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Enflurane Anesthesia for Cesarean Section

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Despite the advantages said to be associated with enflurane as an inhalation anesthetic,[1–5] there has been no report on use of enflurane in obstetric anesthesia. Here, the use of enflurane for cesarean section is reported.

METHODS

Fifty healthy mothers scheduled for elective cesarean section were studied. Gestational age was 38–42 weeks, the mothers were not in labor, and all were considered to have normal placental function. Mothers were encouraged to lie on their sides prior to operation, and during the surgical procedure were maintained in a 15-degree right or left posture by a firm rubber wedge placed beneath shoulder and pelvis to obviate aortocaval occlusion by the pregnant uterus.

In the operating room intravenous administration of lactated Ringer's solution was started and 0.6 mg atropine and 2 mg alcuronium were given intravenously. Patients inhaled oxygen through a nonrebreathing circuit for 5 minutes, after which anesthesia was induced with a thiopental (150–250 mg)–succinylcholine (100–150 mg) mixture and maintained by controlled ventilation with nitrous oxide (4 l/min), oxygen (4 l/min) and enflurane (0.5–0.8 per cent before delivery, 1.5 per cent thereafter) using a Manley ventilator. Further muscle relaxation was obtained by giving 8–10 mg alcuronium. The rationale for the anesthetic induction sequence described has been discussed elsewhere.[6] Material electrocardiograms were continuously monitored on an oscilloscope.

Following delivery of the baby 10 units of oxytocin were given intravenously, followed by a further 20 units during the next 24 hours.

Maternal arterial blood was sampled before induction of anesthesia and again just before delivery. A segment of umbilical cord, approximately 20 cm long, was isolated between two clamps at the moment of birth but before the infant breathed, and blood was drawn from the umbilical artery and vein. Samples were analyzed immediately for acid–base and blood-gas status using a Radiometer (BMS Mark II apparatus). Base deficit was determined using a Severinghaus slide rule (Radiometer blood-gas calculator, BGC 1) and corrections made for hemoglobin desaturation and for fetal hemoglobin.

Following birth, infants were assigned Apgar scores at one and five minutes.[7] The score was modified to exclude points for skin color (Apgar minus color, A–C^a). Gentle catheter suctioning of the pharynx and nasopharynx was used in all neonates unless secretions were so copious that suctioning under direct laryngoscopy was necessary.

Maternal blood pressure and heart rate were measured at least at 5-minute intervals during anesthesia; the subsequent care of the mothers during recovery from anesthesia, including reversal of residual muscle relaxation, pharyngeal suction, and extubation with simulated cough, was as described previously.[6]

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TABLE 1. Mean Acid–Base and Blood-gas Status of Maternal Arterial Blood and of Blood from Umbilical Vessels at the Moment of Birth*

	Maternal Arterial Blood				Fetal Umbilical Blood				Gradients Maternal Arterial Versus Fetal Venous		Gradients Umbilical Artery Versus Umbilical Vein	
	Preinduction (Fi_{O_2} 1.0)		Pre-delivery (Fi_{O_2} 0.5)		Vein		Artery					
*p*H (SEM)	7.45	(0.01)	7.43	(0.01)	7.37	(0.01)	7.33	(0.01)	0.06	(0.01)	0.04	(0.006)
P_{CO_2} mm Hg (SEM)	29	(1.01)	32	(0.83)	43	(1.01)	51	(1.33)	−11	(0.76)	8	(0.9)
P_{O_2} mm Hg (SEM)	489	(23.83)	126	(11.2)	32	(1.04)	21	(1.03)	94	(3.2)	11	(1.08)
Base deficit mEq/l (SEM)	2.7	(0.89)	2.9	(0.52)	1.73	(0.64)†	3.03	(0.69)†	1.17	(0.58)	1.3	(0.49)

* Mean differences or gradients between maternal and fetal values, and mean differences between umbilical-artery and vein values, are shown.

† Values corrected for desaturation and fetal hemoglobin.

Blood loss was not measured directly, but an attempt was made to infuse blood at a rate corresponding to a visual estimate of the amount lost, both on the operating table and for 24 hours afterwards. An estimate of the adequacy of blood replacement was obtained by noting the hemoglobin levels before and 24 and 48 hours after operation. Surgeons were invited to comment on the state of firmness of the uterus during the latter stages of the operation.

On the day after operation mothers were questioned to ascertain the incidence of awareness or dreaming during anesthesia. Enquiries regarding the occurrence of nausea and vomiting or respiratory sequelae were also made.

RESULTS

The mean time elapsed from induction of anesthesia to delivery of the infant was 13.0 minutes (SE 0.56), and the mean time interval from uterine incision to complete delivery of the baby 75 seconds (SE 7.7). The mean duration of surgery was 50 minutes (range 30–90 minutes). The mean birth weight of the infants was 3.2 kg (SE 0.08), and their mean Apgar score, modified to exclude points for color, was 7 at 1 minute (maximum possible 8); all achieved the full score of 8 at 5 minutes. Blood-gas and acid–base values in maternal and umbilical cord blood samples appear in table 1.

The mean volume of blood infused was 1,008 ml (SE 70.0). Preoperatively, hemoglobin was 12.1 g (10–14 g); hemoglobin values at 24 and 48 hours were 13.4 g (10–16 g) and 12.3 g (10–16 g), respectively. There was no adverse comment from the surgeons regarding the state of firmness of the uterus after delivery.

