Sonographic evaluation of internal jugular vein diameter and cross-sectional area measurements as a tool for perioperative assessment of volume status and fluid therapy in pediatric patients undergoing cardiac surgery

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By

Ahmed Abdelaziz Mohamed

M.B.B.CH& M.Sc.

Supervised by

Prof.Dr. Wafaa Mohamed Elsadek

Professor of Anesthesiology, ICU and Pain management

Faculty of medicine

Cairo University

Prof.Dr. Amal Hanfy Abo Elaela

Professor of Anesthesiology, ICU and Pain management

Faculty of medicine

Cairo University

Dr. Heba Mohamed Nassar

Lecturer of Anesthesiology, ICU and Pain Management

Faculty of Medicine,

Cairo University

Dr. Mohamed Maher Kamel

Lecturer of Anesthesiology, ICU and Pain Management

Faculty of Medicine,

Cairo University

Faculty of medicine

Cairo University

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CVPn: noninvasive CVP

CVPi: invasive CVP

CCA: common carotid artery

CSA: cross sectional area

CWD: continuous-wave Doppler

CVP: central venous pressure

CVC: central venous catheter

CO: cardiac output

dSCVe: diameter of subclavian vein during expiration

dSCVi: diameter of subclavian vein during inspiration

ECC: extracorporeal circulation,

Hz: hertz

IABP: intra-aortic balloon pump,

IJV: internal jugular vein.

IVC: inferior vena cava

IVC-CI: inferior vena cava collapsibility index

IJV-CI: internal jugular vein collapsibility index

invCVP: invasive CVP measurement

LV: left ventricle

LiDCO: lithium dilution cardiac output

LVWMA: left ventricular wall motion abnormailty

LVEDA: left ventricular end diastolic area.

LVEDV: left ventricular end diastolic volume

MHz: mega hertz

NICOM: noninvasive cardiac output monitoring

PAEDP: pulmonary artery end diastolic pressure

PAC: Pulmonary Artery Catheters

PPV: pulse pressure variation

PCWP: pulmonary capillary wedge pressure

PRAM: pressure recording analytic method

PiCCO: pulse contour continuous cardiac output

PAC: pulmonary artery catheter.

PLR: passive leg raising test

RV: right ventricle

RVEF: right ventricular ejection fraction.

RVEDV: right ventricular end-diastolic volume

SVV: stroke volume variation

SVR: systemic vascular resistance

SV: stroke volume

SVC: superior vena cava

SCA: Society of Cardiovascular Anesthesiologists

SCV: subclavian vein

TEE: trans-esophageal echocardiography

TPCO: transpulmonary thermodilution cardiac output

TTE: transthoracic echo

US: ultrasound

VR: venous return.

VTI: velocity-time integral

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Purpose: The aim of this study was to compare the ultrasound estimation of the cross sectional area and diameter of internal jugular vein (IJV) with direct estimation of central venous pressure (CVP) and left ventricular end diastolic area (LVEDA) for assessment of intravascular volume in pediatric patients during cardiac surgery.

Materials and Methods: A portable ultrasound machine defined the cross sectional area and diameter of the left internal jugular vein in 16 pediatric patients. CVP was measured directly. Trans-esophageal echo (TEE) was used to estimate LVEDA as another tool for intravascular volume assessment.

Results: There was poor correlation between IJV cross sectional area and diameter with CVP and LVEDA.

Conclusion: Estimation of CVP using ultrasound of the internal jugular vein is not reliable and cannot be used alone to decide further management.

