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On the Misuse of the Laplace Law in Bio Fluid Dynamics AZAM THATTE, JAMES BRASSEUR, Penn State University — The Laplace law is commonly applied in biomechanical analyses of blood vessels, lung alveoli, and the gastrointestinal tract, often without concern to assumptions that underlie its use. This "law" is a simple force balance applied across the wall of a static pressurized (ΔP) vessel *for small thickness-to-radius ratio* τ/r. However, the true thin-wall requirement is more severe than $\tau/r << 1$. Furthermore, because the Laplace law estimates *total* stress rather than *deviatoric* stress, the common practice of evaluating material stiffness by plotting Laplace law stress against strain is, in principle, incorrect. To study the validity of the Laplace law in biomechanical applications, we solved exactly the model problem of an axisymmetric pressurized cylinder of arbitrary thickness, linearly elastic isotropic material, in steady state, with the no-load state ($\Delta P = 0$) as the zero stress state. Vessel radii and all stresses (total, deviatoric, hydrostatic) are predicted as functions of ΔP. We find that the Laplace law is invalid for many biomechanical applications and that total stress is not an appropriate surrogate for deviatoric stress to evaluate stiffness. We propose a model for deviatoric stress that we argue should replace the Laplace law for many biomechanical applications.

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