We have invited select authorities to present background information on challenging clinical problems and practical information on diagnosis and treatment for use by practitioners.

Methods for Induced Abortion

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We describe present methods for induced abortion used in the United States. The most common procedure is first-trimester vacuum curettage. Analgesia is usually provided with a paracervical block and is not completely effective. Pretreatment with nonsteroidal analgesics and conscious sedation augment analgesia but only to a modest extent. Cervical dilation is accomplished with conventional tapered dilators, hygroscopic dilators, or misoprostol. Manual vacuum curettage is as safe and effective as the electric uterine aspirator for procedures through 10 weeks of gestation. Common complications and their management are presented. Early abortion with mifepristone/misoprostol combinations is replacing some surgical abortions. Two mifepristone/misoprostol regimens are used. The rare serious complications of medical abortion are described. Twelve percent of abortions are performed in the second trimester, the majority of these by dilation and evacuation (D&E) after laminaria dilation of the cervix. Uterine evacuation is accomplished with heavy ovum forceps augmented by 14–16 mm vacuum cannula systems. Cervical injection of dilute vasopressin reduces blood loss. Operative ultrasonography is reported to reduce perforation risk of D&E. Dilation and evacuation procedures have evolved to include intact D&E and combination methods for more advanced gestations. Vaginal misoprostol is as effective as dinoprostone for second-trimester labor-induction abortion and appears to be replacing older methods. Mifepristone/misoprostol combinations appear more effective than misoprostol alone. Uterine rupture has been reported in women with uterine scars with misoprostol abortion in the second trimester. Fetal intracardiac injection to reduce multiple pregnancies or selectively abort an anomalous twin is accepted therapy. Outcomes for the remaining pregnancy have improved with experience. (Obstet Gynecol 2004;104:174–85. © 2004 by The American College of Obstetricians and Gynecologists.)

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Pregnancy termination remains a source of great contention. States have imposed mandatory waiting times and restricted minors' access, and there have been legislative attempts to restrict practice. Insurance coverage is uneven. Demonstrations and harassment of abortion providers and patients is a continuing problem, and violence against providers has resulted in injuries and deaths. Yet, half of U.S. pregnancies are unintended, and more than one fifth end in induced abortion.[1] The Alan Guttmacher Institute reported 1,313,000 legal abortions for the year 2000, an abortion rate of 21.3 per 1,000 women aged 15–44 and an abortion ratio of 24.5 per 100 live births.[2] This paper will review methods for abortion used in the United States, describing common techniques in detail.

Legal abortion in the United States is among the safest of medical procedures,[3] in distinction to countries were abortion is illegal.[4] Most U.S. abortions are performed in free-standing clinics or doctor's offices.[2] An increasing proportion of early abortions are induced with the medications mifepristone and misoprostol rather than surgery. Risk of abortion increases with gestational age and varies with type of procedure (Table 1).[5] Dilation and evacuation is safer than other options for the early second trimester. Hysterotomy and hysterectomy, 2 procedures rarely indicated for abortion, are the least safe. General anesthesia has been associated with deaths from respiratory complications thought to be related to inadequate monitoring in the postoperative period.[6] However, a more recent report found no increase in complications with general anesthesia when standard protocols were followed.[7] In the United States, deaths from legal abortion fell rapidly from 4.1 per 100,000 in 1972 to 1.8 in 1976 and have been 1 per 100,000 or less since 1987.[3] The last published national review of mortality risk by both gestational age and type of procedure was for the years 1973–1987.[5] A review by the Centers for Disease Control and Prevention (CDC) for 1993–1997 found

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Table 1. Case-Fatality Rates* for Legal Induced Abortion, by Type of Procedure and Weeks of Gestation, United States, 1972–1987†

	Weeks of gestation						
	≤ 8	9–10	11–12	13–15	16–20	≥ 21	Total
Dilatation and curettage‡	0.3	0.7	1.1	. . .§	. . .	. . .	. . .
Dilatation and evacuation	. . .	. . .	. . .	2.0	6.5	11.9	3.7
Instillation‖	. . .	. . .	. . .	3.8	7.9	10.3	7.1
Hysterectomy/hysterotomy	18.3	30.0	41.2	28.1	103.4	274.3	51.6
Total¶	0.4	0.7	1.1	2.2	6.9	10.4	1.0

* Legal induced abortion deaths per 100,000 legal induced abortions.
† Excludes data for 1972–1973 because gestational-age-by-method data were not collected.
‡ Includes all suction and sharp curettage procedures.
§ Not applicable.
‖ Includes all instillation methods (saline, prostaglandin, other).
¶ Excludes 5 deaths by "other" methods.
Reprinted from: Lawson HW, Frye A, Atrash HK, Smith JC, Shulman HB, Ramick M. Abortion mortality, United States, 1972–1987. Am J Obstet Gynecol 1994;171:1365–72, © 1994, with permission from Elsevier Science Inc.

