Brief Communication

Left Ventricular Outflow Tract Velocity-Time Integral (LVOT VTI) as a Marker of Cardiac Performance: Mortality Data of the ELSA-Brasil Cohort

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Transthoracic Echocardiography (TTE) is a well-established tool for assessing cardiac function and hemodynamics. While Left Ventricular (LV) systolic and diastolic function are commonly used metrics, Cardiac Output (CO) remains central for evaluating hemodynamic status, especially in critical care settings. TTE-derived parameters, such as Left Ventricular Outflow Tract Velocity-Time Integral (LVOT VTI) and LVOT area, when combined with body habitus and heart rate, provide noninvasive estimates of cardiac output. However, the accuracy of CO calculations may decrease when multiple covariates are included, with LVOT diameter being a major source of error.[1] In contrast, isolated LVOT VTI may represent a simpler and more reliable surrogate of cardiac performance.

Among patients with Heart Failure with reduced Ejection Fraction (HFrEF), LVOT VTI values below 12 cm or 8 cm have been associated with worse cardiovascular outcomes, with a progressive increase in risk as VTI decreases.[2,3] Similarly, in intermediate to high-risk pulmonary embolism, LVOT VTI ≤ 15 cm has been associated with higher in-hospital mortality, cardiopulmonary arrest, shock, and need for reperfusion therapy.[4] In secondary mitral regurgitation, LVOT VTI ≤ 17 cm predicts both cardiovascular and all-cause mortality.[5] And in ambulatory adults with stable Coronary Artery Disease (CAD), LVOT VTI ≤ 18 cm was associated with heart failure hospitalization and mortality.[6] Despite these findings, there is limited data to evaluate the usefulness of LVOT VTI in free-dwelling adults.

In this study, we aimed to identify the association between LVOT VTI and mortality among participants in the ELSA-Brasil cohort, a multicenter occupational study of Brazilian adults.[7] Participants underwent standardized TTE between 2008 and 2010 based on published guidelines. All these exams were subsequently analyzed in a core lab.[7] Measurements included LVOT VTI, LV Ejection Fraction (LVEF), Stroke Volume Index (SVI), and Cardiac Index (CI). Mortality was assessed through annual follow-up and adjudicated by the investigators up to December 2022.

Keywords

Echocardiography; Risk Assessment; Mortality; Healthy Volunteers.

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Echocardiographic data were available for 2,237 participants (58.6 ± 9.1 years, 46% male). The mean of LVOT VTI was 19.6 ± 4.0 cm, and 11% had a value of LVOT VTI below the pre-specified cutoff (< 15 cm), a value similar to the other studies' cutoff and positioned between the 10th and 25th percentiles of our sample distribution. Participants with LVOT VTI < 15 cm were slightly older (57 ± 9.9 vs 58.8 ± 8.9, p = 0.009) and showed a higher proportion of males (63% vs 44%, p < 0.001) than the LVOT TVI ≥ 15 cm group. The prevalence of other parameters of cardiac performance below established abnormality thresholds[4,5] was as follows: LVEF < 50% (N = 71, 3%), SVI < 38 mL/m² (N = 1673, 74%), and CI ≤ 2 L/min/m² (N = 905, 40%). The distribution of other relevant variables is depicted in **Table 1**. Over a mean follow-up period of 11.8 ± 2.2 years, 199 (8.9%) participants died (137 males and 62 females).

Mortality was higher among participants with an LVOT-VTI < 15 cm compared with those with higher values (12.6% vs. 8.4%; log-rank test $\chi^2 = 4.68$, $p = 0.026$; **Figure 1**). The multivariable Cox proportional hazards analysis showed that this association was independent of age and sex (Model 1- HR 1.48; 95% CI 1.00–2.18; $p = 0.048$). Additionally, this association remained significant after adjustment for body surface area (Model 2), slightly attenuated after adjustment for systolic blood pressure (Model 3- HR 1.46; 95% CI 0.99–2.15; $p = 0.053$) (**Table 2**). Overall, lower LVOT-VTI was consistently associated with an increased risk of mortality across all models, even after sequential adjustment for demographic and hemodynamic covariates.

Additionally, LVOT TVI showed a weak correlation with height (r = -0.073; p < 0.001), and no significant correlation with weight (r = 0.039; p = 0.067), or with BSA (r = 0.0003, p = 0.99), reinforcing the independence of LVOT TVI with body habitus.

In summary, LVOT VTI <15 cm was associated with a higher mortality among community-dwelling adults in this middle-income country. LVOT VTI may serve as a simple screening metric for cardiac performance in cardiovascular risk stratification of general populations, independently of adjustment for demographic and hemodynamic covariates. Further research is warranted to confirm the independent role of LVOT VTI in risk classification and to define relevant thresholds in specific settings.

