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Combined Spinal–Epidural versus *Epidural Labor Analgesia*

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Background: **Despite the growing popularity of combined spinal–epidural analgesia in laboring women, the exact role of intrathecal opioids and the needle-through-needle technique remains to be determined. The authors hypothesized that anesthetic technique would have little effect on obstetric outcome or anesthetic complications.**

Methods: **Data were prospectively collected from 2,183 laboring women randomly assigned to have labor analgesia induced with either 10 μg intrathecal sufentanil with or without 2.0 mg bupivacaine (n = 1,071) or 10 μg epidural sufentanil and 12.5–25.0 mg bupivacaine (n = 1,112). Immediately after induction, a continuous epidural infusion of 0.083% bupivacaine plus 0.3 μg/ml sufentanil was begun in all patients and continued until delivery. Labor was managed by nurses, obstetricians, and obstetric residents who were unaware of the anesthetic technique used.**

Results: **Anesthetic technique lacked impact on our primary outcome: mode of delivery or labor duration. Infants whose mothers were allocated to the combined spinal–epidural group had a slightly higher umbilical artery carbon dioxide partial pressure (54.2 ± 10.4 *vs.* 53.2 ± 10.2 mmHg). However, only achieving at least 5 cm cervical dilation before induction of analgesia and having a cesarean delivery were independent risk factors for elevated umbilical artery carbon dioxide partial pressure. The frequencies of accidental dural puncture, failed epidural analgesia, headache, and epidural blood patch were low and similar in the two groups.**

Conclusions: **Labor progress and outcome are similar among women receiving either combined spinal–epidural or epidural analgesia. The difference in neonatal outcome appears related to the presence of confounding variables. The combined spinal–epidural technique is not associated with an increased frequency of anesthetic complications. Either technique can safely provide effective labor analgesia.**

DESPITE its growing popularity, the use of combined spinal– epidural (CSE) analgesia for labor remains controversial.[1,2] Few studies have compared the impact of these two techniques on the progress and outcome of labor. One randomized study reported faster initial cervical dilation among women receiving intrathecal sufentanil and bupivacaine *versus* those receiving epidural bupivacaine.[3] Another group reported fewer operative vaginal deliveries among women receiving CSE *versus* epidural labor analgesia.[4] Gambling *et al.*[5] reported more cesarean deliveries for fetal indications among women receiving intrathecal sufentanil compared with those receiving intravenous meperidine. No studies have specifically examined the impact of these techniques on neonatal condition.

Reported technical advantages associated with the needle-through-needle technique (compared with epidural analgesia) include fewer accidental dural punctures[6] and more reliable epidural catheter insertion.[7] Possible disadvantages of the needle-through-needle technique include a high incidence of technical failure,[8] intrathecal catheter insertion,[9] and postdural puncture headache.

This, prospective, quasirandomized, clinical trial compared CSE and epidural labor analgesia in a large number of women. The primary outcome studied was mode of delivery (spontaneous vaginal, operative vaginal, or cesarean). Important secondary outcomes included neonatal condition (as measured by Apgar score and umbilical artery [UA] blood gas values) and anesthetic complications and success. Based on our extensive experience with both techniques, we hypothesized that any differences between them would be minor.

Methods

The Washington University School of Medicine Human Studies Committee approved the protocol. A random number generator assigned a type of labor analgesia: either epidural or CSE analgesia to each day between August 1, 1997, and July 1, 1998. This daily randomization list was posted in the anesthesia workroom, where it was readily available to all obstetric anesthesia providers (anesthesiology residents, certified registered nurse anesthetists, and anesthesiologists). Our goal was to enroll approximately 2,500 patients into the study (1,250 women in each group). Our primary outcome measure was mode of delivery. Such a sample size would provide an 80% probability of detecting 40% increase in the incidence of cesarean delivery (*i.e.*, from 12 to 17%). Important secondary outcomes included neonatal condition and anesthetic complications. The planned sample size had an 80% probability of detecting a twofold difference in the risk of accidental dural puncture (*i.e.*,1 *vs.* 2%).

The study was described during the preanesthetic visit to all women with a singleton gestation who were in labor or planning a trial of labor. Patients were asked to

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verbally consent to receive that day's randomly allocated anesthetic. Consenting patients were not told which anesthetic technique they would receive. Nonconsenting patients also received that day's randomly allocated technique unless they specifically requested an alternative. Patients who did not consent to randomization were asked to consent to only data collection. Anesthetics were induced and maintained according to the protocol described in table 1. The choice between early labor and advanced labor protocols was made by the clinician at the time of induction. The maintenance epidural infusion was begun immediately after injection of the lidocaine–epinephrine "test dose." Additional epidural medication and adjustments of the epidural infusion rate were made at the discretion of the anesthesia care provider.

