

Continuous Noninvasive Hemodynamic Monitoring in Decompensated Heart Failure

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Abstract

Background: The clinical and hemodynamic assessment at the bedside and the use of pulmonary artery catheter for the estimation of hemodynamic data have been used in decompensated heart failure. However, there are no data on the use of continuous noninvasive hemodynamic monitoring.

Objective: To compare the data obtained through noninvasive hemodynamic monitoring with invasive ones in patients with decompensated heart failure and refractory to treatment.

Methods: The non-invasive hemodynamic measurements were obtained through continuous monitoring of systemic blood pressure by the pulse wave model (Modelflow) and compared with measurements obtained by the passage of a pulmonary artery catheter, simultaneously.

Results: A total of 56 measurements were performed in 14 patients studied on different days and time periods. The correlation index between systolic blood pressure measurements was $r = 0.26$ (95% CI = 0.00 to 0.49, $p = 0.0492$) and diastolic ones, $r = 0.50$ (95% CI = 0.27 to 0.67, $p < 0.0001$). The correlation was $r = 0.55$ (95% CI = 0.34 to 0.71, $p < 0.0001$) for cardiac index and $r = 0.32$ (95% CI = 0.06 to 0.53, $p = 0.0178$) for systemic vascular resistance.

Conclusion: There was a correlation between the hemodynamic measurements when compared to noninvasive pulmonary artery catheter measurements. The continuous noninvasive hemodynamic monitoring may be useful for hospitalized patients with decompensated heart failure. (Arq Bras Cardiol 2012;99(3):843-847)

Keywords: Heart failure; blood pressure monitoring; Swan-Ganz catheter

Introduction

Decompensated heart failure in its most severe form requires prolonged hospitalization and use of intravenous medications, whether inotropic agents, vasodilators, or a combination of both¹. Loop diuretics are the main drugs used in the treatment of hypervolemia, as most decompensated patients also suffer from congestion symptoms. For the beginning of treatment, either in the emergency room or infirmary, clinical-hemodynamic classification at the bedside is the most often used one. According to the assessment of perfusion and congestion, patients are classified into the following profiles: A - "warm and dry"; B - "warm and wet;" C - "cold and wet", and L - "cold and dry." Thus, pharmacologic therapy is initiated according to clinical evaluation, by indirectly estimating hemodynamic data, such as cardiac index, systemic vascular resistance and pulmonary capillary wedge pressure (low, normal or high).

Patients refractory to treatment require continuous reassessments and very often remain in use of intravenous inotropic agents for more than five days². The assessment of perfusion and congestion through clinical observation is difficult and the recovery of hemodynamic data by means of objective measures could help establish the best conduct. The pulmonary artery catheter (Swan-Ganz), in addition to being an invasive method, is restricted to use in ICUs and is reserved for specific cases. The continuous noninvasive hemodynamic monitoring has the advantage of being an easily accessible, noninvasive method without complications, of which results can be obtained within minutes.

The objective of the present study was to compare the measurements obtained through noninvasive hemodynamic monitoring with invasive ones in decompensated patients refractory to treatment.

Methods

A total of 14 patients with decompensated heart failure, hospitalized from July 2010 to September 2011 at Hospital Auxiliar Cotoxó - HCFMUSP, Sao Paulo - SP were studied. All patients had the diagnosis established by clinical and hemodynamic assessment at admission and during follow-up. According to this criterion, the patients had profile B or C. After

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five days of dobutamine use without success at medication withdrawal, patients were included in the study.

The noninvasive hemodynamic measurements were obtained through continuous monitoring of systemic blood pressure by pulse wave model - Modelflow - (BMEYE, Nexfin HD, Amsterdam, The Netherlands)³. The cuff positioned in the patient's middle finger calculates cardiac output and systemic vascular resistance beat by beat and the data are displayed directly on the monitor, without the need for conversion or calculations. The same screen shows the cardiac index and the charts of the means of obtained measurements. At any time, new calculations can be made or one can select the ideal time for the obtained means to be shown again. The method involves the development of pulse waves generated by the finger arterial wall through cuff filling using photoelectric plethysmography. While the blood pressure measurement is continuously obtained, the monitor calculates the cardiac output. This method was described in detail by Wilde et al.⁴.