Author Contributions

Conception and design of the research and obtaining financing: Lopes MC, Foppa M, Santos ABS; analysis and interpretation of the data and statistical analysis: Lopes MC, Heidemann Jr. AI, Pianca EG, Foppa M, Santos ABS; writing of the manuscript: Lopes MC,

Table 1 – Baseline characteristics.

	Overall N = 2,237	LVOT VTI < 15 cm N = 246	LVOT VTI ≥ 15 cm N = 1,991	p-value
Male Sex (%)	1028 (46)	157 (64)	871 (44)	< 0.001
Age (years)	58.6 ± 9	57 ± 9.9	58.8 ± 8.9	0.009
Heart rate (bpm)	67 ± 10	73.9 ± 11.6	66.7 ± 10.1	< 0.001
SBP	125.1 ± 18.8	126.1 ± 18.3	125 ± 18.8	0.38
DBP	76.1 ± 10.7	78.8 ± 11.1	75.8 ± 10.7	< 0.001
Height (cm)	163.9 ± 9.3	165.9 ± 9.7	163.7 ± 9.3	< 0.001
Weight (kg)	72 ± 13.5	72.4 ± 13.6	71.9 ± 13.6	0.57
Body surface area (m²)	1.77 ± 0.19	1.79 ± 0.2	1.77 ± -0.19	0.073
Body mass index (kg/m²)	26.5 ± 4.2	25.9 ± 3.55	26.6 ± 4.12	0.11
Hypertension (%)	1019 (45.6)	119 (48)	900 (45)	0.364
Diabetes (%)	459 (20.5)	53 (21)	406 (20)	0.675
LVEF (%)	66 ± 8.2	60.5 ± 11.7	67.1 ± 7.3	<0.001
SV index (mL/m²)	32.8 ± 8.7	25.3 ± 5.9	33.8 ± 8.5	<0.001
Cardiac output (L/min)	3.89 ± 1.1	3.3 ± 0.98	3.9 ± 1.1	<0.001
Cardiac index (L/min/m²)	2.19 ± 0.58	1.8 ± 0.5	2.2 ± 0.59	<0.001

Continuous variables are expressed as mean ± SD and categorical variables as number (percentage). SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; SV: Stroke Volume, LVEF: Left Ventricular Ejection Fraction.

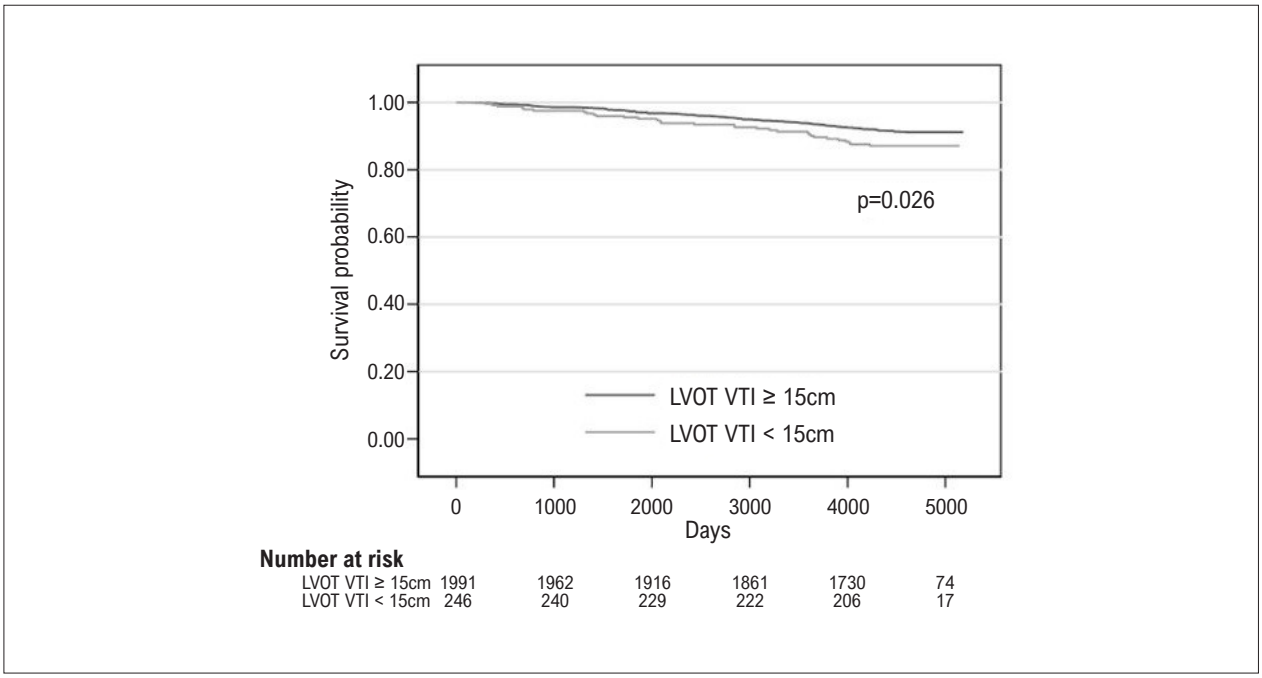

Figure 1 – *Kaplan-Meier survival according to LVOT VTI category (< 15 cm vs. ≥ 15 cm).*

