

# FORT WALTON BEACH MEDICAL CENTER

## POLICY-PROCEDURE

<b>SUBJECT:</b> Impedance Cardiography	<b>POLICY NO:</b> ICG 1-1
<b>DEPARTMENT:</b> Critical Care (ICU, CCU) and Emergency Services	<b>CATEGORY:</b> Patient-Focused Care
<b>Effective Date:</b>	<b>Department Approval:</b> Date:
<b>This Replaces:</b> NA	<b>Department Approval:</b> Date:
<b>Reviewed Dates and Initials:</b>	<b>Administrative Approval:</b> Date:
<b>Revised Dates:</b>	<b>Medical Director:</b> -AND/OR- <b>Committee:</b> Date:

**REVIEWED/REVISED BY:** Elaine Stack RN, HCRM and Deborah Alvater RN, MSN, CCRN      **DATE:** 3/02

**COMMENTS:** New Policy

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## **OUTCOME STANDARD**

Impedance cardiography (ICG), a continuous, noninvasive method to obtain hemodynamic data and assess thoracic fluid status is ordered by the physician, and assessed and monitored by the registered nurse.

## **PURPOSE**

Impedance cardiography is a non-invasive method for detecting and recording changes in cardiac hemodynamic function using thoracic electrical bioimpedance (TEB) technology. ICG is a safe, accurate, reproducible, technology that provides a cost effective alternative for hemodynamic evaluation and continuous monitoring.

The accuracy, precision, and reproducibility of ICG measures of hemodynamics have been documented in clinical studies. ICG has been used effectively in a variety of acute care and ambulatory care settings for patient assessment, selecting pharmacological agents and adjusting dosages, optimizing pacemaker settings, and monitoring patients' responses to therapy. In addition, ICG monitoring facilitates patient education and increases patient involvement in and co-operation with the treatment program, all of which contribute to quality patient care.

## **POLICY STATEMENT**

ICG monitoring is ordered by physicians and performed by critical care and emergency room nurses with training and education in ICG monitoring procedures.

- ❖ Indications
  - Patients with suspected or known cardiovascular disease
  - Differentiation of cardiogenic from pulmonary causes of acute dyspnea
  - Optimization of atrioventricular interval for patients with AV sequential cardiac pacemakers
  - Patients with need of determination for intravenous inotropic therapy
  - Patients with the need for fluid management
- ❖ Precautions
  - Severe aortic regurgitation
  - Minute ventilation driven pacemakers
  - Severe septic shock
  - Weight < 67 > 341 pounds
  - Height < 4'0" > 7'5"
  - HR < 40 > 250

ICG sensors should be replaced every 24 hours. ICG monitor may be moved from patient to patient.

ICG reports are printed and placed on the patient record for physician review and comment. The nurse should notify the physician of abnormal parameters.

## **EQUIPMENT**

- BioZ
- ICG patient cable
- ICG sensors
- Blood pressure measuring device (to obtain mean arterial pressure)

## PROCEDURE

- Leave monitor and printer on and plugged in to avoid warm up delays.
- Press 'Start Monitor', and enter patient data: ID, Name, Gender, Height, Weight, Age, BP (manual entry or ICG),CVP (or use default CVP value), PAOP (or use default CVP value).
  - View default parameters.
  - Adjust as needed.
- Ensure the patient is in the supine position with the head of the bed less than 30 degrees.

