Emergent Dyspnea IMPedance cardiography-aided Assessment Changes Therapy: The ED-IMPACT Trial

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Introduction

In clinically unstable patients presenting to the ED, knowledge of the initial hemodynamic parameters, above and beyond vital signs and clinical impression, may guide diagnosis and therapy such that a reduction in mortality and improved clinical outcomes result. Hemodynamic data has been shown to offer benefit to ED clinical decision making, above and beyond that obtained by the history, physical, and routine ED testing. Useful hemodynamic parameters include systemic vascular resistance (SVR) and cardiac output (CO), neither of which can be inferred accurately based only on clinical grounds. Unfortunately, the common methods to obtain this data requires invasive techniques (i.e. pulmonary artery catheterization), and because of the logistical constraints of a busy emergency department, most ED's are incapable of determining this data.

With the advent of easily available advanced microprocessor computer technology, the hemodynamic data obtainable by impedance cardiography (ICG) monitoring has markedly improved in the last decade. Compared to direct Fick measurements of cardiac output, ICG provides cardiac output data that is equally accurate to that obtained by pulmonary artery catheterization.

Besides the clear cost advantage of ICG over pulmonary artery catheterization, it's non-invasive data collection method does not require intravenous access. ICG data is collected by the placement of four bilateral sensors at the neck and thorax. Each sensor consists of a sensing and receiving electrode. The four outermost electrodes serve to inject a very small electrical current and the four inner sensors measure the corresponding voltage changes, or resistance to the injected current.

Ohm's law (V = IR), defines the relationship where decreasing electrical resistance is proportional to increasing current flow. Water is an excellent electrical conductor, and since blood plasma is predominately water, the measured resistance to electrical flow is proportional to the baseline thoracic water. Low electrical resistance is proportional to the volume of water in the thorax, and when present suggests the presence of extravascular fluid overload.

Furthermore, since electrical resistance decreases with movement of blood within the thoracic cavity, current changes induced as a result of a cardiac pumping cycle can be measured. Since these current changes are directly related to the volume of blood that is moved, they are directly proportional to stroke volume. Stroke volume multiplied by the heart rate, obtained by a concurrently measured ECG, defines cardiac output.

A number of other parameters indicative of myocardial performance and hemodynamic state can be derived from the analysis of ICG data during the cardiac cycle. Finally, knowledge of cardiac output, in relation to systemic blood pressures, allows the calculation of systemic vascular resistance.

To obtain hemodynamic parameters requires only minutes to perform, and may assist the clinician to determine an early diagnosis and thereby allow the prompt implementation of hemodynamic stabilization interventions. No prior study has evaluated the effect of ICG monitoring on clinical decision making in undifferentiated emergency department patients.

In this trial we intentionally selected a population of patients who were acutely dyspneic and older than 65 years of age to provide a high frequency of significant concurrent diseases (e.g., both heart failure and chronic obstructive pulmonary disease in the same patient). This population represents some of the most challenging clinical decision making for the emergency physician and these patients require the greatest amount of diagnostic testing and clinical acumen for optimal outcomes.

Objective

To evaluate the frequency of clinical management changes resulting from the addition of ICG derived hemodynamic parameters to standard care.

Methods

Design: Prospective blinded evaluation of the effect of ICG data on patient care decisions.

Setting: The academic emergency departments of the Cleveland Clinic and the University of Mississippi.

Participants: All ED patients older than 65, presenting with a complaint of dyspnea, were eligible for entry.

ICG data was obtained on all enrolled patients, using the BioZ ICG Monitor (CardioDynamics, San Diego, CA) by a research nurse not involved in the care of the patient. ICG data was blinded to all other medical staff. At the initial emergency department presentation, following the completion of the history and physical exam, and before any central lab or X-ray data was available, the attending emergency physician completed a case report form indicating their anticipated diagnosis, medications to be used, and disposition. The ICG data was then immediately unblinded, and the attending emergency physician repeated completion of the same case report form. Pre and post-ICG data case report forms were compared for differences. The gold standard diagnosis was defined as the diagnosis at emergency department discharge, after all investigative lab, radiologic, and consultative data was available.

Results

55 patients were enrolled, with a mean age of 76.1 +/- 6.9 years; 28 (50.9%) were white, and 27 (49.1%) were African American. The mean ejection fraction was 40.5 +/- 7.1% and the mean initial B-type natriuretic peptide level was 634.9 +/- 585.1 pg/mL. Mean emergency department length of stay was 5.4 +/- 1.49 (range 1.4 to 10.3) hours.

Knowledge of the ICG data resulted in a change of diagnosis in 3 (5.4%) patients, from heart failure to chronic obstructive pulmonary disease, or the reverse. In these cases there were no changes between the post-ICG diagnosis and the final emergency department discharge diagnosis. In 2 cases of pulmonary embolus, the ICG data did not alter the diagnosis. ICG data resulted in 20 medication changes in 13 patients (23.6%). Diuretic dosing changes accounted for 5 (25%) of the changes. There were 15 episodes of medications being added, and 5 episodes of previously ordered medications being discontinued.

Table 1: Mean initial presentation vital signs:

Temperature (C)	36.6
Respiratory rate (bpm)	22.1
Heart Rate (bpm)	82.6
Systolic BP (mmHg)	143.8
Diastolic BP (mmHg)	76.1

Table 2: Past medical history reported at study entry

Disease	Frequency (N)
Chronic Obstructive Pulmonary Disease or Asthma	38% (21)
Heart Failure	53% (29)
Cardiovascular Disease	73% (40)
Heart Failure and COPD	13% (7)

Table 3: Medication changes resulting from the addition of ICG data

Medication Class	Patients with Medication Added After ICG data	Patients with Medication Removed After ICG Data	Total Patients with Medication Changes
Diuretics	3	1	4
Nitroglycerin	2	0	2
Bronchodilators	2	2	4
Steroids	2	1	3
Antibiotics	1	1	2
Anticoagulants	2	0	2
Other	3	0	3

Limitations: In a diverse patient population, with potentially many confounding diagnoses, we used the final emergency Physician diagnosis at the time of discharge from the emergency department as the final gold standard diagnosis. It is possible that this diagnosis was in error and may have lead to inappropriate therapeutic strategies. In the three patients with diagnostic changes as a result of ICG data, the post-ICG diagnosis did not differ from the final emergency department diagnosis. Future studies may need to use longer term outcomes as the gold standard final diagnosis.

Conclusions

ICG data results in diagnosis changes in 5.3% and medication changes in 23.6% of dyspneic emergency department patients older than 65 years of age.