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Echocardiographic determination of resting haemodynamics and optimal positioning in term pregnant women

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Summary

Optimal positioning for anaesthesia in pregnant women involves balancing the need for ideal tracheal intubation conditions (achieved by the head elevated ramped position), with the prevention of reduced cardiac output from aortocaval compression (achieved by left lateral pelvic tilt). No studies have examined the effect on cardiac output of left lateral pelvic tilt in the ramped position. We studied non-labouring, non-anaesthetised healthy term pregnant women who underwent baseline (left lateral decubitus) cardiac assessment using transthoracic echocardiography. We then compared cardiac output, maternal physiological variables, fetal heart rate and comfort scores in three positions: left lateral decubitus; ramped position with wedge; and ramped position alone. Thirty women completed the study. Mean (SD) age, gestation and body mass index were 33.5 (3.93) years, 38.5 (0.94) weeks and 29.0 (3.98) kg.m^{-2}, respectively. Mean ejection fraction, left ventricular internal diameter, and mitral valve E/e' were 55.2 (6.76) %, 4.70 (0.428) cm and 7.50 (1.82) respectively. There were no differences in cardiac output between the positions (p=0.503). There were no differences in systolic (p=0.955) or diastolic (p=0.987) blood pressure, maternal heart rate (p=0.133), oxygen saturation, respiratory rate (p=0.964) or fetal heart rate (p=0.361) between ramped with wedge and ramped alone positions. Left lateral decubitus was most comfortable (p=0.001), however there were no differences in comfort levels between ramped with wedge and ramped alone positions. The ramped position without left lateral tilt is safe and acceptable in non-labouring, non-anaesthetised, healthy term pregnant women. Left lateral pelvic tilt may be unnecessary in the head elevated ramped position in term pregnant women.

Introduction

Failed tracheal intubation and ventilation are important causes of anaesthesia-related maternal morbidity and mortality with an incidence of one in 300 women [1]. Optimal positioning is essential to ensure an adequate view at tracheal intubation and to minimise the risk of airway trauma or difficult or failed tracheal intubation [2]. The ramped position elevates the person's upper body and head until their external auditory meatus and the sternal notch are in the same horizontal plane. This position provides a superior view at laryngoscopy, especially in obese adults, and has become routine in many centres for obese non-pregnant adults undergoing surgery [3]. The ramped position has been recommended in pregnant women undergoing caesarean section as it also improves airway positioning for bag mask ventilation, increases functional residual capacity and reduces reflux symptoms [3,4]. Along with this position, left lateral tilt is recommended as a means of reducing aortocaval compression, thereby preserving venous return and cardiac output.

Aortocaval compression, leading to supine hypotensive syndrome, was described by Howard and colleagues as impairment in venous return and subsequent cardiac output by compression of the inferior vena cava by the gravid uterus when pregnant women lie completely supine [5]. This led to the adoption of left lateral tilt during caesarean section, either achieved by placing a wedge under the right buttock of the patient or by tilting the operating table to the left. Left lateral tilt, however, is not without problems. The left lateral tilt of the thorax on the head and neck, even in the ramped position, may produce anatomical distortion to compound an already difficult obstetric airway, and may make the angle for correct cricoid pressure more difficult to judge [6]. Surgical access may be more difficult and compression neuropathy related to wedge placement during caesarean section has been described [7]. All these issues are exacerbated in overweight, obese and morbidly obese pregnant women who are placed in the left lateral tilt position, with the added issue of potentially dangerous tilting on a relatively narrow operating table [8].

Evidence supporting left lateral pelvic tilt to optimise haemodynamics in pregnant women who are in the ramped position is limited [9]. There are no studies examining whether its addition provides a reduction in aortocaval compression compared with the ramped position alone. Left lateral pelvic tilt may be unnecessary with this optimal ramping in pregnant women. If this is the case, then airway management and surgical access may be safer and maternal comfort levels may be improved.

