Ascending aortic curvature as an independent risk factor for aortic dissection: the mathematical model and underlying equations

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As biomedical engineers with an interest in cardiovascular haemodynamics, we carefully read the study by Poullis et al. [1]. The published article describes a mathematical model of the effects of aortic curvature, aortic diameter and systolic blood pressure on the resultant force on the aortic wall. We find the model to be informative and useful, but we are unable to replicate two of the graphs from the article when using the equations provided by the authors. We believe that there are errors in these two graphs.

In Figure 3b, the authors calculate the effects of the aortic diameter on the reaction force on the ascending aorta. We are able to replicate the curves corresponding to aortic diameters of 20, 25, 30 and 35 mm. However, we cannot replicate the topmost curve in Figure 3b; the authors claim that this curve corresponds to an aortic diameter of 50 mm. Specifically, when we use the equations given by the authors, we calculate that an aortic diameter of 50 mm with an angle of curvature of 0° should give a reaction force on the aortic diameter of 52 N, not 33 N as shown in the figure. We are able to replicate the topmost curve in Figure 4a only by setting the aortic diameter equal to 40 mm rather than the reported 50 mm. We therefore believe that an error exists in the authors’ calculation and/or the chart’s labels.

In Figure 6b, the authors present a graph of the effect of aortic curvature on the height of impact above the aortic valve, for blood being ejected through the aortic valve. In other words, this graph is intended to show that the height above the aortic valve where the aorta receives the greatest impact, from blood being ejected through the aortic valve, increases the straighter the ascending aorta. According to the figure, an angle of curvature of 90° results in a height of impact of 14 cm above the aortic valve. However, this value and most of the values in the graph are non-physical, as a typical length of the ascending aorta is 5 cm [2]. Moreover, the authors state that the equation utilized to calculate the height of impact above the aortic valve is $H = R \sin(90° - \theta)$. This does not correspond to the graph in Figure 6b; if the equation given by the authors is used to calculate the height of impact, then an angle of curvature of 90° should give a height of impact of zero. We are able to replicate the curve in Figure 6b only by using the equation $H = 7R \sin(\theta)$, but as pointed out above, the values in the curve are non-physical. We therefore believe that an error exists in the authors’ calculation and/or the chart’s labels.

Given the clinical and scientific relevance of the study by Poullis et al. [1], we suggest that the authors re-examine the calculations underlying Figures 3b and 6b, so that future engineers and clinicians can best use this important work.

REFERENCES


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