

The Effects of Anesthesia and Pulmonary Ventilation on Blood Loss during Elective Therapeutic Abortion

Bruce F. Cullen, M.D.,* Alan J. Margolis, M.D.,†
Edmond I. Eger, II, M.D.‡

Uterine blood loss was measured in 87 healthy women undergoing elective therapeutic abortion while anesthetized with any of eight anesthetic or ventilatory techniques. A 1 per cent alveolar concentration of halothane produced the highest mean blood loss (283 ml); reduction of halothane to 0.5 per cent and addition of 75 per cent nitrous oxide decreased mean blood loss to 169 ml. Addition of thiopental and meperidine to the halothane-nitrous oxide mixture increased the blood loss to that seen with 1 per cent halothane. Blood loss with 5 per cent alveolar fluroxene was 233 ml. Eighty per cent nitrous oxide plus intravenous thiopental and meperidine yielded a blood loss of 55 ml. Blood losses with all anesthetics, except nitrous oxide plus adjuvants, were significantly larger than the 25-ml loss observed with paracervical-block anesthesia. Hyperventilation (P_{ACO_2} less than 20 torr) did not reduce blood loss significantly in two groups of patients anesthetized with either 0.5 per cent halothane and nitrous oxide or 75 per cent nitrous oxide plus intravenous adjuvants. (Key words: Abortion; Blood loss; Ventilation; Halothane; Fluroxene; Nitrous oxide; Paracervical block; Carbon dioxide.)

CONSIDERABLE BLOOD LOSS may occur during obstetric procedures performed in the first trimester of pregnancy. Eaton¹ reported a range of 100 to 500 ml lost during suction evacuation of the pregnant uterus, and Dvorak *et al.*² described the problem of patients requiring transfusion following therapeutic abortion. General anesthetics may affect blood loss during these procedures by their effects on both uterine tone and uterine blood flow. Reports

of a possible association between pulmonary ventilation and uterine blood flow^{3,4,5} suggest that changes in ventilation may also affect blood loss.

There are few reports correlating obstetric blood loss with type of anesthesia, and no investigators have examined the impact of anesthetic depth. In addition, interpretation of published studies is limited by the problem of inaccurate measurement of blood loss. A new technique for uterine evacuation of the products of conception by suction rather than by curettage has been described.⁶ All shed blood is collected in a trap bottle, so that accurate assessment of blood loss is possible. Using this technique and rapidly-responding anesthetic analyzers, we have examined the effects of various anesthetics and those of normal and increased pulmonary ventilation on blood loss during elective therapeutic abortion.

Method

Eighty-seven healthy young women in the first trimester of pregnancy were studied while undergoing therapeutic abortion, primarily for psychiatric reasons. Each patient was anesthetized with one of eight anesthetic or ventilatory techniques. All patients given general anesthesia were premedicated with 0.6 or 0.8 mg of atropine.

Patients in Group I ($n = 6$) underwent induction with halothane in oxygen. Subsequently, anesthesia was maintained at an alveolar halothane (Fluothane) concentration of 1 per cent. Group II patients ($n = 11$) had anesthesia induced with halothane and nitrous oxide and maintained with 75 per cent nitrous oxide and 0.5 per cent halothane. Patients in Group III ($n = 10$) also were maintained with 75 per cent nitrous oxide and 0.5 per cent halothane, but these patients were premedicated with 2 mg/kg of meperidine (Demerol)

* Research Trainee, Department of Anesthesia.

† Associate Professor, Department of Obstetrics and Gynecology.

‡ Professor, Department of Anesthesia.

