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Ultrasonographic measurement of the subclavian vein diameter for assessment of intravascular volume status in patients undergoing gastrointestinal surgery: comparison with central venous pressure

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ABSTRACT

Background: Previous studies have demonstrated that ultrasonographic measurement of the inferior vena cava diameter is a useful tool for the evaluation of intravascular volume status in preoperative patients. However, ultrasonographic measurement of inferior vena cava diameter could be limited by factors including obesity, bowel gas, or complex abdominal wounds. Our study sought to determine whether subclavian vein (SCV) diameter measured by ultrasound correlate with central venous pressure (CVP), as another indicator of intravascular volume status in patients undergoing gastrointestinal surgery.

Methods: Forty patients (American Society of Anesthesiologists I–II) who underwent elective gastrointestinal surgery and 40 healthy volunteers were enrolled in the study. In the patient group, SCV diameters, during both expiration (dSCVe) and inspiration (dSCVi), were measured with ultrasonography before and after fluid resuscitation. Volunteer baseline measurements were conducted without liquid therapy and the subsequent measurement.

Results: Forty patients (mean age 46 y; 40% female) and 40 volunteers (mean age 43 y; 45% female) underwent SCV sonographic measurements. The average diameters of the SCVe and SCVi in hypovolemic patients (0.68, 0.48 cm) were significantly lower as compared with the SCVe and SCVi diameters of healthy volunteers (0.92, 0.73 cm), whereas the SCV-collapsibility index (0.35) was higher in the hypovolemic patients as compared with the healthy volunteers (0.20). After fluid resuscitation, the SCVe and SCVi diameters in hypovolemic patients (0.88, 0.67 cm) significantly increased, whereas the SCV-collapsibility index decreased (0.23). The pre-SCVe and the post-SCVe were closely correlated to the CVP ($R = 0.612$ and $R = 0.547$, respectively). Similarly, the pre-SCVi and the post-SCVi were correlated to the CVP ($R = 0.452$ and $R = 0.507$, respectively).

Conclusions: SCV diameter is consistently low in patients undergoing gastrointestinal surgery as compared with healthy subjects. Measuring the SCV diameter maybe an important

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addition to the ultrasonographic evaluation of hypovolemia and other potentially volume-depleted patients.

1. Introduction

Preoperative fasting is an important part of preoperative preparation in clinical anesthesia. This prevents the occurrence of asphyxia or inhalation pneumonia, which can be caused by a vomiting reaction during anesthesia or operation process. The fasting time course is ≥6–8 h, which can cause patients to develop hypovolemia. Therefore, before anesthesia induction, timely, accurate, and reproducible determination of intravascular volume status is crucial to supplement the blood volume, reducing the possibility of hemodynamic dysfunction during induction of anesthesia.

There are many parameters that could help in identifying patients with suspected hypovolemia. The traditional paradigm of intravascular volume assessment relies on central venous pressure (CVP), pulmonary artery occlusion pressure, intrathoracic blood volume index, and left ventricular end-diastolic area index [1,2]. These measures cannot be consistently used for hypovolemic patients admitted to the emergency department because they are performed via central venous catheterization, an invasive procedure. There are potential disadvantages to these monitoring options, including infection, thrombosis, data interpretation errors, and iatrogenic injury [3,4].

Ultrasonography has been used in the adult population as a tool for assessing intravascular status in a rapid, objective way [5] and has become an integral part of adult emergency medicine in the clinical practice [6]. Studies have shown that measurement of the inferior vena cava (IVC) diameter and calculation of the IVC collapsibility index appear to be reliable indicators of both intravascular volume status and clinical response to volume resuscitation [7–9]. Ultrasonographic measurements of the IVC and right ventricle (RV) diameters are useful in supplementing the CVP measurement for the evaluation of preoperative patients with hypovolemia [10].

However, current studies carried out in the emergency department or intensive care unit and the measurements of the IVC diameters are limited by patient factors such as abdominal distension, bowel gas overlying the vena cava, tissue edema, complex abdominal wounds, and morbid obesity [11]. Thus, we need to find another central venous diameter measurement as a potential adjunct to the IVC diameter. In this study, we set out to prospectively examine the right subclavian vein (SCV) and investigate the efficacy of the ultrasonographic evaluation of SCV diameters in the diagnosis and treatment of hypovolemia in patients undergoing gastrointestinal surgery.

2. Methods

2.1. Study design

This study was performed at The First People's Hospital of Lianyungang Department of Anesthesiology with the approval of the local ethics committee. Forty healthy volunteers and 40 patients undergoing gastrointestinal surgery were enrolled in the study. Our study collected data that included patient demographics (age, gender, body weight, stature, and body mass index), respiratory (oxygen saturation), and hemodynamic parameters (pulse, blood pressure [BP], CVP).

The control group consisted of healthy volunteers, including medical personnel. The patient age was limited to age <60 y. Patients who had tricuspid failure, right-sided heart disease, portal hypertension, and obstructive lung disease were excluded from the study. All patients were performed preoperative preparation, including preoperative fasting and bowel preparation. Pulse, BP, and CVP were measured in the supine position for patients after a 5-min relaxation period. SCV diameters, during expiration (dSCVe) and inspiration (dSCVi), were measured with ultrasonography before and after fluid resuscitation. Subclavian vein collapsibility index (SCV-CI) was normalized according to the standard formula shown in the following: $\text{SCV-CI} = [(\text{SCVe} - \text{SCVi})/\text{SCVe}] \times 100\%$ [12]. One liter of 0.9% isotonic NaCl solution was administered to the patients as intravenous fluid [4]. The infusion rate was 50 mL/min. After the fluid resuscitation, all measurements (pulse and BP, CVP, dSCVi, and dSCVe) were repeated. These measurements were performed by the same physician that conducted the ultrasonography measurements. Volunteer baseline measurements were conducted without liquid therapy and the subsequent measurements. All the data from both groups and the recent diagnosis of patient groups were recorded on the prepared forms.

2.2. Sonographic technique

SonoSite (MicroMaxx, 2011; SonoSite, Inc., Bothell, WA) equipment was used in all ultrasonographical examinations. Right SCV diameters were checked in the supine position using a high frequency linear array probe (6–13 MHz) and the M-mode. To standardize the measurements, the probe was placed beneath the proximal part of the middle of the clavicle perpendicular to long-axis of the SCV, to obtain the best cross-sectional view of the vein [13] (Fig. 1). After the target vein was localized, the dynamic diameter change was recorded over time using the M-mode to identify and measure the minimum and maximum venous dimensions over the respiratory cycle (Fig. 2).

2.3. Data analysis

Data were analyzed using SPSS 13.0 (SPSS Inc., Chicago, IL) Software for Windows. All data were expressed as mean ± standard deviation. An independent-samples *t*-test was used to compare the variables between the patient group and the control group. A paired *t*-test was used to compare the variables between the pretreatment and posttreatment in the patient group. The relationship between variables was analyzed using the Pearson correlation test. All data fell