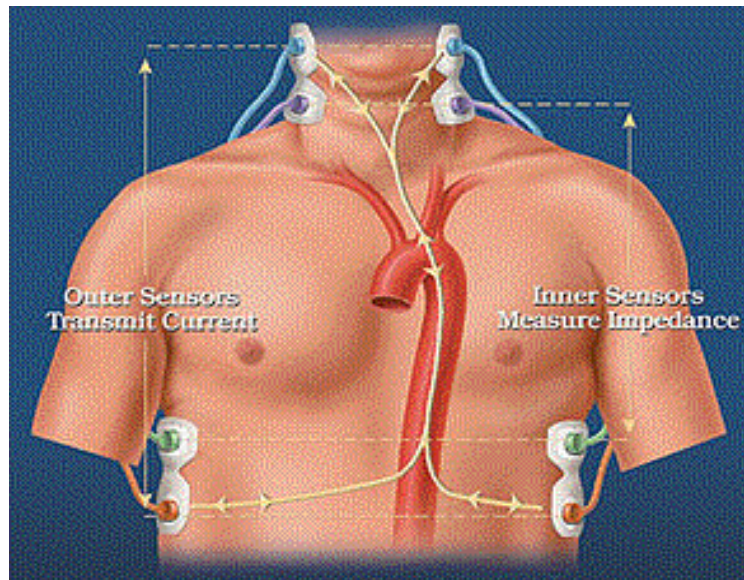
Note: If HOB > 30 degrees, perform consistently at same level documenting same on report.

- Prepare skin for sensor placement to clean and dry hairless skin.

Note: Do not use alcohol or benzoin as sensing will be impaired.

- Impedance cardiography introduces a low energy, high frequency alternating current of a specific frequency and amplitude through the thorax via sets of sensors. The delivered current cannot be felt and is not harmful.
- Landmarks are identified for placement of the upper and lower sensors (Figure 1 Lead Placement).

**Lead Placement** Figure 1



(Reprinted from CardioDynamics, The ICG Company website)

- Attach 4 dual sensors to patient.
  - Use the root of the neck as a reference for vertically locating the rectangular shaped detecting sensor being positioned directly superior and inline with the ear lobe.
    - Heart symbol faces down.
    - Avoid trachea and bone.
  - Use the xiphoid process as a reference for vertically locating the rectangular shaped detecting sensor with the corresponding circular shaped transmitting sensor being positioned directly inferior and along the mid-axillary line.
  - Identify left and right branches of the patient cable (with respect to the patient) as indicated on the patient cable yoke diagram and connect the respective leads in order from top to bottom: blue, purple, green and

orange.

- Heart symbol faces up.
- Identify left and right branches of the patient cable (with respect to the patient) as indicated on the patient cable yoke diagram and connect the respective leads in order from top to bottom: blue, purple, green and orange.
- Verify a secure patient cable connection to the BioZ.
- A low-amplitude, high frequency alternating electrical current is applied to the thorax via the most superior neck and inferior thorax sensors (blue and orange leads respectively). Pulsatile blood volume changes emanating predominantly from the Aorta result in pulsatile impedance changes to the current flow thus producing a waveform (termed the delta Z, impedance, or ICG waveform).

Note: Proper sensor placement is essential for acquisition of accurate hemodynamic and thoracic fluid status data.

- Place the ECG electrodes in a lead that produces an upright R wave.
  - BioZ needs to sense 30 similar beats.
  - Set average lower in Afib, Pacers, LBBB.
  - Observe ICG waveform and ECG displayed on monitor.
  - Note: Hemodynamic calculations depend on artifact-free ICG and ECG waveforms.
- ICG measures the voltage drop, and calculates the impedance (Z) to the applied electrical current.
  - Baseline impedance (Zo), the amount of impedance/conductivity of all of the conductive matter in the thorax, is measured (Appendix A: Definition of Terms).
  - Changes in impedance over changes in time are calculated and displayed numerically and graphically as the ICG waveform to reflect the dynamic state of fluid in the thorax (Appendix B: ECG and ICG Waveforms).
  - The changes in resistance are used to measure and calculate hemodynamic parameters.
  - Changes in thoracic impedance reflect changes in the pulsatile volume of blood flow through the aorta in response to electrical and mechanical events in the myocardium.
- To print report, make sure printer is on. Press [PRINT] hardkey. Select the [STATUS REPORT] softkey followed by the [COMPLETE STATUS] softkey to print the report.
- When finished monitoring, press [STOP MONITORING] hardkey.
- Remove sensors from patient (if one time monitoring event only).

