

Left Lateral Table Tilt for Elective Cesarean Delivery under Spinal Anesthesia Has No Effect on Neonatal Acid–Base Status

A Randomized Controlled Trial

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This article has been selected for the ANESTHESIOLOGY CME Program. Learning objectives and disclosure and ordering information can be found in the CME section at the front of this issue.

ABSTRACT

Background: Current recommendations for women undergoing cesarean delivery include 15° left tilt for uterine displacement to prevent aortocaval compression, although this degree of tilt is practically never achieved. We hypothesized that under contemporary clinical practice, including a crystalloid coload and phenylephrine infusion targeted at maintaining baseline systolic blood pressure, there would be no effect of maternal position on neonatal acid base status in women undergoing elective cesarean delivery with spinal anesthesia.

Methods: Healthy women undergoing elective cesarean delivery were randomized (nonblinded) to supine horizontal (supine, $n = 50$) or 15° left tilt of the surgical table (tilt, $n = 50$) after spinal anesthesia (hyperbaric bupivacaine 12 mg, fentanyl 15 µg, preservative-free morphine 150 µg). Lactated Ringer's 10 ml/kg and a phenylephrine infusion titrated to 100% baseline systolic blood pressure were initiated with intrathecal injection. The primary outcome was umbilical artery base excess.

Results: There were no differences in umbilical artery base excess or pH between groups. The mean umbilical artery base excess (\pm SD) was -0.5 mM (± 1.6) in the supine group ($n = 50$) versus -0.6 mM (± 1.5) in the tilt group ($n = 47$) ($P = 0.64$). During 15 min after spinal anesthesia, mean phenylephrine requirement was greater ($P = 0.002$), and mean cardiac output was lower ($P = 0.014$) in the supine group.

Conclusions: Maternal supine position during elective cesarean delivery with spinal anesthesia in healthy term women does not impair neonatal acid–base status compared to 15° left tilt, when maternal systolic blood pressure is maintained with a coload and phenylephrine infusion. These findings may not be generalized to emergency situations or nonreassuring fetal status. (**ANESTHESIOLOGY 2017; 127:241-9**)

CURRENT recommendations for term women undergoing cesarean delivery include maintenance of left lateral tilt for uterine displacement until delivery, based on the premise that the supine position will result in aortocaval compression (ACC), maternal hypotension, and fetal compromise.^{1,2} In the supine position, the inferior vena cava (IVC) is completely obstructed up to the level of the bifurcation at term³; however, most women experience only limited hemodynamic changes and are asymptomatic (concealed ACC),^{4,5} probably as a result of compensation *via* venoconstriction in the lower limbs, which raises venous pressure, promoting flow through collateral channels such as the paraspinal and azygous veins.⁶ Clinically significant hemodynamic effects, the “supine hypotensive syndrome,” occur in only 8 to 10% of women at term, presumably because of less robust compensatory mechanisms in those individuals.^{4,5}

What We Already Know about This Topic

- It is ubiquitous obstetric anesthesia practice to implement left lateral uterine displacement in all women during cesarean delivery
- It is not known whether after spinal anesthesia in pregnant women, a fluid load, and a phenylephrine infusion to maintain baseline blood pressure can substitute for left lateral uterine displacement

What This Article Tells Us That Is New

- In healthy term pregnant women undergoing elective cesarean delivery after spinal anesthesia, with a crystalloid coload and prophylactic phenylephrine infusion, supine horizontal position or 15° left tilt of the surgical table (in a randomized protocol) had no effect on umbilical artery base excess
- When maternal systolic blood pressure was maintained with fluid and phenylephrine, there was no apparent benefit to left lateral uterine displacement during cesarean delivery

This article is featured in “This Month in Anesthesiology,” page 1A. Corresponding article on page 212. This article has an audio podcast.

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The effects of neuraxial anesthesia, *i.e.*, sympathetic blockade, blunt cardiovascular compensatory mechanisms during cesarean delivery, which may exacerbate maternal hypotension in the supine position. Major concerns were raised decades ago regarding the contribution of ACC to neonatal depression after cesarean delivery.^{7,8} Studies from the 1970s reported superior neonatal clinical and acid–base status when mothers were tilted during cesarean delivery.^{9–12} It subsequently became obstetric anesthesia dogma to institute left lateral displacement of the uterus (LUD) in all women during cesarean delivery. This has been pursued by rubber, foam, or wooden wedges, sand bags, air-filled bags, or bags of fluid, as well as manual displacement.^{9,10} The most common practice is probably left tilting of the surgical table, traditionally aimed at 15°, based on the “Crawford wedge,”¹⁰ although studies show that 15° is practically never achieved.^{13,14}

Because most practitioners rarely achieve or maintain table tilt of 15° and because more effective prevention and treatment of maternal spinal hypotension with controlled delivery of vasopressor agents is achievable today,¹⁵ we questioned the original evidence for and the continued utility of this nearly ubiquitous practice. We hypothesized that there would be no effect of maternal position (15° left table tilt or supine horizontal) on neonatal acid base status in women undergoing elective cesarean delivery with spinal anesthesia with use of a fluid coload and a phenylephrine infusion targeted at maintaining baseline systolic blood pressure (SBP).

