# Journal of Interdisciplinary Science Topics


## Why Hearts Don't Explode


Sophia Bennett
*Natural Sciences (Life and Physical Sciences), School of Biological Sciences, University of Leicester*


28/02/2025



**Abstract**
Heart explosions are medically not possible. But if they were, how much internal pressure would it take to achieve this and is this amount of pressure anywhere close to any previous recorded blood pressures? This paper calculates a required blood pressure of 12877 mmHg to achieve a total heart explosion using Barlow's formula.



**Keywords:** *Health; Biology; Physics; Heart; Pressure*


### Can a Heart Explode?

Some conditions can make the heart beat faster, causing pain and making someone feel like their heart might explode [1]. In reality, heart explosions cannot occur. However, what if they could? This paper calculates how much internal pressure it would take to explode a heart.

### Pressure Formula

Barlow's formula (Equation 1) calculates the burst pressure of cylindrical vessels [2]. Usually, this equation is used for rigid materials such as metal or plastic piping in engineering settings. Although not directly applicable to flexible biological tissues, we can adapt it for a rough estimation. We use this equation as the shape of the heart, including the chambers, can be more comparable to a cylindrical vessel than a spherical one. Barlow's formula:

$$P = \frac{(2T \times S)}{D}, \qquad (eq^n \ 1)$$

where $P$ is the burst pressure (MPa), $T$ is the wall thickness (mm), $S$ is the tensile strength of the material (MPa) and $D$ is the diameter of the vessel (mm).

### Burst Pressure of The Average Heart

To approximate $P$ (MPa) for a human heart (Figure 1), we need the tensile strength of cardiac tissue, the thickness of the heart wall and the diameter of the heart chambers. The model will be based on the average human male and all values quoted to 3 significant figures. The thickness of the heart wall and the shape of the chosen heart area will be assumed uniform with no particular areas of weakness. It is also assumed the heart is healthy with no medical conditions or environmental impact that may affect the strength (for example smoking).

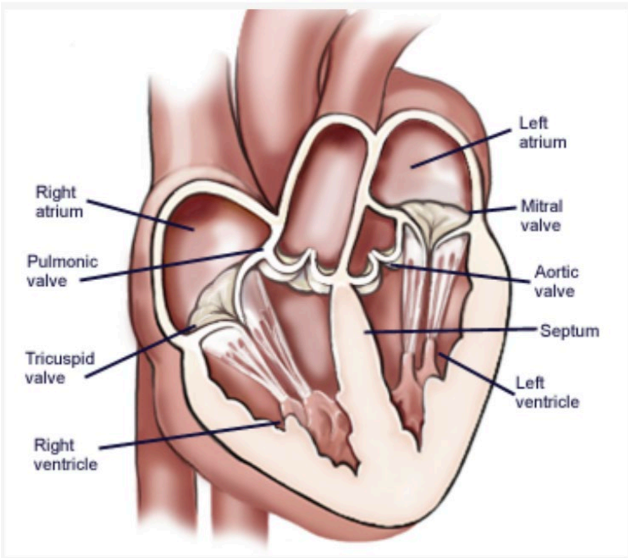


Figure 1 – Diagram of the human heart displaying all chambers and values [3].

Each heart chamber is made up of the same cardiac tissue with a tensile strength ranging from 0.4 MPa to 2.6 MPa [4]. The median value of 1.1 MPa will be used. The thinnest and weakest part of the heart is the right atrium, which is 2 to 6 mm thick [5]. The median value of 4 mm will be used. Its diameter is 3.4 to 5.3 cm [6]. The median value of 4.35 cm

(43.5 mm) will be used. Putting these median values into Barlow's Formula, we can produce Equation 2:

$$P = \frac{\left(2(4.00mm) \times (1.10MPa)\right)}{(43.5mm)}$$

$$P = 0.202MPa \qquad (eq^n\ 2)$$

To convert MPa to mmHg we use the MPa value multiplied by 7501 [7]. This value is equivalent to a blood pressure of 1,515 mmHg. One of the largest documented blood pressures is 370/360 mmHg [8]. This extreme case was observed during a study of blood pressure in weight-lifting males. Based on this, it is fair to say that blood pressures of 1,515 mmHg are not going to have been recorded before in living human individuals and there is no known way of this value being achieved. The calculated pressure is also equivalent to 1.99 atm. A study on the aortic rupture of intracranial arteries noted average pressures of 2.21 atm required [9].