### **PATIENT MONITORING and CARE**

- Assess baseline and trends in thoracic fluid status (TFC). Normal values: men 30-20; women 21-37.
- Assess baseline and trends in continuously displayed cardiac output (CO) or cardiac index (CI)
  - **Normal: CO 4 -8 L/min**
  - **Normal: CI 2.5 - 4.2 L/min/m<sup>2</sup>**
- Assess baseline and changes in preload by evaluating stroke volume (SV) response to physiologic fluid challenge:
  - **Measure and note SV with head of bed elevated**
  - **Place patient supine or lift legs for 'physiologic fluid bolus.'**
  - **Measure and note SV change**
  - **Normal: SV 60 - 100 mL**
  - **Normal: SI: 35 - 65 mL/beat/m<sup>2</sup>**
  - **Formula: CardioDynamics' proprietary ZMARC algorithm**

- Assess baseline and trends in afterload:
  - **Systemic vascular resistance (SVR)**
  - **SVR normal: 742 - 1378 dyne sec cm<sup>-5</sup>**
  - **SVR index normal: 1337 - 2483 dyne sec cm<sup>-5</sup> m<sup>2</sup>**
  - **Formula:  $SVR = \frac{(MAP - CVP)}{CO} \times 80$**

\* Use CI for SVR index calculation
  
- Assess baseline and trends in thoracic fluid content:
  - **Thoracic fluid content TFC (does not correlate to pulmonary artery wedge pressure)**
  - **Normal: 30-50/1000/ohms (males) 21-37/1000/ohms (females)**
  - **Should decrease with position changes (supine to standing)**
  
- Assess hemodynamic parameters and TFC for trends every 1 to 2 hours, following interventions, and as needed.

### **TROUBLESHOOTING ICG**

- Display screen does not show ECG or ICG waveforms.
  - Ensure 'power' or 'on' switches are activated.
  - Ensure sensors are in direct contact with skin.
  - Ensure leads are properly connected to sensors and ICG monitor.
  
- There is excessive noise or 60-cycle interference on ECG or ICG waveforms.
  - Ensure sensors are in direct contact with skin.
  - Ensure leads are properly connected to sensors and monitoring cable.
  - Ask patient to momentarily lay still to eliminate possible motion artifact as a cause of interference.
  
- ICG data does not correspond to patient clinical presentation.
  - Verify correct sensor placement.
  - Ensure good sensor contact with skin.
  - Ensure that leads are properly connected to all sensors.
  - Validate that correct patient height, weight, and other data have been entered.
  - Update blood pressure or means arterial pressure to update the SVR calculation.
  - Update the CVP pressure in the ICG monitor if large changes (e.g., > 10 mm Hg) have occurred in the CVP or the patient has become hypotensive.
  - Verify BioZ and Patient Cable operation with the BioZ.sim