Materials and Methods

This study received the approval of the Columbia University Institutional Review Board (New York, New York) and was registered on www.ClinicalTrials.gov (NCT02243423; registered on September 6, 2014). The principal investigator was Dr. Smiley. The trial was conducted from January 2015 through January 2016 at New York-Presbyterian/Allen Hospital, New York, affiliated with Columbia University. The authors prepared this study report in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines. The full protocol is available by request.

Study Participants

Subjects were American Society of Anesthesiologists status I and II women aged 18 yr or older, nonlaboring, at term with singleton uncomplicated pregnancies, scheduled for elective cesarean delivery under spinal anesthesia, with height 150 to 180 cm and body mass index of at most 40 kg/m². During December 2014 through January 2016, pregnant women scheduled for an elective cesarean delivery at New York-Presbyterian/Allen Hospital received an information letter from their obstetrician about the study during that office visit, explaining that they might be approached for participation in the study on the day of surgery. Evaluation of eligibility and written informed consent was obtained by investigators (attending physicians or nurse anesthetists) on the day of surgery for participation in this randomized controlled study. All women were fasted for at least

8 h per the institution protocol. Women with obstetric conditions that may affect the severity of ACC, such as transverse lie, fetal macrosomia, uterine abnormalities (*e.g.*, large fibroids, bicornuate uterus) and polyhydramnios, ruptured membranes, oligohydramnios, or intrauterine growth restriction were considered not eligible. Women with a hypertensive disorder or any condition associated with autonomic neuropathy (*e.g.*, diabetes mellitus for more than 10 yr), with renal failure, or currently smoking or with illicit drug use were not eligible due to complicated blood pressure management goals and potentially impaired uteroplacental perfusion, and those with severe scoliosis or kyphosis were not enrolled because of the risk of cardiopulmonary pathology and unpredictable effects on ACC.

Randomization and Blinding

A computerized block randomization table was generated by the principal investigator, with randomization in blocks of 10 in a 1:1 proportion for the tilt and supine groups. Assignments were concealed in numbered, sealed opaque envelopes. After enrollment, the envelope with the group assignment (tilt or supine) was opened by an investigator.

Preoperative Procedures

In the preoperative holding area, baseline SBP was measured in the supine, semirecumbent position (head up 45°) with a noninvasive (oscillometric) cuff placed on the left upper arm. The mean of three measures at least 5 min apart was recorded as the baseline SBP. Two dual-electrode skin sensors for the noninvasive hemodynamic monitoring system using bioactance technology (noninvasive cardiac output monitoring [NICOM]; Cheetah Medical Inc., USA) were placed bilaterally on the upper thorax and lateral subcostal regions for cardiac output (CO) measurement.¹⁶ Bioactance technology uses the relative phase shifts that occur when an alternating electric current traverses the thoracic cavity to calculate stroke volume and CO.

Intraoperative Procedures

Before anesthetic administration, baseline SBP, CO, and heart rate (HR) were recorded after 5 min in each of the supine and tilted positions. The first position for these measurements was whichever position was not the assigned group position for the subject, *i.e.*, patients assigned to the supine group first had SBP and CO determined with 15° tilt and then in the supine position before sitting for the spinal anesthetic.

Spinal anesthesia was performed with the patient in the sitting position, with intrathecal injection of hyperbaric bupivacaine 0.75% 12 mg, fentanyl 15 µg, and preservative-free morphine 150 µg. At the conclusion of the intrathecal injection, an IV phenylephrine infusion was initiated at 50 µg/min and a coload of 10 ml/kg lactated Ringer's solution was administered during 5 to 10 min. The patient was placed supine with one pillow under the head and neck. The surgical table either remained horizontal or was turned to 15° of left lateral tilt, depending on the group randomization. The incline of the table was verified using a digital inclinometer

(Digi-Pas DWL 80-E; Digi-Pas Technologies, USA). No supplemental oxygen was provided unless indicated clinically (maternal O₂ saturation less than 95%).

SBP was measured every minute after spinal anesthesia placement until delivery, and the phenylephrine infusion was adjusted after each determination. The infusion was titrated to maintain SBP at baseline. If the SBP was at or above baseline, the infusion was discontinued. If SBP was 90 to 99% of baseline, the phenylephrine infusion was set at 50 µg/min. If the SBP was 80 to 89% of baseline, phenylephrine administered was 100 µg/min. If SBP was less than 80% of baseline, the infusion was set to 200 µg/min. If the SBP remained at less than 80% of baseline after 1 min at 200 µg/min, boluses of IV phenylephrine 80 µg were given. If this regimen was unsuccessful at restoring SBP to greater than 90% of baseline within 3 min, any other indicated maneuver could be used (additional phenylephrine, ephedrine, epinephrine, additional intravenous fluid, or more rapid delivery, and if the patient was supine, the bed could be tilted to 15°). Maternal bradycardia (fewer than 40 beats/min) associated with SBP of less than 90% of baseline could be treated with glycopyrrolate 0.2 to 0.4 mg.