Received from the University of California, San Francisco Medical Center, San Francisco, California 94122. Accepted for publication October 16, 1969. Supported in part by USPHS Grants 5T1 GM 00063-11 and 1 P01 CM 15571-01A1.

and anesthesia was induced with a small dose of thiopental (Pentothal) injected intravenously. Group IV patients ($n = 11$) had anesthesia induced with cyclopropane quickly changed to fluroxene (Fluromar) in oxygen; an alveolar fluroxene concentration of 5 per cent was maintained. Patients in Group V ($n = 10$) were given 2 mg/kg of meperidine intravenously immediately upon arrival in the operating room; anesthesia was induced with a small dose of thiopental injected intravenously, and was maintained with 80 per cent nitrous oxide. Sufficient additional thiopental was administered during the procedure to maintain surgical anesthesia. All patients in Groups I through V had $P_{A_{CO_2}}$ values maintained between 30 to 45 torr.

To determine the effect of low $P_{A_{CO_2}}$ on blood loss, patients in Groups VI ($n = 12$) and VII ($n = 11$) had ventilation controlled such that $P_{A_{CO_2}}$ was maintained at 20 torr or less. Except for the increased ventilation, these patients were anesthetized by the methods used for Groups II and V, respectively.

An endotracheal tube was placed in every patient in Groups I through VII following intravenous administration of 60 to 80 mg succinylcholine (Anectine). Alveolar halothane was analyzed with an infrared halothane analyzer (Beckman) in the presence of oxygen and with an ultraviolet analyzer (Analytic Systems) in the presence of nitrous oxide. Alveolar fluroxene was measured with an infrared ether analyzer (Beckman). The concentration of nitrous oxide was determined by subtraction of inspired oxygen as measured with a Beckman-Pauling oxygen analyzer. An infrared CO_2 analyzer (Beckman) with the head filled with nitrous oxide was used to measure $P_{A_{CO_2}}$. No correction was made for pressure broadening.

Patients in Group VIII ($n = 16$) were not given general anesthesia, but received paracervical blocks with 15–20 ml of 1 per cent lidocaine (Xylocaine). Although premedicated with low doses of any of several different sedatives, the patients were awake throughout the procedure. Ventilation was spontaneous and $P_{A_{CO_2}}$ was not measured.

All abortions were performed using the suction technique described by Kerslake and Casey.⁶ Following dilatation of the cervix, a

suction cannula was introduced into the uterine cavity and all blood and products of conception were aspirated into a trap bottle. A gauze filter separated the products of conception from the liquid aspirate (composed of blood and amniotic fluid). Since amniotic fluid was included in the aspirate, a corrected blood loss was obtained by subtraction of an estimated amniotic fluid volume appropriate for gestational age. Between ten and 16 weeks of gestation, amniotic fluid volume increases approximately 25 ml per week.^{7,8} Gestational age was determined clinically by the obstetrician after consideration of the patient's menstrual history, estimation of uterine size, and examination of the products of conception. During the procedure, blood loss on drapes and sponges was minimal. All patients received continuous intravenous infusions of dilute oxytocin (Syntocinon) (40 U in 1,000 ml of 5 per cent dextrose and $\frac{1}{4}$ physiologic saline solution).

Data were subjected to statistical analysis with Student's t test. Values were considered significant if $P < 0.05$.

Results

The results are summarized in table 1. Blood losses were largest with halothane anesthesia and smallest with paracervical-block anesthesia. Mean corrected blood loss with 1 per cent halothane was 283 ml, significantly higher than the mean blood loss seen with either nitrous oxide plus thiopental and meperidine or paracervical block. Reduction of halothane concentration to 0.5 per cent and addition of nitrous oxide decreased the mean blood loss to 169 ml, still significantly higher than the loss associated with nitrous oxide plus adjuvants or local anesthesia. When thiopental and meperidine were added to the halothane-nitrous oxide mixture (a commonly-practiced clinical technique) blood loss equalled that associated with halothane alone. For the group receiving 5 per cent fluroxene, the mean corrected blood loss was 233 ml. Although this value was 175 ml greater than that associated with the nitrous oxide-plus-adjuvant technique, it was not significantly different, owing to a large standard error due, in part, to one patient at 15 weeks' gestation

who lost 1,000 ml of blood. Blood loss was lowest when local anesthesia only was administered. The 25 ml mean blood loss observed in Group VIII was significantly lower than values for all other groups except the group which received nitrous oxide plus adjuvants at normal PA_{CO_2} values. Hyperventilation appeared to have little effect in reducing blood loss. Mean blood losses in Groups VI and VII were not significantly different from those in Groups II and V, respectively.

