Resuscitation 84 (2013) 304–308

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Resuscitation of the pregnant patient: What is the effect of patient positioning on inferior vena cava diameter?☆,☆☆

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ARTICLE INFO

Article history:
Received 9 July 2012
Received in revised form 6 November 2012
Accepted 11 November 2012

Keywords:
Pregnancy
Inferior vena cava
Resuscitation
Left lateral tilt
Patient positioning

ABSTRACT

Study objective: Patients in the third trimester of pregnancy presenting to the emergency department (ED) with hypotension are routinely placed in the left lateral tilt (LLT) position to relieve inferior vena cava (IVC) compression from the gravid uterus thereby increasing venous return. However, the relationship between patient position and proximal intrahepatic IVC filling has never assessed directly. This study set out to determine the effect of LLT position on intrahepatic IVC diameter in third trimester patients under real-time visualization with ultrasound.

Methods: This prospective observational study on the labor and delivery floor of a large urban academic teaching hospital enrolled patients between 30 and 42 weeks estimated gestational age from August 2011 to March 2012. Patients were placed in three different positions: supine, LLT, and right lateral tilt (RLT). After the patient was in each position for at least 3 min, IVC ultrasound using the intercostal window was performed by one of three study sonologists. Maternal and fetal hemodynamics were also monitored and recorded in each position.

Results: A total of 26 patients were enrolled with one excluded from data analysis due to inability to obtain IVC measurements. The median IVC maximum diameter was 1.26 cm (95% confidence interval [CI] 1.13–1.55) in LLT compared to 1.13 cm (95% CI 0.89–1.41) in supine, $p = 0.01$. When comparing each individual patient's LLT to supine measurement, LLT lead to an increase in maximum IVC diameter in 76% (19/25) of patients with the average LLT measurement 29% (95% confidence interval 10–48%) larger. Six patients had the largest maximum IVC measurement in the supine position. No patients experienced any hemodynamic instability or distress during the study.

Conclusion: IVC ultrasound is feasible in late pregnancy and demonstrates an increase in diameter with LLT positioning. However, a quarter of patients had a decrease in IVC diameter with tilting and, instead, had the largest IVC diameter in the supine position suggesting that uterine compression of the IVC may not occur universally. IVC assessment at the bedside may be a useful adjunct in determining optimal positioning for resuscitation of third trimester patients.

1. Background

The supine hypotensive syndrome (SHS) is a constellation of findings including hypotension, tachycardia, dizziness, pallor and nausea that was first reported in 1931.[1] The principle theory behind SHS is compression of the inferior vena cava (IVC) by the gravid uterus resulting in decreased venous return and cardiac output.[1] Since the 1950s, the standard of care has been to place third trimester patients exhibiting symptoms of SHS in the left lateral tilt (LLT) position.[2–4]

Most of the literature on SHS stems from case reports and studies in healthy patients or patients in the operating room, which have shown evidence supporting the theory of IVC compression.[5–11] Based on these studies the American Heart Association (AHA) recommends full LLT positioning for all late pregnancy patients in hemodynamic distress.[12] While it is convincing that LLT improves hemodynamics when SHS is the cause of hypotension, it is unknown how helpful LLT positioning is for other non-SHS causes of hemodynamic compromise in late pregnancy. Given that the incidence of SHS is estimated at 8%,[1] LLT may not benefit many patients

☆ A Spanish translated version of the summary of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2012.11.011

☆☆ This study was presented as an oral abstract at the Society for Academic Emergency Medicine Annual Meeting in Chicago, IL during May 2012.

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http://dx.doi.org/10.1016/j.resuscitation.2012.11.011

with hemodynamic compromise from other causes. There are potential downsides to LLT positioning if it interferes with administration of therapies and interventions required for stabilization including obtainment of vascular access, intubation, cardiac compressions, cervical spine stabilization or monitoring devices. In cardiac arrest, placing a patient in LLT has been shown to result in less forceful cardiac compressions.[13] Given its potential downsides it would be desirable to determine the need for LLT at the bedside and what position is optimal.

IVC ultrasound (US) visualizes the proximal portion of the IVC as it traverses through the liver before emptying into the right atrium. Measurements of IVC diameter correlate with central venous pressure and preload.[14] It can be performed at the bedside and can assist in managing critically ill patients by estimating volume status.[15] Mechanical compression of the IVC by the gravid uterus occurs distally at the level of the aortic bifurcation,[16] but the net effect on proximal intrahepatic IVC diameter and collapse is unknown. If supine IVC compression occurs, one would expect to see an increase in intrahepatic IVC filling when third trimester patients are moved into the LLT position from supine, but this has not been studied.

