Improving Sonic Rarefactions in Elastic Vessels: Application to the Tourniquet Manoeuvre

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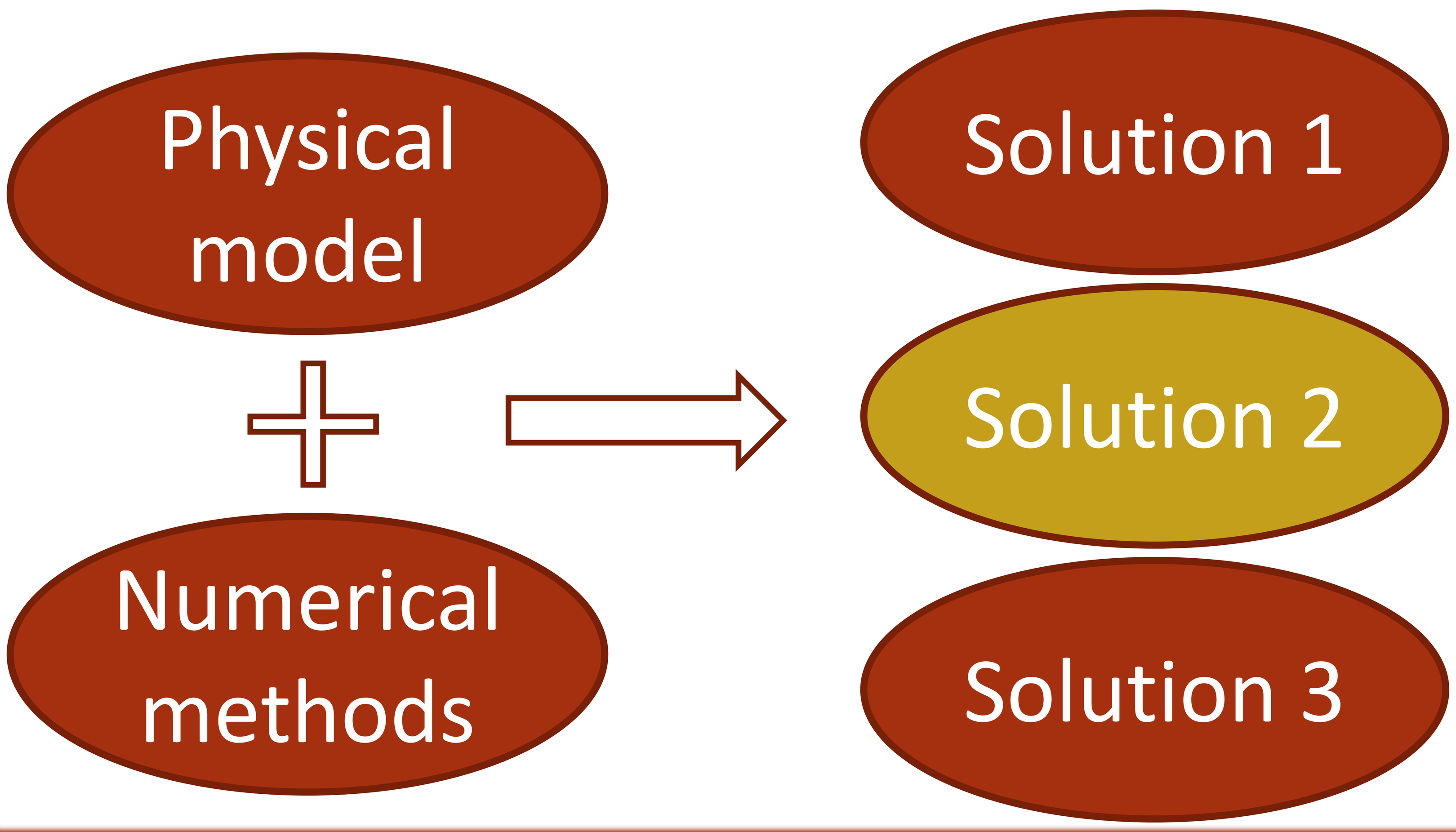
A method to calculate 1D Flow in veins with varying section needs corrections or it can otherwise produce unphysical results.

Entropy Corrections

An *entropy condition* identifies the physically correct solutions among all the solutions produced by a numerical method.



Source term correction

Fluid flow is solved with conservation laws (1), an integral over a control volume

$$\int_{-x_L}^{x_R}\int_0^{\Delta t}\left(\frac{\partial \mathbf{U}}{\partial t}+\frac{\partial \mathbf{F}}{\partial x}-\mathbf{S}\right)dt\,dx=0 \quad (1)$$

Integrating ***U*** and ***F*** is "easy", but ***S*** needs to be approximated by a constant value $\bar{s}$ in each timestep. There are different choices

- **Differential**: Using the hydrostatic force on the walls at each cell.