Keywords Pediatric internal jugular cross-sectional dSCVi CVP

Introduction

Fluid administration is one of the maneuvers to augment cardiac output. Volume expansion is essential to improve the outcome in patient undergoing cardiac surgery. However, unnecessary volume load may cause further deterioration in myocardial function with the development of acute heart failure. Therefore, assessment of the volume status during cardiac surgery is mandatory to optimize hemodynamics to guide fluid therapy. [(1)]

Traditional accepted methods for perioperative volume assessment include measurement of central venous pressure (CVP), However, this method is invasive and can subject the patient to complications. Therefore, it is not applicable in all surgical populations. [(2)]

Left ventricular end-diastolic area (LVEDA) is also a good predictor of preload. One major issue with this parameter is that in the absence of baseline echocardiographic data of absolute levels of LVEDA which varies from patient to patient, depending upon baseline cardiac anatomy and physiology. [(6)] Another issue that require anesthetists with specialized experience who have undergone rigorous training in these techniques.[(14)]

A pilot study reported the successful utilization of ultrasonography of internal jugular vein (IJV) as a non-invasive method to predict CVP as a method for determination of intravascular volume status in spontaneously breathing critical care patient. There was a positive correlation between sonographic measurement of IJV diameter and CVP.[(3)]

Objective:

The aim of the present study is to evaluate the correlation between the ultrasonographic assessment of cross sectional area and diameter of IJV to CVP and LVEDA as tools used to assess the volume status in pediatric patients undergoing heart surgery.

Study outcome measures:

Primary outcome measure:

- Correlation of lJV cross sectional area to CVP.

Secondary outcome measures:

- Correlation of IJV cross sectional area to LVEDA.

Chapter 1

Intravascular volume assessment

Chapter 1:

Perioperative intravascular volume assessment

Introduction:

Assessment of intravascular volume is an essential part of perioperative care and the management of perioperative hemodynamic instability. Insufficient intravascular volume can result in decreased oxygen delivery to tissues and organ dysfunction, while fluid overload can contribute to the development of edema. The injudicious use of inotropes and vasopressors in the hypovolemic patient can be hazardous and increase the risk of a poor outcome. Methods of interpreting intravascular volume range from clinical assessments such as inspection of veins and passive leg raising, to more invasive methods such as central venous and pulmonary artery catheterization, to newer technically intensive methods such as echocardiography. [(4)]

Assessment of Fluid Status by Physical Examination:

The clinician is often faced with unspecific clinical signs of hypovolemia and dehydration. Evaluation of skin turgor, blood pressure, heart rate and urinary output are not reliable and are unsuited for guiding fluid therapy protocols. [(4)]

Many clinicians tend to look at urinary output to guide fluid therapy but this is nonspecific measurement. The passive leg-raising test is an easy, and probably reliable, method to test for hypovolemia. [(5)]

With passive leg raising test (PLR), there is transfer of blood from legs to the intrathoracic cavity with resultant increases in pulmonary capillary wedge pressure (PCWP) and left ventricular preload. The ability of (PLR) to predict fluid responsiveness has been confirmed in several studies with critically ill patients. [(6)]

Static and dynamic measurement of intravascular volume

Compared to the static hemodynamic parameters (CVP, PAWP) which are measured at one point in the cardiac cycle, dynamic parameters have been shown to be more accurate in assessment of intravascular volume and fluid responsiveness. [7]

Central Venous Pressure (CVP):

CVP is the measurement of pressures within the thorax in the superior vena cava (SVC) and serves as a reasonable surrogate for the corresponding right atrial pressures. CVP was the most widely used technique for measuring intravascular volume in critically ill patients. [8]

The reference point for measurement of the CVP is the midaxillary line in the fifth intercostals space. Numerical recordings of CVP are measured at end expiration. In patients with forcible expiration, the true CVP may be better represented by a value at the start of expiration. The standard for testing volume responsiveness is to give a fluid challenge. This involves giving fluids to increase the CVP by 2 mmHg and then determining whether it increased the Cardiac output. [9]

CVP is dependent on venous return (VR) to the heart, right ventricular compliance, peripheral venous tone and posture. It is particularly unreliable in pulmonary vascular disease, right ventricular disease, patients with tense ascites, isolated left ventricular failure and valvular heart disease. [10]

In patients with an intact sympathetic response to hypovolemia, the CVP may actually fall in response to fluid as compensatory venoconstriction is reduced. It is possible to have a low CVP and not be volume responsive, and to have a high CVP and be volume responsive.[11]