The use of a "corrected" volume for lost blood is justified in figure 2. Each point in the graph represents the blood loss of a single patient anesthetized with the nitrous oxide-hyperventilation technique. The solid line is a regression line calculated from the data comparing trap-bottle volume (*i.e.*, shed blood plus amniotic fluid) with weeks of gestation. The dotted line is a graph of the formula employed for estimation of amniotic fluid volume.⁷ The slope of the regression line is 23 ($\gamma = 0.94$) and that of the dotted line is 25. The similarity of these slopes indicates that the volume collected in the trap bottle was proportional to gestational age and that the use of a formula for calculation of amniotic fluid is reasonable.

The sample sizes of all groups except that group given 1 per cent halothane in oxygen were comparable. Additional patients were not subjected to this technique because blood losses were consistently high and we felt that further study might involve an unjustifiable risk. It is noteworthy that gross hemorrhage (greater than 500 ml) occurred in two patients anesthetized with halothane alone, and that it was necessary to discontinue anesthesia to control bleeding.

Thiopental may affect blood loss since it can depress uterine contractility.⁹ This effect was suggested by the increased blood loss found when thiopental was added to the halothane-nitrous oxide mixture. The mean blood loss with halothane and nitrous oxide was 169 ml, but when thiopental (and meperidine) were added it rose to 286 ml. In the absence of halothane, however, thiopental did not appear to have a significant effect on blood loss. Patients in Groups V (80 per cent nitrous oxide, thiopental, meperidine) and VII (75 per cent nitrous oxide, thiopental, meperidine, low PA_{CO_2}) received a dose of thiopental equal to almost twice that given patients in Group III (0.5 per cent halothane, 75 per cent ni-

TABLE 1. Results*

| | Group I | Group II | Group III | Group IV | Group V | Group VI | Group VII | Group VIII |
|---------------------------|---------------------------------------|---|---|---------------------------------|---|---|---|---|
| Sample size | 6 | 11 | 10 | 11 | 10 | 12 | 11 | 16 |
| Anesthetic | 1 per cent halothane | 0.5 per cent halothane; 75 per cent nitrous oxide | 0.5 per cent halothane; 75 per cent nitrous oxide; thiopental; meperidine | 5 per cent fluoroene | 80 per cent nitrous oxide; thiopental; meperidine | 0.5 per cent halothane; 75 per cent nitrous oxide | 75 per cent nitrous oxide; thiopental; meperidine | Paracervical block (1 per cent lidocaine) |
| PA_{CO_2} (torr) | 32.8 ± 1.4 | 38.7 ± 1.0 | 42.9 ± 1.1 | 33.4 ± 0.5 | 34.8 ± 0.6 | 18.9 ± 0.3 | 18.8 ± 0.4 | |
| Corrected blood loss (ml) | 283.3 ± 33.2 _{1, 2, 4, 5, 6} | 169.1 ± 33.9 _{4, 5, 6} | 286.0 ± 65.5 _{2, 4, 5, 6} | 233.6 ± 82.7 _{4, 5, 6} | 38.5 ± 20.4 | 144.6 ± 25.2 _{4, 5, 6} | 52.7 ± 6.3 ₄ | 25.6 ± 6.1 |
| Gestation (weeks) | 11.0 ± 0.7 | 10.9 ± 0.4 | 11.5 ± 0.7 | 11.5 ± 0.7 | 11.7 ± 0.6 | 11.7 ± 0.4 | 12.1 ± 0.7 | 11.0 ± 0.4 |
| Suction time (min) | 4.7 ± 0.5 | 3.5 ± 0.6 ₄ | 4.4 ± 0.8 | 6.4 ± 1.5 | 6.3 ± 1.6 | 6.5 ± 1.1 | 8.6 ± 2.1 | |
| Anesthesia time (min) | 31.7 ± 2.4 | 26.1 ± 2.7 | 23.3 ± 2.3 ₄ | 28.5 ± 2.7 | 27.1 ± 2.8 | 28.3 ± 2.8 | 33.2 ± 2.6 | |
| Gravidity | 2.2 ± 0.7 | 2.6 ± 0.6 | 1.5 ± 0.2 | 2.0 ± 0.3 | 1.6 ± 0.4 | 2.0 ± 0.3 | 1.7 ± 0.5 | |
| Thiopental (mg) | | | 220.0 ± 22.6 _{4, 5} | | 396.5 ± 38.2 | | 520.5 ± 49.2 | |

