CLINICAL OBSTETRICS AND GYNECOLOGY
Volume 46, Number 3, 679–687

Anesthesia-Related Maternal Mortality

JOY L. HAWKINS, MD
University of Colorado School of Medicine

Maternal Mortality in the United States

This year the Centers for Disease Control and Prevention (CDC) published their data on maternal mortality from 1991 to 1999.[1,2] They note that although death from complications of pregnancy have decreased by 99% since 1900, there have been no further decreases in the last 2 decades. In the most recent report, there were 4200 pregnancy-related deaths with an overall mortality ratio of 11.8 deaths per 100,000 live births, a substantial increase from the 7 to 8 per 100,000 reported since 1982. The appearance of an increase is probably just due to better methods of ascertainment, but it is still far from the Healthy People 2010 objective for maternal mortality of 3.3 per 100,000 live births! Those at greatest risk were women of black race, women >34 years of age, and women who received no prenatal care. Among women who died after a live birth, the leading causes of death were embolism and pregnancy-induced hypertension.

A maternal death is devastating to all involved; after all, only in the obstetric patient can mortality be 200%! Although infant mortality has declined steadily due to increased survival of preterm infants and prevention of Sudden Infant Death Syndrome (SIDS), maternal mortality has remained approximately 7.5 maternal deaths per 100,000 live births over the last 15 years, until the most recent report mentioned above.[1–3] The reason for the lack of improvement is unclear. More than half of maternal deaths are preventable—hemorrhage, pregnancy-induced hypertension, infection, and ectopic pregnancy account for 59%. Anesthetic causes have fallen to a "respectable" #7 on the list of causes for maternal mortality in the United States. The causes of pregnancy-related deaths are shown in Table 1.[1,4]

Since about 1991, the United States Centers for Disease Control (CDC) define maternal deaths as those that occur within 1 year of delivery (rather than the 42 days used previously) and that are related to the pregnancy. Thus, the percentage of deaths due to cardiomyopathy, for example, has increased because those deaths often occur after a lengthy illness. Many maternal deaths (perhaps over 30%) are missed because the cause of death on the death certificate does not include the fact that the mother was pregnant. For example, if a woman dies of a pulmonary embolism, but the death certificate does not note she was pregnant, it would not be classified as a maternal death. The

Correspondence: 4200 East Ninth Avenue, B-113 Denver, CO 80262, E-mail: Joy.Hawkins@uchsc.edu

TABLE 1. Causes of Pregnancy-Related Death During Live Birth in the United States, 1991–1997

Embolism	21.4%
Hypertensive disorders	19.4%
Hemorrhage	13.4%
Infection	12.6%
Cardiomyopathy	9.7%
CVA*	5.3%
Anesthesia	1.8%

* CVA = cerebrovascular accident.

Adapted from Berg JC, Chang J, Callaghan WM, et al. Pregnancy-related mortality in the U.S., 1991–1997. *Obstet Gynecol* 2003;101:289–96 (Reference 1).

CDC has begun asking states to link maternal death certificates with live birth or fetal death certificates, thus increasing identification of maternal deaths. This increased ascertainment may be the reason for an apparent increase in pregnancy-related deaths.

Anesthesia-Related Maternal Mortality

What do we know about anesthetic maternal mortality in the United States? In 1987, the CDC established an ongoing National Pregnancy Mortality Surveillance System to monitor maternal deaths at the national level and conduct epidemiologic studies of the deaths of pregnant women.[5] Health departments in all 50 states, the District of Columbia, and New York City provide the CDC with copies of death certificates with patient and provider identification removed. When available, linked birth certificates and fetal death records are also included. These are available from 1979 through 1999.