mortality rates that were lower for the more recent time interval, especially for second-trimester procedures (Whitehead SJ, Bartlett L, Herndon J, Berg CJ. Abortion-related mortality: United States 1993–1997. Presented at the National Abortion Federation, 26th Annual Meeting, April 15, 2002, San Jose, CA.). This group has recently observed that risk of legal abortion increases exponentially with gestational age and that, although death from legal abortion is very rare, 87% of the deaths that are occur could be prevented if women terminating their pregnancies after 8 weeks of gestation had been able to access abortion services during the first 8 weeks of pregnancy instead.[8]

METHODS FOR ABORTION IN THE FIRST TRIMESTER

Vacuum Curettage

Vacuum curettage (also called suction curettage or uterine aspiration) is the most common method of abortion in the United States. By recent convention, procedures performed before 13 menstrual weeks are called suction or vacuum curettage, whereas similar procedures carried out after 13 weeks are described as dilation and evacuation (D&E).[9] Antibiotics are commonly used.[10] An extensive meta-analysis of placebo-controlled trials found marked reduction in postabortal infection with the use of antibiotics[11] Tetracycline or its analogues, doxycycline and minocycline, are recommended because of their broad spectrum of antimicrobial effect and oral absorption.

Pain relief for vacuum curettage is usually provided with a paracervical block of 10–20 mL of 1% lidocaine.[10] The maximum lidocaine dose advised is 4.5 mg/kg, or 20 mL of 1% lidocaine for a 50-kg patient. Deep injection of the anesthetic into the cervical stroma at multiple sites is more effective than injecting the local anesthetic superficially beneath the cervical mucosa.[12] However, deep stromal injection at 12, 4, and 8 is as effective as injections at 12, 3, 4, 8, and 9 and has the advantage of avoiding the lateral cervical vessels.[13] Addition of 2–4 units of vasopressin to the anesthetic solution reduces blood loss from the abortion procedure[14] and may help prevent postabortal uterine atony. Local anesthetics with epinephrine should be avoided in asthmatics because of reports of fatal anaphylaxis from the metabisulfite preservative.[15] Many women experience significant pain, despite paracervical block. In a large study, 34% of patients undergoing first-trimester vacuum curettage under paracervical block reported pain that was "severe" or "very severe."[16] Other means for pain control have been explored. Preoperative administration of nonsteroidal anti-inflammatory drugs have been found to provide modest reduction in pain.[17] Conscious sedation with intravenous midazolam 1–3 mg and fentanyl 50–100 μg is often used.[10] Surprisingly, available studies do not support the efficacy of this practice.[18] Wong and colleagues[19] found that 2 mg of midazolam combined with 25 μg of fentanyl did not improve patients' pain scores, although the patients who received the active agents reported greater satisfaction with their care. Rawling and Wiebe[20] compared 50–100 μg of intravenous fentanyl to placebo in a randomized blinded study and found a small, but statistically significant, reduction in pain scores with fentanyl. Most of their patients also received sublingual lorazepam, 0.5–1.0 mg, one hour before the procedure. These studies confirm the continuing need to improve analgesia for women undergoing outpatient abortion procedures.

The necessary dilatation of the cervix can be accomplished by mechanical cervical dilation with tapered cervical dilators of the Pratt or Denniston design, by hygroscopic dilators such as laminaria, or by prostaglandins. Laminaria use reduces risk for perforation or cer-

vical laceration[21]; however, most U.S. practitioners still use rigid dilators,[10] probably because in experienced hands, risk of perforation with first-trimester abortion is very small,[7] and an extra visit is required when hygroscopic dilators are used. Misoprostol (15-methyl-prostaglandin E_1) offers another alternative. A 400-μg vaginal dose, placed 3–4 hours before procedure, produces enough dilatation for most first-trimester procedures with minimal side effects and little expense.[22,23]

Vacuum curettage, performed with a 6-mm flexible cannula and modified 60-mL syringe, has been used worldwide since the 1970s. Initially, manual vacuum aspiration was used only at 6–7 menstrual weeks. However, manual vacuum aspiration is effective in pregnancies as early as 3 menstrual weeks.[24] Preoperative ultrasonography, careful inspection of the aborted tissue, and follow-up with serial ā-hCG titers ensure complete abortion and allow early diagnosis of ectopic pregnancy. Manual vacuum aspiration is as safe and effective as electric vacuum through 10 weeks of pregnancy.[25] Manual vacuum aspiration is also used to treat incomplete spontaneous abortion in office or emergency room, avoiding the delay and expense of conventional dilation and curettage in the operating room.

Complications of Vacuum Curettage Abortion

Table 2 presents rates of complications of 170,000 procedures performed before 14 menstrual weeks in 3 freestanding specialty clinics in New York City. Minor complications were experienced by 0.846% of patients, and 0.071% needed hospitalization. The most common complication was mild infection, not requiring hospitalization. The next most common was retained tissue or clot treated by repeat uterine evacuation in the clinic.[7] Other complications–perforation, hemorrhage, hematometra, ectopic pregnancy, postabortal pain and bleeding, and infection–are described below.