* Summary of data obtained from patients in eight groups. Results are given as mean ± one standard error of the mean. Level of statistical significance = $P < 0.05$.

¹ Significantly different from Group II.

² Significantly different from Group III.

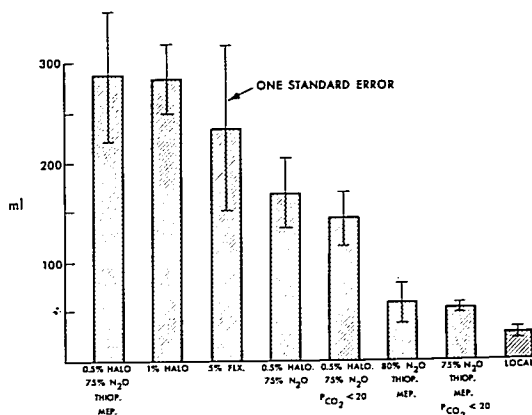
³ Significantly different from Group IV.

⁴ Significantly different from Group VI.

⁵ Significantly different from Group VII.

⁶ Significantly different from Group VIII.

FIG. 1. Graph of the mean corrected blood loss (trap-bottle volume minus amniotic fluid volume for gestational age) for each of the eight anesthetic and ventilatory techniques. The vertical bars represent \pm one standard error of the mean.



trous oxide, thiopental, meperidine), yet blood losses were significantly smaller.

Contrary to what we anticipated, gestational age,^{2,6} duration of anesthesia, duration of uterine aspiration^{1,2} and the obstetrical history (gravity) of the patient did not affect the amount of blood loss during the abortion procedure. For each of these factors, mean differences among groups were small and, with three exceptions, not significant. The dose of oxytocin was assumed not to be a factor in the results. The rates of administration were uniform, and the total dose was four to five times that necessary to produce strong contractions of the uterus at term.

Discussion

Our results indicate that halothane is clearly associated with an increased blood loss during therapeutic abortion, a result predictable from previous work showing that halothane is a potent uterine relaxant.^{10,11} Kerslake and Casey,⁶ and Crawford¹² have suggested that halothane is contraindicated as an anesthetic for therapeutic abortion or evacuation of the retained products of conception because of the enhancement of blood loss associated with its use. However, controversy regarding the relative safety of halothane remains. After a retrospective analysis of 2,572 cases, Batt¹³

concluded that halothane was safe for use during surgical removal of the retained products of conception because the amount of blood administered during the procedure was not increased. Bosomworth¹⁴ found no significant increased blood loss when halothane was used during vaginal delivery at term, but halothane was administered in "the lightest plane of anesthesia . . . compatible with forceps application and episiotomy" and alveolar concentrations were not determined.

Mean blood losses in our patients were significantly larger whether halothane was administered alone or in reduced concentrations combined with nitrous oxide, thiopental, or meperidine. Despite the finding that the large mean blood loss with halothane was well tolerated by these young and healthy patients, the data suggest that halothane, in any combination, should be avoided during obstetric procedures performed in the first trimester of pregnancy. The occasional occurrence of gross hemorrhage could be hazardous to a patient with limited cardiovascular reserve.