When these vital statistics data were reviewed to determine the causes of anesthesia-related deaths[6,7], the information was very limited. When possible, cause of death, type of anesthetic, type of obstetric procedure, and any associated maternal conditions were evaluated. Although many times the data was inadequate, it is almost impossible to get further information, such as medical records. The CDC has no legal power to obtain medical records, autopsy reports, or other information that could provide more data. Some conclusions could be made, however. Anesthesia-related maternal mortality rates (per million live births) could be calculated and compared with rates in the United Kingdom, since the U.K. rates are commonly quoted by anesthesiologists in the U.S. The United Kingdom has published triennial *Reports on Confidential Enquiries into Maternal Deaths in England and Wales* since 1952. These reports provide detailed information on all maternal deaths in each 3-year time period and make recommendations for improvement in care. The anesthesia-related maternal mortality rates in the U.S. and the U.K. proved to be very similar (Table 2).

It was also clear that changes in case fatality rates for general and regional anesthesia had occurred during the period of time being reviewed (Table 3). Although the number of deaths from general anesthesia remained stable until 1990, the number of deaths associated with regional anesthesia declined markedly. This occurred despite the fact that regional anesthesia was being used more often for cesarean delivery in virtually every hospital.[8] The decline in regional deaths occurred in the mid-80s, coincident with the withdrawal of 0.75% bupi-

TABLE 2. Pregnancy-Related Mortality Ratio (PRMR)* due to Anesthesia in the United States vs. England & Wales

Triennium	United States	United Kingdom
1979–81	4.3	8.7
1982–84	3.3	7.2
1985–87	2.3	1.9
1988–90	1.7	1.7
1991–93	1.4	3.5
1994–96	1.1	0.5

Adapted from References 6 and 7 and:

Lewis G, Drife J, Botting B, et al. *Report on Confidential Enquiries Into Maternal Deaths in the United Kingdom, 1994–1996.* London, England: HMSO; 1998.

* Pregnancy-related deaths due to anesthesia per million live births (limited to deaths associated with delivery of live births/stillbirths).

TABLE 3. Numbers of Anesthesia-Related Deaths, Case Fatality Rates, and Risk Ratios (by Type of Anesthesia Provided) in the United States, 1979–1996

Year of Death	Case Fatality Rates General Anesthetics*	Case Fatality Rates Regional Anesthetics*	Risk Ratios
1979–1984	20.0	8.6	2.3
1985–1990	32.3	1.9	16.7
1991–1996	16.8	2.5	6.7

* Per million general or regional anesthetics.

Adapted from References 6 and 7.

vacaine and probably due to increasing awareness of local anesthetic toxicity and increased use of test dosing. Using the number of deaths in each 6-year period, and estimating the number of cesarean deliveries done under regional or general anesthesia each year (note there are more and more calculations and assumptions), case fatality rates and risk ratios could be calculated.

Although the results may not be entirely accurate because of all the missing data and assumptions involved, they do show that general anesthesia is riskier than regional anesthesia in the obstetric patient. Why should that be?

1. During general anesthesia the airway must always be managed, and airway management is more difficult in the obstetric patient. Airway problems were by far the most common cause of anesthesia-related deaths.
2. General anesthesia is often chosen in emergencies when preparation and examination of the patient is not optimal.
3. General anesthesia is used in patients who have failed regional anesthesia (eg, obesity) or have contraindications to its use due to medical conditions (eg, hemorrhage, HELLP). These patients often also have increased risk factors for a difficult airway.
4. Residency training programs may not provide residents adequate exposure to general anesthesia on their obstetric rotations because anesthesiologists, patients, and obstetricians prefer regional anesthesia.

A review performed at a large tertiary care obstetric facility found general anesthesia was used in only about 5% of cesarean deliveries between 1990 and 1995.[9] The indications for cesarean delivery in patients receiving general anesthesia were nonreassuring fetal heart tracing, placenta previa or abruption, maternal disease (primarily HELLP, preeclampsia or ITP), abnormal presentation, and cord prolapse. Their yearly incidence of difficult intubation ranged from 1.3 to 16.3% with 1 maternal mortality due to an unrecognized difficult airway.