Blocks were performed by anesthesiology residents, student nurse anesthetists, certified registered nurse anesthetists, and staff anesthesiologists. Anesthesiology residents and nurses were directly supervised by a staff anesthesiologist. (A dedicated staff anesthesiologist was assigned to labor and delivery 24 h of every day. Additional coverage during daytime hours was usually provided by two anesthesiology residents. Nights and weekends were usually covered by one anesthesiology resident and one certified registered nurse anesthetist.) The epidural space was identified with an 18-gauge epidural needle; intentional dural puncture was performed with a 27-gauge Whitacre needle (Durasafe, Becton Dickenson, Franklin Lakes, NJ). A multiholed, 20-gauge, polyamide catheter (B. Braun Medical, Inc., Bethlehem, PA) was inserted 3–8 cm into the epidural space.

Obstetric residents and labor nurses, unaware of the anesthetic administered, managed labors according to standardized protocols. Oxytocin was given at the discretion of the obstetrician according to standard hospital protocol. Patients remained in bed after the induction of neuraxial analgesia. The duration of the second stage of labor was not arbitrarily limited. The responsible obstetrician determined mode of delivery.

The first stage of labor was defined as the time from the onset of regular painful uterine contractions until the diagnosis of complete cervical dilation. The second stage of labor was the time from complete cervical dilation until delivery. These times were determined by the nurses caring for each patient. Anesthesia duration was the time from first neuraxial drug injection until delivery. Indications for cesarean delivery were determined by the obstetrician. In the case of multiple indications, we recorded the primary one. Indications were divided into four groups: dystocia, nonreassuring fetal condition, abnormal presentation (breech or compound presentation, not persistent malrotation of the fetal head), and other (one cesarean delivery in a woman discovered to have an active herpetic lesion).

At delivery, neonates were cared for by nurses or pediatric residents who were unaware of the anesthetic technique received by the patient. These personnel assigned 1- and 5-min Apgar scores. At Barnes-Jewish hospital, UA blood samples are routinely collected at birth for acid-base analysis.

Sequentially numbered data sheets were included with all anesthetic records. The anesthesia provider was asked to complete one data sheet for each patient. The data sheets included information about patient consent, randomized and actual anesthetic, complications, anesthetic efficacy,[7] and labor outcome. After delivery, the data sheets were returned to the anesthesia workroom, where they were collected and reviewed by a research nurse. Missing data were obtained by reviewing hospital charts.

The research nurse, unaware of the anesthetic given, saw patients at least once while in the hospital after delivery. She also attempted to contact each patient by telephone within 1 week of hospital discharge. Patients were asked if they had any headache since delivery. Patients with headache were asked about positional symptoms. When appropriate, patients with headaches were referred to an anesthesiologist for subsequent care.

Table 1. Anesthetic Techniques

Technique	Induction		Maintenance†
	Early Labor	Advanced Labor*	
Epidural group	45 mg lidocaine + 15 μg epinephrine, then 10 ml bupivacaine, 0.125%, + 10 μg sufentanil *via* epidural catheter	45 mg lidocaine + 15 μg epinephrine, then 15–20 ml bupivacaine, 0.125%, + 10 μg sufentanil *via* epidural catheter	0.083% bupivacaine + 0.33 μg/ml sufentanil at 12 ml/h
CSE group	10 μg intrathecal sufentanil, then 45 mg lidocaine + 15 μg epinephrine, *via* epidural catheter	10 μg intrathecal sufentanil + 2.0 mg intrathecal bupivacaine, then 45 mg lidocaine + 15 μg epinephrine *via* epidural catheter	

* The choice between early labor and advanced labor protocols was made by the clinician at the time of induction. † Maintenance infusions were started immediately after induction.

CSE = combined spinal–epidural.

