

# **Diagnostic and Outcome Prediction Value of Transthoracic Impedance Cardiography in Heart Failure Patients During Heart Failure Flare-Ups**

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# introduction

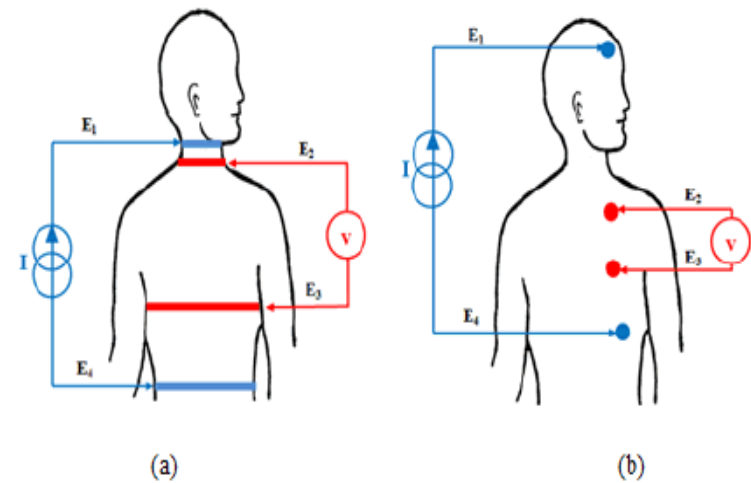
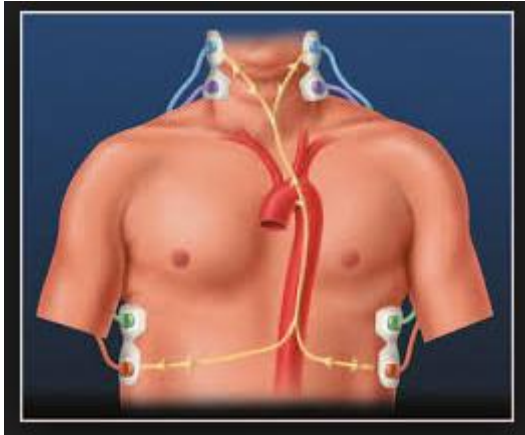
This study aimed at evaluating the diagnostic and outcome prediction value of transthoracic impedance cardiography (ICG) in heart failure (HF) patients admitted for in-hospital treatment due to flare-ups of their condition

# methods

- In total, 120 patients of intensive care units who were admitted due to HF flare-ups were involved to the study.
- The findings of ICG were compared to data obtained by other methods used for diagnosing HF.

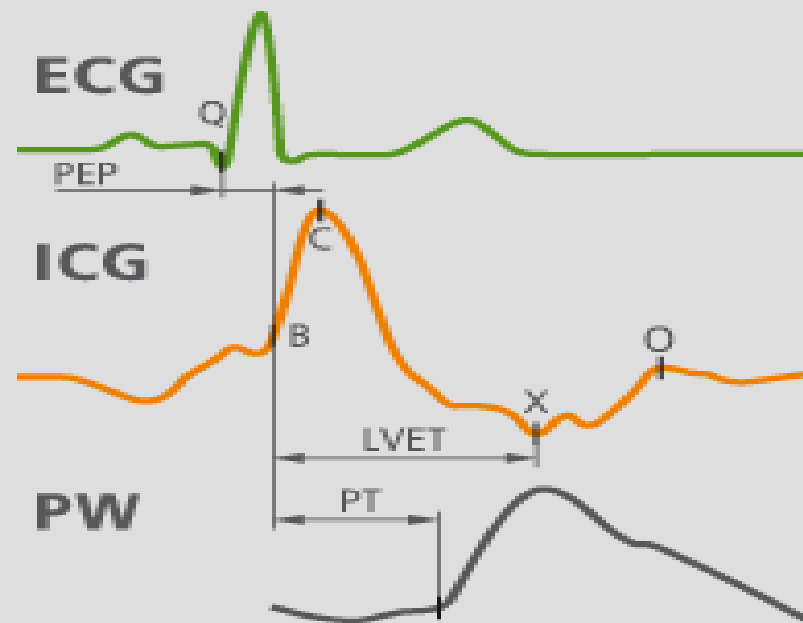
# What is ICG ?

