A COMPARISON OF T₄ AND T₇ DERMATOMAL LEVELS OF ANALGESIA FOR CAESAREAN SECTION USING THE LUMBAR EPIDURAL TECHNIQUE

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ABSTRACT

We compared analgesia to the T₄ dermatomal level with analgesia to the T₇ level with and without prophylactic intramuscular administration of ephedrine 25 mg to determine the adequacy and side effects of such analgesia for caesarean section. Unmedicated patients were prehydrated (727 ± 303 ml of saline solution) and kept in a left lateral tilt position. Sufficient three per cent chloroprocaine was given to obtain analgesia to the T₇ (T₆-T₈) dermatomal level (455 ± 128 mg) or to the T₄ (T₃-T₅) dermatomal level (758 ± 168 mg). Patients who received analgesia to the higher level required less narcotic than those who received analgesia to the lower level (21 per cent versus 48 per cent) ($p < 0.05$). The incidence of hypotension in patients with analgesia at the T₄ level was 21 per cent for those receiving ephedrine and 64 per cent for those who did not receive ephedrine ($p < 0.05$). Intramuscular administration of ephedrine 25 mg was not associated with increased plasma levels of norepinephrine, epinephrine or dopamine. There was no difference in Apgar score, behavioural test scores, neonatal acid-base status or oxygenation in children of mothers in the different groups. We conclude that a T₄ dermatomal level of analgesia, combined with intramuscular administration of ephedrine 25 mg, provides more maternal comfort than a T₇ level of analgesia does, with or without ephedrine, and is without significant maternal or foetal side effects.

KEY WORDS: ANAESTHETIC TECHNIQUES, epidural; OBSTETRICS, Caesarean section, analgesia.

LUMBAR EPIDURAL analgesia is frequently used for caesarean section. Although analgesia to an upper dermatomal level of T₇ is adequate,¹ some physicians advocate analgesia to a T₄ level to provide complete patient comfort during operation.² Since the stress of surgery and the consequent maternal release of catecholamines may lead to uterine vasoconstriction and foetal asphyxia,^{3,4} the greater sympathetic block associated with analgesia at the higher dermatomal

level may result in better foetal outcome. However, analgesia at this level increases the risk of hypotension, which may worsen foetal outcome. Prophylactic intramuscular administration of ephedrine may improve or worsen foetal outcome: it decreases the incidence of hypotension, but may cause a release in maternal catecholamines.⁵ This study compares the two levels of analgesia with and without prophylactic ephedrine, to determine the adequacy of analgesia and the need for supplemental medication, the incidence and severity of hypotension, concentrations of norepinephrine, epinephrine and dopamine in maternal blood as a response to pain and hypotension and their treatment and neonatal status, as measured by Apgar score, neurobehavioural score, acid-base status and oxygenation of umbilical cord blood.

METHODS

We selected 60 patients without systemic disease or impaired placental function who were scheduled for caesarean section within two weeks of term (38–42 weeks gestation). The

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protocol and consent form were approved by the Human Research Committee and informed consent was obtained from all patients. Patients were assigned randomly to one of four study groups according to the level of analgesia received and intramuscular medications given: Group 1 – T₇ level and saline 0.5 ml; Group 2 – T₇ level and ephedrine 25 mg; Group 3 – T₄ level and saline 0.5 ml; and Group 4 – T₄ level and ephedrine 25 mg.

Saline or ephedrine was given in a double-blind manner. All patients were unmedicated and received 700 ml of a balanced salt solution intravenously before the epidural was begun. A lumbar epidural block was done using the loss of resistance technique. Sufficient chloroprocaine 3 per cent was injected to provide analgesia (as determined by pin prick) to a sensory level of T₇ or T₄. Before the start of the study, "analgesia to a T₄ level" was arbitrarily defined as being bilateral analgesia to a level between T₃ and T₅, and "analgesia to a T₇ level" as being analgesia between T₆ and T₈. The uterus was displaced to the left, an additional 700 ml of balanced salt solution was given intravenously and supplemental oxygen was administered by face mask (5 l/min). Hypotension (defined as blood pressure of 23 kPa (98 mmHg) or less, or a decrease in systolic pressure of 25 per cent or more) was treated with additional displacement of the uterus and rapid infusion of more salt solution. If hypotension persisted beyond 30 to 60 seconds, small doses of ephedrine (5–10 mg) were administered intravenously to raise systolic pressure above 13 kPa. Hypertension was defined as an increase in systolic pressure of 25 per cent or more.