How do anesthesiologists in practice maintain their skills in general anesthesia for cesarean delivery with such infrequent use? Consider an anesthesiologist practicing at a hospital with 1500 deliveries per year.[8] If the cesarean delivery rate is 20%, there will be 300 cases, and if 12% are done using general anesthesia there will be 36 such cases per year. With 6 practitioners in the group, each will do an average of only 1 general anesthetic for cesarean delivery every other month!

It would appear that maternal mortality will decrease further only by continuing to increase use of regional anesthesia and providing organized airway management programs for residents and practitioners so they are prepared for obstetric airway emergencies.[9] Even deaths during regional anesthesia may involve airway management. Several of the deaths during regional anesthesia occurred when the block became too high for adequate ventilation and the airway could not be secured, leading to hypoxia and/or aspiration.

However, there are times when general anesthesia *is* the most appropriate choice for

the patient; for example hemorrhage with hemodynamic instability or umbilical cord prolapse. In these cases it should not be avoided. After all, the recent mortality rate was only 17 per *million* general anesthetics. That's a remarkable safety record! We would expect that number to decrease even further as additional tools for managing difficult airways (laryngeal mask airway, Combitube Kendall-Sheridan Catheter Corp., Argyle, NY) become more widely available and as the ASA Difficult Airway Algorithm[30] becomes familiar to all practitioners.

Above all, we need more information about individual cases in which a bad outcome or a "near miss" occurred. We need access to all information about maternal mortalities in an environment free of concerns about liability issues. Then we can analyze why they occurred and research ways to prevent them in the future. We also need to know about the "near misses" and how mortalities were avoided in those instances. We should learn from each other's mistakes so as not to repeat them.

MANAGEMENT OF THE DIFFICULT AIRWAY IN OBSTETRICS

The incidence of failed intubation in obstetric patients is 1:280 while the incidence of failed intubation in the general operating room is 1:2230.[10,11] Therefore, you have over 7 times the chance of dealing with a failed intubation while you are providing general anesthesia on labor and delivery. All personnel on L&D should be familiar with the American Society of Anesthesiologists' (ASA) Difficult Airway Algorithm.[30] Anesthesiologists should plan nursing inservices to instruct them on their role in the failed intubation scenario.

In addition, there should be a difficult airway box *for L&D*[12] with a variety of airway adjuncts for managing the difficult airway. Virtually all general operating rooms have a difficult airway cart, and L&D should have the same access to its own emergency equipment. The ASA Practice Guidelines for Obstetrical Anesthesia[27] state that "Labor and delivery units should have equipment and personnel readily available to manage airway emergencies. Basic airway equipment should be immediately available during the provision of regional anesthesia. In addition, portable equipment for difficult airway management should be readily available in the operative area of labor and delivery units."[27] A laryngeal mask airway or Combitube should be immediately available in the obstetric operating room.[13,14] These can provide lifesaving ventilation as well as access for securing the airway to prevent aspiration.

A "prophylactic regional anesthetic" should be considered when the anesthesiologist anticipates a difficult airway.[15] If the anesthesia team recognizes that a patient has a difficult airway, the obstetrician and anesthesiologist should discuss placement of a continuous epidural or spinal catheter as soon as she is committed to delivery. In *Guidelines for Perinatal Care, 5th ed.*, risk factors that should initiate an anesthetic consultation are listed, including those that might indicate a difficult airway. It goes on to say "Strategies thereby can be developed to minimize the need for emergency induction of general anesthesia in women for whom this would be especially hazardous. For those patients at risk, consideration should be given to the planned placement in early labor of an intravenous line and an epidural or spinal catheter with confirmation that the catheter is functional."[31] In the event there is fetal distress or other need to proceed emergently to the operating room, regional anesthesia can be provided expediently. In addition, the team should understand that starting a case emergently will take extra time to provide a regional anesthetic or to secure the airway. Administer aspiration prophylaxis to any patient with a potentially difficult airway as soon as operative delivery is anticipated. Medications such as H_2-receptor blocking agents may take an hour for maximum effectiveness if general anesthesia is necessary. Have extra, experienced hands available at induction of general anesthesia. Other anesthesiologists

should know if there is a patient with a difficult airway on L&D so they can be prepared to assist if airway management becomes necessary.