Our primary hypothesis was that there was no significant difference in maternal cardiac output with the ramped position combined with left lateral pelvic tilt compared with the ramped position alone, in healthy term pregnant women. Our secondary hypotheses were as follows: that there is no significant change in maternal physiological variables of systolic or diastolic blood pressure, maternal heart rate, oxygen saturation and respiratory rat; no increase in the incidence of maternal self-reported symptoms of nausea, dyspnoea or dizziness; and no changes in fetal heart rate, in the ramped position combined with left lateral tilt compared with the ramped position alone.

We aimed to measure cardiac output by transthoracic echocardiography , maternal physiological variables, fetal heart rate and maternal comfort scores, in three positions: left lateral decubitus; ramped with wedge to achieve left lateral tilt; and ramped position alone, in term pregnant women.

Methods

We conducted a prospective observational study in which 30 healthy term pregnant women (≥37 weeks gestation) with a singleton pregnancy were recruited from a single tertiary referral obstetric hospital, after gaining institutional ethics approval and written consent,. Exclusion criteria were women in labour, or any contraindication to blood pressure measurement on the arm.

All participants rested in the left lateral decubitus position on a comfortable bed in a quiet, temperature-controlled environment for a minimum of five minutes before the measurements. Blood pressures were obtained non-invasively using an automated oscillometric blood pressure monitor [10]. An investigator measured heart rate, respiratory rate and oxygen saturation, using pulse oximetry, and fetal heart rate. ECG leads were attached to the woman. Baseline transthoracic echocardiography measurements were made by a single trained observer using a GE Vivid E9 echocardiography machine with a 7.5 MHz transducer (GE Horten, Norway) using 2-dimensional, M-mode, colour-flow, continuous, pulsed wave and tissue Doppler imaging according to American Society of Echocardiography guidelines, and following the methodology previously published [11,12].

We performed haemodynamic measurements according to standard recommendations and analysis and measurements were made offline. We calculated cardiac output by measuring the left ventricular outflow tract diameter (to determine a cross-sectional area) obtained from the parasternal long axis view, the Doppler-derived velocity time integral of the left ventricular outflow tract , obtained from the apical four-chamber view , and the heart rate.

Ejection fraction was automatically calculated using the auto-ejection fraction function using the apical four-chamber view. We measured fractional shortening using the M-mode recording at the tips of the mitral valve in the parasternal long axis view view. Diastolic function was measured using mitral valve inflow velocities E and A ($cm.s^{-1}$), mitral valve deceleration time (ms), and left atrial diameter (cm). We used myocardial tissue Doppler to record the myocardial interventricular septum and left ventricular diastolic velocities of e´ and a´ and the systolic velocity of s´ , as well as right ventricular diastolic velocities of e´ and a´ and the systolic velocity of s´. The tricuspid annular plane systolic excursion was measured using M-mode on the lateral right ventricular wall. Insonation angles were between 0-5 degrees. We calculated the left ventricular mass using measurements obtained from the parasternal long axis M-mode image of the left ventricle during diastole. The Tei index, the measurement of overall myocardial performance was measured using tissue Doppler time intervals. We calculated stroke work index and cardiac work index using the stroke volume and body surface area, and stroke work index and heart rate, respectively.

After performing baseline transthoracic echocardiography in the left lateral decubitus (left lateral) position, we then placed each woman in the ramped position on the Troop Elevation Pillow™ (Marlin Medical Bayswater North, Victoria, Australia). This pillow is a triangular pillow upon which a normal pillow is placed (Figure 1). Women positioned themselves comfortably on the Troop Elevation Pillow™ to provide horizontal, visually confirmed alignment between the external auditory meatus and sternal notch. A pelvic wedge (Figure 2) was placed under the right buttock and caudal to the Troop Elevation Pillow™ to provide an approximate 15-degree left lateral pelvic tilt (ramped with wedge), confirmed by measuring the angle between the right hand side of the gravid abdomen in the ramped alone position (90°) and the right hand side of the gravid abdomen in the ramped with wedged position using an inclinometer (Figure 3). Each woman rested in this position for five minutes, following which we measured the left ventricular velocity time integral using transthoracic echocardiography and repeated measurements of left arm blood pressure, heart rate by electrocardiography, oxygen saturation, respiratory rate and fetal heart rate. We then returned all patients to the left lateral decubitus position for five minutes. Each woman was then placed in the ramped position on the Troop Elevation Pillow™ without a wedge to provide tilt (ramped alone). They rested in this position for five minutes after which we measured the left ventricular velocity time integral using transthoracic echocardiography and repeated measurements of left arm blood pressure, heart rate by electrocardiography, oxygen saturation, respiratory rate and fetal heart rate. At the end of the measurements we asked women to rate their comfort levels on a 10-point scale in each of the three positions, with one being not comfortable at all, and 10 being the most comfortable they could possibly be.

