International Journal of Obstetric Anesthesia (2010) **19**, 142–148
0959-289X/$ - see front matter
doi:10.1016/j.ijoa.2009.06.007

ELSEVIER
www.obstetanesthesia.com

ORIGINAL ARTICLE

Prospective observational study of serial cardiac output by transthoracic echocardiography in healthy pregnant women undergoing elective caesarean delivery

A. Dennis,[a] I. Arhanghelschi,[b] S. Simmons,[a] C. Royse[c]
[a] *Department of Anaesthesia, Mercy Hospital for Women, Heidelberg*
[b] *St Vincent's Hospital, Fitzroy and Anaesthesia, Australia*
[c] *Pain Management Unit, Department of Pharmacology, University of Melbourne and Department of Anaesthesia and Pain Management, Royal Melbourne Hospital, Parkville, Australia*

ABSTRACT
Background: An understanding of cardiovascular changes in parturients is crucial for their anaesthetic management, but few studies have examined the effect of posture on cardiac output in the peripartum period.
Method: Cardiac output was measured in four different positions by transthoracic echocardiography (Doppler) in 30 term women undergoing elective caesarean delivery. These positions were left lateral level (P1), left lateral with 20° head up (P2), left lateral with 10° head down (P3) measured preoperatively and supine (P4) measured postoperatively.
Results: Mean ± SD cardiac output was 4407 ± 1109 mL/min (P1), 4182 ± 825 mL/min (P2), 4031 ± 798 mL/min (P3) and 4641 ± 1064 mL/min (P4). Cardiac output was significantly less in P3 than in P1 ($P = 0.049$) due to a lower P3 velocity time integral compared with P1 ($P = 0.020$). Postoperatively, in the supine position, there was no difference in cardiac output, although there was a lower heart rate ($P = <0.001$) and increased velocity time integral ($P = <0.001$) compared with P1. The mean differences in interobserver measurements were 0.02 cm (left ventricular outflow tract) and -1.06 cm (velocity time integral). The mean differences in intraobserver measurements were 0.00 cm (left ventricular outflow tract) and -0.22 cm (velocity time integral). Echocardiography was well accepted by all women. Eight women found the left lateral 10° head-down position (P3) uncomfortable due to dizziness, headache, or increased abdominal pressure.
Conclusions: Cardiac output showed large variability and was lower than previously reported. Cardiac output decreased with the left lateral 10° head-down position due to a reduction in stroke volume that has not previously been reported. The transthoracic examination was acceptable to all women.

Keywords: Transthoracic echocardiography; Caesarean delivery; Pregnancy; Posture; Position; Cardiac output; Stroke volume; Velocity time integral

Introduction

An understanding of the cardiovascular consequences of pregnancy is fundamental to the management of pregnant women. Clinical observations confirm that changes occur, although the precise nature and magnitude of these changes is not clear in the literature. Limitations of previous studies of cardiac output (CO) in pregnancy have included small participant numbers, failure to obtain basal resting conditions, wide ranges of gestations, different postures or unspecified conditions and the use of invasive devices to measure cardiac output, which may themselves elevate cardiac output. Thus despite a seemingly large amount of data examining CO throughout pregnancy, heterogeneity of the studies makes interpretation of results difficult.[1] Investigators report normal CO values between 5 and 8 L/min with the peak CO being achieved between 28 and 38 weeks.[2,3] Some studies report a reduction in CO from the second trimester.[4] Serial data from the immediate peripartum period are often missing from longitudinal studies.[1,4]

Accepted June 2009
Preliminary results were presented at the Australian Society of Anaesthetists/New Zealand Society of Anaesthetists Combined Scientific Congress, Wellington Convention Centre, Wellington, New Zealand, October 12, 2008 and the Society of Obstetric Medicine Australian and New Zealand Annual Scientific Meeting November 2008.
Correspondence to: Dr Alicia Dennis, Deputy Head of Anaesthesia, Mercy Hospital for Women, 163 Studley Road, Heidelberg, Victoria, Australia 3084.
E-mail address: adennis@unimelb.edu.au

