





LETTER TO THE EDITOR

Open Access



Calculated left ventricular outflow tract diameter for critically ill patients

Eline G. M. Cox^{1*} , Jacqueline Koeze¹ , Iwan C. C. van der Horst^{2,3}  and Renske Wiersema¹ 

Abstract

A fast and reliable left ventricular outflow diameter (LVOTd) estimation may aid in quickly estimating cardiac output. However, obtaining a correct LVOTd can be difficult in intensive care patients, potentially leading to errors and a cardiac output deviation. In this study, the measured LVOTd was compared with the expected LVOTd when estimated using an existing formula in 1177 critically ill patients. We show that estimated LVOTd based on baseline data can aid when obtaining LVOTd is difficult or impossible and simplified estimation based on a formula may allow for more reliable and accessible measurement of cardiac output.

Keywords: Prospective study, Critical care ultrasound, Cardiac output, Left ventricular outflow tract, Critical care, Intensive care unit

Dear Editor,

Critical care ultrasonography (CCUS) in the intensive care unit (ICU) is increasingly applied [1]. One of the most frequently used measurements is cardiac output (CO), calculated from the velocity–time integral and left ventricular outflow tract diameter (LVOTd). Research has revealed that obtaining a correct LVOTd can be difficult in critically ill patients, potentially leading to errors and a CO deviation [2]. A fast and reliable LVOTd estimation may aid in quickly estimating CO. Therefore, we studied (a) the association between patient characteristics and LVOTd in critically ill patients and (b) an existing formula to estimate LVOTd [3].

We analysed data from two prospective observational cohorts (simple intensive care studies I and II (SICS-I [4] and SICS-II [5])) in which all acutely admitted adults with an expected ICU stay over 24 h were included. Trained researchers performed CCUS to obtain the parasternal long-axis view, and an independent expert performed the

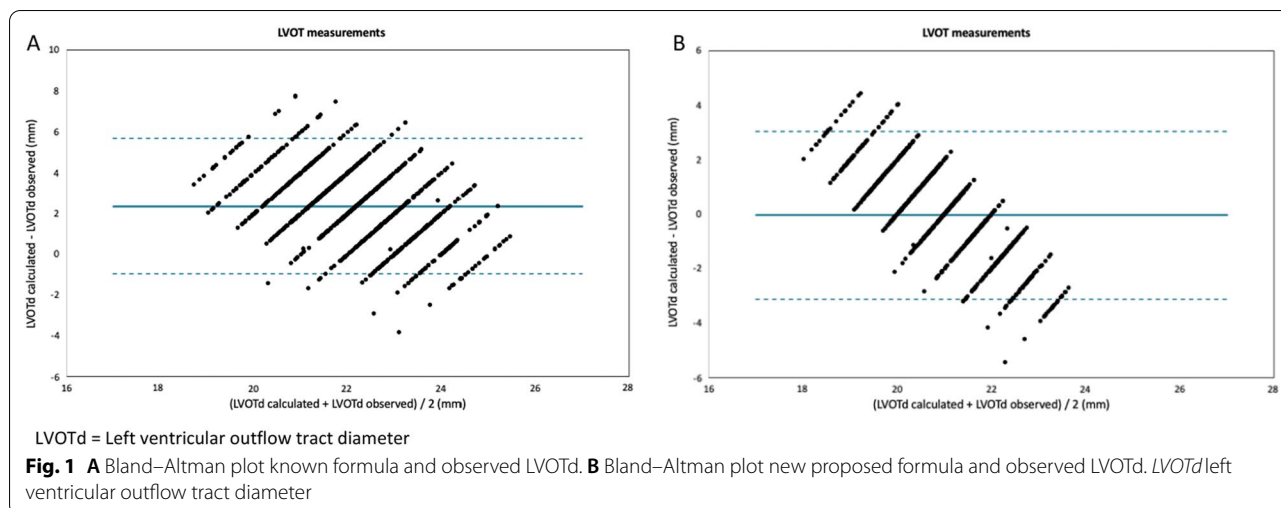
measurements. We used correlations (plots), the Pearson (*r*) coefficient, regression analysis and Bland–Altman plots to assess the data.

