increasing preload. Thus, these monitors can indicate the likelihood of response to fluid bolus, then track the cardiac output response to fluid or other interventions. A typical goal of therapy is an SVV of less than 13%. Newer models compensate for changing vascular resistance during hemodynamic instability. The equipment software may not recognize atypical waveforms such as those that accompany arrhythmias, severe aortic regurgitation or intraortic balloon pumps. Other limitations include a lack of use with spontaneous ventilation, use of 8 cc/kg tidal volumes with fixed respiratory rates, or increasing PEEP. However, studies in intraoperative and ICU settings have shown that the use of this method in early goal-directed therapy reduces morbidity and mortality.

**Esophageal Doppler (ED)**

As invasive as a nasogastric tube, the esophageal Doppler measures the velocity of descending aorta blood flow and calculates stroke volume and cardiac output using several assumptions about aortic anatomy and ascending/arch blood flow, as well as nomograms for patient demographic and size. It estimates preload by measuring the time from aortic pulse waveform upstroke to the return to baseline (flow-time). Investigators have found good agreement with pulmonary artery wedge pressures. ED detects changes in preload, so it is a useful dynamic guide to therapy. Since up to 30% of stroke volume goes cephalad, a correction factor must be included in calculations of stroke volume and cardiac output. Outcomes in surgical patients have improved via goal-directed fluid therapy using ED. The Database of Abstracts of Reviews of Effects found seven randomized controlled trials with 583 patients, and concluded there was “strong evidence” that ED-guided fluid replacement, along with central venous pressure and standard monitoring, reduced perioperative complications. No conclusions were drawn regarding uses in other settings. Limitations of ED include difficulty with probe positioning, a steep learning curve, erroneous assumptions about aortic anatomy, and concerns about responsiveness in dynamic settings.

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**FOR MORE INFORMATION**

- Centre for Reviews and Dissemination. Database of Abstracts of Reviews of Effects (DARE). Esophageal Doppler ultrasound-based cardiac output monitoring for real-time therapeutic management of hospitalized patients: a review. Available at www.crd.york.ac.uk/CRDWeb/ShowRecord.asp?ID=12008008077.