CORRESPONDENCE

Point-of-care ultrasound (POCUS) assessment of central volume status in healthy fasted adults: no evidence for fluid deficit

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To the Editor,

Point-of-care ultrasound (POCUS) assessment of the inferior vena cava (IVC) has been used as a marker of volume status affected by hypovolemia and dehydration.¹ Overnight fasting, implemented to reduce aspiration risk in elective surgical patients, may be associated with intravascular hypovolemia that exaggerates hypotension upon induction of anesthesia.^{2,3} As it may be useful to identify intravascular hypovolemia in fasted patients, we assessed whether this could be achieved with a POCUS evaluation of the IVC.

The study is a prospective, repeated-measures design examining changes in IVC diameter and collapsibility in healthy volunteers during a 16-hour overnight fast. The study was reviewed and approved by the Institutional Review Board of the Keck School of Medicine of the University of Southern California (# HS-18-00237, 26 April 2018). Written informed consent was obtained from each subject, recruited from the perioperative nursing and medical staff at the University of Southern California. Inclusion criteria were adults (18–75 yr), American Society of Anesthesiologists class I or II, and the ability to perform > four metabolic equivalents and to tolerate a 16-hr fast. Exclusion criteria included prior diagnosis of chronic kidney disease or congestive heart failure; use of a non-steroidal anti-inflammatory, glucose-lowering, or antihypertensive medication within 24 hr of the study; pregnancy > three months' gestation; and uncontrolled hypertension.

Measurements were made (orthostatic vital signs at supine/sitting/standing positions, IVC diameter in the subxiphoid long-axis view) at T₀ (16:00 on the day prior to the fast that began at midnight on day 1), T₁ (08:00 on day 2), T₂ (12:00 on day 2), and T₃ (16:00 on day 2). All examinations were performed using an rP19xp phased array probe with a FujiFilm SonoSite X-Porte® ultrasound machine (FujiFilm SonoSite Inc., Bothell, WA, USA). Inferior vena cava measurements were made at tidal volume inspiration and expiration, and then during a “sniff test” (after rapidly inhaling). The IVC diameter was also measured 30 sec after a passive leg raise (PLR) maneuver (with legs elevated to 45°). Caval index, defined as (expiratory IVC diameter - inspiratory IVC diameter)/expiratory IVC diameter, was calculated. The IVC measurements were divided by the exhaled resting IVC diameter to obtain percentages for analysis. The primary endpoint (the change in expiratory IVC diameter during the PLR maneuver) was compared by paired t-test with Bonferroni correction. Secondary endpoints, including caval index and changes in orthostatic vital signs, were analyzed similarly.

A retrospective analysis of measured IVC images in our database (24 healthy controls, different subjects) revealed an expiratory mean (standard deviation [SD]) diameter of 1.7 (0.5) cm. Using an alpha of 0.05, a power of 0.90, and an estimated mean (SD) baseline exhaled IVC diameter of 1.7 (0.5) cm, a minimum sample of 29 subjects was required to detect a clinically meaningful increase of 15%⁴ in expiratory IVC diameter with the PLR maneuver, as assessed with a paired t-test. We enrolled 40 subjects, of which 38 completed the study. The data are summarized in the Table. The PLR maneuver produced no effect at T₁ and T₂, but did show a small increase at T₃: 119 (27)% change from baseline, *P* = 0.02. Reductions in resting supine blood

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Table POCUS measurements at each fasting time point

	Time point 0 (16:00, day 1)	Time point 1 (08:00, day 2)		Time point 2 (12:00, day 2)		Time point 3 (16:00, day 2)	
	Mean (SD)	Mean (SD)	P	Mean (SD)	P	Mean (SD)	P
Weight change (kg)	NA	−0.4 (0.7)	<0.001	−0.8 (0.8)	<0.001	−1.2 (0.9)	<0.001
Supine HR change (beats·min ^{−1})	NA	−3.7 (10.6)	0.04	−6.5 (9.1)	<0.001	−5.7 (10.0)	0.01
Supine MAP change (mmHg)	NA	−2.9 (8.4)	0.03	−4.7 (8.2)	<0.001	−4.6 (9.1)	0.01
Supine to sitting HR change (beats·min ^{−1})	+9.0 (10.6)	+12.4 (10.1)	0.12	+11.4 (9.2)	0.22	+12.1 (7.4)	0.06
Supine to sitting MAP change (mmHg)	+1.0 (7.3)	+3.1 (6.1)	0.22	+3.7 (5.5)	0.09	+4.5 (6.4)	0.08
Sitting to standing HR change (beats·min ^{−1})	+1.2 (10.6)	+0.3 (7.1)	0.70	+1.1 (10.6)	0.90	+0.5 (8.5)	0.81
Sitting to standing MAP change (mmHg)	+1.9 (6.9)	−4.0 (5.9)	0.43	−0.1 (5.0)	0.24	+0.6 (6.5)	0.66
PLR MAP change (mmHg)	+0.1 (7.3)	−0.7 (6.2)	0.71	+0.6 (5.8)	0.69	+1.4 (6.4)	0.51
Resting IVC							
Inhaled (cm)	1.28 (0.46)	1.30 (0.43)	0.88	1.38 (0.37)	0.38	1.26 (0.42)	0.47
Exhaled (cm)	1.79 (0.52)	1.80 (0.52)	0.79	1.84 (0.41)	0.85	1.78 (0.51)	0.64
Caval index (%)	29 (13)	28 (13)	0.81	25 (11)	0.24	28 (12)	0.77
Sniff test (% change from supine)	48 (23)	54 (21)	0.17	46 (22)	0.61	49 (23)	0.87
PLR (% change from supine)	108 (24)	109 (25)	0.55	113 (22)	0.14	119 (27)	0.02

P values have been Bonferroni adjusted for the three time point comparisons. Data presented as mean (SD).

HR = heart rate; IVC = inferior vena cava; MAP = mean arterial pressure; NA = not applicable; PLR = passive leg raise; POCUS = point-of-care ultrasound; SD = standard deviation.

pressure, heart rate, and body weight were observed with increasing *nil per os* (NPO) duration. At rest, there were no associations between NPO duration and inhaled or exhaled IVC diameter, caval index, or sniff test. Heart rate and blood pressure responses to orthostatic maneuvers and other IVC measurements were unchanged.

Our results suggest that POCUS examination of the IVC, as an index of central volume status, has a limited role in identifying the fluid deficit associated with fasting in healthy adults. It is possible that normovolemia during the fast period was achieved by a redistribution of peripheral venous blood to the central circulation.⁵ Studies with more diverse patient populations may show a utility for POCUS assessment of altered intravascular status associated with fasting.

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Conflicts of interest None.

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