Immediate Complications. Excessive bleeding may indicate incomplete abortion, a pregnancy of more advanced gestational age than expected, uterine atony, a low-lying implantation, or uterine injury.[26] Misoprostol, 1,000 μg given rectally or buccally, is an important measure to reduce bleeding. A Foley catheter with a 30-mL balloon inserted into the uterine cavity and inflated with 50–60 mL of sterile saline may stop bleeding during transport. Persistent postabortal bleeding strongly suggests retained tissue or clot (hematometra) or trauma, and the patient is best managed with prompt surgical intervention: laparoscopy and repeat vacuum curettage. Selective uterine artery embolization was successful in 10 of 11 cases of hemorrhage from spontaneous or induced abortion and should be considered where available and when the patient can be stabilized for transport.[27] Rarely, hysterectomy may be necessary. In experienced hands, the risk of uterine perforation is less than 1 in 1,000 first-trimester abortions.[7] Risk increases with gestational age and is greater for parous women than for nulliparous women. Perforation is usually managed by laparoscopy to determine the extent of the injury. Often, the abortion can be completed during the laparoscopic procedure if the injury is midline and there is no active bleeding. The clinical syndrome produced by perforation depends on the location of the injury. Perforations at the junction of the cervix and lower uterine segment can lacerate the ascending branch of the uterine artery within the broad ligament, giving rise to severe pain, a broad ligament hematoma, and intra-abdominal bleeding.[28] Management requires laparotomy to ligate the severed vessels and repair the uterine injury. Low cervical perforations, on the other hand, may injure the descending branch of the uterine artery within the dense collagenous substance of the cardinal ligaments. In this case, there is no intra-abdominal bleeding. The bleeding is external, through the cervical canal, and may subside temporarily as the artery goes into spasm. Deaths have occurred as a result of bleeding several hours or even

Table 2. Complications of 170,000 First-Trimester Abortions

	Number of cases (%)	Rate
Minor complications		
Mild infection	784 (0.46)	1:216
Resuctioned day of surgery	307 (0.18)	1:553
Resuctioned subsequently	285 (0.17)	1:596
Cervical stenosis*	28 (0.016)	1:6,071
Cervical tear	18 (0.01)	1:9,444
Underestimation of gestational age	11 (0.006)	1:15,454
Convulsive seizure†	5 (0.004)	1:25,086
Total minor complications	1,483 (0.846)	1:118
Complications requiring hospitalizations		
Incomplete abortion‡	47 (0.28)	1:3,617
Sepsis§	36 (0.021)	1:4,722
Uterine perforation	16 (0.009)	1:10,625
Vaginal bleeding‖	12 (0.007)	1:14,166
Inability to complete abortion	6 (0.003)	1:28,333
Combined pregnancy¶	4 (0.002)	1:42,500
Total requiring hospitalization	121 (0.071)	1:1,405

* Causing amenorrhea.
† After local anesthesia.
‡ Repeat curettage in the hospital.
§ Two or more days of fever 40°C or higher.
‖ Requiring hospitalization.
¶ Intrauterine and tubal.
Adapted from: Hakim-Elahi E, Tovell HM, Burnhill MS. Complications of first-trimester abortion: a report of 170,000 cases. Obstet Gynecol 1990;76:129–35.

days after an unrecognized low cervical perforation. This complication has usually been managed with hysterectomy, but consideration should be given to arteriography and selective uterine artery embolization.[27]

Lower abdominal pain of increasing intensity in the hour after an abortion suggests hematometra (postabortal syndrome).[29] On examination, the uterus is large, globular, and tense and could be mistaken for a broad ligament hematoma, except that the mass is midline and arises from the cervix. The treatment is immediate reevacuation. Pretreatment with ergot, 0.1 mg intramuscularly, or the use of oxytocin reduces the incidence of this phenomenon,[29] and it is likely that the addition of vasopressin to the paracervical anesthetic has the same benefit.

Early detection of ectopic pregnancy, incomplete abortion, or failed abortion is possible by immediate fresh examination of the specimen. The tissue is rinsed in a strainer and then placed in a clear shallow dish over a source of backlighting. The gestational sac and chorionic villi are easily visualized. If no chorionic tissue is found, a frozen section is needed to rule out ectopic pregnancy. Findings of a few villi but no gestational sac suggest retained pregnancy tissue in the uterus. With later gestations (> 13 weeks), all of the fetal parts must be identified to prevent incomplete abortion.

Later Complications. Patients who have recently had an abortion and are experiencing symptoms often seek care at a local hospital emergency department. Emergency physicians should communicate with the abortion provider to learn the details of the procedure, any suspected complications, results of screening tests, results of the fresh examination of the aborted tissue, and whether Rh-immune globulin was given if the patient is D-negative.