Appendix A: Definition of Terms

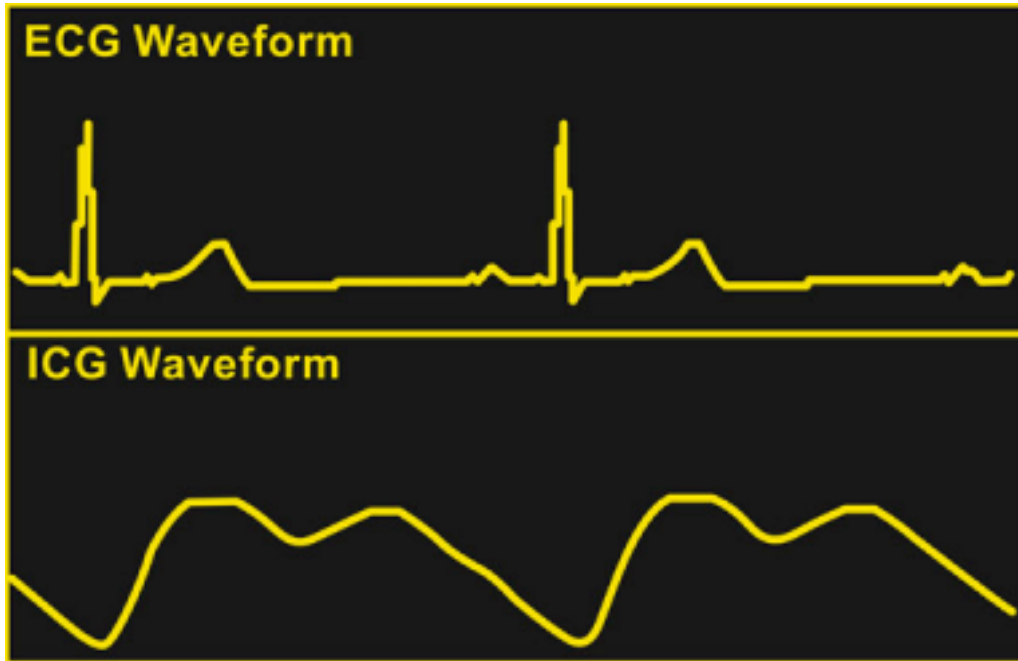
**BioZ.com Parameters**

Parameter	Abbrev.	Definition	Normal Range	Derivation/Formula
Heart Rate	HR	Number of heart beats each minute	58 - 86 bpm (beats per minute)	Measurement of the R-R interval on the ECG and extrapolation to bpm.
Mean Arterial Pressure (SBP & DBP)	MAP	Average pressure exerted by the blood on the arterial walls.	84 – 100 mmHg	<ol style="list-style-type: none"> <li>If SBP and DBP values manually entered, the formula for MAP = (SBP – DBP)*KP) + DBP</li> <li>If automatic BP (oscillometric method is used), MAP is measured directly and SBP and DBP are derived.</li> </ol>
Cardiac Output	CO	Amount of blood pumped by the left ventricle each minute	4.5 – 8.5 l/min (liters per minute)	CO = SV x HR
Cardiac Index	CI	Cardiac Output normalized for body surface area	2.5 - 4.7 l/min/m <sup>2</sup> (liters per minute per meter squared)	CI = CO / BSA
Stroke Volume	SV	Amount of blood pumped by the left ventricle each heartbeat	60 – 130 ml (milliliters)	Z MARC Algorithm: SV = VEPT · LVET · VI
Stroke Index	SI	Stroke volume normalized for body surface area	35 - 65 ml/beat/m <sup>2</sup> (milliliters per heart beat per meter squared)	$SI = \frac{SV}{BSA}$
Systemic Vascular Resistance	SVR	The resistance to the flow of blood in the arterial system (often referred to as “Afterload”)	742 – 1378 dynes sec / cm <sup>5</sup> (dynes second per centimeter to the fifth power)	$SVR = 80 \cdot \frac{(MAP - CVP)}{CO}$
Systemic Vascular Resistance Index	SVRI	The resistance to the flow of blood in the arterial system normalized for body surface area	1337 – 2483 dynes sec m <sup>2</sup> / cm <sup>5</sup> (dynes second meters squared per centimeter to the fifth power)	$SVRI = 80 \cdot \frac{(MAP - CVP)}{CI}$
Acceleration Index	ACI	Initial acceleration of blood flow in the aorta, which occurs within the first 10 - 20 milliseconds after the opening of the aortic valve	Males: 70 – 150 / 100 sec <sup>2</sup> Females: 90 – 170 / 100 sec <sup>2</sup> (per 100 seconds squared)	$ACI = \frac{d^2Z/dt^2_{MAX}}{TFI}$