Clinically relevant changes in physiological variables were defined as follows: a reduction of 20% from baseline in either systolic or diastolic blood pressure; an increase in maternal heart rate of 25% from baseline; a fall in oxygen saturation to < 95% or rise in respiratory rate to > 20/min; and an increased incidence of fetal tachycardia HR > 160/min or bradycardia < 100/min measured by Doppler velocimetry.

We analysed data using SPSS Statistics Version 24 (IBM© SPSS© Statistics Version 24 IBM Corporation 2016, Chicago, Ill). We compared data for the three positions using repeated measures ANOVA with Geisser-Greenhouse correction for the continuous normally distributed data. We calculated an overall ANOVA p value, as well as the mean difference and 95% confidence interval for each group comparison. An adjusted p value was given for multiple comparisons. We used the Friedman test to compare comfort scores between the groups. We conducted a study of a continuous response variable in study subjects comparing their cardiac output in two different positions. Data from our previous study investigating cardiac output in term pregnant women determined the mean (standard deviation) of cardiac output to be 4407 (1109) ml.min^{-1} [11]. For this study, we assumed a clinically relevant difference in mean cardiac output of 750 ml.min^{-1} (approximately 15%) between the ramped with wedge position, and the ramped alone position. If the true difference in the mean change in cardiac output between the two positions was 750 ml.min^{-1}, we needed to study 25 subjects to be able to reject the null hypothesis that this response difference is zero with probability (power) 0.9. The Type I error probability associated with this test of this null hypothesis was 0.05. We recruited 30 women in order to account for the possibility of not being able to measure the cardiac output in some women using transthoracic echocardiography. We determined intra-observer and inter-observer variability using Bland Altman methodology. For intra-observer variability, one observer (ATD) remeasured the left ventricular outflow tract diameter and left ventricular outflow tract diameter velocity time integral stored loops two weeks after the original measurements. The 95% limits of agreement, the within-subject standard deviations, coefficients of variation and repeatability coefficients were calculated. For inter-observer variability a second observer measured the images blinded to the subject position and in random order. Strength of evidence statements are used to interpret p values such that pvalue: 0-0.001 = very strong evidence; 0.001 – 0.01 = strong evidence, 0.01-0.05 = evidence; 0.05 – 0.1 weak evidence; and 0.1 to 1.0 little or no evidence.

Results

Thirty women completed the study and all found the three positions acceptable. No woman experienced complications in any of the three positions. Table 1 shows the baseline characteristics of the women. All women were healthy and asymptomatic of cardiac disease. Table 2 shows the baseline echocardiography measurements in the left lateral position. Cardiac systolic and diastolic function generally showed healthy cardiac function; one woman, however, had a mildly reduced ejection fraction of 45% with a mildly dilated ventricle (5.6 cm), and eight women (27%) had a mitral valve E/e′ value of greater than eight, suggesting the possibility of diastolic impairment.

Table 3 shows the changes in cardiac output, as well as maternal and fetal physiological variables and comfort scores in the three positions. There was no evidence of a change in mean cardiac output between the left lateral, the ramped with wedge and the ramped alone positions (p=0.503). The mean difference in cardiac output between the ramped with wedge and the ramped alone positions was 110 ml.min^{-1} (95% CI -457 to 676 ml.min^{-1}). As the 95% confidence interval did not include the clinically significant value of 750 ml, it is likely that this result represents a true negative result.

