



Brief Report

Ultrasound measurement of inferior vena cava collapse predicts propofol-induced hypotension ^{☆,☆☆}



Arthur K. Au, M.D. ^{a,*}, Dean Steinberg, M.D. ^b, Christopher Thom, M.D. ^a, Maziar Shirazi, M.D. ^c,
Dimitrios Papanagnou, M.D., M.P.H. ^a, Bon S. Ku, M.D., M.P.P. ^a, J. Matthew Fields, M.D. ^a

^a Department of Emergency Medicine, Thomas Jefferson University, Philadelphia, PA, USA

^b Department of Anesthesiology, Thomas Jefferson University, Philadelphia, PA, USA

^c Department of Family and Community Medicine, Thomas Jefferson University, Philadelphia, PA, USA

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ABSTRACT

Study Objectives: Hypotension is a common side effect of propofol, but there are no reliable methods to determine which patients are at risk for significant propofol-induced hypotension (PIH). Ultrasound has been used to estimate volume status by visualization of inferior vena cava (IVC) collapse. This study explores whether IVC assessment by ultrasound can assist in predicting which patients may experience significant hypotension.

Methods: This was a prospective observational study conducted in the operating suite of an urban community hospital. A convenience sample of consenting adults planned to receive propofol for induction of anesthesia during scheduled surgical procedures were enrolled. Bedside ultrasound was used to measure maximum (IVCmax) and minimum (IVCmin) IVC diameters. IVC-CI was calculated as [(IVCmax-IVCmin)/IVCmax × 100%]. The primary outcome was significant hypotension defined as systolic blood pressure (BP) below 90 mmHg and/or administration of a vasopressor to increase BP during surgery.

Results: The study sample comprised 40 patients who met inclusion criteria. Mean age was 55 years, (95%CI, 49–60) with 53% female. 55% of patients had significant hypotension after propofol administration. 76% of patients with IVC-CI ≥ 50% had significant hypotension compared to 39% with IVC-CI < 50%, P = .02. IVC-CI ≥ 50% had a specificity of 77.27% (95%CI, 64.29%–90.26%) and sensitivity of 66.67% (95%CI, 52.06%–81.28%) in predicting PIH. The odds ratio for PIH in patients with IVC-CI ≥ 50% was 6.9 (95%CI, 1.7–27.5).

Conclusion: Patients with IVC-CI ≥ 50% were more likely to develop significant hypotension from propofol. IVC ultrasound may be a useful tool to predict which patients are at increased risk for PIH.

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1. Introduction

Propofol is a short acting intravenous anesthetic agent, routinely used as an induction agent in general anesthesia. Due to its rapid onset, effectiveness and short recovery time, it has gained popularity with Emergency Physicians in providing deep sedation. Hypotension has been shown to be a common side-effect of propofol administration, with rates as high as 49% [1]. It is unclear if this induced drop in blood pressure causes any clinically significant effects on patient outcomes. However, longer postoperative stays and higher death rates are associated with postinduction hypotension [2]. Additionally, hypotensive events in the emergency department (ED) have been correlated to higher death rates during hospitalization [3].

Predicting propofol induced hypotension (PIH) may have the potential to prevent iatrogenesis. Rates of PIH are highest in patients greater than

50 years of age, with pre-existing hypotension and American Society of Anaesthesiologists' Physical Status (ASA-PS) of class II or greater [2]. Additionally, patients with lower intravascular volume status may be more likely to have PIH, but this has not been explored. The current study set out to determine if lower intravascular volume status, as measured by ultrasound, can predict significant hypotension. We hypothesized that an IVC-CI ≥ 50% would be associated with a higher rate of significant hypotensive events in patients receiving a bolus dose of intravenous propofol.

2. Materials and methods

2.1. Design

This was a prospective observational study conducted in the surgical suite of an urban community hospital.

2.2. Population

A convenience sample of consenting adult patients planned to receive propofol for induction of anesthesia during scheduled, non-

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* Corresponding author at: 1020 Sansom Street, Suite 239 Thompson Building, Philadelphia, PA, 19107. Tel.: +1 215 955 6844; fax: +1 215 923 6225.

E-mail address: arthur.au@jefferson.edu (A.K. Au).

emergent, surgical procedures were enrolled over a 4-week period from March - April 2014. Patients planned to receive propofol were screened by an anesthesiologist and included if they were scheduled for uncomplicated procedures with minimal blood loss expected. Patients were excluded if they had a history of heart failure or valvular heart disease, were under the age of 18 or unwilling to consent. All enrolled patients underwent informed consent and the study was approved by the institution's internal review board.