Despite best efforts, occasionally anesthesiologists have an unsuspected difficult airway and intubation is unsuccessful (Table 4). If mask ventilation is difficult or impossible, move immediately to a laryngeal mask airway or other method of ventilation. Because of the parturient's higher metabolic rate and lower functional residual capacity, they become hypoxic and suffer neurologic injury faster than the nonpregnant patient. If the situation deteriorates and cardiopulmonary resuscitation is necessary, ". . . standard resuscitative measures and procedures, including left uterine displacement should be taken. In cases of cardiac arrest, the American Heart Association has stated the following: 'Several authors now recommend that the decision to perform a perimortem cesarean section should be made rapidly, with delivery effected within 4–5 minutes of the arrest.'"[27]

TABLE 4. Management of the Unsuspected Difficult Airway and Failed Intubation

Can't ventilate:
- Intubating laryngeal mask airway (LMA-Fastrach™)[11]
- Cricothyrotomy, jet ventilation
- Surgical airway

Can ventilate, elective procedure:
- Let the patient awaken
- Proceed with regional anesthesia or
- Proceed with awake intubation and general anesthesia

Can ventilate, emergent procedure:
- Continue cricoid pressure throughout the case
- Elevate the head of the bed
- Administer a drying agent to decrease airway secretions
- Administer metoclopramide to increase E-G barrier pressure
- Maintain spontaneous ventilation versus further muscle relaxant
- Provide intravenous anesthesia if uterine atony is a problem
- Tell your surgeons to finish quickly!

If intubation is unsuccessful, the anesthesiologist is able to ventilate, and the case is not emergent (eg, an elective repeat, failure to progress), allow the patient to awaken while ventilating with cricoid pressure (Table 4). At this point, the choice must be made whether to proceed with a regional technique such as epidural or spinal anesthesia or whether to secure the airway awake and proceed with general anesthesia. Although controversial, anesthesiologists with a great deal of experience in regional anesthesia would probably feel more comfortable titrating a continuous epidural or spinal anesthetic, while those with extensive skills in fiberoptic intubation would likely proceed with an awake intubation, recognizing that parturients are considered to have a full stomach, and that sedation should be minimal immediately prior to delivery.

A third scenario (Table 4) would be the case where intubation is impossible, the patient can be ventilated by mask, and the case must proceed emergently (eg, antepartum hemorrhage, complete abruption, umbilical cord prolapse). In this setting, the anesthesiologist is faced with providing anesthesia for a laparotomy in a patient with a full stomach and an unsecured airway. Obstetricians should understand the gravity and precariousness of the situation and complete the case as quickly as possible. To minimize the chance of aspiration, the anesthesia assistant must remain at the head of the bed to provide continuous cricoid pressure throughout the case. If that assistant is the circulating nurse, this implies calling another person into the operating room to take his or her place. Elevate the head of the bed slightly to improve functional residual capacity and perhaps lessen the chance of passive regurgitation. Administer metoclopramide (if not done already) to raise gastroesophageal barrier pressure. A drying agent, such as glycopyrrolate, will minimize secretions that might interfere with mask ventilation. Consider the type of anesthetic to use during the remainder of the case (eg, intravenous agents, such as ketamine or propofol, rather than in-

halational agents that might cause uterine atony). Spontaneous ventilation may be preferred rather than controlled ventilation with muscle relaxation, depending on which technique improves the ability to ventilate by mask.