Patient inclusion took place from March 27th, 2015, to July 22nd, 2017 (SICS-I cohort) and March 14th, 2018, to July 10th, 2019 (SICS-II cohort). In total, 2208 unique patients were included, of which 1177 had validated LVOTd measurements and were included in the current analysis. Mean LVOTd was 21 mm (± 2 mm), with a significant difference between males (22 mm ± 2) and females (20 mm ± 2 mm, $p < 0.001$). LVOTd was associated with sex, height, weight, body surface area and body mass index. In the final multivariate regression, height, weight, and sex were significantly associated with LVOTd. The formula by Leye et al. correlated well but seemed to overestimate LVOTd systematically (mean difference 2.4 mm, ± 1.7 mm, LoA – 1.0 to 5.8 mm). Adjusting the intercept for the included population solved this issue (mean difference 0.0 mm, ± 1.7 mm, LoA – 3.4 mm to 3.4 mm). Figure 1 shows the observed LVOTd in our population and the expected LVOTd (a) when estimated using the formula by Leye et al. and (b) when the formula with adjusted intercept was used. Robustness of our findings was tested by internal bootstrap validation.

*Correspondence: e.g.m.cox@umcg.nl

¹ Department of Critical Care, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands
Full list of author information is available at the end of the article





This analysis shows that using estimated LVOTd based on baseline data can aid when obtaining a parasternal long-axis view is difficult or impossible. LVOTd was, unsurprisingly, associated with height, weight and gender. The formula by Leye et al. correlated well but systematically overestimated LVOTd in our cohort, but adjusting the intercept corrected this issue for the studied population. This is the first study of its kind in acutely admitted critically ill patients with the present sample size, a population in which it may be specifically useful to estimate CO. Even though standardized LVOT will not directly impact therapeutic interventions, small errors in LVOTd measurement lead to major differences in CO because of the mathematical contribution of LVOTd in the formula. However, direct use of VTI is not influenced by LVOT and could also be used to reflect changes in stroke volume. To conclude, simplified estimation based on a formula may allow for more reliable and accessible measurement of CO in the critically ill. Population-based adjustment by calibration of the used formula may possibly further enhance accuracy.

Abbreviations

CCUS: Critical care ultrasonography; ICU: Intensive care unit; CO: Cardiac output; LVOTd: Left ventricular outflow tract diameter; SICS: Simple intensive care studies; LoA: Limits of agreement.

Acknowledgements

In general, we are grateful to all members of the SICS I and II research group who have been mentioned in previous papers. Specifically for the current letter, we thank drs. da Fonseca and dr. van den Brink for their valuable input and expertise.

Author contributions

EGMC and RW drafted the manuscript and conducted the analyses. IvdH created the idea of the study. IvdH and JK critically reviewed the manuscript and agreed with the final version and findings. All authors read and approved the final manuscript.

Funding

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

In unresponsive patients, informed consent was first obtained from the legal representatives. Consent for the use of the study data was asked later if the patient recovered consciousness. The study data were used if the patient died before consent was obtained, and the legal representatives were informed of the study. The study was approved by the local institutional review board (METc 2015/004 (SICS-I) and 2018/203 (SICS-II)).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

¹Department of Critical Care, University of Groningen, University Medical Center Groningen, Groningen, The Netherlands. ²Department of Intensive Care Medicine, Maastricht University, Maastricht University Medical Centre+ Maastricht, Maastricht, The Netherlands. ³Cardiovascular Research Institute Maastricht (CARIM), Maastricht University, Maastricht, The Netherlands.

Received: 9 March 2022 Accepted: 13 June 2022

Published online: 21 June 2022

References

1. Robba C, Wong A, Poole D, et al. Basic ultrasound head-to-toe skills for intensivists in the general and neuro intensive care unit population: consensus and expert recommendations of the European Society of Intensive Care Medicine. *Intensive Care Med.* 2021;47:1347–67.
2. Koster G, Kaufmann T, Hiemstra B, et al. Feasibility of cardiac output measurements in critically ill patients by medical students. *Ultrasound J.* 2020;12:1–9.
3. Leye M, Brochet E, Lepage L, et al. Size-adjusted left ventricular outflow tract diameter reference values: a safeguard for the evaluation of the severity of aortic stenosis. *J Am Soc Echocardiogr.* 2009;22:445–51.

4. Hiemstra B, Koster G, Wiersema R, et al. The diagnostic accuracy of clinical examination for estimating cardiac index in critically ill patients: the Simple Intensive Care Studies-I. *Intensive Care Med.* 2019;45:190–200.
5. Wiersema R, Castela Forte JN, Kaufmann T, et al. Observational study protocol for repeated clinical examination and critical care ultrasonography within the simple intensive care studies. *J Vis Exp.* 2019;143:e58802.

Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Ready to submit your research? Choose BMC and benefit from:

- fast, convenient online submission
- thorough peer review by experienced researchers in your field
- rapid publication on acceptance
- support for research data, including large and complex data types
- gold Open Access which fosters wider collaboration and increased citations
- maximum visibility for your research: over 100M website views per year

At BMC, research is always in progress.

Learn more biomedcentral.com/submissions