Maternal venous blood samples were obtained for determination of catecholamine levels before induction of anaesthesia (control), during abdominal preparation, just before skin incision and three minutes after skin incision. Blood samples were placed on ice immediately and then centrifuged to obtain plasma. The plasma was transferred onto dry ice and kept frozen at –80°C until assayed using a modification of the method of Peuler and Johnson.⁶ This assay is sensitive to about 25 pcg of norepinephrine and epinephrine, and to 40 pcg of dopamine per millilitre of plasma. The assay is linear over a range of 20 to 2,500 pcg/ml of each of the catecholamines. The coefficient of variation of ten samples has averaged 4.1 per cent for the last 100 assays (over a three-year period).

A sample of blood was obtained from the

maternal radial artery at the time of birth to measure acid-base status. Samples of blood were also obtained from the umbilical artery and vein to measure foetal acid-base status. Apgar scores were assessed one and five minutes after birth. Neonatal neurobehavioural status was evaluated at 4 and 24 hours after birth by a neonatologist trained to perform the neurobehavioural test, who was unaware of the protocol. This behavioural test is used to detect subtle neurobehavioural changes.⁷ If the mother was uncomfortable after birth, supplemental intravenous fentanyl or diazepam was given. All data were analyzed for statistical significance using chi-square analysis, analysis of variance and the Student's *t*-test.

RESULTS

To obtain analgesia to the T₇ dermatomal level, 455 ± 128 mg of chloroprocaine (mean $\pm$ S.E.) (range: 300 mg to 1080 mg) was required, whereas 758 ± 166 mg (range: 420 mg to 1140 mg) was required for the T₄ level ($p < 0.01$). The large variance of dose was related to the variance of the height of the patients (143.4 cm to 175.0 cm) in each group. Although no patient required supplemental analgesics before delivery, after delivery 48 per cent of patients receiving analgesia to the lower dermatomal level and 21 per cent of those receiving analgesia to the higher level required such supplements ($p < 0.05$).

Of the patients receiving the higher level of analgesia, 64 per cent of those receiving saline and 21 per cent of those receiving ephedrine became hypotensive ($p < 0.05$). This difference cannot be attributed to differences in uterine displacement or to the amounts of intravenous fluid administered before induction of anaesthesia (753 ± 47 ml versus 713 ± 33 ml) or before delivery (1385 ± 78 ml versus 1375 ± 42 ml).

When all patients were compared, the use of ephedrine was associated with an incidence of hypotension of 29 per cent; the incidence was 55 per cent when ephedrine was not used ($p < 0.05$). Because of our treatment protocol, no patient had systolic blood pressure less than 11.3 kPa (85 mm Hg); however, 17 patients in the saline group and nine patients in the ephedrine group received ephedrine to treat hypotension. The difference in frequency of hypotension between the T₄ and T₇ groups that received ephedrine (21 and 40 per cent) is not statistically significant.

TABLE I
PERCENTAGE OF NEONATES WITH HIGH APGAR SCORES (7 TO 10) AT
ONE AND FIVE MINUTES

Time after birth (min)	Dermatomal level*		Vasopressor†	
	T ₄ n = 28	T ₇ ‡ n = 29	Saline n = 29	Ephedrine Ψ n = 28
1	93	86	90	87
5	100	100	100	100

*Highest dermatomal level of analgesia achieved.

†Prophylactic intramuscular injection of 0.5 ml (25 mg) of ephedrine or 0.5 ml of normal saline.

‡Differences were not statistically significant ($p > 0.05$).

