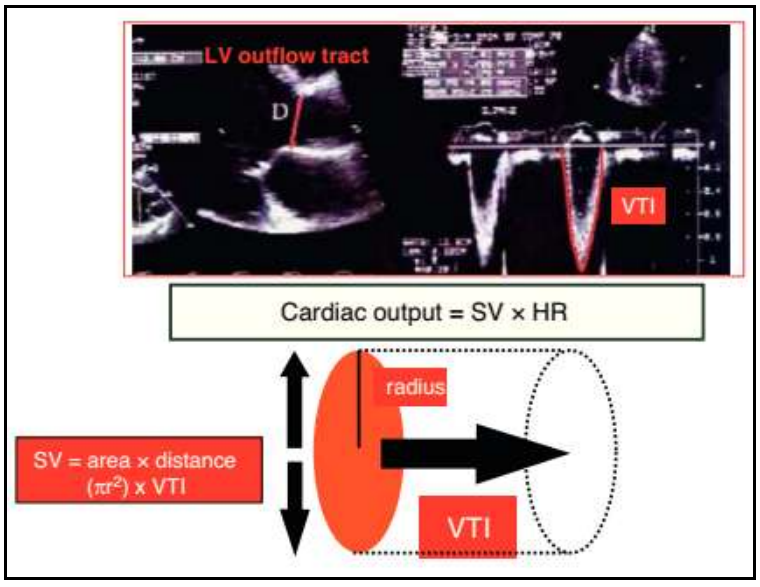

Figure 1. Calculation of cardiac output using echocardiography[5]

Results

A total of 44 patients were enrolled in this study. Most of the patients are male (79.5%) with mean age was 57 years old. Most patients came with acute coronary syndrome (61.4%). The mean value of PPP was 28.15%. On hemodynamic echocardiography examination, we found the mean value of LVOT diameter was 1.9 mm, and LVOT VTI was 12.78. We found the mean the stroke (SV) was 36.85 ± 9.1037 ml, the mean cardiac output (CO) was 3.44 ± 0.819, the mean of systemic vascular resistance (SVR) was 2122.5. The mean cardiac index value was found to be 2.017 ± 0.4773.

Table 1. Baseline Characteristics

Parameter	Value
Male	35 (79.5%)
Age	57.18±11.08
Body weight (kg)	67.27±9.51
Body Height (cm)	165 (150-173)
BMI	24,96±3,11
BSA	1,72±0,14
HR < 100 >100	19 (43.2%) 25 (56.8%)
Systolic Blood Pressure < 120 120 - 139 140 – 159 >160	 22 (50%) 7 (15.9%) 6 (13.6%) 9 (20.5%)
Diastolic Blood Pressure < 80 80 – 100 > 100	 8 (18.2%) 30 (68.2%) 6 (13.6%)
Hypertension Crisis	7 (15.9%)
Acute Coronary Syndrome	27 (61.4%)
Rales	44 (100%)
Diuretic	44 (100%)
Nitrate	23 (52.3%)
ACE-Inhibitor	37 (84.1%)
Inotropic	5 (11.4%)
Proportional Pulse Pressure (%)	28.15 (18-43)

Pearson correlation analysis between PPP and CI found a significant positive correlation with p <0.001 and coefficient r = 0.846 indicating high strength correlation. By using ROC curve, we could find the area under the curve (AUC) from PPP value showing CI in acute heart failure population. In this study, we found the AUC was 0.981 with P value < 0.001. It shows that PPP was significant as parameter to evaluate cardiac index in acute heart failure. The cut off point of < 27.4% shows cardiac index < 2.2 with 95.5% sensitivity and 90.1% specificity. We also correlate PPP with CO, EF, and SVR. We found that PPP showed positive correlation of high significance with CO (r=0.777, p < 0.001) and with EF (r=0.608, p<0.001). However, PPP has a weak negative correlation with SVR (r=-0.337, p=0.025) (Table 3).