Statistics

Data are presented as mean ± SD or median (interquartile range). Demographic variables were compared using unpaired *t* test and the Mann–Whitney U test. Frequency distributions were analyzed with the chi-square test. Analysis of variance was used to explore the effects of parity and anesthetic technique on labor duration and outcome. Linear regression was used to examine the relation between anesthetic duration and UA blood gas measurements. Multiple logistic regression was used to examine the role of patient-, obstetric-, and anesthetic-related variables on the relative risk of instrumental or cesarean delivery, elevated UA carbon dioxide partial pressure (P_{CO_2}; > 64 mmHg; this cutoff value was based on the mean + 1 SD of our sample). Independent variables were removed from the model one at a time until all remaining variables had a significant impact on the relative risk of the outcome of interest. The results are reported as odds ratios (ORs) and 95% confidence intervals (CIs). Because not all patients received their allocated anesthetic technique, the data were grouped according to allocated anesthetic (intent to treat). The data also were analyzed according to protocol compliant groupings. $P < 0.05$ was considered significant.

Results

Between August 1, 1997, and July 1, 1998, 2,838 parturients with single gestations requested neuraxial labor analgesia. Completed data sheets were returned for 2,183 (76.9%) women (table 2). This study includes 71.5% of the women receiving CSE analgesia and 82.6% of those receiving epidural analgesia ($P < 0.05$). Labor outcomes were similar with 14.0% of eligible parturients and 13.9% of included parturients progressing to cesarean delivery (P = nonsignificant). Five of the 655 women with missing datasheets delivered before the epidural space could be located, 16 refused to consent to data collection, and 6 received ropivacaine as part of their anesthetic. The reasons that datasheets were missing for the other 628 patients are unknown.

The final study included 1,071 women allocated to the CSE analgesia group and 1,112 women assigned to the epidural analgesia group. These two groups were demographically similar (table 3). Ninety-two percent of women received their allocated anesthetic. Table 4 shows the distribution of anesthetics received. Noncompliance was most often caused by technical failure (n = 67), provider choice (n = 39), patient requesting the alternative technique (n = 28), or enrollment in another study (n = 18). Failure to obtain cerebrospinal fluid (CSF) *via* the spinal needle was the most frequent cause of technical failure (n = 54). The "provider choice" group included 15 patients allocated to the epidural group who received CSE analgesia because of rapidly progressing labor.

Table 2. Anesthetics Received by All Laboring Patients and Study Patients

Anesthetic Received	All Patients	Study Patients	% Patients Included
Combined spinal–epidural	1,427 (50.3%)	1,021 (46.8%)	71.5
Epidural	1,400 (49.3%)	1,157 (53.0%)	82.6
Spinal	1	1	100.0
Spinal catheter	4	3	75.0
None	6	1	16.7
Total	2,838	2,183	76.9

Primary Outcome

Parity, but not allocated anesthetic, had a significant effect on mode of delivery (table 5). Parity, but not allocated anesthetic, also had a significant effect on the duration of the first and second stages of labor and anesthesia duration (figs. 1 and 2).

Multiple logistic regression revealed that the probability of spontaneous vaginal delivery was increased by mulitparity (OR, 1.8; 95% CI, 1.4–2.3), late (after 5-cm cervical dilation) induction of labor analgesia (OR, 1.5; 95% CI, 1.2–2.1), spontaneous, nonaugmented labor (OR, 1.4; 95% CI, 1.1–1.8), and rapid progression of labor (delivery within 120 min of induction of labor analgesia; OR, 2.4; 95% CI, 1.6–3.6). The probability of instrumental vaginal delivery also was increased by late induction of labor analgesia (OR, 1.6; 95% CI, 1.2–2.3), rapid progression of labor (OR, 1.9; 95% CI, 1.2–3.0), and spontaneous, nonaugmented labor (OR, 1.4; 95% CI, 1.0–2.0). Early induction of labor analgesia, delivery more than 120 min after induction of analgesia, and use of oxytocin were associated with cesarean delivery.

There were 304 (13.9%) cesarean deliveries among the study patients. The indications for cesarean deliveries were similar between the CSE and epidural groups (table 6). Fourteen cesarean deliveries were performed within 90 min of induction of anesthesia. Five of these women were allocated to the CSE group and nine to the epidural group. Two women, allocated to the epidural group, received CSE analgesia, one for an attempted breech version, the other because of a rapidly progressing labor with existing fetal heart rate abnormalities. Eleven of these urgent surgeries were for nonreassuring fetal condition, and three were for abnormal presentation. Most of these patients had existing risk factors for urgent cesarean delivery (*i.e.*, prematurity, n = 3; pregnancy-induced hypertension, n = 5; absent prenatal care, n = 1; maternal substance abuse, n = 1; or compromised fetal condition, n = 6). Among these women, severe fetal heart rate decelerations occasionally followed artificial rupture of membranes either before (n = 2) or after (n = 2) induction of labor analgesia.