If the assigned patient position was found to significantly impair surgical access or believed to be negatively affecting maternal hemodynamic status, the position of the surgical table was adjusted. In the tilt group, after uterine incision, the surgical table was moved to complete horizontal to facilitate the application of fundal pressure by an assistant and access to the head of the neonate by the primary surgeon during delivery.

Statistical Analysis

This was a parallel-group randomized controlled trial. Our hypothesis was that during cesarean delivery with spinal anesthesia, maternal supine position would be noninferior to the 15° left lateral tilted position. The primary outcome was the mean base excess (BE) in the umbilical artery (UA) blood at birth. Secondary outcomes were mean umbilical artery pH; umbilical vein (UV) BE and pH; total dose of phenylephrine administered in the first 15 min after the spinal anesthetic and until delivery; maternal SBP, HR, and CO every minute until delivery; Apgar scores at 1 and 5 min; and the incidence of nausea and vomiting in each group.

The primary outcome, UA-BE, and the secondary outcomes, including blood gas variables and CO, were compared by unpaired *t* test. The difference between the mean CO at baseline in the tilted and supine position was analyzed by a paired *t* test. A linear mixed effects model for longitudinal measurements was used to test for differences between groups and over time with respect to SBP, CO, and phenylephrine dose. Categorical outcomes were compared by chi-squared test or Fisher's exact test. All analyses were preplanned.

We determined that a 2 mmol/l difference in UA-BE would constitute a potentially significant and clinically relevant difference between groups in the primary outcome based on differences in UA-BE reported in prior studies of positioning during cesarean delivery.^{9–11} Indeed, Ngan

Kee *et al.*¹⁷ reported a 2.9 mM median difference in UA-BE between women receiving ephedrine *versus* phenylephrine infusions during elective cesarean delivery with spinal anesthesia. In conjunction with the other findings among fetuses in the ephedrine group in the latter study (decreased pH and higher concentrations of lactate, glucose, and catecholamines), this BE difference has been considered significant enough to shift clinical practice toward a preference for phenylephrine. We estimated (based on pilot data) within group SDs of 1.5 mM. A tolerance limit of 1 mM was chosen, because this magnitude of difference was regarded as not having any clinical importance. For a one-tailed analysis with α 0.5 and 90% power, we calculated a sample size of 39 per group and, for a two-tailed analysis, 49 per group. We therefore aimed to enroll 50 patients per group.

Results

Of 149 women assessed for eligibility, 108 women consented to participate. One patient was excluded before randomization because her surgery was delayed, one patient's surgery was cancelled, one patient had fetal macrosomia, one patient had height less than 150 cm, and four patients were excluded because of elevated SBP in the holding area. One hundred women were randomized (tilt, *n* = 50; supine, *n* = 50) (see CONSORT flow diagram in fig. 1). There was one excluded case in the tilt group due to a drug error in the spinal dose. Six other cases in the tilt group were prematurely discontinued after skin incision (operating table turned to horizontal before delivery) because of surgeon inability to proceed in the tilted position. These cases were included in the intention-to-treat analysis.

Maternal Demographics

There were no statistically significant differences in patient characteristics between groups (table 1).

Neonatal Outcomes

There was no significant difference between groups with respect to the primary outcome, mean UA-BE. The UA-BE (mean \pm SD) in the supine group was -0.5 ± 1.6 mM *versus* -0.6 ± 1.5 mM in the tilt group (*P* = 0.64). The estimate for the upper bound of the one-sided 95% CI for the mean difference (0.1 mM) in UA-BE between the two arms was 0.4 mM, which means the difference should not be greater than this value. With the predetermined tolerance limit of 1 mM, this indicates that the supine position is not inferior to the tilt position. A box plot of the distribution of values by group is represented in figure 2. There were also no significant differences between groups in UA pH, UV-BE, pH (table 2), or Apgar scores. One patient in the tilt group had an Apgar score of 5 at 1 min. All other Apgar scores were either 8 or 9 at 1 min. At 5 min, all neonates had an Apgar score of 9. There was no correlation between time from spinal anesthesia to delivery or PE dose with neonatal acid-base status or Apgar scores. There was no difference in the mean time (\pm SD) from spinal anesthesia to delivery between groups. The