ASPIRATION OF GASTRIC CONTENTS

This remains the number one cause of death in obstetric anesthesia,[6] frequently associated with a difficult or failed intubation, so much of the preceding discussion pertains here. How can we prevent this complication? Although encouraging use of regional anesthesia appears obvious, aspiration can also occur during a high spinal or epidural block when the patient cannot cough or clear her airway effectively. Decreasing the volume and acidity of gastric contents pharmacologically seems logical, but there are no outcome studies to prove their use is beneficial. Opiates are known to delay gastric emptying, so regional analgesia for labor should be favored in patients with a suspected difficult airway. Both the ASA *Practice Guidelines for Obstetrical Anesthesia*[27] and several American College of Obstetricians and Gynecologists' statements support modest amounts of clear liquids in labor, but oppose any intake of solid foods. The ASA Guidelines go on to say ". . . patients with additional risk factors of aspiration (eg, morbid obesity, diabetes, difficult airway), or patients at increased risk for operative delivery (eg, non-reassuring fetal heart rate pattern) may have further restrictions of oral intake, determined on a case-by-case basis." Anesthesiologists should teach their nursing colleagues on L&D the correct method of providing cricoid pressure and have an in-service for them on the steps in the difficult airway algorithm.

LOCAL ANESTHETIC TOXICITY

Local anesthetic toxicity is the leading cause of death during regional anesthesia,[6] however its occurrence has decreased markedly in the last decade. Newer local anesthetics, such as ropivacaine and levobupivacaine, may have a better safety profile than bupivacaine, but their place in obstetric anesthesia remains unclear due to cost issues. For surgical procedures lidocaine still has the best safety profile of all the amide drugs. Prevention of local anesthetic toxicity centers on incremental dosing and using a test dose.

What is an appropriate test dose in obstetrics? A test dose is administered through the epidural catheter with two markers; one which would show whether the catheter is in a blood vessel to prevent systemic local anesthetic toxicity, and another which would show whether the catheter is in the cerebrospinal fluid (CSF) to prevent an extremely high block or "total spinal." A number of different drugs and techniques have been used with varying degrees of success. For example, epinephrine is the most commonly used agent for testing for intravascular placement of an epidural catheter, but there are concerns about epinephrine's use in pregnancy. There are different dose-response curves in parturients than in nonpregnant patients, there are concerns about epinephrine's effect on uterine blood flow, the specificity is poor in a laboring patient whose heart rate varies with contractions, and there are maternal consequences if the patient has preeclampsia or chronic hypertension.[16,17] Other test dose regimens advocated for the parturient include: 2-chloroprocaine,[18] air,[19] fentanyl, or sufentanil,[20] aspiration and fractionation only without a marker[21], and isoproterenol (only theoretical pending neurotoxicity studies)[22].

Should test dosing be different for the laboring patient versus the parturient for elective cesarean delivery? Probably. When an epidural is placed for elective cesarean delivery rather than in the laboring patient, there is less heart rate variability to confuse interpretation of an epinephrine response. There is also more chance of toxicity when a higher, more concentrated dose of local anesthetic is given than that used for labor. As a technical point, injecting fluid (saline or local anesthetic) through the epidural needle

may help decrease the incidence of intravascular catheter placement if at least a 10cc volume is used.[23]

HIGH SPINAL OR EPIDURAL BLOCK

Preventing a high spinal or epidural block involves more test dose issues, now looking for ways to detect inadvertent injection of local anesthetic into the CSF. The extent of spinal block depends on the number of milligrams of local anesthetic given, the baricity and the volume used, and the position of the patient. Probably the best indicator of a subarachnoid injection is onset; if the laboring patient is comfortable in one contraction, the catheter is subarachnoid until proven otherwise! As noted earlier, airway equipment and pressors must be immediately available.

If a "total" spinal occurs, there are two problems: 1) lack of preload and an empty heart, causing hypotension and decreased cardiac output, and 2) paralysis of the respiratory muscles, leading to hypoxia and aspiration. Treatment involves airway management with ventilation and intubation, fluids, pressors, left uterine displacement and elevation of the legs to promote venous return and improve cardiac output.