Table 3. Demographic Variables Allocated by Group Assignment (Intent to Treat)

	CSE			Epidural		
	All Patients (n = 1,071)	Nulliparous (n = 441)	Parous (n = 630)	All Patients (n = 1,112)	Nulliparous (n = 468)	Parous (n = 644)
Age (yr)	24.6 ± 6.2	22.2 ± 6.0	26.3 ± 5.7	24.6 ± 6.2	22.2 ± 5.8	26.2 ± 5.8
Height (cm)	163.5 ± 7.0	163.6 ± 7.1	163.4 ± 6.9	163.5 ± 7.8	162.9 ± 8.6	163.8 ± 7.1
Weight (kg)	83.8 ± 18.4	82.1 ± 17.8	84.9 ± 18.6	83.1 ± 19.6	81.5 ± 20.4	84.2 ± 18.8
% ≥ 37 weeks gestation	85.1	84.4	85.6	85.6	84.2	86.6
Cervical dilation at induction of analgesia (cm)	4.0 (1.5)	4.0 (2.0)	4.5 (2.0)	4.0 (1.0)	4.0 (1.5)	4.5 (1.6)
% receiving oxytocin during labor	46.7	48.6	45.4	47.0	47.1	46.9

Data are mean ± SD or median (interquartile range).

CSE = combined spinal–epidural.

Secondary Outcomes

Neonatal data are shown in table 7. UA P_{CO_2} was slightly higher in the CSE group and decreased as anesthetic duration increased only in the CSE group (fig. 3). Nine babies were born with significant acidosis (UA *p*H < 7.00[10]; 5 CSE, 4 epidural). Multiple logistic regression revealed that the probability of an elevated UA P_{CO_2} (> 64 mmHg) was increased by late induction of labor analgesia (OR, 1.4; 95% CI, 1.0–1.8) and decreased by both spontaneous (OR, 0.3; 95% CI, 0.2–0.4) and operative (OR, 0.6; 95% CI, 0.4–0.8) vaginal delivery. Allocated anesthetic technique was not an independent predictor of any neonatal outcome measured.

There were 27 accidental dural punctures among enrolled patients. Allocated anesthetic technique lacked impact on the frequency of accidental dural puncture (table 8). There were 50 accidental dural punctures among eligible patients (1.8%). However, the relative risk of accidental dural puncture among eligible patients (2.0%, CSE *vs.* 1.4%, epidural) also was not significantly different. Allocated anesthetic technique also lacked impact on the frequency of failed epidural analgesia (table 8).

We obtained information about headaches after delivery from 2,065 patients. Headache was reported by 5.9% and positional headache by 1.6% of women. Ten of the 34 patients with a positional headache received an epidural blood patch. The frequency of positional headache and blood patch was not affected by allocated or actual anesthetic (table 8).

Protocol Compliant Analysis

The data also were examined using protocol-compliant groupings. Anesthetic technique still lacked impact on duration of labor or mode of delivery. Infants in both groups had similar Apgar scores at 1 and 5 min. Instrumental delivery was more common among women having rapid labors and those receiving labor analgesia after achieving 5-cm cervical dilation. Oxytocin use was associated with fewer instrumental deliveries (data not shown).

The differences in UA blood gas values were greater, but still biologically trivial, among the protocol-compliant patients (UA *p*H: 7.26, CSE *vs.* 7.27, epidural, $P < 0.05$; UA P_{CO_2}: 54.5 mmHg, CSE *vs.* 53.0 mmHg, epidural, $P < 0.01$). However, multiple logistic regression revealed that anesthetic technique was not an independent predictor of any included neonatal outcome (data not shown).

Anesthetic technique again lacked impact on the frequency of accidental dural puncture, failed epidural analgesia, positional headache, or epidural blood patch (table 8). Patients allocated to the CSE technique who received epidural analgesia because of failure to obtain CSF through the spinal needle appeared to be at higher risk for certain complications. Catheters were not in the epidural space in 2 of 54 of these women (3.7%; $P = 0.06$), and they had a higher risk of positional headache (5 of 54, 9.3%; $P < 0.001$ *vs.* all other patients). However, none of these women received an epidural blood patch.

Table 4. Allocated *versus* Actual Anesthetic

	Actual Technique				
Allocated Technique	CSE	Epidural	Continuous Spinal	Spinal	None
CSE (n = 1,071)	961	106	2	1	1
Epidural (n = 1,112)	60	1,051	1	0	0

CSE = combined spinal–epidural.