The passage of the Swan-Ganz catheter and measurements obtained through it followed the established recommendations⁵ and the values were compared at the same time with the values obtained by continuous noninvasive hemodynamic monitoring.

For the measurements obtained through the Swan-Ganz catheter, we used the cardiac output module (DX-AJDEC-0)-compatible with the Dixtal® monitor, model DX 2023 using the thermodilution method. Seven consecutive measurements of cardiac output were carried out in each analysis; the mean value was calculated and used for the statistical analysis. At this point, the other hemodynamic variables were recorded. At the same time the invasive measurements were performed, the noninvasive measurements were continuously acquired through the noninvasive monitor positioned next to the patient. Thus, both measurements were taken simultaneously.

Statistical analysis

The results were tabulated and analyzed using the software Microsoft® Excel 2007 (Microsoft Corporation, Seattle, WA, USA). The software used for statistical analysis was BioEstat release 5.0⁶. The methods were compared by Pearson's linear coefficient of correlation. The level of significance was set at $p < 0.05$.

Results

The study included 14 male patients, evaluated by continuous noninvasive hemodynamic monitoring and pulmonary artery catheter. Mean age was 52 ± 10 years, mean systolic blood pressure was 100 ± 15 mmHg, mean diastolic blood pressure was 66 ± 11 mmHg and patients received dobutamine at a mean dose of 7.9 ± 3.8 mcg/ kg/ min. Regarding hemodynamic variables: cardiac index of 2.99 ± 0.43 L/min, systemic vascular resistance of $1,720 \pm 455$ dynes/sec.cm-5.m-2 and pulmonary capillary wedge pressure of 27.9 ± 10.7 mmHg.

A total of 56 hemodynamic measurements were obtained by continuous noninvasive hemodynamic monitoring (Figure 1) and, in parallel, 56 measurements by invasive monitoring during the five-day follow-up, with each patient being assessed four times.

The correlation index between systolic blood pressure measurements was $r = 0.26$ (95% CI = 0.00 to 0.49, $p = 0.0492$) and for diastolic blood pressure, $r = 0.50$ (95% CI = 0.27 to 0.67, $p < 0.0001$). The correlation was $r = 0.55$ (95% CI = 0.34 to 0.71, $p < 0.0001$) for cardiac index and $r = 0.32$ (95% CI = 0.06 to 0.53, $p = 0.0178$) for systemic vascular resistance. The charts are shown in Figures 2 and 3.

Discussion

The use of the hemodynamics at the bedside for the treatment of decompensated heart failure is critical to decision-making that will allow the patient's clinical compensation in as little time as possible⁷. A wrong decision can compromise treatment or prolong hospital stay.

Since the publication of Nohria et al.⁷, the clinical-hemodynamic correlation at the bedside has been based on clinical evaluation of the patient in two minutes, using as parameters of perfusion mainly the blood pressure and of congestion, jugular stasis and dyspnea. However, chronic patients with multiple decompensation episodes a year present at the time of admission use of high doses of medications such as beta-blockers and angiotensin-converting enzyme inhibitors, while maintaining low blood pressure and, sometimes, with chronic congestion, with no crackles at the initial examination and lower-limb edema maintained by venous stasis, which complicates the clinical assessment. Depending on the duration of hospital stay, such signs become increasingly more difficult to analyze.

This study proposes to correlate data obtained through continuous noninvasive hemodynamic monitoring with data from the pulmonary artery catheter, a method that has been long accepted and studied. It is estimated that 50% of hospitalized patients with clinical diagnosis of heart failure have preserved ejection fraction⁸. Considering that, the estimate of hemodynamic data through clinical evaluation is probably not reliable.

