ACUTE TREATMENT OF HEART FAILURE WITH IMPEDANCE CARDIOGRAPHY MONITORING OF CARDIAC INDEX AND THE ABILITY TO IMPROVE PATIENT OUTCOME

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Introduction

A great deal of literature has recently described the ability to noninvasively monitor cardiac index (CI) in a variety of acute care settings. The use of noninvasive Thoracic Bioimpedance, also known as Impedance Cardiography or ICG, monitoring of central hemodynamic values has successfully treated heart failure patients and been use in a variety of other settings including anesthesia, post-cardiac surgery and ICU.

Usual treatment in the ED relies heavily on clinical assessment, vital signs and radiographic findings to dictate intervention. Despite continued reassessments, therapeutic interventions made in the absence of central hemodynamic monitoring are sub-optimal and result in increased mortality.

Advanced treatment decisions that could be made by the Emergency Physician are usually delayed until the patient undergoes invasive monitoring in the ICU. Prior articles have described early and immediate invasive monitoring and subsequent improved outcome of critically ill geriatric patients.

In the treatment of critical HF, pulmonary artery catheterization (PAC) is considered the “gold standard” for diagnosis and guidance of therapy, allowing the treating physician to optimize fluid status and cardiac function. The PAC is most useful in geriatric patients because they often have multiple medical problems that must be taken into account and are on medications that may confuse the clinical picture.

Despite subsequent reviews and calls for better investigation of PAC outcome-based research, the use of the PAC in the ED is impractical at best and is not a viable monitoring option in most EDs. Recent studies utilizing ICG to determine cardiac function and fluid status allow for earlier determination of cardiac function in the ED setting without risk to the patient or costly and invasive set-up.

The software used to calculate and interpret bioimpedance derived cardiac output and stroke volume has recently been advanced to the point where cardiac output parameters can be obtained with reasonable accuracy and expediency at the bedside.

Cardiac output values from the BioZ.com™ monitor used in this study have closely correlated (r=0.85 - 0.90) to those values determined by PAC thermodilution in multiple studies in over 2000 matched patient-data sets.

No existing study has actually found that such monitors improve patient outcome from therapeutic use in patient care. This study will evaluate the predictive values of early noninvasive monitoring in predicting outcome in critically-ill heart failure patients.

Methods

Patients presenting to an urban Community Hospital Emergency Department with acute signs and symptoms consistent with HF were entered into this prospective, convenience study.

IRB-approved comparison of non-protocol treatment with a noninvasive cardiac index monitor (CardioDynamics International Corporation, San Diego, CA) evaluating patients who improved (CI+) following 60 minutes of ED therapy compared those with no CI improvement (CI-); while maintaining heart rates < 90 bpm, based on total hospital stay (days) and hospital charges; t-test: a = 0.05 study.

Results

A total of 58 patients were enrolled over 60 days with an average age of 74.4 years (95% CI: 68.9-79.9), and 64.9% were of female gender. The mean length of hospital stay was 5.4 days (95% CI: 4.3-6.5), with 15.4% discharged directly from the ED. The chief complaints with the greatest prevalence were shortness of breath and dyspnea.

The mean NYHA Class of 2.2
(Range: Class I-IV)
and Killip Class of 1.8 (Range: Class I-IV).

Initiating presenting Vitals included:
HR: 86.2 bpm
MAP: 101.3 mmHG
CI: 2.7 L/min/m^2 (95% CI: 2.3-3.1).

There was no difference in mean CI between the two groups following 60 minutes of acute resuscitation in the ED and after 24 hours of in-hospital care: CI+ and CI-. However, 54% of those HF did improve (CI+) their CI values without relying on an increased HR > 90 bpm. CI+ patients had a trend toward reduced LOS: 4.9 days vs. 6.1 days for (CI-); p=0.19 and reduced hospital charges $13,102 compared to $15,660 (p< 0.05 for CI- with respect to trends of CI and HR parameters).

Females improved at greater rates than males: 73.7% in CI+ group vs. 57.8% (males in CI- group, t-test; p<0.04). There was no difference in hospital transfers or mortality between the study groups.

Noninvasive measurement (ICG) better predicted overall hospital charges on arrival than any other change in vital signs during the initial resuscitation in the ED; ANOVA: p <0.05.