There was strong evidence of a difference in mean systolic blood pressure, mean diastolic blood pressure and mean arterial pressure between the three groups; however, these were only between the left lateral and ramped with wedge and ramped alone positions, and were very small mean differences with increases in the ramped positions, unlikely to be clinically significant. There was no evidence of differences in these variables between the ramped with wedge and ramped alone positions (Table 3).

There was strong evidence of changes in mean maternal heart rate between the three positions; however, like the blood pressure changes, these were only between the left lateral position and the ramped positions, and were unlikely to be clinically significant. There was no evidence of mean differences in oxygen saturation, respiratory rate or fetal heart rate in the three positions (Table 3).

There was strong evidence of a difference in median comfort scores in the three positions (p=0.001). The median (IQR [range]) in the left lateral position was 8 (7.75- 9 [5-10]), in the ramped with wedge position 6 (5-8 [2-10]) and the ramped alone position 7 (6-8 [2-10]). The left lateral position was more comfortable than the ramped with wedge position (p=0.002) and the ramped alone position (p=0.020); however, there was no evidence of a difference in median comfort scores between the ramped with wedge and ramped alone positions (p>0.999). There was no increase in the incidence of maternal self-reported symptoms of nausea, dyspnoea or dizziness, in the ramped positions with or without a wedge.

Intra- and inter-observer agreements were good. Intra-observer variability was mean (SD), 0.00 (0.45) mm for the left ventricular outflow tract diameter and 0.10 (0.46) cm.s^{-1} for the left ventricular outflow tract velocity time integral. For the left ventricular outflow tract diameter this equates to 95% of the intra-observer measurements being within 0.9 mm (4.2%) of the mean left ventricular outflow tract measurement for the two observations of 20.9 mm. For the left ventricular outflow tract velocity time integral this equates to 95% of the intra-observer measurements being within 0.9 cm.s^{-1} (3.6%) of the mean value for the two observations of 25.3 cm.s^{-}1.

Inter-observer variability was mean (SD) 0.00 (1.27) mm for the left ventricular outflow tract diameter and 0.60 (1.17) cm.s^{-1} for the left ventricular outflow tract velocity time integral. For the left ventricular outflow tract diameter this equates to 95% of the interobserver measurements being within 2.5 mm (12.0%) of the mean left ventricular outflow tract measurement for the two observers of 20.8 mm. For the left ventricular outflow tract velocity time integral this equates to 95% of the inter-observer measurements being within 2.3 $cm.s^{-1}$ (9.0%) of the mean value for the two observers of 25.6 $cm.s^{-1}$.

Discussion

This is the first study to investigate haemodynamics using transthoracic echocardiography in term pregnant women in the ramped position with and without a right lateral wedge. We found no evidence of a change in maternal cardiac output between the left lateral decubitus position and the ramped positions with or without a wedge. There were no significant changes in maternal physiological variables, namely: systolic blood pressure; diastolic blood pressure; mean arterial pressure; maternal heart rate; oxygen saturation; or respiratory rate; between the ramped positions with or without a wedge. There were no changes in fetal heart rate between the between the ramped positions with or without a wedge. Our data suggests that the ramped position without a wedge (i.e. without left lateral tilt) is safe and acceptable in non-labouring, non-anaesthetised, healthy term pregnant women, and that the left lateral tilt is unnecessary in the ramped position in term pregnant women.

Left lateral tilt has been shown in a previous study to provide a 5% increase in cardiac output at an angle of > 15 degrees compared with supine [13]. In a proportion of pregnant women, cardiac output was shown to decrease by more than 20%, when they were tilted to less than 15 degrees. Despite these changes in cardiac output, no changes were seen in systolic pressure and no woman experienced the supine hypotensive syndrome. This suggests that cardiac output measurement is a more sensitive marker for aortocaval compression than expression of symptoms or changes in physiological variables due to sympathetic compensation in healthy pregnant women. In our study there were no changes in cardiac output between the three positions, suggesting that the ramped position maintains cardiac output and minimises aortocaval compression.

