ANAESTHETIC CONTRIBUTION TO MATERNAL MORTALITY

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The Confidential Enquiries into Maternal Deaths in England and Wales are unique in British medicine in that they appraise systematically the results of medical work. The original enquiry was started in 1928, but was completely revised in 1952, since when there have been 10 reports covering a period of 30 years. Each maternal death is reviewed carefully to ascertain if additional or different action might have given the mother a better prospect of survival.

The difficulties in collecting accurate information retrospectively in this type of report are well known, as is their examination from an elitist standpoint. It is a feature, however, that each successive one is more complete than its predecessor, because of the free participation of all those who have been concerned with the mother's care and who realize the importance of the enquiries. This is particularly true for anaesthesia, practitioners of which are much concerned with anaesthetic mortality and wish to pinpoint those areas where improvements can be made. Another unique feature is the "retrieval rate", which is almost 100%. Thus the causes of virtually all anaesthetic deaths from 1952 to 1981 are known.

The purpose of this paper is to examine the causes of anaesthetic related maternal mortality as presented in these enquiries.

CONFIDENTIAL ENQUIRIES INTO MATERNAL DEATHS

Maternal death

It is agreed internationally that maternal deaths are either direct or indirect. The International Classification of Disease, Ninth Review (ICD 9) (Classification, 1977) defined direct obstetric deaths as "those resulting from obstetric complications of the pregnant state (pregnancy, labour and the puerperium), from interventions, omissions, incorrect treatment, or from a chain of events resulting from any of the above." Thus in this context, anaesthesia is regarded as an intervention. Indirect deaths are "those resulting from previous existing disease, or disease that developed during pregnancy and which was not due to direct obstetric causes, but which was aggravated by physiologic effects of pregnancy."

ICD 9 defines a maternal death as "the death of a woman while pregnant or with 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidenta..." Walker (1986) has pointed out that such a time interval is likely to exclude a substantial and increasing proportion of maternal deaths, since increasing expertise in resuscitation and intensive care allows patients to be kept alive for much longer periods. Support for his views comes from the observations of Rochat and colleagues (1981) who, in a study in Georgia, found that the 42-day limit excluded 17% of deaths from maternal causes. They suggested that increasing the interval to 90 days would increase the detection of maternal deaths without including an excessive number of non-maternal deaths.

The most recently published enquiry (Report, 1986), however, has included deaths that have occurred between 43 days and 1 year after delivery and abortion. These are now termed "late" deaths and are dealt with in a separate chapter in the report, but include none related to anaesthesia.

Mechanism of the enquiry

The basic mechanism of the enquiry is shown in figure 1. The instigator of an investigation of a maternal death is the District Medical Officer (DMO) of the area in which the mother was
usually resident, who receives copies of all death certificates. There is no requirement for anyone involved in a mother’s care to report a death. An enquiry form (MCW 97) is sent to general practitioners, health visitors, community physicians, consultant obstetricians and any other relevant staff who have been concerned with her care. This form has been altered so as to encourage reporting not only of failures of clinical care, but also of any other factors leading to a low standard of care, such as shortage of resources for staffing, administrative failures and inadequate back-up facilities.

The completed form is returned to the DMO, who then sends it to the regional obstetric assessor. Since 1973, a regional anaesthetic assessor has reviewed all cases who have received an anaesthetic, and there is no doubt that this has resulted in a marked improvement in the report, from an anaesthetic point of view. Terms such as “hypoxic cardiac arrest” have now disappeared and the classification of anaesthetic-related mortality is more meaningful. The form MCW 97 is sent subsequently to the Chief Medical Officer at the Department of Health and Social Security, where the Department’s central assessors in obstetrics and gynaecology, anaesthetics and histopathology prepare the final report from all the available information. At all stages, strict confidentiality is maintained. The names of the mothers are erased from all forms, and the latter are destroyed after publication of the report. The delay in the appearance of the latest report resulted from problems with confidentiality, resulting in temporary suspension of the enquiry for 8 months, in addition to industrial action and to transfer of the responsibility for initiation of the report to the DMO (Cloake, 1986).

The actual number of deaths in each triennium since 1952 is shown in table I. One of the most disturbing aspects is the number of deaths associated with avoidable factors, where there has been a departure from accepted anaesthetic practice. This particular term has been omitted from the latest report as it implied that, if a particular course of action had been avoided, the patient would not have died. It has been replaced by the term substandard care, which also encompasses administrative failure as already mentioned. It would be correct to comment that much higher standards are now expected of anaesthetists than would have been at the inception of these reports.