The most common postabortal complaint is lower abdominal pain and bleeding. If there is no response to simple analgesics or if bleeding is excessive and prolonged, the pain severe, or fever is present, retained tissue or clot and early endometritis must be expected. Patients with only low-grade fever and no signs of peritonitis are safely managed with broad spectrum oral antibiotics and vacuum evacuation in the clinic.[7] Patients with signs of more serious disease, such as generalized abdominal tenderness and guarding, tachycardia, significant fever, and prostration, may have more advanced sepsis. They will require immediate hospital care,[4] with eradication of the infection by prompt uterine evacuation, high-dose combinations of antibiotics, and intensive care for cardiovascular support with fluid resuscitation, monitoring with central lines, and vasopressors as needed to achieve normal blood pressure. Adult respiratory distress syndrome may develop, necessitating ventilatory support. If there is hemolysis or failure of the patient to improve within 12–24 hours after uterine evacuation, then hysterectomy may be needed.[4,28] Septic abortion with shock was common when abortion was illegal but is now rare in the United States. However, it continues to be a major problem in the developing world. A recent review from 12 hospitals in 3 West African countries concluded that complications of induced abortion accounted for nearly one third of all maternal deaths.[30]

Medical Abortion in the First Trimester

Three highly effective regimens for early medical abortion are available in the United States: 1) mifepristone (RU-486) with misoprostol, 2) methotrexate with misoprostol, and 3) misoprostol alone. The combination of mifepristone with a prostaglandin analogue was the first highly effective means for medical abortion. Mifepristone is an analogue of norethindrone, with high affinity for progesterone receptors. It acts as a false transmitter and blocks natural progesterone. It can effectively induce abortion of early gestations after a single oral dose. Effectiveness is increased to approximately 95% by the addition of low-dose prostaglandin analogue.[31] In more than 17,000 cases treated in France, complete abortion was produced in 95% of cases. About 2% aborted incompletely and required vacuum curettage, 1% required urgent curettage for bleeding, and about 1% did not respond at all.

Mifepristone was initially combined with either of the prostaglandins sulprostone or gemeprost. However, 3 myocardial infarctions, with one death, occurred in smokers over age 35 years.[32] This problem proved to be related to one prostaglandin: sulprostone. Gemeprost and misoprostol had not been connected with myocardial infarction until recently (see below).

The U.S. Food and Drug Administration (FDA) labeling specifies mifepristone 600 mg orally followed by misoprostol 400 μg orally 2 days later in a physician's office. Use is limited to the first 49 days of amenorrhea. During the many years between the clinical trials and FDA approval, investigators found that 200 mg of mifepristone was as effective as the 600-mg dosing initially approved and that misoprostol as an 800-μg vaginal dose is more effective than 400 μg taken by mouth.[33,34] Vaginal misoprostol produces a lower peak serum level but provides a more sustained blood level of the drug.[35] With mifepristone plus vaginal misoprostol 800 μg, the gestational age for effective treatment can be safely extended from 49 to 63 days of amenorrhea.[33] The second drug, misoprostol, can be administered at 24, 48, or 72 hours after the mifepristone, with no difference in efficacy,[37] and pilot studies suggest the interval could be reduced still further. It is safe for women to self-admin-

ister the misoprostol at home.[36] Many U.S. practitioners follow what has been called the "evidence-based protocol" adopted by the National Abortion Federation and the Planned Parenthood Federation of America: mifepristone, 200 mg orally, followed by self-administered vaginal misoprostol, 800 μg taken at home at a time elected by the patient.

Methotrexate combined with misoprostol is another effective medical regimen for early abortion. Methotrexate is usually given as a single intramuscular dose of 50 mg/m^2 followed at 3–7 days with 800 μg of vaginal misoprostol. Misoprostol is repeated in 24 hours if expulsion of the gestational sac has not occurred. In a multicenter trial, 53% aborted after the first dose of misoprostol, an additional 15% after the second dose, and a total of 92% by 35 days.[38] In an extensive experience in the United States Planned Parenthood Clinics, 1,973 women were treated at up to 49 days since last menses. Eighty-four percent had a complete medical abortion. Thirteen percent had suction curettage, most commonly because of patient choice. Curettage for persistent viable pregnancy occurred in 1.4%. Curettage was used less often as centers gained experience with the protocol.[39]

Several investigators have studied misoprostol alone. A variety of regimens have been studied, and results have been variable.[33] The best results have been obtained with vaginally administered doses of 800 μg. Jain and colleagues[40] compared 200 women treated with vaginal misoprostol 800 μg alone within 56 days of last menses with historical controls treated with mifepristone plus oral misoprostol. The misoprostol-alone group had 88% complete abortions, whereas the mifepristone/misoprostol controls had a 94% rate of complete abortion. We have used vaginal misoprostol 800 μg initially, followed by 800 μg at 24 hours, if needed. A complete abortion rate of 92% was obtained among 273 patients treated (Borgatta L, Chen A, Mullally B, Stubblefield PG. Early medical abortion using misoprostol alone in a low income setting [abstract]. Obstet Gynecol 2003;101: 14S). This regimen approaches the efficacy of mifepristone/misoprostol and is much less expensive.