The difference in the incidence of hypertension between patients receiving analgesia to the T₄ dermatomal level (11 per cent) and those receiving analgesia to the T₇ level (16 per cent) was not significant. However, more patients who received prophylactic ephedrine became hypertensive (21 per cent versus 7 per cent) ($p < 0.05$). This was primarily confined to patients receiving additional amounts of ephedrine to treat hypotension.

There was no statistically significant difference among the four groups in maternal arterial pH, PaCO₂, base excess and degree of oxygenation at birth (Table II).

No difference in blood levels of norepinephrine, epinephrine or dopamine existed between the two levels of analgesia (Figures 1 and 2) or between the administration of ephedrine or saline, even when we excluded patients receiving saline who also received ephedrine intravenously for hypotension.

FIGURE 1 The percentage change from control values of maternal blood levels of norepinephrine during abdominal preparation and skin incision, and three minutes after skin incision in patients receiving analgesia to the T₄ or T₇ dermatomal levels. No difference exists between the two groups ($p > 0.05$).

FIGURE 2 The percentage change from control values of maternal blood levels of epinephrine during abdominal preparation and skin incision, and three minutes after skin incision in patients receiving analgesia to the T₄ or T₇ dermatomal levels. No difference exists between the two groups ($p > 0.05$).

No difference between groups existed for neonatal birth weight (3338 ± 60.6 g), prepartum anaesthesia time (49.7 ± 4.5 minutes) or time from uterine incision to delivery (3.2 ± 0.2 minutes). There was also no difference in the number of high Apgar scores (seven or better) at one or five minutes after birth (Table I). Acid-base status of umbilical venous blood or umbilical arterial blood at birth did not differ among groups (Table II). Using the Scanlon neurobehavioural test, we found similar scores for neonates, regardless of level of analgesia of the mother, in 19 of 20 observations (Table III). Similarly, neonatal neurobehavioural observations of children whose mothers had received ephedrine were similar to those of neonates whose mothers had received saline.

DISCUSSION

We compared two levels of analgesia using lumbar epidural technique during caesarean sec-

TABLE II
MATERNAL AND NEONATAL ACID-BASE DATA (Means $\pm$ SEM)

	Dermatomal level*		Vasopressor†	
	T ₄ n = 28	T ₇ n = 29	Saline n = 29	Ephedrine n = 28
Maternal arterial blood				
pH	7.44 $\pm$ 0.04	7.43 $\pm$ 0.03	7.44 $\pm$ 0.03	7.44 $\pm$ 0.03
P _{aO₂} (kPa)	21.0 $\pm$ 9.6	18.8 $\pm$ 8.6	19.8 $\pm$ 8.6	20.1 $\pm$ 10.0
P _{aCO₂} (kPa)	3.7 $\pm$ 0.7	3.7 $\pm$ 0.4	3.7 $\pm$ 0.5	3.7 $\pm$ 0.5
Base deficit (mmol/l)	5.1 $\pm$ 2.8	5.8 $\pm$ 1.9	5.5 $\pm$ 2.5	5.4 $\pm$ 2.4
Umbilical venous blood				
pH	7.33 $\pm$ 0.04	7.30 $\pm$ 0.08	7.32 $\pm$ 0.07	7.31 $\pm$ 0.04
P _{O₂} (kPa)	4.0 $\pm$ 0.9	4.1 $\pm$ 1.2	4.1 $\pm$ 1.1	4.0 $\pm$ 1.1
P _{CO₂} (kPa)	5.1 $\pm$ 0.7	5.5 $\pm$ 0.8	5.2 $\pm$ 0.8	5.5 $\pm$ 0.8
Base deficit (mmol/l)	5.5 $\pm$ 1.9	5.3 $\pm$ 2.3	5.6 $\pm$ 2.3	5.2 $\pm$ 1.8
Umbilical arterial blood				
pH	7.25 $\pm$ 0.04	7.22 $\pm$ 0.08	7.25 $\pm$ 0.07	7.22 $\pm$ 0.06
P _{aO₂} (kPa)	2.0 $\pm$ 0.5	2.1 $\pm$ 0.9	2.1 $\pm$ 0.4	2.1 $\pm$ 1.1
P _{aCO₂} (kPa)	6.8 $\pm$ 1.1	7.2 $\pm$ 1.2	6.8 $\pm$ 0.7	7.3 $\pm$ 1.5
Base deficit (mmol/l)	4.0 $\pm$ 2.5	4.2 $\pm$ 3.4	4.2 $\pm$ 2.9	4.0 $\pm$ 3.0

*Highest dermatomal level of analgesia achieved.