Is it safe to perform spinal anesthesia for cesarean section or tubal ligation after a fully dosed but failed epidural anesthetic?[24] There are numerous case reports of excessively high blocks requiring intubation in this setting, perhaps because the expanded epidural space compresses the CSF. When an epidural is inadequate for surgery, the anesthesiologist must balance the risk of airway management during general anesthesia with the risk of a high spinal block that may also require intubation. If the anesthesiologist chooses to proceed with spinal anesthesia, anticipate problems and be prepared for the need for rapid airway intervention and general anesthesia.

Conclusions

In summary, there is room for both optimism and improvement. Clearly, anesthesia-related maternal mortality rates are improving (Table 2). Similar to American and British experience, a recent review of maternal mortalities in Israel found a 25% overall decline from 1979 to 1995. Most recently, they had a maternal mortality rate of only 5 per 100,000 births.[25] The proportion of anesthesia-related deaths declined from 11% in the first 9-year time period to 0 in the most recent.

Others are looking for ways to gather more complete data on maternal mortalities. A review of maternal deaths in a 10-hospital urban perinatal network in the United States found a strikingly higher maternal mortality ratio; 22.8 maternal deaths per 100,000 live births rather than the reported national rate of 7.5 per 100,000.[26] The group was able to identify "all" maternal deaths in their perinatal network, and because they formed a peer-review committee, they were able to review each case in detail. The deaths were deemed potentially preventable in 37%, and there was a provider factor identified in >80%. Pulmonary embolus and cardiac disease together accounted for 40% of the pregnancy-related deaths. There was only one anesthesia-related death, and it was attributed to central nervous system depression in a patient who was receiving multiple narcotics, as well as other potentially depressive medications at the time of delivery.

Using similar methodology, a state-maintained database was used to determine the incidence and causes of maternal mortality.[28] They reported an overall delivery mortality rate of 16.4, which they also attributed to improved detection. Anesthesia-related mortality accounted for 5.2% of the deaths. Unfortunately, since it was an anonymous database, no further information could be obtained about the specifics of each case.[29] The use of smaller perinatal groups or state maternal mortality committees should improve identification of maternal deaths and eventually provide more in-depth information to use for prevention programs.

The preventable death of a young healthy

mother is surely one of life's greatest tragedies; we must continue to improve our care until these cases become of historical interest only.

