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Clinical Assessment of Hemodynamically Unstable Patients

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Abstract

Purpose of Review—Clinical examination of hemodynamically unstable patients provides timely, low risk and potentially useful diagnostic and prognostic information. This review will examine the evidence behind the use of clinical examination findings to drive treatment decisions and predict outcomes in patients with hemodynamic instability. An additional goal of the review is to place the use of clinical examination in context of more invasive techniques to diagnose and treat hemodynamically unstable patients.

Recent Findings—The development of novel diagnostic tests based on recently developed technology has focused attention on methods to determine when a test should enter routine clinical use. The widespread incorporation of pulmonary artery catheterization into clinical practice prior to formal evaluation of it's to improve outcomes highlights the importance of properly evaluating diagnostic tests in critically ill patients. Formal evaluation of clinical examination as a diagnostic test will allow better understanding of its role in the hemodynamic evaluation in the critically ill.

Summary—Clinical examination remains an important initial step in the diagnosis and risk stratification of patients. Despite limitations of current techniques, the availability, low risk and ability to perform repetitive tests ensure that clinical examination of the hemodynamically unstable patient will continue to be a useful tool for the intensivist until more useful tests are validated in this patient population.

Keywords

physical examination; shock; septic shock; critical illness

Introduction

Clinical examination plays a key role in the diagnosis of hemodynamic instability. From the emergency room to the intensive care unit, the use of physical findings to risk stratify and treat patients has long been an important part of the clinician's armamentarium. The use of selected physical examination findings has been validated to replicate the findings of more invasive methodologies, and to serve as a surrogate marker for short-term treatment efficacy.

This review will cover the use of physical examination findings to guide physician's diagnostic and treatment decisions in the hemodynamically unstable patient. The risks and benefits of clinical examination will be compared to more invasive diagnostic testing. The rationale for use of individual components of the clinical examination including vital signs, toe temperature,

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toe-ambient temperature gradient and capillary refill time will be discussed. In addition, this manuscript will describe key concepts regarding when to incorporate a diagnostic test into routine clinical practice.

Development of Clinical Assessment in the Triaging of Critically Ill Patients

Beecher and colleagues proposed the use of capillary refill time to diagnose the presence of shock in injured patients. In 1947, he categorized patients as having normal, definite slowing and very sluggish capillary refill time (CRT), and correlated these findings with the presence and severity of shock in patients(1). This discrete classification of CRT was more useful than pulse, or systolic blood pressure in the classification of patients with shock(1).

Initial trauma scores(2) have also included the presence of capillary refill time as part of a scoring index to predict the need for emergency surgical evaluation(3). Other clinical examination techniques used as diagnostic tests of hemodynamic instability in a broad range of critically ill patients include urinary output, mental status, temperature change, and blood pressure. These measurements have been included in severity of illness scoring systems, consensus guidelines for the treatment of the critically ill, and in protocols for randomized clinical trials.

Clinical Examination as a Diagnostic Test in the Critically Ill

Diagnostic tests are used to detect the presence of disease in patients. They can therefore be used to classify patients with a disease (or syndrome), to follow a patient's response to therapy, to risk stratify patients, to identify asymptomatic patients with disease, and to rule out disease. Clinical examination in the critically ill is primarily used for the first three purposes: for example to determine whether the patient has hemodynamic instability, to determine whether the patient is responding to therapy and to stratify risk. A new diagnostic test for the critically ill should enter general use (or remain in use) if the test assists a clinician in answering one of the questions listed above(4).

The use of the clinical exam can therefore be evaluated as a diagnostic test. When a clinician measures the systolic blood pressure or capillary refill time the measurements taken should be precise, accurate, and provide the clinician additional information about whether a specific disease or syndrome is present. If clinical examination fits the criteria of a diagnostic test, it should, for example, improve the ability of the clinician to make the diagnosis of hemodynamic instability or shock(4). Some tests are also useful as an “umpire” test when there is diagnostic uncertainty or divergence between different tests. (4). Recent rules have been created to guide the analysis of a proposed diagnostic test(5). It An additional criteria for some diagnostic tests is whether the tests results are correlated with a patient's outcome.(6)

Relative Merits of Clinical Assessment

Clinical assessment provides a number of advantages over the use of invasive methods to assess severity of illness and adequacy of the initial resuscitation of the hemodynamically unstable patient. Clinical assessment methods are readily available and can be performed without the use of additional specialized equipment. Several types of clinical assessment including change in temperature and mean arterial pressure have been validated to predict mortality in patients with critical illness in different patient populations. In addition, there is evidence that response to therapy in hemodynamically unstable patients may predicted by changes in clinical exam. Further, clinical assessment is low risk and can be repeated as often as necessary

Clinical examination has some obvious limitations. The methodology used for common types of clinical assessment may vary between clinicians. One such example is the use of capillary

refill time (CRT), where either pulp pressure or fingernail pressure may be used for determination of the capillary refill time. CRT measurement may have substantial inter-observer variability. Some components of the clinical exam may lack accuracy; a non invasive cuff blood pressure may not accurately reflect intra-arterial blood pressures in patients with shock(7). Further, clinical examination often will not provide additional information about the etiology of a patient's hemodynamic instability. Finally, some measures, including CRT, while commonly used, have not been validated using modern statistical methods to predict outcome in patients. Table 1 lists the advantages and disadvantages of using clinical assessment to assess hemodynamic instability in patients.