Approximately 85% of women starting medical abortion with mifepristone/misoprostol or misoprostol alone will abort within 3 days of misoprostol administration, but for a few, expulsion of the pregnancy will take several weeks. Vaginal ultrasonography is customarily performed to ensure that the uterine cavity is empty. Presence of an intact gestation with cardiac echoes 2 weeks after start of medication is considered a failed abortion. If a gestational sac is present but no fetal cardiac activity is present, the patient may elect to simply wait for expulsion, take more misoprostol, or have surgical evacuation. If medical abortion fails, surgical termination is advisable because there is possible risk for fetal malformation from misoprostol[41] and from methotrexate.[42]

Complications of Early Medical Abortion

Vaginal bleeding and cramping abdominal pain are expected at the time of expulsion, but persistent bleeding is also the principle complication of early medical abortion. The duration of bleeding or spotting averages 9–16 days after mifepristone/misoprostol abortion, and up to 8% of women may experience some bleeding for as long as 30 days (Mifeprex medication guide. Danco Laboratories, LLC, New York, NY). The need for curettage is related to gestational age and ranges from 2.1% at 49 days or less and 3.1% at 50–56 days to 5.1% at 57–63 days in abortions induced with 200 mg of mifepristone and 800 μg of vaginal misoprostol.[43] Of curettages needed for bleeding, more than half were late, at 3–5 weeks after expulsion of the pregnancy.

Hausknecht[44] has summarized the complications reported to the manufacturer of mifepristone from November 2000 to May 31, 2002 for an estimated 80,000 women who received mifepristone for early medical abortion during this interval. One hundred thirty-nine adverse events were reported. Most of these reports were of vacuum curettage for bleeding or for persistent nonviable pregnancy. A death was reported of a woman with a ruptured ectopic pregnancy who refused hospitalization. Ten women experienced infection (0.013%). One of the cases was quite serious. The patient developed fever 3 days after a successful abortion and rapidly developed sepsis with adult respiratory distress syndrome, but was treated successfully. A 21-year-old woman had a coronary artery thrombosis after receiving vaginal misoprostol. She was treated with balloon angioplasty and survived.

Since the Hausknecht report, 2 deaths have occurred from sepsis. A 27-year-old woman participating in a clinical trial of mifepristone/misoprostol died of multiple organ system failure from *Clostridium sordellii* sepsis after a complete abortion of a 5.5-week gestation, despite excellent care, including prompt hysterectomy (Wiebe E, Guilbert E, Jacot F, Shannon C, Winikoff B. A fatal case of *Clostridium sordellii* septic shock syndrome associated with medical abortion. Obstet Gynecol. In press, 2004). *Clostridium sordellii* infection is exceedingly rare, presents with subtle clinical findings, progresses very rapidly, and is almost uniformly fatal. In another sepsis case, as yet reported only in the lay press, a young woman died of septic shock attributed to endomyometritis with retained pregnancy tissue 7 days after receiving mifepristone and misoprostol at 7 weeks of gestation. No bacteriological information is available (Carter M. Autopsy data released in RU-486 death. *Tri-Valley Herald*, California,

November 1, 2003). More than 1,000,000 women in the world have been treated with mifepristone/misoprostol, and the case fatality rate appears no higher than the best surgical abortion mortality data.[3] Nonetheless, these cases demonstrate that serious sepsis is possible with early medical abortion as with surgical abortion and childbirth.

SECOND-TRIMESTER ABORTION

In 2000, only 12.5% of abortions were performed for patients at or after 13 weeks.[3] This is, however, a very important group, including virtually all patients who have antenatal diagnosis of congenital anomalies, many women with serious illness, and a disproportionate share of very young women. In the 1970s when abortion became legal throughout the United States, abortion after 12 weeks was generally accomplished in hospital by labor induced with intra-amniotic hypertonic saline. Practice changed rapidly after a series of articles from the CDC demonstrated that second-trimester D&E procedures provided in out-patient settings were safer than the labor induction methods as then practiced.[45] In 2000, D&E was used for 99% of abortions at 13–15 weeks, 94.6% at 16–20 weeks, and 85% at 21 weeks or later.[3]

Dilation and Evacuation

Detailed descriptions of D&E technique are published.[46–49] Initial reports of second-trimester surgical abortion from England described both mechanical dilation of the cervix with large metal dilators and laminaria placed overnight before instrumental evacuation through the cervix.[47] Hanson, Hern, and others popularized the use of laminaria in the United States.[47–49] Laminaria methods have prevailed, probably because of concerns about cervical injury from mechanical dilation to large diameters and the greater technical ease of second-trimester procedures after laminaria treatment. Synthetic osmotic dilators, Lamicel (Merocel Corporation, Mystic, CT) and Dilapan (JCEC Company, Kendall Park, NJ), are also used. More laminaria are used as gestational age advances to accomplish the necessary wider dilatation. After 20 weeks, 10 or more laminaria are needed. Placement of 10–13 laminaria into the cervical canal at 20–23 weeks produced dilatation greater than 14 mm by the next day in all but 2 of 126 patients.[50] An initial set of 2–3 medium laminaria, with 4 or more new laminaria added to the first set 6 hours later, produced dilatations of 18 mm or more by the next day in 92% of patients treated.[51] Misoprostol treatment may replace laminaria in the early second trimester. Misoprostol 600 μg administered buccally 2–4 hours before procedure at 14–16 weeks of gestation produced sufficient dilatation to allow insertion of a 14-mm vacuum curette or permitted easy dilation to this diameter.[52]

