

Use of Systolic Time Ratio and B-type Natriuretic Peptide to Predict Mortality in Patients with Heart Failure

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Introduction

The use of noninvasive hemodynamic monitoring via impedance cardiography (ICG) for patients with heart failure is increasing. This modality is especially useful in the outpatient setting due to its ease of use, safety profile, and cost effectiveness. Managing the heart failure patient remains a challenge due to the difficulty of obtaining objective data that predicts disease progression and clinical progress.¹ ICG provides the ability to obtain serial hemodynamic data at each clinic visit.

In addition to providing cardiac index (CI), thoracic fluid content (TFC), and systemic vascular resistance (SVR), ICG also provides a lesser known index called systolic time ratio (STR). The STR is the ratio of electrical to mechanical timing in the heart and represents the pre-ejection period (PEP) divided by the left ventricular ejection time (LVET). Hence, a greater STR is indicative of worsening ventricular function.² Furthermore, STR has characteristics related to the force of contraction of the ventricle, which may be similar to dp/dt .

Similar to the role of STR in indicating worsening ventricular function, plasma B-type natriuretic peptide (BNP) levels have been shown to reflect the degree of heart failure and volume overload. BNP is a cardiac neurohormone secreted from the cardiac ventricles as a response to ventricular volume and pressure overload. BNP, unlike atrial natriuretic peptide (ANP), has a high presence in ventricular storage granules and is directly proportional to ventricular volume expansion acutely.³ BNP is an accurate predictor of left ventricular end diastolic pressure (LVEDP).

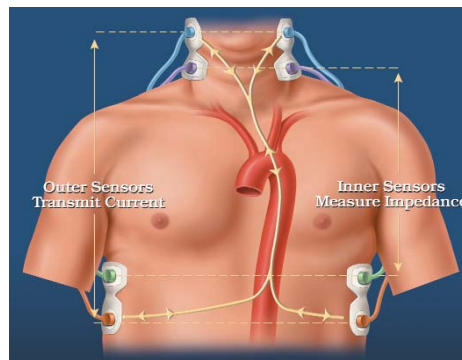
BNP has shown in multiple studies to correlate very well to the degree of heart failure based on NYHA class and also to prognosis and mortality. Although exact values vary from study to study, in general, a BNP level below 80-90 pg/mL has a 98% negative predictive value in ruling out heart failure as a diagnosis. Levels between 100-400 pg/mL are a gray zone. Above 400 pg/mL, BNP accurately identifies patients with heart failure at increased risk of events.

The aim of this study was to assess the relationships between STR, BNP levels, and mortality in outpatients with heart failure.

Methods

- A retrospective analysis of two consecutive groups of patient charts from our heart failure clinic was conducted
- ICG parameters and BNP laboratory levels were collected
- The most recent visit STR and BNP results were used for the study
- Group A consisted of those patients who received STR measurements at each clinic visit
- Group B consisted of patients who received both STR and BNP measurements at each clinic visit
- STR > 0.5 was considered above normal range
- BNP levels > 400 pg/ml were considered above normal range

Impedance Cardiography (ICG)



- Alternating current is transmitted through the chest
- Current seeks the path of least resistance: the blood filled aorta
- ICG measures the baseline impedance to this current
- With each heartbeat, blood volume and velocity in the aorta change ICG measures the corresponding change in impedance
- ICG uses the baseline and changes in impedance to measure and calculate hemodynamic parameters

Results

Table 1. Group Characteristics

	Group A (N = 73)		Group B (N = 68)	
	Active N = 49	Deceased N = 24	Active N = 45	Deceased N = 23
NYHA Class (Average)	2.2	3.6	2.9	3.8
Age (Average)	61	67	64	67
Ischemic Heart Disease	N = 27	N = 16	N = 29	N = 16
Non-ischemic Heart Disease	N = 22	N = 8	N = 16	N = 7

Results continued

Group A

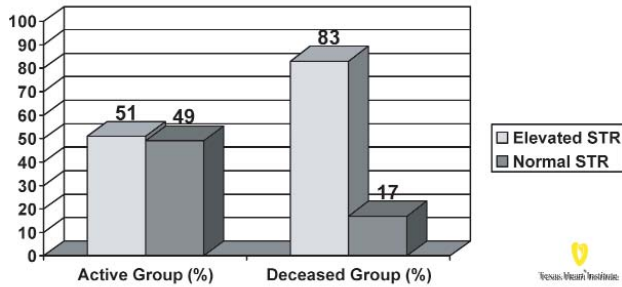
Active Group

- STR was elevated in 25/49 (51%)