Note on Limitations: The BioZ.com™ was found to have some limitations in the presence of some arrhythmias, particularly frequent premature ventricular contractions. The lack of central pressures monitoring is occasionally a problem; although it requires central venous access, it may enhance the usefulness of this monitor.

TABLE 1:
Noninvasive Monitor Values for Cardiac Hemodynamics in Geriatric Heart Failure Patients

Clinical Subset	NYHA and Killip	Base Impedance (95% CI)	Cardiac Index (95% CI)	Stoke Volume (95% CI)
I		24.8 (21.3 – 28.3)	4.09 (2.68 – 5.50)	82.5 (63.6-101.4)
II		17.7 (15.4 – 20.1)	4.42 (2.72 – 6.12)	87.3 (74-100.6)
III		27.6 (21.2 – 34.0)	2.0 (1.54 – 2.46)	42.9 (20.9-64.9)
IV		16.9 (12.4 – 21.3)	1.98 (1.71 – 2.25)	57.8 (39.8-75.8)

TABLE 2:
Vital Signs for Heart Failure Patients Classified into Functional Classes Based on Cardiac Index and Thoracic Impedance

Clinical Subset	Age (years)	Heart Rate Beats/min.)	MAP (mm Hg)	Respiratory Rate b/min)	Pulse Ox (%)
I	76.2	103.8	129	27.2	94.4
	(70.8-81.7)	(93.3-114.2)	(114-145)	(23.3-31.4)	(93.5-95.2)
II	76.8	94.8	129	27.2	92.5
	(72.4-81.2)	(86.2-103.4	(141.2-117.0)	(30.4-24.1)	(91.6-93.4)
III	70	101.3	122.5	24	95
	(65.0-75.4)	(125.2-77.2)	(101.5-142.9)	(18.5-30.5)	(93.4-96.6)
IV	75.4	96.3	125	23.3	92.4
	(70.4-81.3)	(90.7-101.7)	(106.1-133.1)	(19.8-26.7)	(90.3-94.5)

Clinical Subsets versus Vital Signs. Ninety-five percent confidence intervals noted in parenthesis. Statistical differences using one-tailed paired t test for Age: I-III, HR: II-III and III-IV.

Discussion

Given that the diagnosis of severe HF carries a dismal prognosis despite current treatment regimens, the most effective treatment of HF is intervention before cardiac reserve and compensatory mechanisms have been exhausted. The geriatric population has a diminished ability to compensate, with left ventricular filling during diastole being reduced by 50% between the ages of 20 and 80 in healthy males. The earlier appropriate resuscitation is delivered, the greater the potential to improve outcome for acute HF in elderly patients.

In this study, the signs and symptoms used to evaluate HF (heart and respiratory rate, pulse oximetry, and mean arterial blood pressure) were poor descriptors in the geriatric population, making the Emergency Physician unable to identify the pre-clinical shock state.

Initial vital signs failed to differentiate HF classes (Forester) likely due to concealment of early physiologic decompensation. In addition, tachycardia is often overlooked in terms of impact on cardiac output. Heart rate and blood pressure demonstrated no difference amongst the first three subclasses, while only stroke volume and the resultant cardiac index accurately identified inadequate cardiac function.

The availability of objective, central hemodynamic data makes it possible to utilize treatment pathways based on parameters such as cardiac index, pulmonary artery pressure, and left ventricular filling volumes.

Noninvasive hemodynamic monitoring in the ED setting allows for more accurate and effective treatment by providing the treating EP with hemodynamic indicators required for effective interventions. Despite controversy over correlation with PACs, the BioZ.com™ also enables Emergency Physicians to reassess their interventions by following trends.

The analysis of vital signs measured upon ED arrival showed how poorly heart rate and blood pressure differentiate the severity of HF changes. The ability of the CO monitor to provide continuous monitoring and identify response to treatment will improve care and hopefully improve survival.

Conclusion

The routine use of noninvasive ICG monitoring of cardiac index in the acute treatment of heart failure allows for better identification of patients who demonstrate early response to therapy and trend to shorter hospital stays and reduced hospital costs, improving patient outcomes.