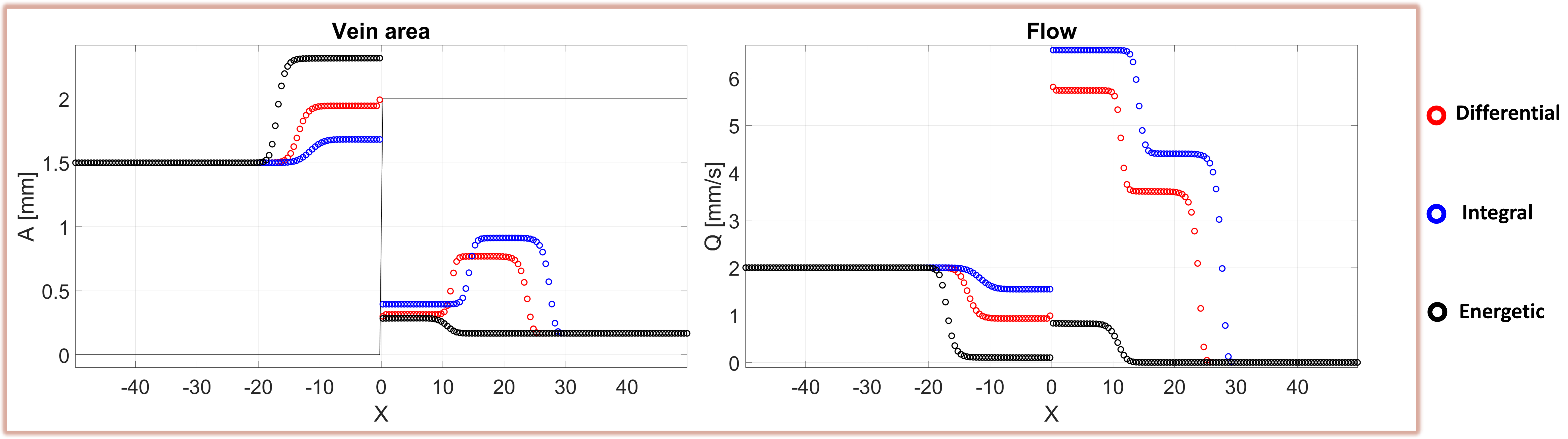
$$\bar{\mathbf{S}}=-g\tilde{A}\Delta z \quad (2)$$

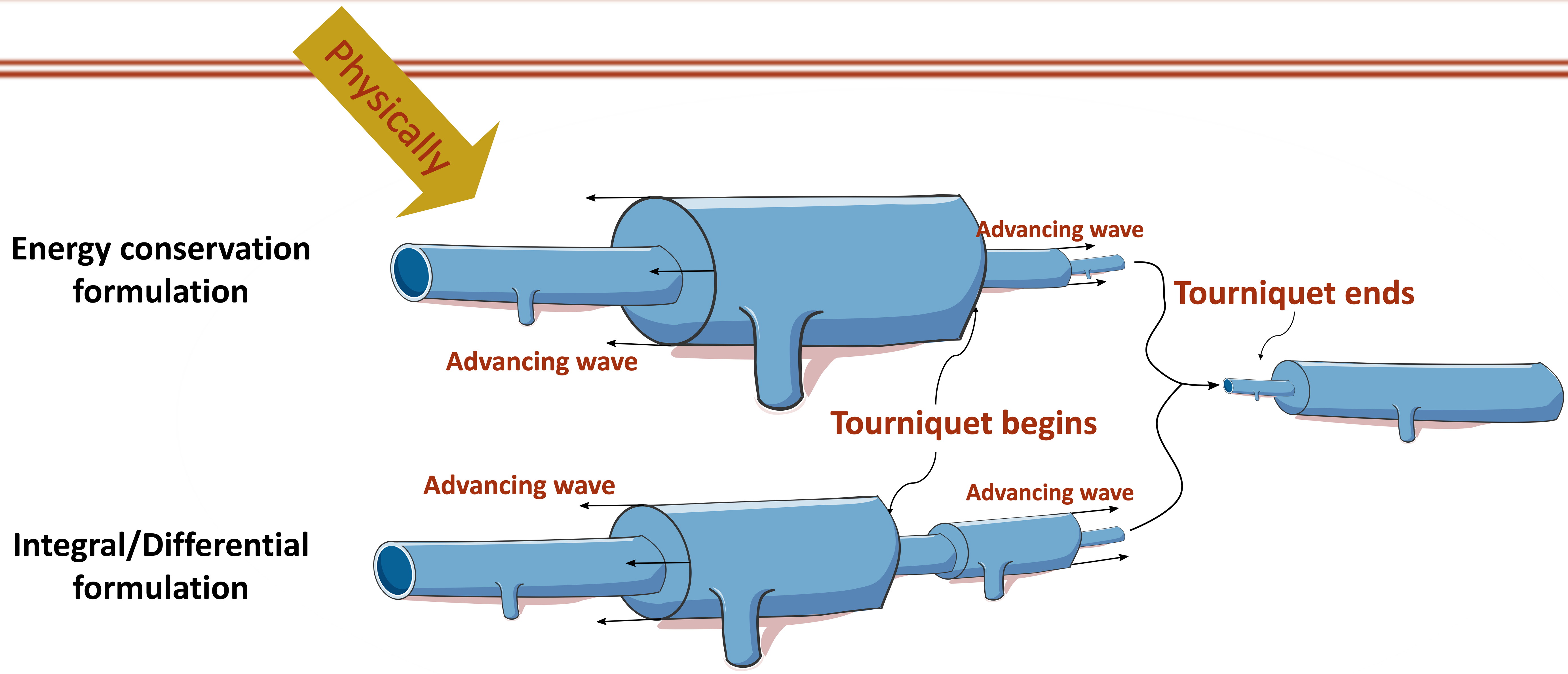
- **Integral**: The pressure exerted by the wall discontinuity is integrated on the section.

$$\bar{\mathbf{S}}=\int_{z-r}^{z+r}-g\tilde{A}dz' \quad (3)$$

- **Energetic**: The weighted average of the Differential and Integral formulations is taken according to energy conservation arguments.

Numerical results





Conclusions

- The differential and integral formulations of the source term are insufficient when dealing with large discontinuities.
- Formulating the source term based on energy conservation arguments often produces better results, except when dissipation

Future work

- Better source term integration.
- Extension to vessel junctions.
- Calculations of stress on venous walls.
- Addition of dissipation.

References

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