†Prophylactic intramuscular injection of 0.5 ml (25 mg) of ephedrine or 0.5 ml of normal saline.

TABLE III
PERCENTAGE OF NEONATES WITH HIGH SCORES ON NEUROBEHAVIOURAL TESTING AT 4 AND 24 HOURS AFTER MATERNAL ANAESTHESIA

	Hours after maternal anaesthesia	Dermatomal level*		Vasopressor†	
		T ₄ n = 28	T ₇ n = 29	Saline n = 29	Ephedrine n = 28
Overall	4	71	57	54	74
	24	73	67	69	71
Pin-prick response	4	63	39‡	44	59
	24	87	44	69	62
Tone (truncal)	4	71	39	50	61
	24	87	87	79	92
Rooting	4	42	34	34	44
	24	70	42	54	58
Sucking	4	57	66	57	66
	24	93	57	63	87
Moro's response	4	75	77	75	78
	24	87	69	63	94
Sound response	4	58	34	42	52
	24	78	66	78	66
Placing	4	75	66	49	91
	24	77	87	91	75
Alertness	4	42	26	36	52
	24	78	58	70	66
Pin-prick habituation	4	72	68	70	70
	24	72	68	70	70

*Highest dermatomal level of analgesia achieved.

†Prophylactic intramuscular injection of 0.5 ml (25 mg) of ephedrine or 0.5 ml of normal saline.

‡The only statistically significant difference ($p < 0.05$).

tion. Bonica¹ advocates analgesia to the T₇ dermatomal level for this surgical procedure. However, this level of analgesia is anecdotally associated with aching and cramping pain following delivery of the neonate during exteriorization of the uterus for repair. Afferent impulses from the uterus may travel in the splanchnic nerves, entering the cord at the fifth to tenth thoracic segments.⁸ Datta and Alper² advocate analgesia to the T₄ dermatomal level to avoid these complications during caesarean section. Our study demonstrates that 21 per cent of patients with a T₄ dermatomal level of analgesia required supplemental medication compared with 48 per cent of the patients with a T₇ dermatomal level of analgesia.

Possible complications of higher sensory and sympathetic block include an increased incidence of hypotension, with consequent impaired uterine blood flow and foetal well-being.⁹ Marx and coworkers¹⁰ report better biochemical conditions for the foetus and improved clinical conditions for the neonate when hypotension is prevented rather than treated. Ralston and Shnider⁵ report no difference in Apgar scores between neonates of mothers who become hypotensive and those who do not, provided hypotension is detected early and treated promptly. The incidence of hypotension is reported to be as high as 82 per cent in patients receiving analgesia to the T₄ dermatomal level who do not receive prophylactic ephedrine, prehydration with lactated Ringer's solution or left uterine displacement.⁵ In our study, analgesia to the T₄ dermatomal level without ephedrine was associated with an incidence of hypotension of 64 per cent, despite the use of left uterine displacement and prehydration with lactated Ringer's solution. This incidence is reported to decrease to 17 per cent⁵ when ephedrine is given in addition to left uterine displacement and prehydration. This figure is similar to the incidence of hypotension for patients in our study who received analgesia to the T₄ dermatomal level and ephedrine (21 per cent).

The prophylactic use of vasopressors in obstetrics is controversial because they may produce uterine vasoconstriction, hypertonus, foetal hypoxaemia and acidosis. These problems can be avoided by using ephedrine, a vasopressor that produces little alpha-adrenergic activity.^{11,12} Despite this, the incidence of hypertension was greater in the ephedrine group than in the saline group (21 versus 7 per cent). However, the similarity of Apgar scores, acid-base status and neurobehavioural test scores of

our four study groups confirm the safety of prophylactic ephedrine as well as analgesia to the T₄ dermatomal level. In addition, the absence of statistically significant differences in neonatal outcome, despite differences in the incidence of hypotension, affirms the importance of prompt diagnosis and treatment of hypotension.