**Impedance cardiography (ICG)** is a noninvasive technology measuring total electrical conductivity of the thorax and its changes in time to process continuously a number of cardiodynamic parameters, such as Stroke Volume( SV) Heart Rate( HR), Cardiac Output( CO) , Ventricular Ejection Time( VET) ; Pre-ejection Period and used to detect the impedance changes caused by a high-frequency, low magnitude current flowing through the thorax between additional two pairs of electrodes located outside of the measured segment.



*Figure 1. Electrode configurations for the impedance cardiography ICG signal measurements: (a) tetrapolar-band electrodes, (b) tetrapolar-spot electrodes.*

## Measured Signals



- . In impedance cardiography, synchronous pulse variations of blood volume in the thorax – and especially in the thoracic aorta – are evaluated and used for calculating the stroke volume and different hemodynamic parameters. The parameters evaluated during ICG may be used in various fields of medicine, including HF diagnostics, the evaluation of the risk, and the effectiveness of the therapy applied. In addition, these parameters may help in distinguishing between causes of dyspnea
- For the determination of the stroke volume the first mathematical derivative of the impedance pulse wave (IMP) is used. This curve is known as **ICG wave** form in which selected fiducial points are detected, such as the B and the X-points corresponding with the opening and the closing of the aortic valve, and the C-point which is the maximum of the ICG curve. Based on these curve points the stroke volume is calculated using an empirical equation.

# Results

- Statistically significant ( $p < 0.05$ ) results were obtained when evaluating differences in ICG data between admission and discharge from the intensive care unit.
- In addition, a correlation was detected between brain natriuretic peptide (BNP) and thoracic fluid content index



**Table 1.** Characteristics of the studied population.

Parameters	Mean $\pm$ 95% CI
Sex (M/F)	60/60
Age (years)	68.9 $\pm$ 2.2
Systolic blood pressure (mmHg)	126.3 $\pm$ 3.6
Diastolic blood pressure (mmHg)	77.8 $\pm$ 3.6
Respiratory rate (breaths/minute)	27.3 $\pm$ 0.9
Heart Failure NYHA class	3.3 $\pm$ 0.1
Intravenous dose of diuretics (mg/day)	98.5 $\pm$ 4.8
Parameters	%
Coronary artery disease (relevant diagnosis)	86.0
Arterial hypertension (relevant diagnosis)	68.7
Cardiomyopathy (relevant diagnosis)	91.0
Chest X-ray: pulmonary congestion/edema	92.3

**Table 2.** Results of differences in ICG data between admission to and discharge from the intensive care unit evaluated by using the Wilcoxon signed ranks test.

ICG parameter	Admission (intensive care unit) mean (95% CI)		Discharge (intensive care unit) mean (95% CI)		Wilcoxon test p-value
TFC (1/kOhm)	47.5	(44.6–50.4)	43.8	(41.0–46.6)	<0.001
TFCI (1/kOhm/m <sup>2</sup> )	25.2	(23.4–27.0)	23.4	(21.6–25.2)	<0.001
SI (mL/m <sup>2</sup> )	30.9	(28.7–33.1)	33.9	(31.8–36.0)	<0.001
CO (L/min)	5.0	(4.7–5.3)	5.3	(5.0–5.6)	<0.001
STR	0.43	(0.38–0.48)	0.35	(0.32–0.38)	<0.001
LCW (kg*m)	6.0	(5.6–6.4)	6.3	(5.9–6.7)	<0.001
LCWI (kg*m/m <sup>2</sup> )	3.1	(2.9–3.3)	3.2	(3.0–3.4)	<0.001

- For instance, when monitoring patients with HF, ICG data (cardiac output (CO), systolic time ratio (STR)) were found to correlate ( $r=0.85$ ) with the ejection fraction (EF) [5]. A correlation ( $r=0.65-0.8$ ) was also detected between ICG data and CO

**Table 3.** Correlation of BNP and ICG data.

ICG parameter	Spearman's r	p-Value
TFC	0.32	<0.001
TFCI	0.4	<0.001
SI	−0.15	0.093
CO	−0.23	0.012
STR	0.18	0.05
LCW	−0.29	0.002
LCWI	−0.25	0.006

# conclusion

- ICG data might be applied for the diagnosis and prognosis of HF, although the links between ICG and HF need further evaluation.