Parameter	Abbrev.	Definition	Normal Range	Derivation/Formula
Velocity Index	VI	Peak velocity of blood flow in the aorta	33 - 65 / 1000 sec (per 1000 seconds)	$VI = \frac{dZ/dt_{MAX}}{TFI}$
Thoracic Fluid Content	TFC	The electrical conductivity of the chest cavity, which is primarily determined by the intravascular, intraalveolar, and interstitial fluids in the thorax	Males: 30 – 50 / kohm Females: 21 - 37 / kohm	$TFC = \frac{1}{TFI}$
Left Cardiac Work	LCW	An indicator of the amount of work the left ventricle must perform to pump blood each minute	5.4 - 10 kg m (kilogram meter)	$LCW = (MAP - PAOP) \cdot CO$
Left Cardiac Work Index	LCWI	LCW normalized for body surface area	3.0 - 5.5 kg m / m <sup>2</sup> (kilogram meter per meter squared)	$LCWI = (MAP - PAOP) \cdot CI$
Systolic Time Ratio	STR	The ratio of the electrical and mechanical systole	0.3 – 0.5	$STR = \frac{PEP}{LVET}$
Pre Ejection Period	PEP	The time interval from the beginning of electrical stimulation of the ventricles to the opening of the aortic valve (electrical systole)	Depends on HR, preload, and contractility	Time interval from the beginning of the Q wave on the ECG to the B point on the dZ/dt waveform
Left Ventricular Ejection Time	LVET	The time interval from the opening to the closing of the aortic valve (mechanical systole)	Depends on HR, preload, and contractility	Time interval from the B point to the X point on the dZ/dt waveform

- VEPT Volume of Electrically Participating Tissue (volume conductor for size of thorax affected by height, weight, and sex)
- TFI Thoracic Fluid Index, which is the baseline thoracic impedance,  $Z_0$
- SBP/DBP Systolic Blood Pressure/Diastolic Blood Pressure
- KP A variable which is dependant on pulse pressure ratio, usually varying between 0.25 – 0.33
- BSA Body Surface Area
- $dZ/dt_{MAX}$  Maximum of the first time derivative of delta Z
- $d^2Z/dt^2_{MAX}$  Maximum of the second derivative of delta Z
- CVP Central Venous Pressure, the BP in the thoracic vena cava and right atrium (default value of 6 mm Hg)
- PAOP Pulmonary Artery Occlusion Pressure or “wedge” pressure (default value of 10 mm Hg)

## Appendix B: ECG and ICG waveforms



### REFERENCES

- Buell, J. (2001). A Guide to Interpreting Computerized Impedance Cardiographic Data. [www.cardiobeat.com](http://www.cardiobeat.com).
- CardioDynamics The ICG Company. BioZ.com operation manual and website [www.cardiodynamics.com](http://www.cardiodynamics.com).
- Lasater, M. (2000). Impedance Cardiography: A Method of Noninvasive Cardiac Output Monitoring. [AACN's Continuing Education Website](#).
- Lynn-McHale, D., & Carlson, D. (2001). Noninvasive Hemodynamic Monitoring: Impedance Cardiography. [AACN Procedure Manual for Critical Care](#) (4<sup>th</sup> ed.). W.B. Saunders, 421-30.
- Pranulis, M. (2000). Impedance Cardiography Noninvasive Hemodynamic Monitoring Provides an Opportunity to Deliver Cost Effective, Quality Care for Patients with Cardiovascular Disorders. [Journal of Cardiovascular Management](#), vol. 11, no.3. Publication of the American Academy of Medical Administrators.
- Rosenberg, P., & Yancy, C. (2000). Noninvasive Assessment of Hemodynamics: An Emphasis on Bioimpedance Cardiography. [Current Opinion in Cardiology](#), vol. 15, no. 3. Lippincott, Williams, & Wilkins.
- Strobeck, J., & Silver, M. (2000). Impedance Cardiography: Noninvasive Measurement of Cardiac Stroke Volume and Thoracic Fluid Content. [Congestive Heart Failure](#), vol. 6, no. 2.
- Ventura, H., Pranulis, M., Young, C., & Smart, F. (2000). Impedance Cardiography: A Bridge Between Research and Clinical Practice in the Treatment of Heart Failure. [Congestive Heart Failure](#), vol. 6, no 2.
- Von Rueden, K., & Turner, M. (1999). Advances in Continuous, Noninvasive Hemodynamic Surveillance. [Critical Care Nursing Clinics of North America](#), vol. 11, no. 1.