Table 2. Baseline Characteristics of Echocardiography

Parameter	Value
LVEDD	56,41±4,421
LVESD	51 (41 – 59)
EF	36,22±8,037
IVSD	8 (6 – 13)

IVSS	11 (9 – 16)
LVOT	1.9 (1.7 – 2.2)
LVOT VTI	12.78 ± 0.136
RAP	9 (3-15)
SV (ml)	36.85 ± 9.1037
CO (L/min)	3.44 ± 0.819
CI (L/min/m^2)	2.017 ± 0.4773
SVR (dynes x s/cm^5)	2122.5 (1366-4222)

Table 3. Correlation PPP with CI, CO, EF, and SVR

Parameter	Correlation coefficient	P value
CI	0.846	<0.001
CO	0.777	<0.001
EF	0.608	<0.001
SVR	-0.337	0.025

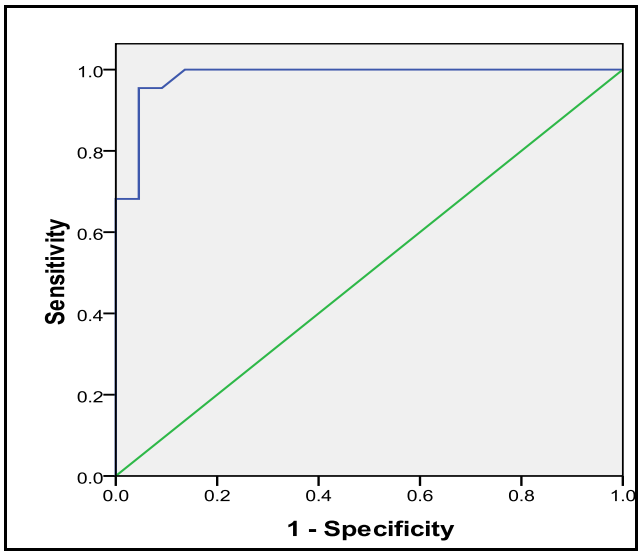

Figure 2. ROC curve of PPP

Discussion

In this study, mean right atrial pressure (RAP) was 9, the mean CO was 3.44 ± 0.819, the value of SVR was 2122.5, and the mean cardiac index value was found to be 2017 ± 0.4773. Similar results were found in 2001 study by Shah et al where the average RAP was 10 mmHg, the CO value was 3.8, and the mean CI value was found to be 2.1.[6] There is a difference with the results of the study by Petrie where it found that the average RAP was 11.6, the SVR value was 1546, and the mean CI value was found to be 2.35.[7] This might be caused by differences in body area between Asia and Europe, but in this study it was not explained. It may also be caused by the accuracy and aggressiveness of administration of therapy. In this study there was a heart defect value that was not in accordance with the diagnosis of acute heart failure, namely that there was a heart rate below 100 times per minute, it might affect the results and cause bias. Another thing that happened was that in this study the systolic and diastolic blood pressure values were initially not normally distributed. This might be due to the therapy that the patient had previously obtained, but was not listed in this study. Maybe in the next study multivariate analysis is needed to get rid of factors that can cause bias.

In this study we found a very strong positive correlation between PPP and CI with a correlation coefficient ($r = 0.846$, $p < 0.001$). This is consistent with several similar studies conducted in patients with acute heart failure. In 2017 Petrie said that in patients treated for acute heart failure, the cardiac index correlated

positively with PPP, when PPP increased, the cardiac index increased or improved. In the study it was also stated that in patients with very low cardiac function, PPP had a very strong correlation with the cardiac index (r = 0.967).[7] Maeda in 2016 stated that in patients with PPP <39%, the use of inotropic agents tend to increase during follow-up indicating that PPP could be used as a determinant of management strategies.[8]

In this study PPP results with a cut off point <27.4% showed a heart index value <2.2 and ≥ 27.4 showed a heart index value> 2.2 with a sensitivity value of 95.5%, a specificity of 90.1%. In a small study in heart failure patients with a low ejection fraction it was reported that PPP <25% had a sensitivity and specificity of 91% and 83% to determine heart index ≤2.2 L / min / m2.[9]

There is a significant positive correlation between the value of PPP with CO and EF. Whereas SVR has a negative correlation with PPP. This is highly suspected because CO is a major factor in determining CI. Janani showed a positive correlation between PPP and EF in patients with chronic heart failure (r = 0.6676).[2] However, a study by Kawakami in the population of patients with acute decompensated heart failure showed that there was a positive correlation between PPP and EF, where subjects with PPP <40% had EF <37%. So that PPP can be used to estimate low EF at the initial evaluation in the emergency room.[10]

Study Limitation

This study comes from single medical center with a relative small number of patients. We correlate PPP with CI, we didn't correlate it with the gold standard examination using catheterization.

Conclusion

There was a strong correlation between proportional pulse pressure and cardiac index in patients with acute heart failure. Therefore, proportional pulse pressure is a simple parameter from routine physical examination to evaluate cardiac index in acute heart failure population that is easy and applicable in all clinical practice.

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