Fluroxene anesthesia was also associated with a significantly increased blood loss. There have been no reports on the relative uterine relaxing properties of fluroxene, but clinical studies have shown that fluroxene may impede and actually terminate active labor in

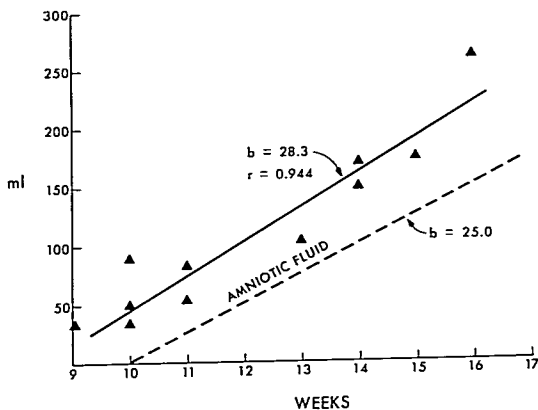


FIG. 2. Graph demonstrating the validity of the correction for amniotic fluid volume. Trap bottle volume (ml) is plotted on the y axis, and weeks of gestation on the x axis. Each triangle represents the trap-bottle volume measured for each of 11 patients anesthetized with 75 per cent nitrous oxide, plus intravenous adjuvants, plus hyperventilation. The solid line is a regression line calculated from the data comparing trap-bottle volume and weeks of gestation. The slope (b) of this line equals 28.3, with a correlation coefficient (γ) equal to 0.944. The dotted line is a graph of the formula employed to calculate amniotic fluid

volume. This formula is $V = 25(W - 10)$, where V = amniotic fluid volume and W = weeks gestation. The slope (b) of this line equals 25.0.

the woman at term.^{15, 16} Large blood losses with this agent were not unexpected, therefore, and it, too, should be avoided in these procedures.

Clinical experience suggests that nitrous oxide, in nonhypoxic concentrations, has little inhibitory effect on uterine contractility.^{9, 17} The minimal blood losses in our patients receiving this agent plus thiopental and meperidine support these clinical impressions. Even when abortions were performed late in the first trimester (i.e., in the 14th, 15th, and 16th weeks of gestation) blood losses remained at low levels when nitrous oxide plus intravenous adjuvants were employed. In the past, these pregnancies have been considered too mature for operative intervention by the suction technique because of increased difficulty in removing the products of conception, prolonged suction time, and a resultant increased amount of bleeding.^{5, 6} Because blood loss with the nitrous oxide-plus-adjuvant technique was only slightly more than that in patients given local anesthesia, probably patients may safely undergo general anesthesia with this combination of agents without concern for excessive blood loss owing to uterine relaxation.

A correlation between P_{aCO_2} and obstetric blood loss has not been reported previously. We were prompted to study this relationship because of several articles reporting an association between maternal hyperventilation and fetal and newborn acidosis.^{3, 4, 5} Morishima *et al.*⁴ and Moya *et al.*³ theorized that maternal hypocapnia reduced uterine blood flow. Similarly, we hypothesized that any reduction in uterine blood flow produced by hyperventilation would decrease blood loss during therapeutic abortion. The data do not support this hypothesis.

There are several possible reasons why hyperventilation did not appear to reduce blood loss significant. Primarily, the degree of hypocapnia may not have been sufficient to cause a significant decrease in uterine blood flow. Both Moya *et al.*³ and Morishima *et al.*⁴ stated that significant fetal distress was not observed until the maternal P_{aCO_2} had fallen below 17 torr. In Groups VI and VII the mean P_{aCO_2} was only 19 torr, reflecting a still higher P_{aCO_2} because of the alveolar-arterial CO_2 gradient. Second, Motoyama *et al.*⁵ have presented evidence that the fetal distress resulting from maternal hyperventilation is the result of changes in placental vascular resistance and intraplacental shunting. If such were the case,

hyperventilation would not be expected to reduce uterine bleeding once separation of the placenta had occurred. Last, there is the possibility that the uterine vessels become more sensitive to changes in pH as duration of pregnancy increases, and that changes in flow observed at term may not occur during the first trimester of pregnancy.