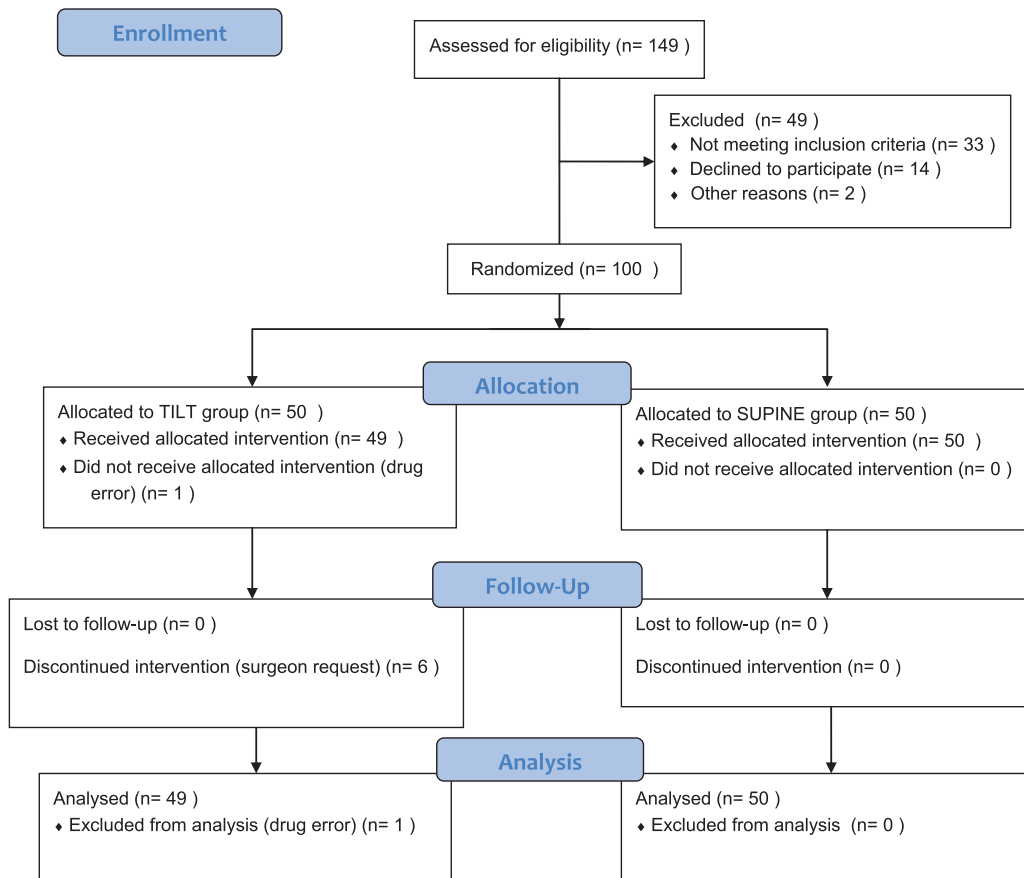


Fig. 1. Consolidated Standards of Reporting Trials (CONSORT) flow diagram.

Table 1. Maternal Demographics

	Supine Group (n = 50)	Tilt Group (n = 49)	P Value
Age (yr)	30 ± 6	30 ± 5	0.91
Race (B/W/O)	24/24/2	20/27/3	0.74
Gestational age (wk)	39 ± 1	39 ± 0	0.71
Neonatal weight (g)	3,532 ± 431	3,431 ± 424	0.25
Height (cm)	162 ± 7	161 ± 5	0.68
Weight (kg)	82 ± 12	80 ± 12	0.45
BMI (kg/m ²)	31.3 ± 3.8	30.8 ± 4.0	0.53

The values represent mean ± SD. Continuous variables were compared by unpaired *t* test, and racial distribution was compared by chi-square test. B = black; BMI = body mass index; O = other; W = white.

mean time from spinal anesthesia to delivery was 24 ± 8 min in the supine group and 24 ± 7 min in the tilt group, *P* = 0.95.

Maternal Hemodynamic Parameters and Phenylephrine Use

Blood Pressure. Baseline SBP was similar between groups: blood pressure was 115 ± 10 (n = 50) for the supine group and 117 ± 11 (n = 50) for the tilt group (*P* = 0.46). Cross-sectional analyses showed that SBP was slightly lower but not significantly lower in the supine group compared to the tilt group at 1, 2, 5, 6, 7, 8, 10, 11, 12, 13, and 14 min after administration of spinal anesthesia. SBP was significantly