Postural changes are frequently employed during the establishment of neuraxial anaesthesia and for management of hypotension and maternal collapse, but few studies have examined the effect of posture on cardiac output in the peripartum period. It is expected that CO would increase in the head-down position and decrease in the head-up position based on physiological data in the healthy non-pregnant population.[5] The effect of the head-down position has not previously been examined in this setting, although the presence of the fetus may contribute to changes in cardiac output via aortocaval compression, or by compressing the heart inducing diastolic dysfunction. Anecdotally, many women find certain postures uncomfortable or intolerable in late pregnancy; changes in cardiac output could contribute to these symptoms. It is also important to account accurately for fetal weight, but few studies are performed on the day of birth.[6,7]

Transthoracic echocardiography (TTE), as a means of non-invasive monitoring, is used increasingly in anaesthesia and critical care. Portability, accuracy, ease of use and a variety of training courses have encouraged its use.[8] It can provide far greater diagnostic insight than currently employed methods into the cardiovascular complications of pregnancy and obstetric critical illness. TTE using Doppler echocardiography has been validated against thermodilution techniques employing invasive monitors[1] and is reproducible in pregnancy for assessment of cardiac output.[9–11] With increasing maternal age and morbid obesity and problems related to maternal cardiovascular disease, it is important in the first place to define normal cardiovascular parameters in healthy women at term.[12]

The aim of this study was to determine cardiac output by TTE in four different positions in healthy term pregnant women having elective caesarean delivery.

Methods

This study was conducted with Institutional Ethics Committee approval and written informed consent was obtained from all patients. Patients were recruited before the day of surgery.

Study group: Thirty fasted healthy term women were enrolled and the study was performed on the day of elective caesarean delivery with fetal heart rate assessment immediately beforehand. Inclusion criteria: age 18-39 years, body mass index (BMI) $<33\ kg/m^2$, gestation $\geqslant 37$ weeks, singleton pregnancy, fundal height equivalent to dates and ASA physical status I or II. Exclusion criteria: patient refusal, after-hours surgery, current administration of vasoactive drugs including salbutamol and thyroxine, pre-existing or gestational diabetes, smoking, pre-existing or gestational hypertension or preeclampsia, and known uterine abnormality.

Anaesthesia for the caesarean delivery, use of medications and intravenous fluids were at the discretion of the individual consultant anaesthetists. The study investigators were not involved in the delivery of anaesthesia.

Preoperative haemodynamics: Women rested in the left lateral position on a comfortable bed in a quiet, temperature-controlled environment with partners present for a minimum of 10 min before the measurements. Baseline systolic and diastolic blood pressure was obtained non-invasively using the left arm recording the diastolic value as Korotkoff V. An electrocardiogram was attached. No medication or anaesthesia was given before the preoperative TTE assessments and no intravenous access or intravenous fluids were given.

Patient position and image acquisition: All TTE studies were performed by one observer, the principal investigator (AD) using a MicroMaxx P17 5 – 1 MHz transducer SonoSite®. Four serial TTE studies were performed under standardised conditions in three different positions preoperatively and one position postoperatively. All positions were quantified by an inclinometer and the time to perform the examination was recorded. The four positions were left lateral level (P1), left lateral 20° head up (P2), and left lateral 10° head down (P3), performed preoperatively; and supine (P4) performed postoperatively within 1 h of delivery in the postanaesthetic care unit (PACU).

A parasternal long axis (PLAX), parasternal short axis (PSAX), apical 4- and 5-chamber (A4C, A5C) TTE examination including two-dimensional imaging and continuous, pulse wave, colour flow and tissue Doppler were performed with the aim of acquiring the best images.

In each woman the following method was used to acquire the images to determine cardiac output. In the left lateral level position (P1) the left ventricular outflow tract (LVOT) image was obtained from the PLAX view. A good quality image was defined as one in which the aortic valve could be seen and the structure looked tubular. A zoomed two-dimensional image in systole during quiet breathing was recorded. The LVOT velocity time integral (VTI) was recorded using the A5C view, with the Doppler integration angle $<20°$ to flow. An optimal image was assessed by maximal chamber size, a vertical long axis and maximal mitral valve opening size. Pulse wave Doppler was used with a 3-mm sample volume placed within the LVOT approximately 0.5 cm proximal to the aortic valve. At least three consecutive beats were recorded.

Whilst remaining on her left side, the woman was placed 20° head-up (P2) and the above TTE examination repeated within 5 min. She was then placed in the 10° head-down position (P3) and the above TTE examination repeated again within 5 min. In the PACU the woman was placed in the supine position (P4). Sensory