Despite the increasing use and perceived benefits of the ramped position for caesarean section, the literature regarding the benefit of a left lateral pelvic tilt in addition to this position is sparse, and left lateral displacement of the uterus is routinely used. A previous small observational study using magnetic resonance imaging insix patients found little evidence of improvements in aortocaval compression in a 15 degree head elevated position pelvic tilt position [14]. However, there are no large studies looking at whether the addition of left lateral pelvic tilt to the head up position provides a haemodynamic benefit.

Baseline cardiac measurements in this group of women support data from previous studies that show a reduction in both systolic and diastolic function in some asymptomatic term pregnant women. The significance of this requires further investigation, as it is unclear whether or not these women have longer-term increased risks of cardiovascular disease. Despite its advantages in enabling rapid diagnosis of symptoms of heart failure and shortness of breath in pregnant women, and being recommended for use in pregnant women, echocardiography is still not commonly utilised in pregnancy [15, 16]. Baseline term pregnant data from this study will however add to the reference data in this area.

Larger studies investigating the ramped position without a left lateral pelvic tilt in women who have received neuraxial anaesthesia are necessary to extrapolate these findings to the caesarean section clinical scenario. The ramped position without left lateral pelvic tilt may offer advantages if general anaesthesia is required at the beginning or during caesarean section in that it does not distort the airway anatomy, it is likely to improve surgical access, and may minimise risk related to injury from the wedge itself or extreme lateral tilt.

The strengths of this study are that it is a unique and novel observational study in which term pregnant women underwent a series of postural changes over an approximate thirty-minute period, during which changes in haemodynamic variables were measured non-invasively by transthoracic echocardiography. Cardiac output was measured with transthoracic echocardiography using the left ventricular outflow tract diameter and left ventricular outflow tract velocity time integral, which is a reproducible and reliable method. Participants were a homogenous group limited to healthy women greater than 37 weeks gestation. Participants acted as their own controls.

The limitations of this study are that it was performed in healthy, unmedicated term pregnant women where the time in the three positions was limited to five minutes. Whilst the mean body mass index was in the overweight range, we did not include obese or morbidly obese women in this study, possibly limiting its translation to this group. The study was limited to women who had not received medication or neuraxial anaesthesia, and serves as a preliminary study to assess cardiac output changes in different positions in women undergoing caesarean section. Despite the positive inter-observer variability data, the position sequence was not randomised, which may have led to measurement bias in the analyses.

The ramped position without left lateral tilt in non-labouring, non-anaesthetised term pregnant women is safe, feasible and acceptable. The left lateral tilt appears unnecessary in non-labouring non-anaesthetised term pregnant women in the ramped position. There are no changes in cardiac output between this position and the left lateral position, and maternal and fetal physiological variables were unchanged with or without the lateral wedge. Further studies in women undergoing neuraxial anaesthesia are needed to confirm these findings in the intra-operative setting.

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Author contributions

ATD: concept, study design, echocardiography, data analysis, write up

AB: participant recruitment, write up

TM: participant recruitment

JMC: inter-observer variability measurements

LL: participant recruitment

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Table 1 Baseline characteristics of women undergoing left lateral decubitus, ramped with wedge and ramp alone positioning studies. Values are mean (SD).

Characteristic	
Age; yr	33.5 (3.93)
Gestation; wk	38.5 (0.94)
Weight; kg	79.2 (11.4)
Height; m	1.65 (0.07)
Body mass index; $kg.m^{-2}$	29.0 (3.98)
Body surface area; m^2	1.86 (0.14)

Table 2 Baseline echocardiographic measurements in left lateral decubitus position. Values are mean (SD).