Deceased Group

- STR was elevated in 20/24 (83%) ($p < 0.0071$)
 - 18/24 (75%) deaths were due to progressive heart failure
 - 15/18 (83%) of HF deaths and 2/6 (33%) non-HF deaths had a high STR ($p < 0.019$)
 - 17/20 (85%) deceased patients had high STR
 - 15/17 (88%) deceased patients had HF as a cause of death and a high STR ($p < 0.0005$)

Group A (Elevated STR)



Group B

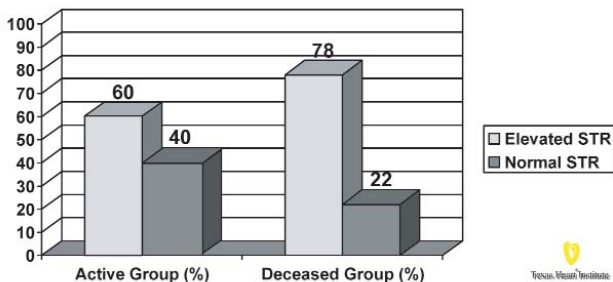
Active Group

- STR was elevated in 27/45 (60.0%)
- BNP levels were elevated in 7/45 (15.5%)
- Both BNP and STR were elevated in 4/45 (8.8%)

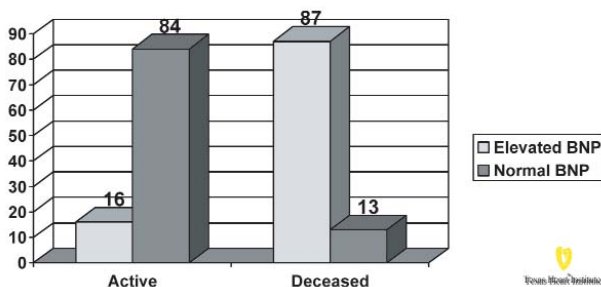
Deceased Group

- STR was elevated in 18/23 (78.2%) ($p < 0.007$)
- BNP levels were elevated in 20/23 (86.9%) ($p < 0.0001$)
- Both BNP and STR were elevated in 18/23 (78.2%) ($p < 0.0001$)

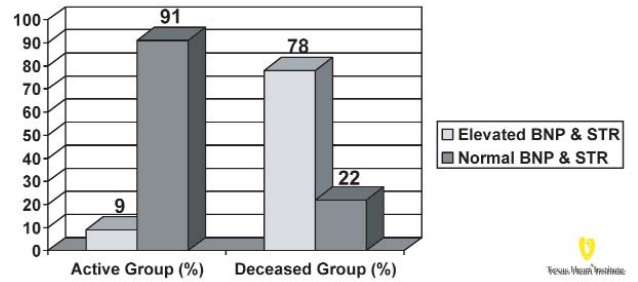
Group B (Elevated STR)



Group B (Elevated BNP)



Group B (Elevated STR & BNP)



Systolic time ratio is a poorly understood and often underutilized parameter, which can be used to assess contractile function of the left ventricle at rest. A higher STR correlates with worsening ventricular function, contractile reserve, and in this patient population, NYHA class, and mortality. Elevated BNP levels above 400 pg/mL are also associated with worsening NYHA class and increased mortality.

These individual, and relatively low cost tests have both diagnostic and prognostic relevance in patients with heart failure individually. Used in combination, STR and BNP parameters may enhance risk stratification and improve management of patients with heart failure. They may have utility in helping to triage patients to appropriate advanced therapies such as transplant. Future prospective studies need to be done to validate the use of combined STR and BNP to diagnose the severity of heart failure and determine prognosis. Furthermore, there may be a role of STR measured during exercise as part of a prognostic evaluation for a patient with heart failure.

Conclusion

- STR is an overlooked and possibly significant parameter to assess contractile function of the ventricle.
- These results suggest that high STR measurements correlate to NYHA class and mortality when taken alone.
- STR and BNP are noninvasive parameters may be useful individually and in combination in risk stratification and management of outpatients with heart failure.
- When combined with BNP levels, the additive prognostic power becomes greater than either parameter alone.
- Further studies are needed to determine if stress STR is a marker for contractile reserve and thus may have a prognostic power in heart failure.

1. Strobeck, JE, et al. Impedance cardiography: Noninvasive measurement of cardiac stroke volume and thoracic fluid content. *Congest Heart Fail.* 2000;6:4.
2. Ventura, HO, et al. Impedance cardiography: A bridge between research and clinical practice in the treatment of heart failure. *Congest Heart Fail.* 2000;6:44.
3. Maisel, AS, et al. Rapid measurement of b-type natriuretic peptide in the emergency diagnosis of heart failure. *New England Journal of Medicine.* 2002;347:162.