Assessing Volume Status

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KEYWORDS

• Shock • Fluid resuscitation • Cardiac output • Stroke volume • Hemorrhage
• Hemodynamic monitoring • Noninvasive monitoring • Critical care

KEY POINTS

- Shock is a physiologic state associated with high morbidity and mortality rates.
- Fluid resuscitation has long been a part of the acute resuscitation armamentarium.
- Emergency physicians have a major impact on patient survival. The clinician has several tools available to evaluate volume status.
- Each modality has its benefits and limitations, but, to date, no one test can indicate with 100% accuracy which patients will be truly volume responsive.

INTRODUCTION

Shock, by definition, is a condition of inadequate tissue perfusion; during resuscitation, the clinician's goal is to restore the patient's perfusion of organs and tissues. The importance of early goal-directed therapy and early intervention by emergency physicians for hypotensive patients has been shown in multiple studies,[1,2] most classically by Rivers and colleagues[3] for patients presenting in septic shock. One of the most important principles of Rivers' study was the use of targeted and aggressive fluid resuscitation to improve tissue perfusion.

Fluid resuscitation has long been a part of the acute resuscitation armamentarium. Its goal is to increase cardiac filling and stroke volume (ie, cardiac output). What is often less clear, however, is accurately determining whether the patient who is currently hypotensive will actually respond to a fluid bolus (**Fig. 1**); that is, before administering a fluid bolus, it is very difficult to determine if the patient will respond.

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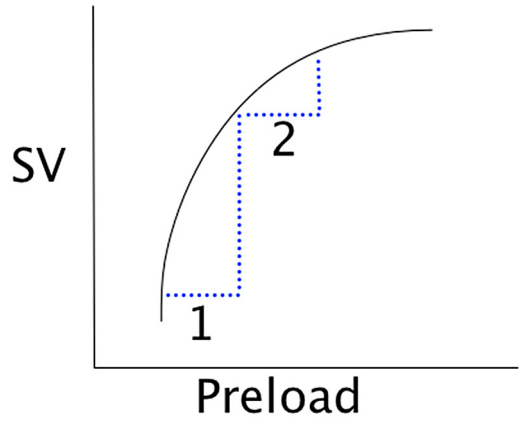

Fig. 1. Frank-Starling relationship of the heart. When the left ventricle is underfilled (1), an increase in preload brings on a large increase in stroke volume, and the patient is said to be volume responsive. When the left ventricle is closer to maximum end-diastolic volume (2), the increase in stroke volume is minimal for the same increase in preload.

This goal has proved to be perpetually elusive. In most studies, more than 40% of intensive care unit patients receiving a fluid bolus did not show the desired increase in cardiac output.[4] The harm of unnecessary and excessive fluid administration was shown in multiple studies, which suggest that the deleterious effects of fluid overload likely go far beyond simple pulmonary edema.[5–9] The endpoint of a goal-directed fluid strategy has placed increasing emphasis on finding a true "Goldilocks" state of fluid balance (ie, to not administer too much fluid or withhold too much).

This article describes the various tools available to the emergency physician to help answer an often perplexing question at the bedside: "Does this hemodynamically unstable patient need intravenous fluids?"

PHYSICAL EXAMINATION

Classic medical school teaching tells us to rely on the physical examination and vital signs to guide our resuscitation strategy, and this instruction extends into our clinical practice.[10] However, when the objective findings are evaluated for their correlation with actual changes in perfusion and cardiac output, few of them perform well.[11,12]

One example is estimation of jugular venous pressure during the physical examination, which is used to evaluate abnormalities of the left-sided circulation. Not only is jugular venous pressure difficult to measure under some circumstances (eg, when assessing an obese patient), but its true value can be confounded by numerous coexisting pathologies (eg, valvular disease, pulmonary hypertension). Another commonly used marker, urine output, can fail to accurately indicate the success of resuscitative efforts because it can be difficult to distinguish oliguria secondary to circulatory dysfunction (prerenal azotemia) from intrinsic kidney injury (eg, acute tubular necrosis) in the acute care setting. Even our most common and fundamental goal in resuscitation—improvement in the arterial pressure—does not necessarily correlate with improved cardiac output and, therefore, does not necessarily reflect improved perfusion.[13]

Once the limitations of the physical examination were realized, advanced resuscitation techniques for patients in shock shifted to using cardiac filling pressures as a