Haemodynamic and systolic variables	
Systolic blood pressure; mmHg	117 (14.7)
Diastolic blood pressure; mmHg	73.2 (8.69)
Mean arterial pressure; mmHg	87.9 (10.1)
Heart Rate; BPM	74.6 (10.3)
Cardiac output; $l.min^{-1}$	6.07 (1.51)
Cardiac index; $l.min^{-1}.m^{-2}$	3.24 (0.67)
Left ventricular ejection fraction; %	55.2 (6.76)
Left ventricular fractional shortening; %	41.0 (7.36)
Stroke volume; ml	73.8 (16.4)
Left ventricular tissue Doppler s′ (septal); $cm.sec^{-1}$	8.81 (1.64)
Left ventricular tissue Doppler s′ (lateral); $cm.sec^{-1}$	8.70 (1.87)
TAPSE; cm	2.94 (0.94)
Right ventricular tissue Doppler s′ (lateral); $cm.sec^{-1}$	13.4 (2.45)
Diastolic variables	
Left ventricular internal diameter (diastole); cm	4.70 (0.43)
Left atrial size; cm	3.63 (0.41)
Mitral valve E/A	1.73 (0.52)
Mitral valve DT; msec	190 (41.8)

Left ventricular tissue Doppler e′ (septal); $cm.sec^{-1}$	11.0 (2.50)
Left ventricular tissue Doppler e′ (lateral); $cm.sec^{-1}$	13.9 (2.84)
Right ventricular lateral e′; $cm.sec^{-1}$	15.1 (3.67)
Mitral valve E/septal e′	7.50 (1.82)
Structural and performance variables	
Stroke work index; $mmHg.ml.m^{-2}$	3452 (833.1)
Cardiac work index; $mmHg.l.m^{-2}$	275 (78.0)
Left ventricular mass; g	155 (39.2)
Tei index	0.48 (0.12)

TAPSE, tricuspid annular plane systolic exertion; DT, deceleration time

Table 3 Maternal physiological variables and fetal heart rate in the left lateral position, the ramped with wedge position and the ramped alone position.