In conclusion, the choice of anesthetic appears to have a definite effect upon the amount of blood loss incurred during elective therapeutic abortion. Blood losses were greatest with halothane, and were not significantly altered by reductions in concentration or the addition of nitrous oxide or other adjuvants. Blood losses with fluroxene were not significantly different from those with halothane. Blood losses were smallest with paracervical-block anesthesia, but were not significantly larger with general anesthesia with nitrous oxide plus intravenous thiopental and meperidine. Hyperventilation was not associated with further significant reductions in blood loss. We believe that the results obtained in this study also apply to anesthetics given for incomplete abortion, cesarian section, and other operative procedures on the gravid uterus.

Halothane was supplied for this study by Ayerst Laboratories. Fluroxene was supplied by Ohio Medical Products. The authors also wish to thank Dr. Gary K. Stuart and Miss Dianne Impelman for their assistance in this investigation.

References

- Eaton, C. J.: Uterine aspiration for evacuation of the pregnant uterus, *J.A.M.A.* 207: 1887, 1969.
- Dvorak, Z., Trnka, V., and Vasicek, R.: Termination of pregnancy by vacuum aspiration, *Lancet* 2: 997, 1967.
- Moya, F., Morishima, H. O., Shneider, S. M., and James, L. S.: Influence of maternal hyperventilation on the newborn infant, *Amer. J. Obstet. Gynec.* 91: 76, 1965.
- Morishima, H. O., Moya, F., Bossers, A. C., and Daniel, S. S.: Adverse effects of maternal hypoxaemia on the newborn guinea pig, *Amer. J. Obstet. Gynec.* 88: 525, 1964.
- Motoyama, E. K., Rivard, G., Acheson, F., and Cook, C. D.: The effect of changes in maternal pH and P_{CO_2} on the P_{50} of fetal lambs, *ANESTHESIOLOGY* 28: 891, 1967.
- Kerslake, D., and Casey, D.: Abortion induced by means of the uterine aspirator, *Obstet. Gynec.* 30: 35, 1967.
- Wagner, C., and Fuchs, F.: The volume of amniotic fluid in the first half of pregnancy, *J. Obstet. Gynec. Brit. Comm.* 69: 151, 1963.
- Rhodes, P.: Volume of liquor amnii in early pregnancy, *J. Obstet. Gynec. Brit. Comm.* 73: 23, 1966.
- Friedman, E. A.: Effects of drugs on uterine contractility, *ANESTHESIOLOGY* 26: 409, 1965.
- Munson, E. S., Maier, W. R., and Caton, D.: Effects of halothane, cyclopropane and nitrous oxide on isolated human uterine muscle, *J. Obstet. Gynec. Brit. Comm.* 76: 27, 1969.
- Miller, J. R., and Stoelting, V. K.: Halothane in obstetric anesthesia, *ANESTHESIOLOGY* 26: 256, 1965.
- Crawford, J. S.: The place of halothane in obstetrics, *Brit. J. Anaesth.* 34: 386, 1962.
- Batt, B.: Is halothane safe for surgical removal of retained products of conception?, *Anesth. Analg.* 48: 338, 1969.
- Bosomworth, P. B., Sikora, F., and Welch, C. M.: Fetal ECG and obstetrical blood loss with halothane anesthesia, *ANESTHESIOLOGY* 23: 140, 1962.
- Cavallaro, R. J., and Dornette, W. H. L.: Fluoromar anesthesia in obstetrics, *Obstet. Gynec.* 17: 447, 1961.
- Martin, E. M., and Bosnak, J. N.: Trifluoroethylvinyl ether (Fluroxene, Fluoromar) in obstetrics, *Canad. Anaesth. Soc. J.* 9: 419, 1962.
- Bosomworth, P. B.: The effect of anesthetics and analgesics on uterine contractility, *Amer. J. Med. Sci.* 248: 728, 1964.