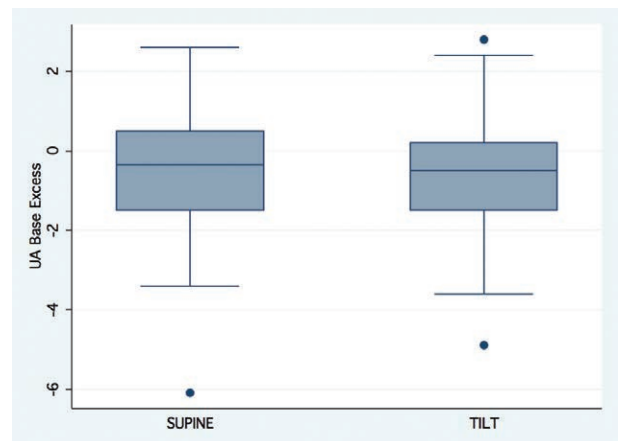


Fig. 2. Box plot of umbilical artery (UA) base excess (mmol/l) by group. Dots represent outlier values.

lower in the supine group at 3, 4, 9, and 15 min from the administration of spinal anesthesia (fig. 3). To examine whether changes in SBP over the first 15 min (*i.e.*, the trends of SBP over time within each group) were different between groups, we tested the time*group interaction term using a linear mixed effect model for longitudinal measurements. The time*group term was not statistically significant, which suggested that the trends of SBP over time for the two groups

Table 2. Neonatal Acid–Base Status according to Maternal Position

	Supine Group	Tilt Group	P Value
UA blood gases	(n = 50)	(n = 47)	
pH	7.28 ± 0.05	7.28 ± 0.04	0.39
Pco ₂ (mmHg)	55 ± 7	55 ± 11	0.69
Po ₂ (mmHg)*	19 ± 3	19 ± 5	0.57
HCO ₃ (mmol/l)	25 ± 1	25 ± 1	0.88
Base excess (mmol/l)	-0.5 ± 1.6	-0.6 ± 1.5	0.64
UV blood gases	(n = 49)	(n = 47)	
pH	7.33 ± 0.05	7.33 ± 0.04	0.49
Pco ₂ (mmHg)	46 ± 6	46 ± 5	0.68
Po ₂ (mmHg)	26 ± 5	26 ± 5	0.95
HCO ₃ (mmol/l)	23 ± 1	24 ± 1	0.54
Base excess (mmol/l)	-1.7 ± 1.3	-1.6 ± 1.5	0.91

The values are means ± SD.

*Po₂ values less than 17 mmHg are reported by the laboratory as “less than 17 mmHg” and were treated as 17 mmHg for this analysis.

UA = umbilical artery; UV = umbilical vein.

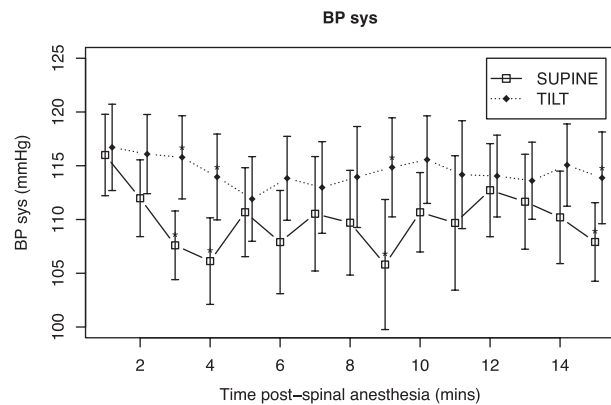


Fig. 3. Mean systolic blood pressure (mmHg ± SD) by group over first 15 min after spinal anesthesia (supine group, n = 50; tilt group, n = 49). At least 45 of 50 supine and at least 44 of 49 tilt subjects had systolic blood pressure (BP sys) measurements at each minute. *Time points where there was a significant difference between groups.

were not different. Therefore, we further tested whether repeated measures of SBP were different between the supine and tilt groups, also using a linear mixed effect model for longitudinal measurements testing the term “group.” The overall group effect showed that SBP measurements in the supine group were significantly lower from the initiation of spinal anesthesia until the 15-min time point ($P = 0.03$). One patient assigned to the tilt group became symptomatic after 3 min supine, with her SBP decreasing from 122 to 75 mmHg and HR increasing from 95 to 123/min.

Cardiac Output. Baseline CO was measured in both tilted and supine positions, in the operating room right before the spinal anesthetic was administered. The baseline CO was 8.4 l/min in the tilted versus 8.1 l/min in the supine position, a difference of 0.3 l/min (95% CI [0.2, 0.5]) ($P = 0.002$, paired t test). There was no difference in mean baseline CO values in each position for the two assigned groups ($P = 0.37$

for the supine position, and $P = 0.77$ for the tilted position, paired t test). After spinal anesthesia was administered, the difference in mean CO between the supine group and tilt group increased over time and became significant at 9 min after injection of the spinal dose (fig. 4). The linear mixed effect model testing for time*group interaction on CO data suggested that the trend of CO during the first 15 min was significantly decreased in the supine group ($P = 0.014$).

Three subjects (one tilt and two supine) did not undergo CO assessments at baseline or intraoperatively due to machine unavailability. Some intraoperative CO measurements at certain time points could not be recorded due to interference from electrocautery, but most measurements were recorded for all subjects.