Instrument technique for uterine evacuation varies with gestational age and with the preference of the surgeon. At 13–15 weeks, evacuation is readily performed with vacuum cannula of 12–14 mm diameter, with ovum forceps used as an adjunct, or the surgeon may prefer to use forceps as the primary instrument and use the vacuum only the end of the procedure. The 16-mm cannula system (MedGyn, Lombard, IL) allows evacuation with the vacuum curette alone through 16 weeks, but at 17 weeks and beyond, even this large-diameter aspiration system is not adequate by itself.[53] Forceps evacuation becomes the primary method and vacuum, the secondary. A variety of large ovum forceps is used: Sopher, Hern, Bierer, and Kelly placenta forceps.[54]

Intravenous oxytocin, 40 or more units per 1,000 mL, is commonly used during the procedure or begun after uterine evacuation is completed. Two to four units of vasopressin are mixed with the local anesthetic solution or diluted with 10–20 mL of sterile saline and injected into the cervix.[14] If general anesthesia is elected, potent inhalation agents should be avoided or used only in low concentrations to avoid uterine atony and increased blood loss. Combinations of oxygen, intravenous propofol or short-acting barbiturates, and short-acting narcotic analgesics or nitrous oxide are preferred. Intraoperative real-time ultrasonography has been reported to reduce risk of uterine perforation on a teaching service where trainees were learning to perform D&E.[54] The obese patient presents special problems. A small study found a trend for increased procedure difficulty, procedure time, and blood loss with increasing body mass index.[55] Patients with BMI greater than 30 required 20% longer time for procedure and were rated as 40% more difficult by the operator. Placenta previa is not a contraindication to laminaria with D&E.[56] Previous cesarean delivery does not increase perioperative risk of D&E.[57]

A further evolution of technique is the intact D&E procedure. This involves 2 or more days of laminaria treatment to obtain wide dilation of the cervix. Then an assisted breech delivery of the trunk of the fetus is accomplished under ultrasound guidance, and the calvarium is decompressed and delivered with the fetus otherwise intact.[48] Federal legislation passed in 2003 to ban so called "partial-birth abortions," although nominally appearing to be aimed at "late term" abortions by intact dilation and extraction, is worded so broadly and vaguely that it appears also to make intact D&E illegal at any gestational age and may threaten standard D&E as well (Partial-Birth Abortion Ban Act of 2003, S. 3–8, 108th Congress, First Session, 2003). The potential application of the legislation to all D&E procedures and the

resulting threat and deterrent imposed on physicians who perform them provide one ground on which the legislation is being challenged in federal court as of this writing.

Hern has developed a combination D&E technique useful for later procedures.[46,47] After multistage laminaria treatment over 2 or more days, 1.5–2.0 mg of digoxin are injected into the fetus under ultrasound guidance, the membranes are ruptured, and intravenous oxytocin is started (167 mU/min). An assisted delivery is performed after a few hours.

Complications of Dilation and Evacuation

Complications of second-trimester surgical abortion are the same as those of first-trimester surgical abortion and may be no more frequent when laminaria are used. Jacot and colleagues[58] report fewer complications in abortions performed by D&E after laminaria at 15–20 weeks than were experienced by the same physicians with vacuum curettage procedures at less than 15 weeks gestation. In a large study reported from Australia, a perforation rate of 0.05% was noted with first-trimester vacuum curettage, whereas the rate was 0.32% for D&E at 13–20 weeks.[59] When complications occur, they are potentially more serious. Perforations occurring with first-trimester abortion are often safely managed with laparoscopy; however, a perforation occurring with second-trimester D&E may lead to bowel injury and will likely require laparotomy.[60] Hemorrhage during or after D&E can be caused by an incomplete procedure, uterine atony, or trauma as in the first trimester, but at the later gestational ages, risk for disseminated intravascular coagulopathy (DIC) increases. Risk for DIC has been reported as 8 per 100,000 first-trimester procedures, 191 per 100,000 second-trimester D&E procedures, and 658 per 100,000 saline-induced abortions.[61] Embolic phenomena, including amniotic fluid embolism, are rare and are less frequent with vacuum curettage and D&E than with labor-induction techniques,[62] but must be considered when a patient exhibits respiratory difficulty while undergoing an abortion.