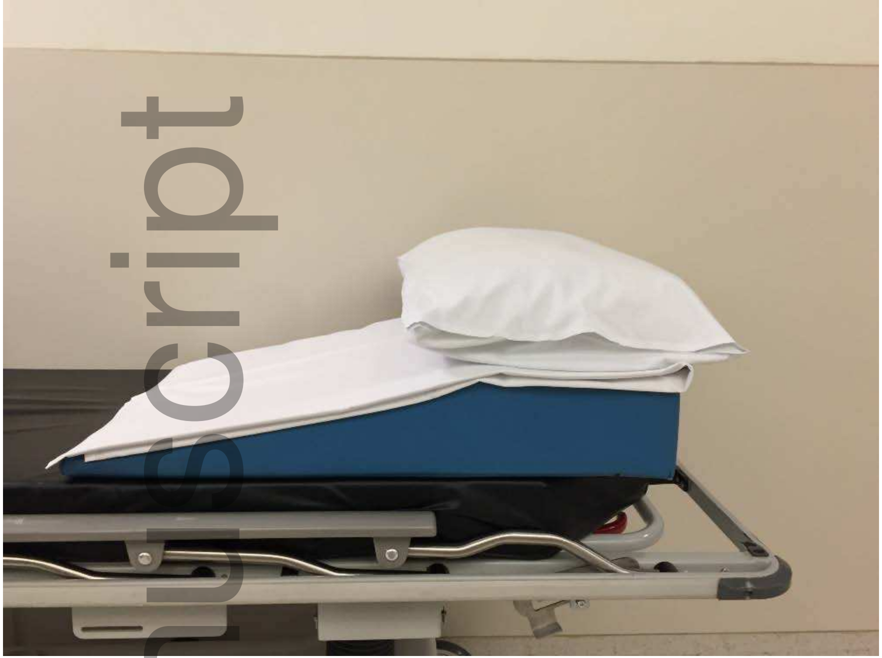
Variable	Position	Mean (SD)	ANOVA p value	Position Comparison	Mean difference	95% confidence interval	Adjusted p value
Cardiac output;	Left lateral only	6068 (1511)	0.503	Left lateral only vs Ramped with wedge	102	-318 to 522	0.822
$ml.min^{-1}$	Ramped and wedge	5966 (1452)		Left lateral only vs Ramped alone	213	-350 to 773	0.626
	Ramped alone	5857 (1504)		Ramped with wedge vs Ramped alone	110	-457 to 676	0.883
Systolic BP;	Left lateral only	117 (14.7)	0.005	Left lateral only vs Ramped and wedge	-6.6	-12.3 to -0.8	0.022
mmHg	Ramped with wedge	124 (12.0)		Left lateral only vs Ramped alone	-7.1	-13.3 to -0.8	0.024
	Ramped alone	124 (16.1)		Ramped with wedge vs Ramped alone	-0.5	-4.8 to 3.8	0.955
Diastolic BP;	Left lateral only	73.2 (8.69)	0.001	Left lateral only vs Ramped with wedge	-5.3	-10.3 to -1.2	0.011
mmHg	Ramped with wedge	79.0 (11.1)		Left lateral only vs Ramped alone	-5.5	-9.4 to -1.7	0.003
	Ramped alone	78.8 (8.36)		Ramped with wedge vs Ramped alone	0.2	-3.5 to 4.0	0.987
Mean arterial pressure;	Left lateral only	87.9 (10.1)	0.001	Left lateral only vs Ramped with wedge	-6.0	-10.5 to -1.6	0.067
mmHg	Ramped with wedge	93.9 (10.9)		Left lateral only vs Ramped alone	-6.0	-10.2 to -1.9	0.003
	Ramped alone	93.9 (10.3)		Ramped with wedge vs Ramped alone	-0.0	-3.2 to 3.2	>0.999
Maternal heart rate;	Left lateral only	74.6 (10.3)	<0.001	Left lateral only vs Ramped with wedge	-3.5	-6.4 to -0.7	0.014
BPM	Ramped with wedge	78.1 (12.7)		Left lateral only vs Ramped alone	-5.8	-8.2 to -3.5	<0.001
	Ramped alone	80 .4 (13.1)		Ramped with wedge vs Ramped alone	-2.3	-5.2 to 0.6	0.133
Oxygen saturation;	Left lateral only	98.2 (0.66)	0.523	Left lateral only vs Ramped with wedge	0.1	-0.1 to 0.3	0.498
SpO_2 %	Ramped with wedge	98.1 (0.71)		Left lateral only vs Ramped alone	0.1	-0.2 to 0.4	0.644

	Ramped alone	98.1 (0.66)		Ramped with wedge vs Ramped alone	0.0	-0.3 to 0.3	>0.999
Respiratory rate; BrPM	Left lateral only	17.5 (3.67)	0.494	Left lateral only vs Ramped with wedge	0.4	-0.5 to 1.4	0.502
	Ramped with wedge	17.1 (3.77)		Left lateral only vs Ramped alone	0.3	-0.6 to 1.3	0.648
	Ramped alone	17.2 (4.06)		Ramped with wedge vs Ramped alone	-0.1	-1.1 to 0.8	0.964
Fetal heart rate; BPM	Left lateral only	141 (13.5)	0.246	Left lateral only vs Ramped with wedge	-3.0	-8.8 to 2.8	0.402
	Ramped with wedge	144 (12.8)		Left lateral only vs Ramped alone	1.1	-4.1 to 6.2	0.867
	Ramped alone	140 (12.6)		Ramped with wedge vs Ramped alone	4.1	-3.2 to 11.3	0.361

ANOVA, analysis of variance; BP, blood pressure; BPM, beats per minute; BrBP,breaths per minute