Comparison of clinical exam versus invasive methodologies to assess hemodynamically unstable patients

While clinical examination is frequently limited by issues of validation and inter-observer variability, it may be useful to compare the use of clinical examination versus more sophisticated monitoring devices to assess critically ill patients. Many of the limitations of clinical examination are shared with more invasive diagnostic testing. For example, the use of the pulmonary artery catheter has led to concerns about intra-observer variability in readings, inability to use the monitor to improve outcomes, and failure of the monitor to predict response to therapy(8). While there are many novel methods to measure cardiac output and filling pressure, none of these novel techniques have yet been shown to improve patient outcomes when used in critically ill patients. Table 2 compares the risks and benefits of clinical examination versus invasive diagnostic testing in hemodynamically unstable patients.

Methods of Clinical Assessment of Hemodynamic Instability

Vital signs and surrogates of organ specific perfusion such as capillary refill time and urine output are the most commonly used clinical examination methods to evaluate hemodynamic instability. In the sections below, the evidence supporting the use of these techniques as a diagnostic test for hemodynamic instability will be reviewed.

Vital signs

Vital signs are often the first method of clinical assessment in the evaluation of whether a patient has hemodynamic instability. Vital signs are commonly used for triage decisions, activation of medical emergency teams, and as a component of severity of illness scoring systems. However, individual vital signs often will not substantially alter the pretest probability of a patient having a specific diagnosis such as shock. A short discussion of individual vital signs can be found below

Pulse

Alterations in pulse may provide a first indication that a patient is developing hemodynamic instability. While many factors may influence the pulse rate, including fever, exercise, medications, and thyroid hormone status, a high pulse rate is often a sign of high levels of endogenous catecholamines, blood loss or dehydration. Studies of normal volunteers undergoing phlebotomy and acutely ill patients suggest that the change in pulse related to postural changes may be a useful marker for hypovolemia (9) In addition, a high or low pulse rate has been used as a criteria for activation of a medical emergency team (10). However, the presence of a high or low pulse rate is neither sensitive nor specific for the diagnosis of hemodynamic instability.

Respiratory rate

Respiratory rates have been included in most severity of illness scoring systems, are a diagnostic criteria for acute respiratory failure, and have also been incorporated into the criteria for initiating a medical emergency team. Although respiratory rates may provide useful information about the severity of illness, they lack adequate specificity or sensitivity to serve as a stand-alone diagnostic test for hemodynamic instability. The change in respiratory rates may be more useful as a marker of response to therapy.

Blood Pressure (Mean Arterial Pressure)

Adequate blood pressure is necessary to maintain appropriate perfusion to organs that autoregulate blood flow such as the brain and kidney. It is therefore reasonable to consider blood pressure or mean arterial pressure (MAP) as appropriate indicators of critical illness or clinical instability. A systolic blood pressure < 90 mm hg or decrease in systolic blood pressure > 40 mm hg are diagnostic criteria for severe sepsis and septic shock(11). In addition, orthostatic blood pressure changes may be a useful marker of hypovolemia or blood loss (9). It is important to note that non- invasively measured blood pressure may not accurately reflect intra-arterial pressures(7).

MAP and length of time a patient's MAP is < 65 mm hg are independent predictors of mortality in patients with septic shock.(12) However, a treatment that increased blood pressure increased mortality rates in patients with septic shock(13), and the target MAP used in clinical trials varies widely(14).

Temperature

Extremes of temperature are highly suggestive of clinical instability, and temperature is one of the components of most severity of illness scoring systems. However, temperature is not a sensitive indicator of hemodynamic instability, and medications and exposure, in addition to severe sepsis may cause hyperthermia. In addition to core temperature, information on skin and extremity temperatures have been correlated with patient outcomes. Kaplan and colleagues examined 264 consecutive surgical ICU patients to determine whether a dichotomized determination of skin temperature was able to stratify patients into high or low cardiac outputs. Those patients with warm extremities had higher cardiac outputs (8.2 versus 5.3) and higher venous oxygen saturations that did those with cool extremities. Those patients who had warm versus cold extremities did not have differences in pulse, systolic or diastolic blood pressure, or paO2(15). In 100 patients with signs of shock, Joly and Weil showed that toe temperature was correlated with cardiac index at 3 hours of admission; other measurements of temperature, including toe- ambient temperature gradient, rectal or finger temperature, were less well correlated with cardiac index compared with toe temperature(16). In 15 patients with shock, toe temperature was correlated with cardiac index in cardiogenic but not septic shock(17). Given the relatively small number of patients enrolled and the divergent findings of these trials, skin or toe temperature does not provide adequate sensitivity or specificity to be a stand-alone marker of clinical instability.