Labor Induction Methods

Hypertonic Solutions. Intra-amniotic hypertonic saline was the first effective labor induction method for second-trimester abortion.[63] Hypertonic urea was introduced as a potentially safer agent because intravascular injection would not be harmful. An intra-amniotic dose of 80–90 g is an effective agent for labor induction, but injection-to-abortion intervals are prolonged. Regimens were developed for augmenting urea with intravenous oxytocin or prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$). Prostaglandin $F_{2\alpha}$ is no longer available in the United States, but 2 mg of its 15-methyl analogue, carboprost tromethamine (Hemabate, Pharmacia & Upjohn, Kalamazoo, MI) can be substituted.[64]

Intra-Amniotic Prostaglandin $F_{2\alpha}$. Prostaglandin $F_{2\alpha}$ was the first prostaglandin available in the United States. Intra-amniotic $PGF_{2\alpha}$ was effective, but often required a second injection and was associated with transient fetal survival in some cases, significant gastrointestinal side effects, failure of the primary technique, and, in the primigravida, risk for cervical rupture. Overnight treatment with laminaria tents reduced the mean time from instillation to abortion from 29 hours to 14 hours, reduced risk for cervical injury, and reduced the need for second injections.[65] Two milligrams of carboprost tromethamine was successfully substituted for $PGF_{2\alpha}$ in a series of 4,000 consecutive cases.[66]

Systemic Prostaglandins. Three different prostaglandins are available in the United States: dinoprostone (prostaglandin E_2), carboprost tromethamine (Hemabate), and misoprostol. Dinoprostone is given as a 20-mg vaginal suppository every 3 hours. The mean time to abortion is 13.4 hours, with 90% of patients aborting by 24 hours.[67] Reducing the dinoprostone to 10 mg at 6 hour intervals combined with high-dose oxytocin (see below) resulted in the same efficacy but fewer gastrointestinal side effects.[68] Intramuscular carboprost tromethamine at 250 μg every 2 hours produces mean times to abortion of 15–17 hours, with about 80% of patients aborting by 24 hours.[69] About one third of patients treated with dinoprostone 20-mg doses will have a temperature elevation of 1°C or more. This is not seen with carboprost tromethamine, which slightly reduces body temperature.

Misoprostol. The first study of misoprostol for second-trimester abortion was that of Jain and Mishell.[70] They used 200 μg placed vaginally every 12 hours and compared this with dinoprostone 20 mg every 3 hours. Misoprostol was equally effective and had fewer side effects of vomiting, diarrhea, or fever. Herabutya and O-Prasertsawat[71] compared 200-, 400-, and 600-μg doses at 12-hour intervals and reported rates of abortion by 48 hours to be 70.6%, 82%, and 96%, respectively. However, the rates of nausea and vomiting, diarrhea, and fever also increased with the dose.[71] Doses as high as 400 μg vaginally every 3 hours have been used.[72] The ideal dose and interval for misoprostol is still under investigation; however, we would caution that high doses and short intervals may increase risk for uterine rupture. The effect of misoprostol on temperature is dose related: fever is not seen at a dose of 200 μg per 12 hours, but increases as dose increases and intervals are shortened. Laminaria tents inserted at the onset of misoprostol treatment do not shorten the interval to abortion or improve efficacy.[73] Whether overnight treatment with laminaria would improve efficacy has not been studied.

Three cases of uterine rupture have been reported in women with previous cesarean delivery. Two were at 23 weeks.[74,75] One was at an unspecified gestational age less than 24 weeks.[76] Misoprostol 200–400 μg was given at intervals of 4–6 hours. Two other articles report small series of second-trimester patients treated with misoprostol after a single cesarean where no rupture occurred.[77,78] The absolute risk for uterine rupture cannot be stated until larger case series are reported.

Mifepristone and Prostaglandins. Second-trimester abortion with mifepristone followed by the prostaglandin analogues, gemeprost and misoprostol, has been well studied.[79–82] Mifepristone is administered, and then 3 days later the patient is hospitalized for prostaglandin treatment. Typical intervals from start of the prostaglandin to abortion are 7–9 hours, much shorter than those usually reported with prostaglandins alone. Doses of 200 mg of mifepristone appear just as effective as 600 mg.[82] Recent studies use misoprostol more often than gemeprost because of the low cost and high efficacy.[80]

High-Dose Oxytocin. Oxytocin in sufficient doses can be effective as a primary abortifacient. Fifty units in 500 mL of 5% dextrose and normal saline is given over a 3-hour period. After 1 hour of rest, oxytocin infusion is repeated, adding 50 additional units to the next 500-mL infusion, and continuing with 3 hours of infusion and 1 hour of rest. This is repeated until the patient aborts or a final solution of 300 U of oxytocin in 500 mL is reached (1,667 mU/min).[83]

Use of Feticidal Agents. Transient fetal survival is a problem with all prostaglandin methods. To prevent this and to shorten the interval to abortion, feticidal agents are commonly used. These include 60 mL of a 23% saline solution,[65] intra-amniotic urea,[63] ultrasound-guided fetal intra-cardiac injection of potassium chloride, and 1.0–1.5 mg of digoxin given either as an ultrasound-directed intrafetal injection or just into the amniotic sac. Intra-amniotic digoxin 1.0 mg does not increase maternal cardiac arrhythmia.[84] It is likely that the use of feticidal agents reduces the induction to abortion interval and improve efficacy, but this has not been subjected to a controlled trial. Intra-amniotic digoxin alone has been noted to induce labor, leading to abortion over the course of 2–3 days.[50]

Retained Placenta. Retained placenta is common with all prostaglandin abortions. Because patients remain at risk for bleeding until the placenta is expelled, Kirz and Haag[85] recommend instrumental evacuation under conscious sedation if placental expulsion has not occurred by 30 minutes. Li and Yin[86] reported that 800 μg of rectal misoprostol led to prompt expulsion of the placenta in all of 8 women treated at 30 minutes after fetal expulsion.

