Citation for published version (APA):
This model expresses stroke volume, \( V_{stoke} \), as the sum of distending flow and outflow terms. Each term contains an unknown physical variable: compliance, \( C(P) \), or resistance, \( R \).

\[
V_{in} \rightarrow P \rightarrow C(P) \rightarrow R \rightarrow P_{out}
\]

Stroke Volume = Distending Flow in the large arteries + Outflow through smaller arteries

\[
V_{in} = \int_{P(t_0)}^{P(t_f)} C(P) dP + \frac{1}{R} \int_{t_0}^{t_f} [P - P_{out}] dt
\]

Several simplification methods have been used to eliminate one unknown variable. An independent calibration measurement is used to estimate the other variable, facilitating continuous CO monitoring.

**1. Why is this clinically important?**

Cardiac output (CO) monitoring is used to assess the haemodynamics of critically ill patients. It is used to guide fluid administration and vasoactive drug use. Monitors estimate CO from the arterial blood pressure (ABP) wave using the Windkessel model of the circulation. **Aim:** To assess the accuracy of existing methods for CO monitoring using the Windkessel model during a change in vascular tone.

**2. The Windkessel Model**

**3. Clinical Evaluation**

**Methods**

ABP signals were acquired from 15 critically ill patients, alongside reference CO measurements, \( CO_{ref} \). The dosage of norepinephrine infusion, a vasoactive drug, was doubled during the recording giving a step-change in vascular tone. Continuous CO, \( CO_{est} \), was estimated using each simplification method. \( CO_{est} \) values were calibrated with \( CO_{ref} \) prior to dosage increase. The precision of each method was assessed by comparing \( CO_{ref} \) during double dosage with the mean \( CO_{est} \) during that \( CO_{ref} \) measurement.

**Results**

See table. The most accurate methods maintained both compliance and outflow terms. The remaining methods, which eliminated one of the terms, tracked CO less well during changes in vascular tone.

**4. Conclusion**

CO monitoring using the Windkessel model is more accurate during changes in vascular tone when distending flow and outflow terms are maintained. No methods tracked CO within the clinically-acceptable ±30%.

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**References**