Phenylephrine Use. The mean phenylephrine dose administered during the 15 min after spinal anesthesia and at delivery was significantly greater in the supine group: 789 ± 321 (n = 49) versus the tilt group -611 ± 228 (n = 48) ($P = 0.002$), but the time trend for the phenylephrine changes over time were not different between the two groups ($P = 0.26$).

Outliers. Extreme findings were approximately evenly distributed between groups: UA pH was less than 7.2 (three tilt and two supine), UA base excess was less than -3 (three tilt and three supine), UV pH was less than 7.2 (one tilt and one supine), and UV base excess was less than -3 (seven tilt and five supine). Ten patients (five tilt and five supine) experienced mild or moderate nausea, and only two patients vomited intraoperatively, both of whom were in the supine group. One of the patients in the supine group vomited and received a single dose of ephedrine 10 mg IV in response to an acute drop in blood pressure to 44/22 mmHg with a heart rate of 130/min at 6 min after spinal anesthesia. The next minute after treatment, the blood pressure rebounded to 198/104 mmHg with a heart rate of 61/min, and then the blood pressure gradually decreased to baseline levels by 7 min later. Eight subjects had a heart rate of fewer than 50 beats/min at one or more time points (25 individual time points) during the first 15 min after

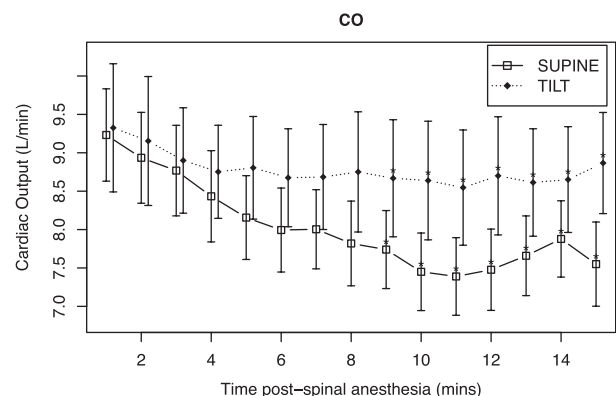


Fig. 4. Mean cardiac output (CO; l/min ± SD) by group over first 15 min after spinal anesthesia (supine group, n = 49; tilt group, n = 48). At least 38 of 49 supine and 41 of 48 tilt subjects had cardiac output measurements at each minute. *Time points where there was a significant difference between groups.

spinal injection. No subjects received glycopyrrolate, atropine, or epinephrine. At 15 min, cumulative phenylephrine doses of more than 1,000 μg were administered in 2 tilt and 12 supine patients. Boluses of phenylephrine were required in 1 tilt and 3 supine cases. Supplemental nasal cannula oxygen 2 to 4 l/min was provided in 3 tilt and 1 supine cases. In 1 tilt subject, oxygen was provided because of surgeon request after a transient fetal heart rate deceleration noted immediately after intrathecal injection. The other cases received oxygen because of maternal room air O_2 saturation of less than 95%. All available measurements were included in the analyses.

Discussion

The key finding in our study is that maternal supine position during planned cesarean delivery with spinal anesthesia in healthy term women does not impair neonatal acid–base status compared to 15° left tilt, with use of both a crystalloid coload and phenylephrine infusion titrated to maintain baseline maternal SBP. To our knowledge, this is the first randomized controlled clinical trial designed to specifically answer this question with contemporary anesthetic techniques. Our findings do not support the historical practice and current recommendations for LUD as being essential during elective cesarean delivery to support maternal hemodynamics, prevent spinal-induced maternal hypotension, and maintain neonatal acid–base status in healthy nonlaboring women with uncomplicated pregnancies. However, these findings may not apply to urgent or emergent cesarean delivery or to fetuses with nonreassuring status, given the increased PE requirement and decreased CO in the supine group.

The dogma that LUD must be performed during cesarean delivery is codified in the 2016 National Institute for Health and Care Excellence guidelines (United Kingdom) and the 2016 Practice Guidelines for Obstetric Anesthesia created by the American Society of Anesthesiologists Task Force on Obstetric Anesthesia and the Society for Obstetric Anesthesia and Perinatology.^{1,2} A 2013 Cochrane review concluded that there is limited evidence regarding the value of tilting or flexing the surgical table or the use of other devices and uterine displacement techniques during cesarean section, while pointing out that the effect of maternal position may vary with different clinical situations, such as multiple gestation, macrosomia, or polyhydramnios.¹⁸