In recent studies, the use of continuous noninvasive hemodynamic monitoring has been used in the evaluation of acutely decompensated patients.

Nowak et al.⁹ studied the use of this method in the emergency room for the treatment of critically-ill patients, comparing systemic blood pressure and heart rate measurements obtained continuously with intermittent measurements obtained manually, with a statistically significant correlation. The same authors¹⁰ studied 40 patients and compared the cardiac index and systemic vascular resistance obtained by continuous noninvasive hemodynamic monitoring with a simple questionnaire applied to the physicians of an emergency unit. They asked objectively whether the patient had a low, normal or high cardiac index and systemic vascular resistance at the clinical evaluation. There was a low correlation between the clinical analysis and the noninvasive measurements, demonstrating the difficulty to estimate hemodynamic data of patients using clinical data only. These results can directly interfere in the management of acute patients.

Stover et al.¹¹ assessed the use of this method in the intensive care unit, studying 10 critically-ill patients, mostly in septic shock, at the same time that hemodynamic measurements

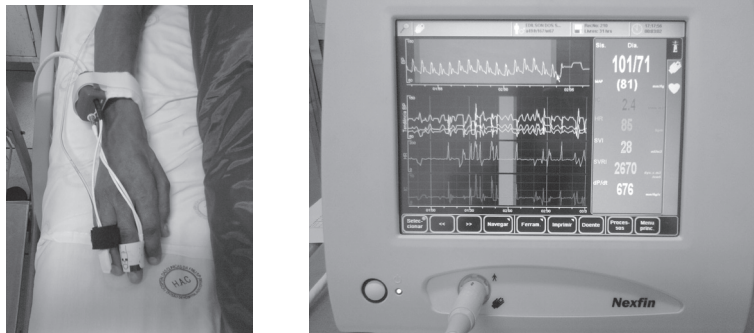


Figure 1 - Continuous noninvasive hemodynamic monitoring – BMEYE.

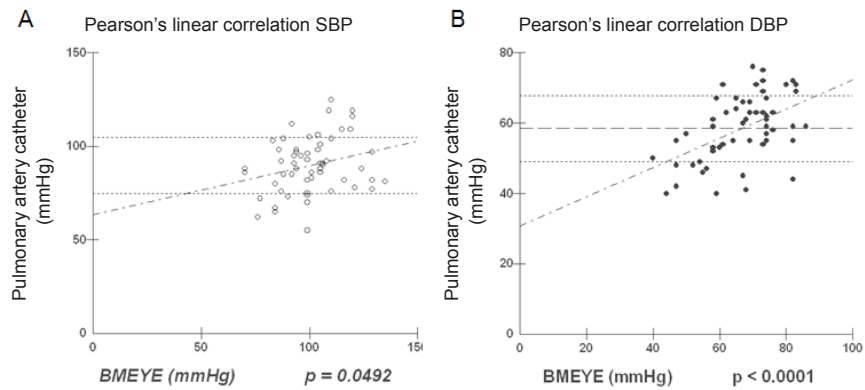


Figure 2 - Pearson's linear correlation - A: SBP (systolic blood pressure), B: DBP (diastolic blood pressure).