Discussion

This is the largest report to date comparing CSE and epidural labor analgesia. Our study design attempted to limit the differences between these two groups. All patients received 10 μg sufentanil during induction of analgesia. All received a lidocaine–epinephrine "test dose." Pain relief was maintained with the same continuous epidural infusion mixture. In addition, the maintenance epidural infusion was started at the same time. The differences between the two groups were the route of injection of sufentanil (intrathecal *vs.* epidural) and the additional 12.5–25 mg bupivacaine given to the epi-

Table 5. Labor Duration and Obstetrical Outcome (Intent to Treat)

	CSE			Epidural		
	All Patients (n = 1,071)	Nulliparous (n = 441)	Parous (n = 630)	All Patients (n = 1,112)	Nulliparous (n = 468)	Parous (n = 644)
Duration first stage of labor (h)	10.0 (8.7)	11.2 (9.1)	9.2 (8.4)	9.8 (8.5)	10.8 (8.6)	8.9 (8.0)
Time from analgesia to full cervical dilation (h)	3.3 (4.1)	4.7 (4.6)	2.7 (3.4)	3.4 (4.2)	4.2 (5.0)	2.9 (3.5)
Duration second stage of labor (min)	29.0 (44.0)	44.5 (58.0)	20.0 (29.5)	31.0 (46.0)	48.0 (66.8)	22.0 (29)
Anesthesia duration (h)	4.3 (4.9)	5.8 (5.4)	3.5 (3.8)	4.4 (5.0)	5.6 (5.6)	3.6 (3.9)
Mode of delivery						
Spontaneous vaginal	68.3%	59.2%	74.8%	70.2%	60.7%	77.2%
Operative vaginal	17.2%	23.6%	12.7%	16.4%	20.9%	13.0%
Cesarean	14.5%	17.2%	12.5%	13.4%	18.4%	9.8%

Data are median (interquartile range), or percent. Parity, but not allocated anesthetic, had a significant ($P < 0.0001$) effect on the duration of the first and second stages of labor and anesthesia duration. Parity, but not allocated anesthetic, had a similar significant effect on mode of delivery.

CSE = combined spinal–epidural.

dural group patients for induction of labor analgesia. We found that these differences in anesthetic technique lacked impact on labor progress or outcome.

Few other studies have compared obstetric outcomes associated with CSE and epidural labor analgesia.[11] Tsen *et al.*[3] reported faster initial cervical dilation and shorter time from induction of analgesia to full cervical dilation among 50 laboring nulliparous women receiving CSE analgesia *versus* 50 women receiving epidural analgesia. However, second-stage duration and mode of delivery did not differ. Our study found no differences in the duration of labor or mode of delivery that could be attributed to anesthetic technique.

There are several possible explanations for the discrepancies between these two studies. First, the results reported by Tsen *et al.*[3] might have arisen by chance alone. Given the similarities in the maternal physiological responses to these two techniques, we believe this explanation is most likely. However, the rapid decrease in plasma epinephrine concentration associated with CSE labor analgesia[12] may produce a transient increase in uterine activity and a brief increase in the rate of cervical dilation. In our study, the routine use of a lidocaine–epinephrine test dose may have counterbalanced any technique-related effect on uterine activity. Incomplete blinding (the rapid onset of analgesia and the high frequency of itching readily identify patients who have received CSE analgesia) also may have led to unrecognized differences in obstetric management in either study.

Other investigators have reported a decrease in the use of forceps or vacuum for vaginal delivery among patients receiving CSE analgesia. Nageotte *et al.*[4] designed a study to examine the effect of ambulation on labor progress and outcome. Women assigned to the CSE group had significantly higher rates of spontaneous vaginal delivery and lower rates of instrumental vaginal delivery. Most likely, this higher frequency of spontaneous vaginal delivery reflects the lower concentration of bupivacaine used for maintenance in the CSE patients (0.0625 *vs.* 0.125%).[13,14] Nageotte *et al.*[4] also limited their study to

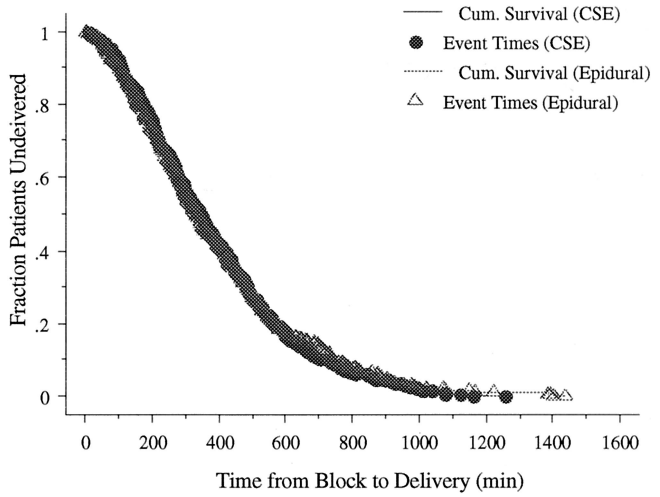

Fig. 1. Duration of labor after induction of either combined spinal–epidural (CSE) or epidural labor analgesia in nulliparous patients. Each symbol represents an individual patient.