References

1. Berg CJ, Chang J, Callaghan WM, et al. Pregnancy-related mortality in the United States, 1991-1997. *Obstet Gynecol*. 2003; 101:289–296.
2. MMWR. 2003;52:1–8.
3. MMWR. 1998;47:705–707.
4. Berg CJ, Atrash HK, Koonin KM, et al. Pregnancy-related mortality in the United States, 1987-1990. *Obstet Gynecol*. 1996; 88:161–167.
5. Ellerbrock TV, Atrash HK, Hogue CJR, et al. Pregnancy mortality surveillance: a new initiative. *Contemp Obstet Gynecol*. 1988; 31:23–24.
6. Hawkins JL, Koonin LM, Palmer SK, et al. Anesthesia-related deaths during obstetric delivery in the United States, 1979–1990. *Anesthesiology*. 1997;86:277–284.
7. Hawkins JL, Chang J, Callaghan W, et al. Anesthesia-related maternal mortality in the United States, 1991-1996. An update. (abstract) *Anesthesiology*. 2002;97:A1046.
8. Hawkins JL, Gibbs CP, Orleans M. *Martin-Salvaj, Beaty B*: Obstetric anesthesia work force survey, 1981 versus 1992. *Anesthesiology*. 1997;87:135–143.
9. Tsen LC, Pitner R, Camann WR. General anesthesia for cesarean section at a tertiary care hospital 1990–1995: indications and implications. *IJOA*. 1998;7:147–152.
10. Lyons G. Failed intubation. *Anaesthesia*. 1985;40:759–762.
11. Samsoon GLT, Young JRB. Difficult tracheal intubation: a retrospective study. *Anaesthesia*. 1987;42:487–490.
12. Rasmussen GE, Malinow AM. Toward reducing maternal mortality: the problem airway in obstetrics. *Int Anesthesiol Clin*. 1994;32:83–101.
13. McClune S, Regan M, Moore J. Laryngeal mask airway for caesarean section. *Anaesthesia*. 1990;45:227–228.
14. Ferson DZ, Rosenblatt WH, Johansen MJ, et al. Use of the intubating LMA-Fastrach in 254 patients with difficult-to-manage airways. *Anesthesiology*. 2001;95:1175–1181.
15. Morgan BM, Magni V, Goroszenuik T. Anaesthesia for emergency caesarean section. *Br J Obstet Gynaecol*. 1990;97:420–424.
16. Colonna-Romano P, Lingaraju N, Godfrey SD, et al. Epidural test dose and intravascular injection in obstetrics: sensitivity, specificity, and lowest effective dose. *Anesth Analg*. 1992;75:372–376.
17. Colonna-Romano P, Norris MC. Controversies in anesthesia. *Anesthesiol Rev*. 1993;20: 19–24.
18. Grice SC, Eisenach JC, Dewan DM, et al. Evaluation of 2-chloroprocaine as an effective intravenous test dose for epidural analgesia. *Anesthesiology*. 1987;67:A627.
19. Leighton BL, Gross JB. Air: an effective indicator of intravenously located epidural catheters. *Anesthesiology*. 1989;71:848–851.
20. Yoshii WY, Kotelko DM, Rasmus KT, et al. Fentanyl for epidural intravascular test dose in obstetrics. *Reg Anesth*. 1993;18:296–299.
21. Norris MC, Fogel ST, Dalman H, et al. Labor epidural analgesia without an intravascular test dose. *Anesthesiology*. 1998;88: 495–501.
22. Leighton BL, DeSimone CA, Norris MC, et al. Isoproterenol is an effective marker of intravenous injection in laboring women. *Anesthesiology*. 1989;71:206–209.
23. Mannion D, Walker R, Clayton K. Extradural vein puncture - an avoidable complication. *Anaesthesia*. 1991;46:585–587.
24. Gupta A, Enlund G, Bengtsson M, et al. Spinal anaesthesia for caesarean section following epidural analgesia in labour: a relative contraindication. *Int J Obstet Anes*. 1994;3:153–156.
25. Yoles I, Maschiach S, Berlovitz Y, et al. Maternal mortality in Israel in the years 1975–1995; causes and trends. (abstract) *Am J Obstet Gynecol*. 1998;178:210.
26. Panting-Kemp A, Geller SE, Nguyen T, et al. Maternal deaths in an urban perinatal network, 1992–1998. *Am J Obstet Gynecol*. 2000;183:1207–1212.
27. Task Force on Obstetrical Anesthesia. Practice guidelines for obstetrical anesthesia. *Anesthesiology*. 1999;90:600–611.

28. Panchal S, Arria AM, Labhsetwar SA. Maternal mortality during hospital admission for delivery: a retrospective analysis using a state-maintained database. *Anesth Analg*. 2001;93:134–141.
29. Hawkins JL, Birnbach DJ. Maternal mortality in the United States: where are we going and how will we get there? *Anesth Analg*. 2001;93:1–3.
30. Caplan R, Benumof JL, Berry FA, et al. Practice guidelines for management of the difficult airway. *Anesthesiology*. 1993;78: 597–602.
31. The American Academy of Pediatrics and The American College of Obstetricians and Gynecologists. Guidelines for Perinatal Care, 5th Edition. Washington, DC., 2002, p.141.