There was no change in maternal serum electrolytes, urea, glucose or proteins; however, significant though slight elevations in bilirubin and liver enzyme levels were noted. Polymorphonuclear leukocytes also increased significantly postoperatively. No patient reported dreaming or recall of surgical events. Four mothers complained of nausea (8 per cent) and two vomited within 12 hours of operation (4 per cent).

No arrhythmias were observed, but systolic blood pressure invariably fell by 10–30 mm Hg. Systolic blood pressure below 80 mm Hg was treated by reduction in the inspired concentration of enflurane.

DISCUSSION

The desire to ensure freedom from awareness of factual recall by use of general anesthesia for cesarean section is tempered by concern for the possibility of fetal and perinatal depression. Depression can be biochemical, pharmacologic, or both. The former can be initiated *in utero* by any factor that disturbs placental blood-gas interchange

(e.g., maternal hypotension). The latter is due to transfer of anesthetic agents to the fetus and is manifest by birth of a depressed baby requiring resuscitation. We did not measure blood levels of enflurane, but the 13-min mean time from induction of anesthesia to delivery should have been sufficient for significant placental transfer of enflurane; despite this, however, Apgar scores at birth compared well with those in other series in which nitrous oxide–oxygen alone was given for maintenance of anesthesia.[9–10]

The blood-gas and acid–base status of umbilical venous blood at the moment of birth is a useful index of fetal respiratory status in the minutes preceding delivery,[11] and the gradient between these values and those of maternal arterial blood is of value in assessment of the efficiency of placental gaseous interchange.[12] High Apgar scores and normal acid–base status at birth not only indicate a favorable perinatal course,[13] but also suggest that subsequent development of the infant will be normal.[14] In this report, Apgar scores, the acid–base status, and maternal-to-fetal gradients compared favorably with those reported after uncomplicated vaginal delivery in a group of 77 unpremedicated, unanesthetized parturients,[15] suggesting that enflurane anesthesia has no important deleterious effect on the fetus or newborn.

Maternal awareness has been reported to occur with use of the nitrous oxide–oxygen–relaxant sequence for cesarean section.[16] Crawford found evidence of awareness in 26 per cent of parturients who received 50 per cent nitrous oxide, and in 8.6 per cent who received 67 per cent nitrous oxide. In the present study the problem of awareness was obviated, apparently without additional risk to either mother or fetus.

In the present study careful attempts were made to maintain a steady hemoglobin level by matching blood loss with simultaneous blood replacement; that hemoglobin levels remained unchanged after operation, and in no instance decreased more than 2 g/100 ml, suggests that the mean volume of blood given (1,008 ml) represented the amount actually lost. This figure corresponds to that reported in Moir's studies[17] of the effect of anesthesia on blood loss of cesarean section, suggesting that enflurane in the concentration used in our study is unlikely to be associated with excessive hemorrhage.

Oxygen availability, an important issue in any surgical procedure, is perhaps even more critical in obstetric anesthesia; maternal metabolic rate is considerably increased in late pregnancy and during labor,[18] and maternal cardiac output may be reduced by occlusion of the inferior vena cava by the gravid uterus.[19] These factors must be acknowledged in anesthesia for operative obstetrics, and the opportunity to give at least 50 per cent oxygen in the inspired anesthetic gases, afforded by use of a potent volatile agent such as enflurane, is advantageous.

The absence of factual recall, flexibility of inspired oxygen level, absence of excessive bleeding, and apparent absence of pharmacologic or biochemical fetal depression observed in the 50 patients having cesarean section during enflurane anesthesia in the present study suggest more extensive trial of the drug for this purpose.

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An Unusual Ocular Complication after Anesthesia

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Diminished vision in a patient after anesthesia is of interest and concern to the anesthesiologist.[1] This report describes the occurrence of acute epithelial edema of the cornea and marked decrease in visual acuity after general anesthesia in a patient with previously undetected endothelial dystrophy of the cornea, a complication heretofore unreported, to our knowledge.

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REPORT OF A CASE

A 60-year-old woman weighing 65 kg was admitted to the hospital for a right iliac node dissection and perfusion. She had had a malignant melanoma removed from her right leg 6 weeks earlier with general anesthesia. Eight months prior to the present admission, she had had a bilateral Keller operation for hallux valgus with general anesthesia. Physical examination, including examination of sclerae, conjunctivae, and pupils, revealed no abnormality. Complete blood count, activated coagulation time, total serum proteins, blood urea nitrogen, and serum calcium were within normal ranges. Urine, chest roentgenogram, and electrocardiogram were normal.

Preoperative medication was meperidine (Demerol), 75 mg, hydroxyzine (Vistaril) 35 mg, and atropine, 0.4 mg, administered im 45 minutes preoperatively. Induction of anesthesia was accomplished with thiopental (Pentothal) 250 mg iv, and nitrous oxide, 66 per cent in oxygen, and halothane, 1.0 per cent. Endotracheal intubation was accomplished easily following succinylcholine (Anectine) 50 mg, given iv. Five per cent boric acid opthalmic ointment was instilled into the conjunctival sac of each eye and the lids were closed.

Following a right iliac node dissection, the patient was given heparin, 200 units/kg. Catheters were placed in the external iliac artery and vein and passed to mid-thigh. The right lower extremity was isolated by an Esmarch tourniquet and the patient was put on a pump with a bubble oxygenator