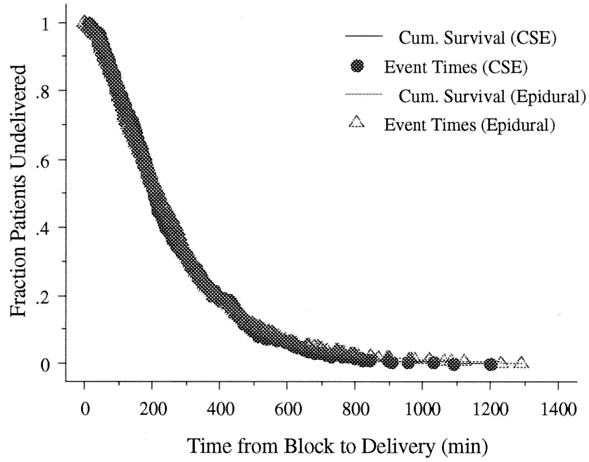

Fig. 2. Duration of labor after induction of either combined spinal–epidural (CSE) or epidural labor analgesia in parous patients. Each symbol represents an individual patient.

Table 6. Indications for Cesarean Section (Intent to Treat)

	CSE			Epidural		
	All Patients	Nulliparous	Parous	All Patients	Nulliparous	Parous
Dystocia	66	33	33	76	52	24
Nonreassuring fetal status	85	41	44	63	32	31
Abnormal presentation*	4	2	2	9	1	8
Other	0	0	0	1	1	0
Total	155/1,071 (14.4%)	76/441 (17.2%)	79/630 (12.5%)	149/1,112 (13.4%)	86/468 (18.4%)	63/644 (9.8%)

* Breech (n = 9), transverse lie (n = 2), compound presentation (n = 2).

CSE = combined spinal–epidural.

nulliparous women in early labor. Our study of both parous and nulliparous women used the same epidural infusion mixture in both groups. Late induction of labor analgesia and rapid progression of labor, but not anesthetic technique, were associated with more frequent instrumental (and spontaneous vaginal) deliveries.

More important than minor differences in labor progress is the possibility that CSE analgesia increases the risk of emergency cesarean delivery. Fetal bradycardia has been reported after induction of labor analgesia with intrathecal opioids.[15] Most studies suggest that incidence of this event is similar with either intrathecal or epidural labor analgesia.[16–18] However, Gambling *et al.*[5] reported more cesarean deliveries for fetal indications among women receiving intrathecal sufentanil compared with those receiving intravenous meperidine. In their randomized prospective study, 8 of 400 women receiving intrathecal sufentanil underwent emergency cesarean delivery for fetal bradycardia within 60 min of block (*vs.* none of the 352 women receiving intravenous meperidine). Similar studies from the same institution found no increased risk of emergency cesarean delivery associated with epidural labor analgesia.[19,20] In contrast, other investigators have reported no difference in the incidence of emergency cesarean delivery for fetal indications among women receiving intrathecal sufentanil compared with those receiving either no or intravenous labor analgesia.[21]

Although 14 (0.06%) of our patients underwent cesarean delivery within 90 min of initial intrathecal or epidural drug injection, this risk did not correlate with anesthetic technique (table 7). Most of these emergency surgeries appear unrelated to anesthetic intervention. These patients had existing signs of nonreassuring fetal condition, underwent acute obstetric intervention (artificial rupture of membranes) shortly after induction of analgesia, or had other confounding obstetric factors (nuchal cord).