In most instances, the primary factor leading to the mother’s death is obvious and can easily be classified. Many deaths have more than one cause,
and here the assessor attempts to select the factor most likely to have caused death. As a result, therefore, the major causes of anaesthetic-related mortality have been identified and have indicated the direction of required research and teaching.

**MAJOR CAUSES OF DEATH**

The majority of anaesthetic deaths are associated with induction of general anaesthesia and result from two main causes, namely inhalation of gastric contents and failure to intubate the trachea (which in turn may provoke the former).

**Inhalation of gastric contents**

**The problem of gastric acidity**

The first description of the inhalation of gastric contents in obstetric patients was by Hall (1940), who coined the term chemical pneumonitis. The problem was highlighted by Mendelson (1946), who described an asthma-like syndrome resulting from inhalation of liquid gastric contents. Mendelson performed animal experiments which showed the severe reaction that resulted from instillation of unneutralized gastric juice or hydrochloric acid 0.1 mol litre$^{-1}$ to the lungs, all the animals dying within a few hours. Further work by Teabeaut (1952) in rabbits showed that the severity of the pulmonary lesions was related to the pH of the gastric aspirate, the critical value being 2.5. This is the value accepted by most anaesthetists as being that below which severe pulmonary damage occurs (Vandam, 1965). Supporting evidence for this value comes from a small series of non-obstetric patients reported by Lewis, Burgess and Hampson (1971). They related mortality following aspiration to the pH of the aspirate: 100% when the pH was < 1.75, 25% when the pH ranged from 1.75 to 2.4, but no deaths when pH was greater than 2.4.

Because of the severity of acid aspiration, it was logical that attempts should be made to increase the intragastric pH above the so-called critical value, and the methods of achieving this have recently been reviewed (Morgan, 1984). The main methods involve either regular antacid therapy or inhibition of gastric acid production with $H_3$-receptor antagonists. Mist.magnesium trisilicate B.P., although effective in increasing intragastric pH, has the disadvantages that it does not mix well with gastric contents and should be recently prepared (Crawford and Potter, 1984). It is also particulate, and antacids of this type have been shown themselves to cause a severe reaction when instilled to the lungs (Gibbs et al., 1979). Sodium citrate is unpalatable, has a short shelf-life and would appear not to be as reliable as mist.magnesium trisilicate in increasing intragastric pH (White, Clarke and Stanley-Jones, 1976; Hester and Heath, 1977; Dewan et al., 1982). Despite its drawbacks, mist.magnesium trisilicate remains the most widely used antacid in the U.K. (Sweeney and Wright, 1986).

The main drawback of the $H_3$-receptor antagonists is that they do not have any effect on acid that has already been produced and remains in the stomach. Timing of administration is therefore critical, although they can be combined effectively with a single dose of antacid (Gillett, Watson and Langford, 1984). Cimetidine is associated with a

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**TABLE I.** Maternal mortality figures obtained from the Confidential Enquiries into Maternal Deaths In England and Wales. *This term has been replaced by “substandard care”, first used in 1979-81

<table>
<thead>
<tr>
<th>Years</th>
<th>Maternal mortality per 1000 total births</th>
<th>Number of deaths from anaesthesia</th>
<th>Percentage true maternal deaths from anaesthesia</th>
<th>Percentage with avoidable factors*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1952-54</td>
<td>0.53</td>
<td>49</td>
<td>4.5</td>
<td>—</td>
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<tr>
<td>1955-57</td>
<td>0.43</td>
<td>31</td>
<td>3.6</td>
<td>77</td>
</tr>
<tr>
<td>1958-60</td>
<td>0.33</td>
<td>30</td>
<td>4.0</td>
<td>80</td>
</tr>
<tr>
<td>1961-63</td>
<td>0.26</td>
<td>28</td>
<td>4.0</td>
<td>50</td>
</tr>
<tr>
<td>1964-66</td>
<td>0.20</td>
<td>50</td>
<td>8.7</td>
<td>48</td>
</tr>
<tr>
<td>1967-69</td>
<td>0.16</td>
<td>50</td>
<td>10.9</td>
<td>68</td>
</tr>
<tr>
<td>1970-72</td>
<td>0.13</td>
<td>37</td>
<td>10.4</td>
<td>76</td>
</tr>
<tr>
<td>1973-75</td>
<td>0.11</td>
<td>31</td>
<td>13.2</td>
<td>90</td>
</tr>
<tr>
<td>1976-78</td>
<td>0.11</td>
<td>30</td>
<td>13.2</td>
<td>93</td>
</tr>
<tr>
<td>1979-81</td>
<td>0.11</td>
<td>22</td>
<td>12.2</td>
<td>100</td>
</tr>
</tbody>
</table>
number of side effects, and in particular inhibits drug metabolizing enzymes in the liver involving anticoagulants, barbiturates, benzodiazepines, propranolol and theophylline (Manchikanti, Kraus and Edds, 1982). It may result in significant hypotension when given by the i.v. route (Hammond and Ware, 1983). Ranitidine has far fewer side effects, is longer acting, but is also slower in onset than cimetidine.

