Editorial: Fundamental enrichment of ratio-based metrics in cardiology

Peter L. M. Kerkhof\(^1\)* and Qi Fu\(^2\)

\(^1\)Department of Radiology and Nuclear Medicine, Amsterdam University Medical Centers, Amsterdam, Netherlands; \(^2\)Institute for Exercise and Environmental Medicine at Texas Health Presbyterian Hospital Dallas, Internal Medicine at University of Texas Southwestern Medical Center, Dallas, TX, United States

KEYWORDS
ratiology, ejection fraction, coronary flow reserve, global function index, augmentation index, exercise, aortic stenosis

Introduction

Ratio theory has fascinated scholars since the early descriptions, then referred to as *anthypaieresis* (meaning reciprocal subtraction), and described in Book V of Euclid’s *Elements* which theory was developed by Eudoxus, who lived around 350 BCE, half a century before Euclid (1).

Paired measurements such as systolic and diastolic blood pressure are often converted to yield their difference (i.e., pulse pressure), mean value, or ratio. For the ratio-based candidate the systolic pressure is divided by the diastolic pressure reading, yielding a dimensionless metric, also for the reciprocal (2). Such unitless ratios have acquired a prominent place in cardiology, although their isolated use may reflect an incomplete description of the data set that is actually available (3).

The present theme-based collection of publications focuses on various traditional ratio-based applications, but now enriched with a more comprehensive interpretation of these dimensionless ratios. Essentially, the authors explore the impact of an associated companion metric based on the Pythagorean theorem. This companion is calculated for the data that is already available to derive the ratio, without the need to collect additional measurements. Only the combination of ratio and corresponding companion offers the full picture.

Ratiology

The most popular index to evaluate ventricular performance concerns ejection fraction (EF). As not all investigators accept the universal validity of EF, appealing variants have been developed. Among them the global function index (GFI) which introduces the myocardial mass normalized to tissue density (to eliminate physical units for this term), and employs mean ventricular volume rather than filling volume.
Diaz et al. demonstrated that the dimensionless companion metric, AIXc, remained unchanged but AIX was increased during exercise in water compared to land. Similar findings were reported by Fukuie et al. who found that aortic augmentation index (AIX), calculated from the ratio of pulse pressure to the square root of heart rate, was lower in water than on land. These results suggest that the rise in arterial pulse pressure, and brachial-ankle and heart-ankle pulse wave velocities decreased after training.

Information vs. knowledge

Finding a single metric that reflects the full information content embodied by two or more independent measurements refers to just another holy grail. Accumulation of details, especially when derived from primary variables by mathematical manipulation such as division, does not necessarily contribute to further understanding or promote knowledge. The process of gaining (further) insight requires availability of sound underlying concepts applied to available fundamental data. For example, ventricular pump action can be adequately characterized by the simultaneous measurement of pressure and volume, resulting in a graphical representation. This route permits calculation of stroke work and cardiac power output, each associated with sound physical dimensions. However, such knowledge is not embodied by EF, which construct only shows the outcome of a mathematical procedure (- yielding a bare number - ) that we get when end-systolic volume is divided by EDV (5). Likewise GFI and VAC yield numbers that merely compete for relative impact, as all refer to interconnected algorithms based on ESV, EDV, their difference, ratio or average value. Moreover, GFI and VAC also each carry a corresponding companion, similar to EF. Note that the companion metric is not an alternative for the traditional ratio-based metric, but actually constitutes a mandatory complementary element that may not be neglected.

Corollary

We conclude that incorporation of the documented companion metric offers incremental value to the study of cardiovascular (patho)physiology, and constitutes a fundamental enrichment for patient management in clinical practice.

Author contributions

Both authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
Publisher’s note

All claims expressed in this article are solely those of the authors and do not necessarily represent those of their affiliated organizations, or those of the publisher, the editors and the reviewers. Any product that may be evaluated in this article, or claim that may be made by its manufacturer, is not guaranteed or endorsed by the publisher.

References

1. Hogendijk JP. Anthyphairetic ratio theory in medieval islamic mathematics. In: Yvonne Dold-Samplonius et al., editor. From China to Paris: 2000 Years Transmission of Mathematical Ideas Vol 46. Stuttgart: Franz Steiner Verlag Boethius Band (2002). p. 187–202.

2. Konradi AO, Madlyansky AL, Kolesova EP, Shlyakhto EV, Kerkhof PL. Role of ratio-based metrics in cardiology. Russian J Cardiol. (2020) 3929:145–53. doi: 10.15829/1560-4071-2020-3929

3. Kerkhof PLM, Peace RA, Handly N. Ratiology and a complementary class of metrics for cardiovascular investigations. Physiol. (2019) 34:250–63. doi: 10.1152/physiol09056.2018

4. Tona F, Osto E, Kerkhof PLM, Montisci R, Famoso G, Lorenzoni G, et al. Multiparametric analysis of coronary flow in psoriasis using a coronary flow reserve companion. Eur J Clin Invest. (2022) 52:e13711. doi: 10.1111/eci.13711

5. Kerkhof PL, Diaz-Navarro RA, Heyndrickx GR, Handly N. La serendipia en torno la fracción de eyección: una revisión de la historia, la casualidad y la cuasi-funcionalidad de una métrica aplaudida. Revista Medica de Chile. (2022) 150:232–40. doi: 10.4067/S0034-988720220000200232