**Why is there a difference?**

Arteries and the heart, although working for the same system, are different in structure. Under normal circumstances, these structures do not explode. It is factors such as the thickness and flexibility of the walls that prevent bursts. Artery walls consist of three layers. Intracranial arteries specifically have smaller innermost and middle layers [10]. These are the tunica intima, containing mostly elastic fibres and the tunica media, made of smooth muscle, responsible for constriction and dilation. The heart walls are also three layers made of endothelial cells, cardiac muscle tissue, blood vessels, nerves, and adipose tissue going from the inner to outer layer [11]. The atria specifically have thinner walls too as they require less force to contract than the ventricles. The pressure in the right atrium is 1 to 7 mmHg, whereas intracranial pressure is 5 to 15 mmHg [12, 13]. These facts help explain the difference in pressure required to burst each structure. Additionally, under regular conditions, these structures would not explode due to blood pressure regulation in the body. This involves the autonomic nervous system and baroreceptor [14]. Valves also aid in the maintenance of blood pressure by preventing backflow and realistically, the pressure withstood by these would also affect the pressure needed to burst a heart and arteries [3].

**Total Heart Explosions**

What if you wanted a full heart explosion, similar to something in a cartoon? To burst all regions of the heart, we must consider the strongest region of the heart with the best measurements from the average ranges. These will guarantee a total explosion of even the strongest hearts. Taking the maximum tensile strength of cardiac tissue (2.4M Pa) [4], the maximum thickness (15 mm) [15] and the smallest diameter of the left ventricle (42 mm) [16], we can produce Equation 3:

$$P = \frac{\left(2(15mm) \times (2.4MPa)\right)}{(42mm)}$$

$$P = 1.71MPa \qquad (eq^n\ 3)$$

This would require a blood pressure of 12,826 mmHg. Even giraffes who have the highest known average blood pressure of an animal, only have pressures of around 300/180 mmHg [17]. Giraffes, unlike humans, have multiple internal structures to support cardiac tissue under such pressure. This includes specialised valves that prevent blood from pooling in the head and flowing back into the skull, thicker heart muscle walls and support structures in the arteries.

**Conclusion**

Heart explosions, while not medically possible, are an interesting point of study in terms of the battle between pressure and tensile strength. A blood pressure of 12,826 mmHg must be achieved for a total heart explosion of the strongest hearts. This is not naturally possible due to the tight regulation of blood pressure in the body and has never been recorded higher than 360 mmHg.

**References**

[1] Lavarone, K. (2022) *Heart explosion: Can it happen? Causes and more*, MedicalNewsToday, Available at: https://www.medicalnewstoday.com/articles/heart-explosion [Accessed: 28 February 2025]

[2] Dimitris (2015) *Pipes and Barlow's formula*, fxsolver, Available at: https://www.fxsolver.com/blog/2015/08/10/pipes-and-barlows-formula/ [Accessed: 28 February 2025]

[3] Cleveland Clinic (2017). *4 Heart Valves: What They Are and How They Work*, Cleveland Clinic. Available at: https://my.clevelandclinic.org/health/body/17067-heart-valves [Accessed: 12 February 2025]

[4] Muslov, S., Lotkov, A.I., Arutyunov, S.D. & Albakova, T.M. (2021) *Calculation of the Parameters of Mechanical Properties of the Heart Muscle*, Materials For Human Life Support And Environmental Protection, 12, pp 433-440. DOI:10.1134/S2075113321020398