Recognition of ACC and concerns about its negative consequences date back more than seven decades. Postural shock in pregnancy was first described in the literature in 1942,¹⁹ with Howard *et al.*⁴ later promoting the term “supine hypotensive syndrome.” Manometric and dye studies of the 1950s and 1960s demonstrated virtually complete IVC obstruction by the term gravid uterus in the supine position, and investigators came to the conclusion that venous return occurs *via* collateral channels.^{4,20,21} Compression of the aorta by the gravid uterus in the supine position has been inferred from lower blood pressure or decreased blood flow in the lower extremities but has never been proven to have clinically

significant effects.^{8,22–24} Dye injection studies have shown filling defects in the distal aorta and common iliac arteries and narrowing at L3–L5 vertebral levels, but the aorta was far more likely to be displaced laterally to the left of the vertebral column.^{25,26} During uterine contractions, more marked aortic obstruction was observed. Recent magnetic resonance imaging of 10 nonlaboring term pregnant women demonstrated that when compared to the supine position, IVC volume increased significantly only at 30° or more of left tilt, and the aorta was never compressed in any position.³

Although there is a published report about performing cesarean section in the full (90°) lateral position, this does not appear to be a feasible strategy for most practitioners.²⁷ In recent decades 15° has become established as the recommended degree of incline, presumably as a compromise between fully lateral and completely supine. Clinical trials from the 1970s compared maternal tilt *versus* the supine position during cesarean delivery and reported superior neonatal clinical and acid–base status in women who were tilted.^{9–12} The most influential study impacting current practice was by Crawford *et al.*¹⁰ In total, 87 cases under general anesthesia were supine; 63 were tilted using a 15° rubber wedge, with no mention of randomization, maternal hemodynamics, or vasopressor use. The majority in the tilted group were tilted to the right for the convenience of the surgeons. The investigators reported a statistically significant but probably not clinically meaningful difference of mean UA pH of 7.309 ± 0.039 in the tilt group *versus* 7.27 ± 0.091 in the nontilt group ($P < 0.001$). There was no difference in mean UA-BE between groups, suggesting that the small difference in pH was respiratory rather than caused by metabolic acidosis. The use of general anesthesia, right *versus* left tilt, and the lack of maternal hemodynamic support (or even information) makes this study of limited relevance to current practice.

Analysis of umbilical cord blood pH, BE, and lactate together provides an objective measure of the metabolic state of the fetus during delivery. The American College of Obstetricians and Gynecologists suggests an UA pH of less than 7.00 and a BE of at most -12 mM to be indicative of significant perinatal morbidity and long-term adverse outcomes.²⁸ During normal labor, BE decreases by 3 mM on average; however, with severe fetal compromise, as reflected by terminal bradycardia, BE may decrease by up to 1 mM every 2 to 3 min.²⁹ Although UA-BE has the disadvantage of being a calculated value, it is considered to be more reflective of neonatal metabolic status than pH.³⁰ Lactate produced by the fetus appears early during hypoxia but persists longer than CO_2 after restoration of normoxia. UA pH has both a metabolic and respiratory component. Isolated respiratory acidosis is believed to indicate short-term compromise to the uteroplacental or fetoplacental circulation; more sustained hypoxemia results in metabolic acidosis due to anaerobic metabolism. The UA-BE was selected as the primary outcome for this study because it is a linear measure of metabolic

acid accumulation, whereas pH is a logarithmic measure and is less ideal for the purposes of comparison between treatment groups; however, these components provide different types of information and may not be assessed in isolation.

A recent study of 80 term women undergoing elective cesarean section with spinal anesthesia randomized women to the supine position or to use of a 20° lumbar–pelvic wedge.³¹ Investigators noted no difference in the incidence of hypotension but reported higher vasopressor (ethylephrine boluses) requirements and nausea in the supine group. In our study, there were statistically significant differences in SBP between groups during the first 15 min, with lower SBP in the supine group and significantly higher phenylephrine administration. However, the phenylephrine doses were within typical ranges reported in other studies,³² and there were no differences with respect to neonatal acid–base status or clinical status.

Preanesthesia mean CO was approximately 4% greater in the tilt *versus* supine position, without significant differences in maternal SBP or heart rate. This is consistent with a prior report using suprasternal Doppler ultrasound, with mean CO shown to be only 5% higher at 15° and 90° (full lateral) tilt compared with 0° (supine) and 7.5° tilt, although SBP was similar among all positions.³³ The authors reported that even with evidence of “severe ACC” (11 of 157), identified by a difference of at least 20% CO between the tilted and supine positions, nonlaboring patients did not exhibit overall significantly lower blood pressure. Other changes noted were diastolic and mean blood pressure lower at 15° *versus* 7.5° tilt, and at a tilt of 15° or higher the pulse pressure was elevated. Systemic vascular resistance was lower with greater degrees of tilt. In our study, during the 15 min after spinal anesthesia, the supine group required a significantly higher phenylephrine dose, and CO was significantly lower than in the tilt group ($P = 0.014$).

During baseline measurements in the operating room, one patient became symptomatic (dizziness, shortness of breath, and agitation) after 3 min in the supine position. Her SBP fell from 122 mmHg at baseline to 75 mmHg, and her heart rate increased from 88 to 99/min at baseline to 123/min. Her symptoms were relieved by tilting her 15° to the left; her CO increased from 9 l/min supine to 10.8 l/min after 5 min of being tilted. This patient had been allocated to the tilt group, and her surgery proceeded uneventfully thereafter.