Toe- Temperature Gradient

Since toe or rectal temperature measurement may be affected by ambient temperature, several authors have proposed the use of a temperature gradient to determine adequacy of circulation. As noted above, Joly and Weil showed that the toe- ambient temperature gradient does not correlate with cardiac output or index, and is a less useful measure than toe temperature alone (16) In a larger series of 71 patients, Hening and colleagues compared toe temperature with toe-ambient temperature gradient, cardiac index, lactate, and MAP as a predictor of mortality

at during patients ICU course(18). Using jackknife analysis, toe temperature and toe- ambient temperature difference were better at discriminating between survivors or non survivors than were MAP, lactate, or cardiac index after admission to the ICU.

Clinical Surrogates of Organ Perfusion

Urine output and capillary refill time are commonly used clinical surrogates of organ perfusion. Their utility as diagnostic tests for hemodynamic instability will be discussed below

Urine Output

Oliguria is one of the signs of organ-specific hypoperfusion suggestive of inadequate renal perfusion or cardiac output. It is a useful tool to evaluate whether additional volume challenges may improve cardiac output, and has been incorporated as a marker of improved perfusion in many clinical trials. Since oliguria may have causes other than renal hypoperfusion, it may not be a specific marker of hemodynamic instability, but oliguria can be used as a marker of adverse outcomes and can assist with risk stratification. Recent consensus recommendations have recommended a treatment goal of 0.5ml/kg/hour urine output of a surrogate treatment endpoint in patients with severe sepsis. (19) While this treatment goal is commonly used in clinical practice and clinical trials, it has not yet been validated against more invasive diagnostic tests

Capillary refill time

Capillary refill time (CRT) is frequently used to assess the degree of instability in patients presenting to the emergency room or ICU. Since the original description by Beecher and colleagues, CRT has been incorporated into clinical practice, severity of illness scoring systems and clinical trial design. CRT is commonly measured at either the fingernail bed or the pulp of a finger, and the time for the return of normal coloration after temporary occlusion is measured.

CRT with a cutoff of > 6 seconds has been shown to be a sensitive measure of hypovolemia in children. (20). However, age, gender, and ambient temperature have all been shown to affect the measure of CRT in normal volunteers, and the presence of a CRT > 2 or 3 seconds was not predictive of blood loss in phlebotomized volunteers(9). In addition, the CRT has been shown to have poor intra-observer agreement when a cutoff a two seconds was used in adult emergency room patients(21)(21).

Capillary refill time, in conjunction with urine output and cardiac index, was used as part of a treatment algorithm in a study of liberal versus conservative fluid strategies in 1000 patients with acute lung injury(22). Work is underway to validate the utility of CRT in these patients as a marker of filling pressures (Todd Rice, personal communication). In addition, a recent study using CRT and a subjective measure of peripheral perfusion found that resuscitated critically ill patients with either CRT > 4.5 seconds or cool extremities (to an examiners hands), or both, were more likely to have an elevated lactate or an increase in Sequential Organ Failure Assessment Scores (SOFA) over the first 48 hours of ICU admission compared with those patients who had neither(23). Of note, these measurements were made within the first 24 hours of ICU admission after the patient had been resuscitated to a MAP > 65 without requiring changes in vasopressor dosing for > 2hours. (23)

Conclusion

Clinical examination allows for rapid and repeated assessment of a critically ill patient. In conjunction with patient's history and diagnostic testing, clinical examination provides additional useful information that may increase the likelihood of making a proper diagnosis.

Limitations of clinical examination as a diagnostic test of hemodynamic instability include lack of validation when used as a diagnostic test or marker of treatment efficacy or outcome. It is likely that clinical examination will remain an important part of the clinician's armamentarium until better diagnostic tests are available. Clinical examination should be one of the benchmarks against which novel diagnostic tests in the hemodynamically unstable patient are compared.

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Table 1

Benefits and Drawbacks Of Clinical Examination For Risk Stratification

Benefits	Drawbacks
Immediate Information Available	Cannot Distinguish Between Forms of Shock
Some Measures Validated for Risk Stratification	Many Measures Not Validated for Risk Stratification
Repeated Measures Feasible – Can Tailor Therapy to Results	Less emphasis placed on teaching clinical skills in many medical schools
Measurements Low Risk	
Skills are easily taught- do not require technical skills	

Table 2

Comparison of Clinical Examination Versus Invasive Diagnostic Testing For Diagnosis and Treatment of Clinical Instability

Clinical Examination	Invasive Diagnostic Testing
Immediate Information Available	Requires Procedure Prior to Results
Some Measures Validated for Risk Stratification	Some Measures Validated for Risk Stratification
Repeated Measures Feasible – Can Tailor Therapy to Results, but primarily unproven as a method to titrate therapy	Repeated Measures Feasible – Can Tailor Therapy to Results, but primarily unproven as a method to titrate therapy
Measurements Low Risk	Measurements Higher Risk
Cannot distinguish between forms of shock	Can distinguish between many forms of shock