As it is not known which mother might require an anaesthetic in labour, it is the routine in the majority of units in the U.K. for all mothers to receive some form of therapy to increase intragastric pH. This practice has been questioned recently by Thorburn and Moir (1987), who calculated that, if antacid therapy was practised routinely for all mothers in labour in England and Wales, some 800000 mothers per year would receive it in the hope of preventing the death of four, and that approximately 700000 mothers would have received therapy for a disorder from which they had not been at risk in the first place. They studied 100 patients undergoing emergency Caesarean section, giving cimetidine 200 mg i.m. when the decision to perform the operation was made, and 30 ml of sodium citrate 0.3 mol litre$^{-1}$ by mouth preceding general anaesthesia. These patients had not received routine antacid therapy during labour. No patient had a gastric aspirate of pH less than 2.7 and only one less than 3.0. These figures are certainly no worse than those obtained from studies on routine antacid therapy.

The assumption made in the maternal mortality reports that those who have inhaled gastric contents died from acid aspiration is not valid, as in no instance was the pH of the aspirated material reported. Indeed, it would be reasonable to assume that the pH would have been greater than the critical value in most of these mothers. Taylor and Prys-Davies (1966) found that 57% of mothers who had not received antacid therapy had an intragastric pH greater than 2.5, and since that time such therapy has become routine in British obstetric practice.

Is there, therefore, a continued need for antacid therapy? There are several reports of severe lung damage and death following aspiration of gastric contents containing antacids (Bond, Stoelting and Gupta, 1979; Heaney and Jones, 1979; Whittington, Robinson and Thompson, 1979). The increasing use of antacids in labour has not been associated with a reduction in mortality from inhalation (Reynolds, 1983). On the other hand, Crawford and Opit (1976) found a striking relationship between provision of antacid prophylaxis and the sequelae of aspiration, while Hutchinson (1979) reported that the frequency of severe acid aspiration decreased from 1:11000 to 1:40000 when magnesium trisilicate came into routine use.

Animal work (James et al., 1984) has shown that even a small volume of fluid instilled to the lungs is associated with a high mortality if the pH is low. If gastric fluid was buffered effectively, much higher volumes than previously thought, could be tolerated. Little work has in fact been undertaken on the relationship between pH and the volume that has to be inhaled to produce lethal results. In adults, the critical volume of fluid of pH less than 2.5 is accepted as 25 ml, but this value is that quoted by one group of workers who refer to preliminary unpublished work (Robert and Shirley, 1974).

It may, therefore, be concluded that efforts should continue, to increase the intragastric pH in obstetric patients, but the most effective and reliable method and most appropriate agents of doing this have yet to be found. It is important, however, that anaesthetists do not become complacent and believe that inhalation of gastric contents of high pH is a benign process, and therefore abandon methods of preventing regurgitated material from entering the lungs. The consequences of inhalation depend not only on the pH of the aspirate, but also on the amount and distribution within the lungs and the presence or absence of food, particulate matter and bacteria (Wynne and Modell, 1977). Schwartz and colleagues (1980) have shown that gastric contents at pH 5.9 can produce pulmonary changes that are as severe as those produced by hydrochloric acid at pH 1.8.

**Intragastric volume**

The factors affecting gastric emptying have been reviewed by Nimmo (1984), and it should be the aim of every anaesthetist to keep the stomach empty (Reynolds, 1983). In modern obstetric practice, prolonged labour is avoided and hence there is no longer any need to give fluids by mouth, as fluid requirements may be administered i.v.