Maternal stress leads to adrenergic stimulation produced by the release of endogenous catecholamines.^{3,4} The increased levels of catecholamines can constrict uterine vessels and reduce uterine blood flow, which in turn lead to foetal asphyxia. The differences in the levels of catecholamines in venous blood samples have proven to be accurate indicators of differences in the level of catecholamines in arterial blood for a wide range of patient conditions.¹³ Thus, our choice of sampling site is not the most likely reason we found no significant difference between the levels of catecholamines in the study groups. Studies have shown that increased sympathetic tone above a block compensates for decreased sympathetic tone in the blocked area.¹⁴ Studies by us and other investigators¹⁵⁻¹⁷ clearly demonstrate that norepinephrine released at the sympathetic nerve ending is responsible for changes in blood pressure that attend alterations in sympathetic stimulation. A portion of this released norepinephrine reaches the plasma. Although the norepinephrine released at the sympathetic nerve ending, and much of the epinephrine released from the adrenal gland, can have hormonal effects, studies have shown that the concentrations of norepinephrine in the blood of our patients would have possessed little hormonal effect.¹⁸ Thus in our study the change in plasma catecholamines was used as a reflection of the change in overflow at sympathetic nerve endings. The lack of a significant change in plasma norepinephrine or epinephrine with ephedrine prophylaxis, even when one excludes patients in the saline group who were treated for hypotension, implies several things. Ephedrine may have more direct action than indicated by classical studies. Also, in the dose administered, the effect of ephedrine on sympathetic outflow may be such that a neurotransmitter effect is produced without major spillover into plasma. Finally, measuring norepinephrine levels in plasma may be too insensitive a method of detecting small but significant changes in sympathetic outflow, when so many other stimuli that effect sympathetic outflow are occurring.

Our study indicates that analgesia to the T₄

dermatomal level during caesarean section and a prophylactic intramuscular injection of ephedrine 25 mg provide a greater degree of maternal comfort and a lower incidence of hypotension than does analgesia to the T₇ dermatomal level, with or without ephedrine, and is without significant maternal or foetal side effects.

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RÉSUMÉ

On a comparé l'analgésie épidurale remontant à D₄ à l'analgésie à D₇ (avec ou sans administration intramusculaire prophylactique d'éphédrine 25 mg) pour évaluer l'efficacité et les effets secondaires de la technique lors de césariennes. Des patients qui n'avaient pas été prémédiqués ont été d'abord hydratées (solution physiologique 727 ± 303 ml) et maintenues en position latérale gauche inclinée. De la chloroprocaine 3 pour cent a été administrée en quantité suffisante pour atteindre D₇ (455 ± 128 mg) ou D₄ (758 ± 163 mg). Les patientes dont le niveau analgésique était le plus élevé ont eu besoin de moins de narcotiques que celles dont le niveau était plus bas (21 pour cent contre 48 pour cent) ($p < 0.05$). L'incidence d'hypotension chez les patientes analgésées jusqu'à D₄ a été de 21 pour cent pour celles qui avaient reçu de l'éphédrine et de 64 pour celles qui n'en avaient pas reçu ($p < 0.05$). L'administration intramusculaire d'éphédrine 25 mg n'a pas produit d'élévation des taux plasmatiques de norépinéphrine, d'épinéphrine ou de dopamine. Le score d'Apgar, les tests comportementaux, l'équilibre acido-basique ou l'oxygénation ont été identiques chez les mères des différents groupes. Les auteurs concluent qu'une analgésie au niveau D₄ avec une injection intramusculaire d'éphédrine 25 mg procure plus de confort à la mère qu'au niveau D₇ avec ou sans éphédrine et que cette analgésie ne présente pas d'effets secondaires significatifs pour la mère et pour le nouveau-né.