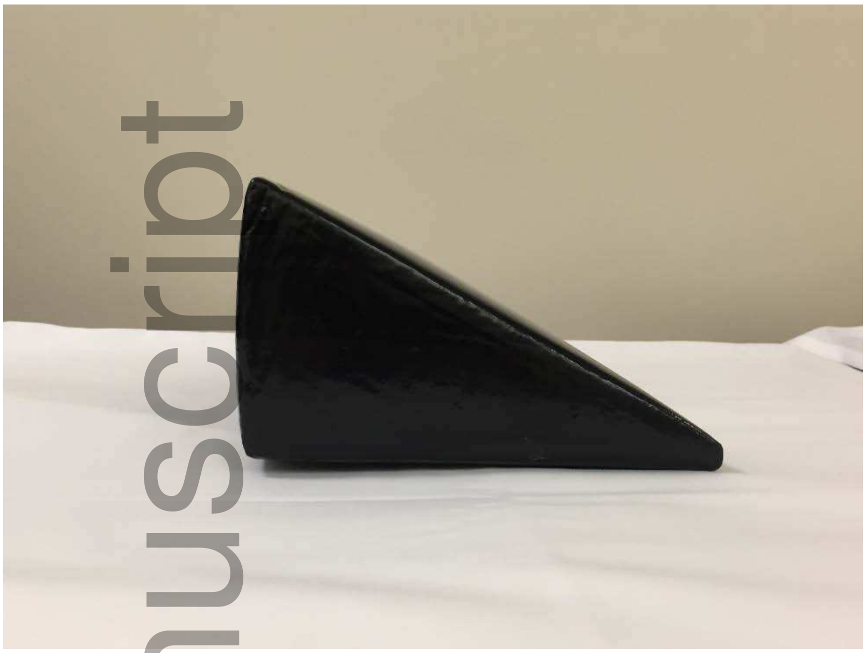
Wedge, wedge placed under right pelvis to displace the abdomen to the left (left lateral tilt)

Figure 1 Troop Elevation Pillow™



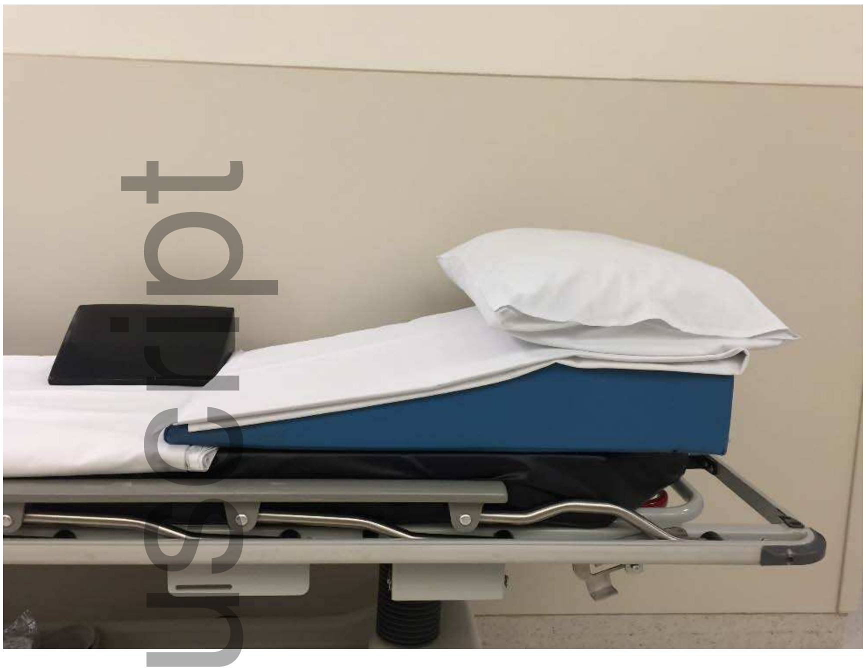
This figure shows the Troop Elevation Pillow™ of dimensions length 65 cm, height 12 cm, top horizontal surface 24 cm, diagonal 53 cm providing a ramped angle of approximately 15˚. A sheet and normal pillow are placed on top of the elevation pillow.

Figure 2 Pelvic wedge



This figure shows the pelvic wedge of dimensions length 20 cm, height 10 cm, diagonal 18 cm providing a tiled angle up to approximately 25˚.

Figure 3 Combination of troop elevation Pillow and right pelvic wedge



This figure shows the position of the right pelvic wedge in relation to the Troop Elevation Pillow™.