2.3. Protocol

Patients were screened and enrolled in the preoperative suite on the day of their scheduled procedures. Enrolled patients were placed in supine position and baseline blood pressure and heart rate was recorded. Ultrasound images of the IVC were then obtained using either the subxiphoid or intercostal window. The IVC was visualized and 6-second clips were recorded in both longitudinal and transverse planes. IVC measurements were made using M-mode in the transverse plane, as measuring in the longitudinal plane can lead to off-midline measurements which result in smaller IVC diameter measurements [4]. Maximum (IVCmax) and minimum (IVCmin) IVC diameters were measured approximately 2 cm below the entry of the hepatic veins during a normal respiratory cycle. IVC-CI was calculated as $[(IVCmax - IVCmin) / IVCmax \times 100\%]$ [5]. Ultrasounds were performed by physicians with fellowship training in emergency ultrasound and had each previously performed greater than 20 IVC ultrasounds. All deidentified clips and measurements were reviewed by another blinded physician to ensure that measurements were of adequate quality.

Research assistants, blinded to IVC measurements, traveled with the patients to the operating suites, where they recorded vital signs every 3 minutes from the beginning of surgery until 21 minutes after propofol administration. All intraoperative medication and fluid administration was also recorded. Treating anesthesiologists were also blinded to the

preoperative IVC measurements. All medications, including propofol and vasopressors, were dosed at the discretion of the anesthesiologists.

The primary outcome was significant hypotension defined as a systolic blood pressure (BP) below 90 mmHg and/or administration of a vasopressor to increase BP within 21 minutes after the administration of propofol. Assuming an approximate 50% rate of PIH, we hypothesized that patients with an IVC-CI < 50% would have a low rate (<10%) of PIH whereas patients with an IVC-CI \geq 50% would have a high (\geq 75%) rate of PIH. To detect this difference, it was determined that 13 patients needed to be enrolled in each IVC group. Because patients were enrolled randomly, without prior knowledge of IVC-CI, at least 10 additional patients would be required to ensure enough patients in each group to detect the outcome of interest.

2.4. Data Analysis

Summary statistics were generated for the participants' characteristics (age, sex, BMI), preoperative vital signs (pulse rate, systolic blood pressure, diastolic blood pressure), and primary study measurements (IVCmin, IVCmax and IVC-CI). Participants were stratified by incidence of PIH. Their characteristics, vital signs and primary study measurements were compared by calculating the difference in mean values or proportions between those with and without PIH. Corresponding 95% confidence intervals (CIs) of the differences were calculated. Differences were considered significant at the $P = .05$ levels for all analyses. Performance characteristics of the ability of an IVC-CI \geq 50% to predict PIH were calculated, along with corresponding 95% CIs.

3. Results

A total of 51 patients were enrolled in the study. IVC ultrasounds were performed by 5 different physicians. One patient was excluded due to a history of aortic stenosis. 10 additional patients were excluded due to inadequate imaging quality. This resulted in 40 patients meeting

Table 1
Comparison of participants by incidence of propofol induced hypotension.

Participant Characteristics	All participants, n = 40	Propofol induced hypotension n = 18	No propofol induced hypotension n = 22
Demographics, mean (95%CI)			
Age, y	55 (95%CI,49–60)	58 (95%CI,49–66)	53 (95%CI,45–61)
Female, %	53% (95%CI,36–68)	57% (95%CI,34–78)	43% (95%CI,22–66)
Male, %	47% (95%CI,32–64)	32% (95%CI,13–57)	68% (95%CI,43–87)
BMI, (kg/m ²)	29 (95%CI,27–30)	28 (95%CI,25–30)	29 (95%CI,27–32)
Preoperative Vital signs, mean (95%CI)			
Pulse rate, (beat/min)	73 (95%CI,68–77)	75 (95%CI,68–82)	70 (95%CI,65–75)
Systolic BP, mmHg	141 (95%CI,135–147)	135 (95%CI,126–144)	146 (95%CI,138–153)
Diastolic BP, mmHg	77 (95%CI,74–80)	75 (95%CI,70–79)	79 (95%CI,75–83)
Propofol dose and Inferior Vena Cava (IVC) Measurements, mean (95%CI)			
Propofol dose (mg/kg)	2.4 (95%CI,2.2–2.6)	2.4 (95%CI,2.2–2.7)	2.3 (95%CI,2.1–2.6)
IVCmax, cm	1.6 (95%CI,1.5–1.8)	1.6 (95%CI,1.5–1.8)	1.7 (95%CI,1.5–1.9)
IVCmin, cm	1.0 (95%CI,0.8–1.1)	0.9 (95%CI,0.7–1.1)	1.0 (95%CI,0.9–1.2)
IVC-CI	41 (95%CI,35–47)	44 (95%CI,35–54)	38 (95%CI,31–46)
Operative Variables			
Procedure Type			
Gynecologic	7	5	2
Otolaryngologic	2	2	0
Orthopedic	18	6	12
Urologic	6	3	3
General Surgical	7	5	2
Paralytics			
Administered	13	6	7
Not Administered	27	12	15
Airway Type			
Endotracheal Intubation	25	12	13
Laryngeal Mask	11	3	8
General Mask	3	2	1
Tracheostomy	1	1	0

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