CHEST

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Does Golden Ratio Reside in Pulmonary Circulation?

To the Editor:

We have read the recent article in *CHEST* (May 2019) by Chemla et al[1] with great enthusiasm and interest. The most astonishing number series and ratio in the universe, namely the golden ratio, which arose from the Fibonacci series, have been evaluated in pulmonary hemodynamic and pressure components. Briefly, Chemla et al[1] have tested the presence of the golden ratio by pulmonary pressure components of systolic pulmonary artery pressure (sPAP), mean pulmonary artery pressure (mPAP), and diastolic pulmonary artery pressure (dPAP). In pulmonary artery hypertension (PAH), median values of sPAP/mPAP and mPAP/dPAP were found to be 1.591 (98% phi [Φ]) and 1.559 (96%Φ), respectively. In control patients, mean sPAP/dPAP and mPAP/dPAP were 1.572 (97%Φ) and 1.470 (91%Φ), respectively. Finally, they stated that both in patients with PAH and in control patients, the fluctuations in sPAP and dPAP around mPAP exhibited a constant scaling factor matched to Φ.

We highly appreciated seeing such an association between the golden ratio (also synonymous with golden number, golden mean, or Φ) and pulmonary hemodynamics. However, we would like to discuss some issues to fully understand the precise existence of Φ in the pulmonary vascular system, cardiovascular system, and nature as well. The Φ number, first described by Euclid as an "extreme and mean ratio," and later called the golden ratio, is a definite number with unique properties and acts in our life by means of aesthetics, art, architecture, music, and plants. It also resides in the human body either as a reflection of beauty, proportion of bones, or as a regulator of heart rhythm, BP, and pumping functions.[2-6] To understand the existence of the golden ratio or Φ number in pulmonary circulation, pulmonary hemodynamic components need to be measured by well-defined standardized objective methods and clear cutoff points. In this regard, sPAP and dPAP measured by right heart catheterization fluid-filled pressure give objective values. However, mPAP is a subsequently acquired measure of calculation to assess the so-called mean pulmonary pressure in pulmonary vasculature, defined by human kind artificially. Therefore, mPAP may not reflect the possible existence of Φ in pulmonary circulation precisely and might lead to misinterpretation of data. Although the authors have used mPAP, instead of mean pulmonary artery pulse pressure (mPApp), which is supposed to be almost identical to mPAP,[7] in the equation of the golden ratio, we do not think that the mPAP is a good measure to assess golden proportions. Inside of mPAP, use of mPApp would give valuable readouts and novel insights to understand the harmony of pulmonary circulation and the golden ratio. Likewise, systolic BP (A), diastolic BP (B), and pulse pressure (C), respectively, in the equation of extreme and mean ratio (A/B = B/C) (Fig 1)

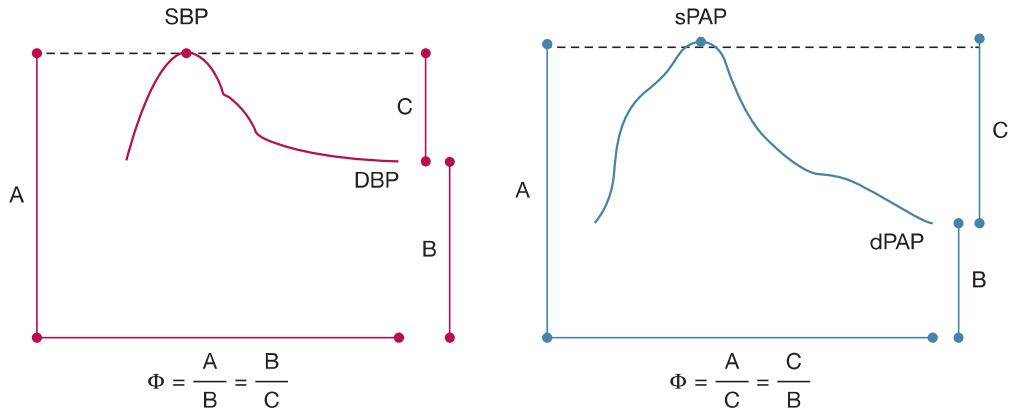

Figure 1 – *Formulation of golden ratio in systemic[5] (left) and pulmonary circulation[1] (right). DBP = diastolic BP; dPAP = diastolic pulmonary artery pressure; SBP = systolic BP; sPAP = systolic pulmonary artery pressure.*

have been found to be close to the golden ratio.[5] In a similar manner, sPAP (A), dPAP (B), and mPApp (C), respectively, have been shown to be identical to its systemic counterpart, except the replacing of B and C in the equation (A/C = C/B). Given the minimization of wasted space and the need for energy, the golden ratio seems to play its regulatory role in pulmonary circulation the other way around in a cute manner. Additionally, Chemla et al[1] have also shown indirectly that the higher the PAP, the lower the ratios deviating from Φ in the equations. In another way, divergence of ratios from Φ indicates more severe pulmonary hypertension.

In conclusion, the golden ratio resides in our body to play its harmony in pulmonary circulation and in the cardiovascular system.[2,3] Understanding the role of subtle regulators in pulmonary, cardiovascular, and other systems would have new steps to put novel insights into physiology and pathophysiology and even spirituality of our body and eventually well-being of human kind. With the support of further studies, the golden ratio or proportion might inherently yield diagnostic and prognostic implications in the cardiovascular era.

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Response

To the Editor:

We thank Yetkin et al for their enthusiasm and interest in our article.[1] They first challenge the use of the mean pulmonary artery pressure (mPAP) in the geometric progression we documented. They support the notion that mPAP is "defined by human kind artificially" and suggest that mPAP may not be "measured by well-defined standardized objective methods and clear cutoff points." On these points, we disagree. There is no reason to not analyze mPAP because this is the fundamental metric of defining pulmonary hypertension. The mPAP also allows calculation of derived variables such as pulmonary vascular resistance, which plays a major role in the hemodynamic phenotyping of patients with pulmonary hypertension, and which can be regarded as a measure of the dissipation of hydraulic energy per unit time (hydraulic power) within the pulmonary vascular bed.[2] We studied the mPAP values invasively obtained by the reference method, namely right heart catheterization. With this method, the mPAP is not a derived variable but is measured as the pulmonary artery pressure-time integral divided by heart period, thus precisely characterizing the steady component of pulmonary artery pressure. Furthermore, because mPAP is integrated over the entire cardiac cycle, it is less prone to measurement errors because of high-frequency artifacts than systolic pulmonary artery pressure (sPAP) and especially diastolic pulmonary artery pressure (dPAP) and pulmonary artery pulse pressure (PApp) (PApp = sPAP − dPAP). Therefore, mPAP has strong physiologic, energetic, and clinical grounds, and to abandon mPAP is to abandon the entire body of research in pulmonary hemodynamics since right heart catheterization was first invented by Cournand, Forssman, and Richards. In an attempt to avoid hazardous conclusions, it has been highly recommended to try to justify why the golden ratio (phi [Φ] = 1.618) may be a preferred number in the field under study.[3,4] In our study, we extensively described the strong pathophysiologic background supporting our approach.[1] Conversely, in the second part of their letter, Yetkin et al propose to replace mPAP by PApp in the geometric progression, but they do