[5] Gupta, D.K. (2019) *Chapter 17: Assessment of the Atria*, in Essential Echocardiography – A Companion to Braunwald's Heart Disease, by Soloman, S.D & Gillam, L.D. Elsevier. DOI: 10.1016/B978-0-323-39226-6.00017-5

[6] Morgan, M., Campos, A., Silverstone, L et al. (2024) *Right atrium*, Reference article, Radiopaedia.org DOI:10.53347/rID-34116 [Accessed: 28 February 2025]

[7] CheckYourMath (2025). *Convert MPa to mmHg - Pressure Conversions*. [online] Checkyourmath.com. Available at: https://www.checkyourmath.com/convert/pressure/megapascals_mmhg.php [Accessed: 28 February 2025]

[8] Narloch, J.A. & Brandstater, M.E. (1995) *Influence of breathing technique on arterial blood pressure during heavy weight lifting*, Archives of Physical Medicine and Rehabilitation, DOI: 10.1016/s0003-9993(95)80578-8

[9] Ciszek, B., Cieślicki, K., Krajewski, P. & Piechnik, S.K. (2013) *Critical Pressure for Arterial Wall Rupture in Major Human Cerebral Arteries*, Stroke, 44, 11, pp 3226-3228. DOI:10.1161/STROKEAHA.113.002370

[10] Galliard,F., Bell, D., Hacking, C. et al. (2021) *Intracranial arteries*, Reference article. Radiopaedia.org, DOI:10.53347/rID-4757 [Accessed: 28 February 2025]

[11] White, S. (2024) *The Heart Wall*, TeachMeAnatomy, Available at: https://teachmeanatomy.info/thorax/organs/heart/heart-wall/ [Accessed: 28 February 2025]

[12] Lichtblau, M., Bader, P.R., Saxer, S., Berlier, C., Schwarz, E.I., Hasler, E.D., Furian, M., Grünig, E., Bloch, K.E. & Ulrich, S. (2020) *Right Atrial Pressure During Exercise Predicts Survival in Patients With Pulmonary Hypertension,* Journal of the American Heart Association, 17;9(22):e018123. DOI:10.1161/JAHA.120.018123

[13] TeachMeSurgery (2020) Intracranial Pressure Monitoring, TeachMe, Available at: https://teachmesurgery.com/neurosurgery/flow-and-pressure/icp-monitoring/ [Accessed: 28 February 2025]

[14] Armstrong, M., Kerndt, C.C. & Moore, R.A. (2023). *Physiology, Baroreceptors*. Nih.gov. Available at: https://www.ncbi.nlm.nih.gov/books/NBK538172/ [Accessed: 28 February 2025]

[15] Ho, S.Y. (2009) *Anatomy and myoarchitecture of the left ventricular wall in normal and in disease*, European Journal of Echocardiography, 10, 8, pp iii3-iii7. DOI:10.1093/ejechocard/jep159

[16] Saito, T., Inohara, T., Yoshijima, N., Yashima, F., Tsuruta, H., Shimizu, H., Fukuda, K., Naganuma, T., Mizutani, K., Yamawaki, M., Tada, N., Yamanaka, F., Shirai, S., Tabata, M., Ueno, H., Takagi, K., Watanabe, Y., Yamamoto, M. & Hayashida, K. (2021) *Small Left Ventricle and Clinical Outcomes After Transcatheter Aortic Valve Replacement*, Journal of the American Heart Association, 6;10(7):e019543. DOI:10.1161/JAHA.120.019543

[17] Lawrence, E. (2015) *Giraffes have high blood pressure. Why don't they drop dead? Available at:* https://www.novartis.com/stories/giraffes-have-high-blood-pressure-why-dont-they-drop-dead [Accessed: 28 February 2025]