Maternal analgesia could affect fetal condition in several ways. Carbon dioxide freely crosses the placenta, and maternal respiratory depression would increase fetal P_{CO_2}. In laboring women, 10 μg intrathecal sufentanil increases maternal end-tidal carbon dioxide[22] and, in nonpregnant volunteers, depresses the ventilatory response to carbon dioxide.[23] Because this effect is most likely caused by systemic absorption and redistribution of sufentanil to brainstem respiratory centers,[23,24] the maternal respiratory responses to intrathecal and epidural sufentanil should be similar. Multiple events during the induction of labor analgesia could acutely decrease uterine, placental, or umbilical blood flow and consequently increase fetal P_{CO_2}. Maternal hypotension will decrease uterine blood flow. Although maternal hypotension can follow intrathecal sufentanil,[25] the frequency of this event is similar with CSE and epidural labor analgesia.[6] Thus, the lack of impact of anesthetic technique on neonatal condition was not surprising.

Another important secondary outcome of this study was the effect of anesthetic technique on the success

Table 7. Neonatal Outcome (Intent to Treat)*

	CSE			Epidural		
	All Patients	Nulliparous	Parous	All Patients	Nulliparous	Parous
Birth weight (g)	3,195 ± 603	3,131 ± 604	3,240 ± 599	3,216 ± 599	3,142 ± 613	3,270 ± 583
Apgar[1]	8 (0)	8 (0)	8 (0)	8 (0)	8 (0)	8 (0)
Apgar[5]	9 (0)	9 (0)	9 (0)	9 (0)	9 (0)	9 (0)
UA pH	7.26 ± 0.08	7.25 ± 0.07	7.27 ± 0.08	7.27 ± 0.08	7.25 ± 0.07	7.27 ± 0.08
UA P_{CO_2} (mmHg)	54.2 ± 10.4	54.6 ± 9.9	54.0 ± 10.7	53.2 ± 10.2	53.7 ± 9.1	53.0 ± 10.9
UA BE	−4.1 ± 3.0	−4.4 ± 3.1	−3.9 ± 3.0	−4.3 ± 3.0	−4.6 ± 2.8	−4.0 ± 3.2

* Parity had a significant effect ($P < 0.05$) on birth weight, uterine artery pH (UA pH), and uterine artery base excess (UA BE). Allocated anesthetic had an effect on uterine artery partial pressure of carbon dioxide (UA P_{CO_2}).

CSE = combined spinal–epidural.

Table 8. Selected Anesthetic Complications after Combined Spinal Epidural or Epidural Labor Analgesia

	Intent to Treat		Protocol Compliant	
	CSE	Epidural	CSE	Epidural
Accidental dural puncture	14/1,071 (1.3%)	13/1,112 (1.2%)	11/961 (1.1%)	11/1,051 (1.0%)
Intravascular catheter	64/1,071 (6.4%)	49/1,112 (4.4%)	58/961 (6.0%)	43/1,051 (4.1%)
Failed epidural*	8/1,067 (0.8%)	8/1,111 (0.7%)	5/961 (0.5%)	8/1,051 (0.8%)
Positional headache	17/1,011 (1.7%)	17/1,054 (1.6%)	11/909 (1.2%)	16/998 (1.6%)
Blood patch	4 (0.4%)	6 (0.6%)	4 (0.4%)	5 (0.5%)

* Local anesthetic injected into the epidural catheter produced neither analgesia nor sensory change.

CSE = combined spinal–epidural.

rate of labor epidural analgesia and the frequency of several common technique-related complications.

Nonrandomized studies have reported either a lower risk of accidental dural puncture associated with the needle-through-needle CSE technique compared with "traditional" epidural analgesia (1.7 *vs.* 4.2%)[6] or a similar risk (0.38 *vs.* 0.13%).[26] Our randomized study found no increased risk of accidental dural puncture associated with epidural anesthesia.

Some investigators have expressed concern that the needle-through-needle technique may increase the frequency of subarachnoid catheter placement.[9] However, neither the current nor several other clinical and laboratory studies support this claim.[6,26,27]

The needle-through-needle technique has been associated with a lower probability of failed epidural catheters.[7] Our study found no difference in the numbers of failed or replaced epidural catheters. The higher failure rate among women in whom CSF could not be identified during attempted CSE analgesia probably reflects coincident difficulty in locating the epidural space.

Intentional dural puncture with a small-gauge pencil-point needle should occasionally result in postdural puncture headache. However, neither this study nor a smaller, nonrandomized study could find any increase in the risk of positional headache associated with the needle-through-needle CSE technique.[6] Although the risk of positional headache may indeed be the same with the CSE and epidural techniques, the available studies may be inadequately powered to detect a real but small difference. The frequency of positional headache after spinal anesthesia for cesarean delivery with a 27-gauge Whitacre needle is 0.5% (J. C. Carvahlo, personal communication, August 2000§). A study with an 80% chance of detecting an increase in positional headache from 1.6 to 2.1% would require more than 10,000 patients per group. The increased frequency of positional headache when the CSE technique is abandoned because of inability to obtain CSF suggests that some of these women suffered unrecognized dural puncture.

