# STARLING PUBLISHED STUDIES

- OVER 100 PEER REVIEWED PUBLICATIONS
- MULTIPLE CLINICAL SETTINGS (ICU/OR/ED/EXERCISE LAB/OUTPATIENT)
- COMPARATIVE ANALYSES AGAINST ALL MAJOR TECHNOLOGIES, INCLUDING SWAN GANZ, PULSE CONTOUR, DOPPLER AND FICK

## VALIDATION

Starling is the only non-invasive monitor that has been successfully compared to thermodilution in multiple clinical settings.

| Rich, J et al. Noninvasive cardiac output measurements in patients with pulmonary hypertension. *Eur Respir J.* 2013;42;125-33. | - 50 consecutive patients with Pulmonary Hypertension receiving a right heart catheterization were also monitored with Starling and indirect Fick.  
- The study showed that the **Starling** had improved accuracy and precision than Thermodilution compared to the Fick.  
- **Starling** accurately detected directional changes to a vasoactive medication administration. |
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| Heerdt PM et al. Noninvasive cardiac output monitoring with bioreactance as an alternative to invasive instrumentation for preclinical drug evaluation in beagles. *J Pharmacol Toxicol Methods.* 2011;64:111-8. | - **Starling** algorithm was compared to an Aortic Flow Probe in beagles. Aortic Flow Probe is the gold standard in measuring flow.  
- In over 516 distinct measurements the **Starling** exhibited high accuracy and precision when compared with the aortic flow probe  
- This study also highlights the algorithm’s ability to handle low flow states:  
  - Accuracy compared to Flow Probe: **Starling** 95%  
  - Precision (bias) compared to Flow Probe: **Starling** 6.1% vs. Flow Probe 0.8%  
  - Sufficient fidelity to detect and quantify acute, drug induced, directional changes in CO |
**FLUID MATTERS**

**IV FLUIDS CAN CAUSE HARM...**

- Fluid is an independent predictor of mortality (Marik, 2017)
- Only ~50% of hemodynamically unstable patients will respond to IV fluid by increasing cardiac output and perfusion (Bentzer, 2016)
- Assessing whether fluid may help or harm a patient is a critical step in optimizing treatment.

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- Meta-analysis evaluating over 50 studies (2260) patients looking tests to predict fluid responsiveness. This is the largest fluid responsiveness analysis to date.
- Summary fluid responsiveness is 50% (95% CI 42% to 56%). The study evaluates physical exam, CVP, Pulse Pressure Variation, IVCc, ECHO, Cardiac Output / Stroke Volume to assess fluid responsiveness
- Physical exam and CVP cannot be used to reliably predict fluid responsiveness.
- Pulse Pressure, SV Variation, IVCc work in very limited clinical conditions (require controlled ventilation).
- SV change was the best predictor of fluid effectiveness (Sensitivity 88%, Specificity 92%).

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- In this Premier database analysis, 23,513 patients with severe sepsis and septic shock were admitted to ICU from the ED.
- Day 1 fluid averaged 4.4L, and for each liter over 5L, mortality increased by 2.3%, and added $999 treatment cost.
- Even the small difference of 600cc can increase the patient’s risk.

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**ASSESSING FLUID RESPONSIVENESS**


- The study demonstrated that a PLR maneuver using the Starling provides an accurate method of assessing volume responsiveness in critically ill patients.
- PLR results (SV>10%=Fluid Responsive) were compared to Carotid Doppler in 34 hemodynamically unstable patients.
- The PLR maneuver had a sensitivity of 94% and a specificity of 100% for predicting volume responsiveness (one false negative).
- **Starling** is the only non-invasive technology with a validation study evaluated during the PLR.

- Retrospective matched, single-center study, SV group comprised 100 patients, with 91 patients in the UC group.
- The study concluded that optimized fluid management in patients with severe sepsis and septic shock may lead to improved clinical outcomes.
  - Reduced Fluid Balance and reduced time on Pressors
  - Reduced Length of Stay (2.89 Days)
  - Decreased need for Mechanical Ventilation (25%) and Acute Dialysis (13.25%)