Hysterotomy and Hysterectomy. Hysterotomy is essentially a cesarean delivery. There is little indication for this procedure as the primary method for abortion, because the risk of major complications and death is greater with hysterotomy or hysterectomy than for any other technique (Table 1). In most cases, failed abortion is now managed with systemic prostaglandins or D&E, and the only need for hysterotomy in failed abortion is when a uterine anomaly is present.

Fetal Death in Utero

Fetal death in utero can be managed by D&E or labor induction. Coagulopathy is a potential problem with either method. Use of oxytocin and intracervical vasopressin during D&E may reduce this risk. In our opinion, the Trendelenburg position should be avoided to reduce the risk negative pressure in the uterine veins. Induction with vaginal prostaglandin E_2 is highly effective after fetal death, producing fetal abortion in about 10 hours, but often with significant vomiting, diarrhea, and fever. Beyond 24 weeks gestation, the full dose of 20-mg prostaglandin E_2 should not be used because uterine rupture may occur. The 20-mg suppository can be cut into quarters and administered 5 mg at a time for better control of uterine activity.[87] Misoprostol regimens are increasingly used to manage fetal death. The regimen of vaginal misoprostol 200 μg at 12-hour intervals reported by Jain and Mishell[70] is safe and effective in the second trimester. However, the dose should be reduced in the third trimester. The American College of Obstetricians and Gynecologists[88] has suggested a labor-induction regimen for living pregnancies in the third trimester of an initial dose of 25 μg (one quarter of a 100-μg tablet) at 6-hour intervals, increasing to a maximum of 50 μg at 6-hour intervals. In our opinion, these dosing guidelines should also be followed for cases of third-trimester fetal death. Uterine rupture has been described after a single 200-μg vaginal dose given to a third-trimester primiparous pregnant woman with no prior cesarean.[89]

If hemorrhage begins after abortion by either surgical or medical regimens, DIC should be suspected. If the uterus appears intact on manual exploration, intramuscular carboprost should be given immediately, because it will often stop the bleeding, even in the presence of DIC, and reduce the need for blood products. The misoprostol regimen of 1,000 μg given rectally, as used successfully for postpartum hemorrhage, may well be effective in these cases.[90]

Comparing Dilation and Evacuation and Induction Methods

There is no recent large study comparing current D&E procedures with current labor-induction methods. A

1980 study[91] with 100 women randomized to D&E or intra-amniotic $PGF_{2\alpha}$ found fewer complications with the D&E. The largest comparative study dates from 1984,[92] when 2,805 women undergoing abortion with intra-amniotic urea plus $PGF_{2\alpha}$ at 13–24 weeks were compared with 9,572 women who had undergone D&E. Most of the urea-treated patients were at 17–24 weeks, whereas most of the D&E patients were at 13–16 weeks. The serious complication rate, as defined by the authors, was 1.03% for the induction regimen, compared with 0.49% for D&E, but when the analysis was limited to patients at 17–24 weeks, the complication rates were the same. A 2002 retrospective cohort study[76] of 297 women compared D&E with medical abortions at 14–24 weeks, all performed by 1 of 4 experienced physicians. A complication occurred in 29% of the medical abortion patients versus 4% of the D&E patients ($P < .001$); however, most of the complications of the medical abortion were retained placenta. Misoprostol was the most effective of the medical regimens but still produced more complications that D&E.

Selective Fetal Reduction

In cases of multifetal pregnancies, selective reduction by means of ultrasound-guided intra-cardiac injection of potassium chloride is used to avoid the risks of extreme prematurity for the surviving pregnancies. In a series of 3,513 women treated in a multinational study,[93] fetal loss was higher at first and fell as the operators gained experience. Fetal loss was higher with higher starting numbers of gestations (starting number ≥ 6, 15.4%, decreasing to 6.2% loss for starting numbers of 2 gestations) and was also higher if more fetuses were left intact (finishing number 3, loss rate 18.4% decreasing to 6.7% for finishing number of gestations of one). The presence of one anomalous fetus of a multifetal gestation is another indication for selective termination. A 1999 report[94] from the same group describes 402 patients treated for this indication with no treatment failures. Rates of pregnancy loss after procedure, by gestational age at the time of procedure, were 5.4% at 9–12 weeks, 8.7% at 13–18 weeks, 6.8% at 19–24 weeks, and 9.1% for procedures done at 25 weeks or more. No maternal coagulopathy occurred, and no ischemic damages or coagulopathies were seen in the surviving neonates. Selective reduction should not be attempted with monoamniotic twins or for twin-twin transfusion syndrome because of the possibility of embolic phenomena and infarction in the surviving twin. Maternal serum alpha-fetoprotein remains elevated into the second trimester after first-trimester procedures.

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