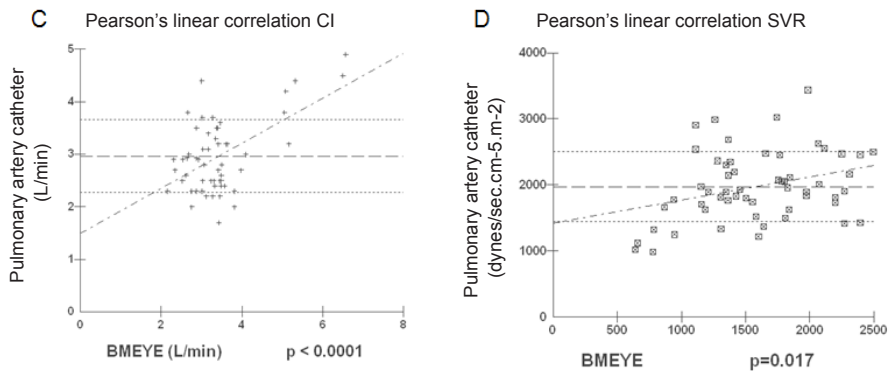


Figure 3 - Pearson's linear correlation - C: CI (cardiac index), D: SVR (systemic vascular resistance).

were obtained through the pulmonary artery catheter. In this study, the main measures analyzed for clinical decision-making were the measurements of blood pressure and heartbeat. Although the cardiac index did not interfere with the management of the septic patient, it was also compared in the statistical analysis. The results showed no correlation between blood pressure measurements by the two methods. Concerning the cardiac index, the authors concluded that there was no correlation between the measurements, although it showed to be promising.

As there are no randomized studies for this practice in decompensated heart failure, the noninvasive measurements were correlated with those obtained through the Swan-Ganz catheter using the thermodilution method in our study^{12,13}. Although the Evaluation Study of Congestive Heart Failure and Pulmonary Artery Catheterization Effectiveness (ESCAPE Trial) study did not demonstrate¹⁴ alterations in mortality with the catheter use, the Brazilian guidelines indicate the procedure for managing difficult cases or when there are questions that can be resolved by hemodynamic evaluation¹⁵.

Patients considered to be refractory to treatment were selected considering the time of use of intravenous inotropic agents. Those who had used the medication for more than five days underwent noninvasive monitoring and at the same time, the Swan-Ganz catheter was used to allow the comparison between measurements.

The results showed correlation between noninvasive and invasive measurements of diastolic blood pressure, cardiac index and systemic vascular resistance. There was a positive trend in the correlation between systolic blood pressure measurements.

Although not the objective of the present study it is worth reporting that, based on those measures in four of the 14 cases presented, the clinical procedures were changed. Three cases required volume and were receiving a diuretic. In one case, vasodilators were increased and inotropic agents were withdrawn. That is, three patients considered to be congested by clinical evaluation were hypovolemic (low pulmonary capillary wedge pressure) and one patient with high-dose inotropic agent still had vasoconstriction and needed vasodilator adjustment (high systemic vascular resistance and low cardiac index). It is not possible to estimate the pulmonary capillary pressure measurements by a noninvasive method, but in refractory cases the continuous noninvasive hemodynamic monitoring can assess important variables for the treatment of decompensated heart failure with statistically significant correlation.

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As it is an easily and non-invasively acquired measurement, the use of this method in patients considered refractory to treatment can direct therapy and, in some cases, change the conduct. The hemodynamic evaluation of objective measures showed to be different from the clinical evaluation. For decompensated patients, especially those who come to the emergency room, clinical assessment is still critical. The continuous noninvasive hemodynamic monitoring in this study was used in hospitalized patients considered refractory already in prolonged use of inotropic and vasodilator agents.

The continuous no-invasive hemodynamic monitoring was able to adequately measure the cardiac index and systemic vascular resistance in hospitalized patients with decompensated heart failure, when compared with pulmonary artery catheter measurements. The clinical and hemodynamic assessment can be readjusted by using this method.

With the validation of a noninvasive method, we initiated a study to assess whether noninvasive hemodynamic measurements assist in treatment decision-making (doses of vasodilator and inotropic agents) and prognostic stratification of decompensated patients, checking for correlation between measurements with the re-hospitalization and mortality rates.

Conclusion

There was a correlation between the noninvasive hemodynamic measurements when compared to pulmonary artery catheter measurements. The continuous noninvasive hemodynamic monitoring may be useful for hospitalized patients with decompensated heart failure.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

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