This study has several limitations that must be considered. First, we have completed data sheets on only 77% of eligible parturients. There are several possible expla-

§ A total of 7,623 parturients received spinal anesthesia with a 27-gauge Whitacre needle for cesarean delivery. The frequency of positional headache was 0.5%; 0.2% of patients received an epidural blood patch. Written communication from: José Carlos Almeida Carvalho, M.D., Ph.D., F.A.N.Z.C.A., Professor of Anesthesiology at the Masters and Ph.D. Program, University of São Paulo School of Medicine, São Paulo, Brazil.

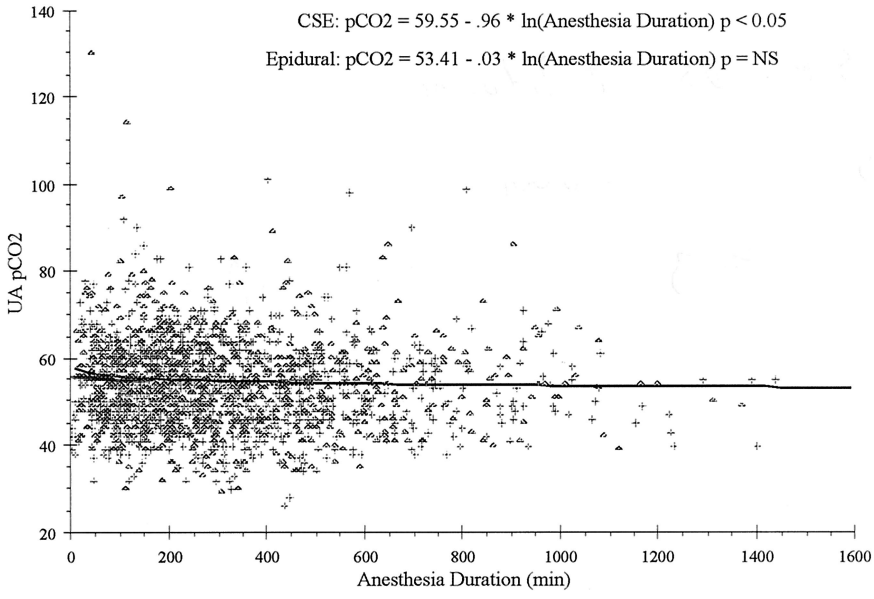

Fig. 3. Relation between umbilical artery carbon dioxide partial pressure (Pco_2) and anesthesia duration. The regression lines were determined by the above equations. Each triangle represents a patient receiving combined spinal–epidural (CSE) analgesia and each cross a patient receiving epidural block.

nations for these missing data sheets. Patients may be missing because of "planned" protocol violations (*i.e.*, performing epidural analgesia on a "CSE day"). This speculation is supported by the fact that data were recorded on 82% of patients allocated to epidural analgesia but only 70% of those allocated to the CSE technique. Additional selection bias appears to have occurred in the underreporting of accidental dural puncture. Lastly, and most likely, data sheets were probably either not completed or lost.

Second, only 92% of women received their allocated anesthetic. Some of these protocol violations could have influenced the study results (*i.e.*, choosing the CSE technique for women in advanced labor, choosing epidural analgesia after failing to obtain CSF during attempted CSE analgesia). We attempted to limit these weaknesses by confining patients to their allocated technique and by using multivariate analyses to control for confounding variables.

This study was not randomized in the traditional sense. We chose to randomize anesthetic techniques by day rather than by patient for logistical reasons. This method of randomization also may have contributed to some selection bias. Anesthetists may have chosen not to record data on patients in whom they planned to provide an alternate anesthetic.

Lastly, it was impossible to fully blind the nursing and obstetric personnel caring for our patients. The rapid onset of analgesia and the high frequency of itching readily identified patients in the CSE group. However, obstetric care at Barnes-Jewish hospital is largely protocol-driven and unlikely to be significantly effected by nurse or obstetrician awareness of the specific type of neuraxial labor analgesia used.

In summary, this quasirandomized, prospective clinical trial examined obstetric, neonatal, and anesthetic outcomes associated with needle-through-needle CSE and epidural labor analgesia. We found no differences in obstetric or neonatal outcome that could be explained exclusively by choice of anesthetic technique. Intentional dural puncture with a 27-gauge needle does not increase the risk of positional headache after neuraxial labor analgesia.

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