2. Study objective

We hypothesized that IVC ultrasound is feasible in third trimester patients and will demonstrate an increase in IVC diameter by placing patients in the LLT position when compared to the supine position.

3. Materials and methods

3.1. Design

This was a prospective observational cohort study.

3.2. Setting

The study was conducted on the labor and delivery floor of a large urban tertiary care center from August 2011 to March 2012.

3.3. Participants

Any hemodynamically stable pregnant patient in the third trimester (between 30 and 42 weeks gestational age) not in active labor was eligible for inclusion. Patients unable to comply with the three positions or unable or unwilling to consent were excluded. Each morning that a study sonographer was available eligible patients were approached for enrollment. All patients underwent informed consent and the institution's internal review board approved the study.

3.4. Protocol

Enrolled patients underwent IVC ultrasound in three different positions in the following order: Supine, LLT, and right lateral tilt (RLT). A wedge shaped body-positioning pillow with a 30° angle was used to standardize the degree of tilt amongst the subjects. Once the subjects were in each position, blood pressure, heart rate, and fetal heart rate were monitored and recorded.

Subjects were asked to remain in each position for a minimum of 3 min to allow for any fluid shifts to normalize prior to measurements being taken. The IVC was then visualized and images obtained using either the subxiphoid or intercostal window (also known as the anterior axillary window, Fig. 1)[17] in both longitudinal and transverse planes. While the IVC was visualized in both planes, the IVC was always measured in the transverse plane in order to ensure that the M-mode beam was cutting through the true middle of the IVC and avoid making an erroneous paramedian measurement, which is a common pitfall of longitudinal measurements and underestimates IVC diameter. The IVC was measured approximately 2 cm distal to the branching of the hepatic vein in the short-axis. Maximum (max) IVC diameter was measured during expiration and minimum (min) IVC diameter during inspiration. The caval index (CI) was calculated in each position using the formula CI = (max – min)/max.[14] Study personnel not involved with the ultrasound recorded values for each IVC ultrasound and hemodynamics. Three physician sonologists with advanced ultrasound training (one year dedicated emergency ultrasound fellowship) performed the ultrasound examinations. The sonologists had each performed at least 20 previous IVC ultrasounds.

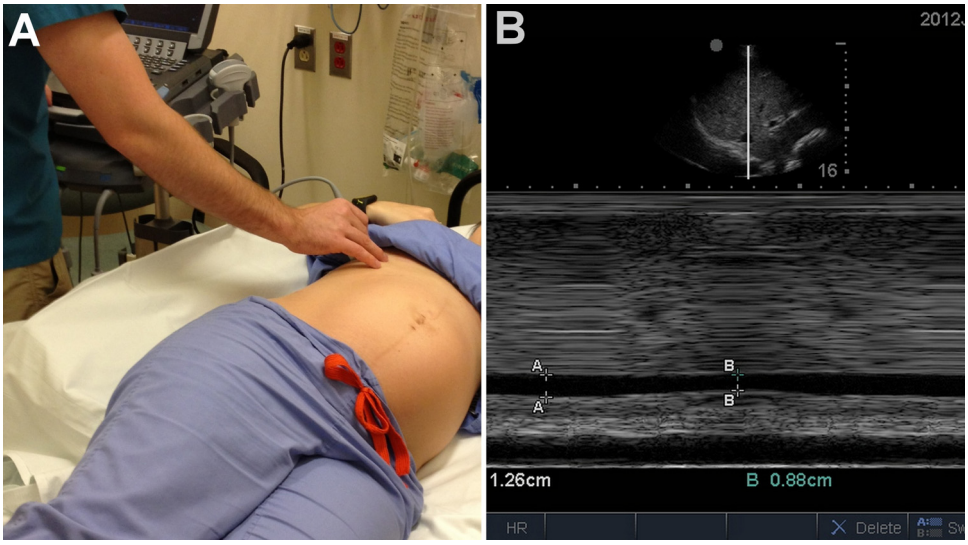

Fig. 1. (A) Ultrasound of the IVC using the intercostal window of a patient in her third trimester of pregnancy. The patient is held in the left lateral tilt position by a 30° wedge pillow, which was used in the study to standardize patient position. (B) M-mode image showing respiratory variation of the IVC in transverse plane. The maximum diameter occurs during expiration (A) and the minimum diameter during inspiration (B).