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Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Table 2 – Multivariable Cox proportional hazards models for all-cause mortality according to LVOT-VTI (< 15 cm vs. ≥ 15 cm)

	Model 1	Model 2	Model 3
		HR (95% IC), p-value	
Age (years)	1.09 (1.07–1.12), p < 0.001	1.09 (1.07–1.12), p < 0.001	1.08 (1.06–1.11), p < 0.001
Male sex	2.58 (1.91–3.50), p < 0.001	2.70 (1.90–3.84), p < 0.001	2.47 (1.74–3.52), p < 0.001
LVOT-VTI < 15 cm	1.48 (CI 1.00–2.18), p = 0.048	1.48 (1.00–2.17), p = 0.048	1.46 (0.99–2.15), p = 0.053
BSA (m²)	—	0.81 (0.34–1.92), p = 0.637	0.83 (0.35–1.98), p = 0.682
SBP (mmHg)	—	—	1.01 (1.01–1.02), p < 0.001
p (overall model)	< 0.001	< 0.001	< 0.001

LVOT-VTI: left ventricular outflow tract velocity–time integral; BSA: body surface area; SBP: systolic blood pressure; HR: hazard ratio; CI: confidence interval.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any thesis or dissertation work.

Ethics Approval and Consent to Participate

This study was approved by the Ethics Committee of the Hospital Clínicas de Porto Alegre under the protocol number 0017.1.069.000-06 194/06. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

Use of Artificial Intelligence

The authors did not use any artificial intelligence tools in the development of this work.

Availability of Research Data

All datasets supporting the results of this study are available upon request from the corresponding author.

References

1. Goldman JH, Schiller NB, Lim DC, Redberg RF, Foster E. Usefulness of Stroke Distance by Echocardiography as a Surrogate Marker of Cardiac Output that is Independent of Gender and Size in a Normal Population. Am J Cardiol. 2001;87(4):499-502. doi: 10.1016/s0002-9149(00)01417-x.
2. Dini FL, Barletta V, Ballo P, Cioffi G, Pugliese NR, Rossi A, et al. Left Ventricular Outflow Indices in Chronic Systolic Heart Failure: Thresholds and Prognostic Value. Echocardiography. 2025;42(2):e70109. doi: 10.1111/echo.70109.
3. Tan C, Rubenson D, Srivastava A, Mohan R, Smith MR, Billick K, et al. Left Ventricular Outflow Tract Velocity Time Integral Outperforms Ejection Fraction and Doppler-Derived Cardiac Output for Predicting Outcomes in a Select Advanced Heart Failure Cohort. Cardiovasc Ultrasound. 2017;15(1):18. doi: 10.1186/s12947-017-0109-4.
4. Yuriditsky E, Mitchell OJ, Sibley RA, Xia Y, Sista AK, Zhong J, et al. Low Left Ventricular Outflow Tract Velocity Time Integral is Associated with Poor Outcomes in Acute Pulmonary Embolism. Vasc Med. 2020;25(2):133-40. doi: 10.1177/1358863X19880268.
5. Gentile F, Buoncristiani F, Sciarrone P, Bazan L, Panichella G, Gasparini S, et al. Left Ventricular Outflow Tract Velocity-Time Integral Improves Outcome Prediction in Patients with Secondary Mitral Regurgitation. Int J Cardiol. 2023;392:131272. doi: 10.1016/j.ijcard.2023.131272.
6. Ristow B, Na B, Ali S, Whooley MA, Schiller NB. Left Ventricular Outflow Tract and Pulmonary Artery Stroke Distances Independently Predict Heart Failure Hospitalization and Mortality: The Heart and Soul Study. J Am Soc Echocardiogr. 2011;24(5):565-72. doi: 10.1016/j.echo.2010.12.024.
7. Mill JG, Pinto K, Griep RH, Goulart A, Foppa M, Lotufo PA, et al. Medical Assessments and Measurements in ELSA-Brasil. Rev Saude Publica. 2013;47 (Suppl 2):54-62. doi: 10.1590/s0034-8910.2013047003851.