We acknowledge several limitations. First, all subjects were nonlaboring healthy women with fetuses with reassuring status, and it is unknown whether our findings can be extrapolated to laboring women, women with comorbid conditions such as preeclampsia or morbid obesity or emergency cesarean delivery, or cases involving fetuses with nonreassuring status. Another limitation is that the actual degree of a patient’s pelvic tilt may have been different from the degree of table tilt; it has been shown that pelvic tilt tends to be greater than the table angle because the weight

of the uterus leads to further axial rotation of the abdomen and bony pelvis.³⁴ Greater variability in the degree of pelvic tilt has been demonstrated in high body mass index patients.³⁵ We did not account for engagement of the fetal head, which has been suggested to decrease the severity of IVC compression.³⁶ We acknowledge that NICOM has not been rigorously validated for the measurement of CO during pregnancy. Umbilical arterial blood samples were validated as being arterial by verifying that the pH was lower by at least 0.02 in the arterial sample compared with the venous sample,³⁷ but there may have been errors in interpretation of data due to misclassification of umbilical arterial and venous samples. The impact, if any, of maternal position on surgical outcomes was not assessed. Finally, maternal satisfaction with the assigned position was not measured.

Most anesthesiologists greatly overestimate the degree of tilt (most achieve approximately 5 to 10°), and many women report feeling unsafe at much lesser degrees of tilt than 15°. Many obstetricians dislike this amount of tilt because it increases the difficulty of surgical access.¹⁴ In six of our tilt cases, the obstetricians found it nearly impossible to proceed in the tilted position and asked us to untilt the surgical table. We believe that tilting the surgical table by 15° is impractical, is almost never achieved in reality, has been demonstrated to have minimal to no hemodynamic benefit, and, as we have demonstrated, leads to no difference in clinical outcome in healthy women undergoing planned cesarean delivery.

In a recent report, the 15° tilted position was tolerated by obstetricians in only 3% of cases because the tilted position was detrimental to operating conditions.¹⁴ The solution implemented subsequently at that institution was to maintain 15° left tilt only during surgical preparation, after which the degree of tilt was reduced to a position acceptable to the surgeon immediately before skin incision. To our knowledge, no studies have examined surgical outcomes such as the incidence of intraoperative complications or impact on surgical times or scar alignment with respect to the maternal supine *versus* tilted position. Because a minority of term pregnant women are unable to tolerate the supine position and experience hemodynamic benefit from being tilted, their described solution represents a practical compromise in limiting the period of time spent in the supine position.

Conclusions

Tilting the surgical table by 15° does not improve neonatal acid–base status compared to the supine horizontal position in healthy term nonlaboring women with uncomplicated pregnancies, when baseline SBP is maintained with a phenylephrine infusion after a crystalloid coload. Our data suggest that current recommendations on maternal positioning during elective cesarean delivery under spinal anesthesia in this healthy uncomplicated population of pregnant women may no longer be necessary. Our findings may not be generalized to circumstances of urgent or emergent cesarean delivery, particularly in the setting of nonreassuring fetal status.

Confirmatory studies are warranted to corroborate our findings, as well as further investigations involving other obstetric cohorts such as laboring women, fetuses with nonreassuring status, hypertensive women, and morbidly obese women. An important focus should be to identify the minority of pregnant women with less robust compensatory mechanisms, in whom left uterine displacement may be important.

Acknowledgments

We acknowledge Cheetah Medical Inc., Vancouver, Washington, for providing NICOM monitors and disposable sensors for this investigation.

Research Support

Support was provided solely from institutional and/or departmental sources.

Competing Interests

The authors declare no competing interests.

Reproducible Science

Full protocol available at: al3196@cumc.columbia.edu. Raw data available at: al3196@cumc.columbia.edu.

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Hill of “Cocoene,” “Cocoaine,” or Cocaine: Anesthetic Friend or Fiend?



Besides printing a crooked obverse (*top*) on his ca. 1888 “Friendship” trade card, Dr. George E. Hill (ca. 1847 to 1923) misspelled his local anesthetic on the reverse as “Cocoene” (*bottom*). In Pennsylvania periodicals, his spelling misadventures advertised his numbing medication as “Cocoaine.” In August of 1905, *The Scranton Truth* juxtaposed stories of success and failure with cocaine. The success focused on one of Hill’s patients who was still using her same prosthetic teeth 14 yr after her anesthetic; the failure, titled “Cocaine Fiend Arrested,” followed a cocaine addict’s relapse. Is it any wonder then that a wary American public was questioning whether cocaine was a friend or a fiend? (Copyright © the American Society of Anesthesiologists’ Wood Library-Museum of Anesthesiology.)

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