Among the most potent factors delaying gastric emptying are opioid analgesics (Nimmo, Wilson and Prescott, 1975; Todd and Nimmo, 1983). The majority of instances of inhalation of gastric contents occur during induction of general anaesthesia for Caesarean section and it is
mentioned frequently in the Confidential Enquiries that labour was prolonged. It is these mothers who could well have received large doses of opioids. Repeated doses of opioids should be avoided in labouring women and other forms of analgesia should be made available. In the absence of mechanical obstruction, opioid analgesics are the major cause of delayed gastric emptying in the perioperative period, while regional analgesic techniques are without important effects (Nimmo, 1984). Holdsworth (1978) found the mean intragastric volume in labour to be 22 ml in those who had extradural analgesia, compared with 50 ml in those without.

It is no longer routine to empty the stomach before induction of general anaesthesia in obstetric patients. The exceptions would be those who have taken a recent meal or been in labour for many hours and have received several doses of an opioid analgesic. The various methods of emptying the stomach have been discussed by Morgan (1984).

**Prevention of inhalation of regurgitated material**

I.v. induction of anaesthesia is almost universal in obstetrics, so that active vomiting is not a problem. In all obstetric patients, induction must be accompanied by efforts to prevent any regurgitated material from entering the lungs. The danger period is the time from loss of consciousness until the airway is secured by a cuffed tracheal tube.

**Lower oesophageal sphincter (LOS) pressure.** One approach to the prevention of regurgitation is to increase the tone of the LOS. Metoclopramide has been shown to increase the sphincter pressure (Brock-Utne et al., 1976; Laitinen et al., 1978) and, apart from this drug and domperidone, most other drugs have a depressant effect on LOS tone, thereby facilitating any propensity to regurgitation (Cotton and Smith, 1984). However, atropine, which is frequently given i.v. at induction, consistently decreases LOS tone, but the effect is not evident until 3 min after administration (Cotton and Smith, 1981), when tracheal intubation would already have been performed. Furthermore, Skinner and Camp (1968) showed that, although atropine decreased the sphincter pressure, it did not increase the incidence of reflux, suggesting that pressure is not the only factor associated with reflux. This is in direct contrast to the findings of Fisher and colleagues (1977).

Conflicting results have also been reported of a combination of atropine and metoclopramide on LOS tone. Thus Brock-Utne and colleagues (1976) showed that a combination of metoclopramide 10 mg and atropine 0.6 mg i.v. given simultaneously produced no change in barrier pressure. However, Cotton and Smith (1981) showed that the effect of atropine predominated when the two drugs were given consecutively, irrespective of the order of administration.

It is very difficult to envisage that administration of a drug will result in such an increase in LOS pressure that it will prevent regurgitation at induction of anaesthesia. Reliance should not be placed on this method of preventing aspiration of gastric contents.

**Position at induction.** Goodrich (1979) has recommended that all anaesthetists should be proficient at induction of anaesthesia and tracheal intubation in the head-down, left-lateral position. This ensures that any regurgitated material cannot enter the lungs but, although acceptable as a general principle, it is not really a practical proposition in obstetrics because of the difficulties of turning and keeping a mother at term, attached to monitoring equipment, in this position. Induction in the lithotomy position should be avoided whenever possible, because the associated increase in intragastric pressure makes regurgitation more likely, but there are a few rare occasions, for example after-coming head of a breech, when it is necessary. Tracheal intubation under local analgesia is not a feasible technique for the majority of obstetric patients.

**Cricoid pressure.** Rosen (1981) pointed out that approaches to the subject of prevention of aspiration abound, but that the lynchpin of physical prevention is correct application of cricoid pressure. Despite the fact that it has been used in many hundreds of thousands of obstetric cases, in the literature there is only one record of failure of cricoid pressure (Whittington, Robinson and Thompson, 1979). There are, however, many reports of deaths after either failure to apply cricoid pressure or its release before passage of a cuffed tracheal tube. Enquiries of examination candidates, and observations of junior anaesthetic staff, nurses and operating department assistants indicate that the majority do not apply cricoid pressure in the recommended manner. The fault for this must lie with consultant staff for not teaching, and ensuring, the correct application of the technique.

The method of application of cricoid pressure as described by Sellick (1961) is shown in figures.
2 and 3. "Before induction the cricoid is palpated and lightly held between the thumb and second finger; as anaesthesia begins, pressure is exerted on the cricoid cartilage mainly by the index finger." He also stressed that the neck should be extended, bringing the cervical vertebrae forward so that it is easier to occlude the oesophagus by backward pressure on the cricoid. He showed radiologically that contrast media maintained at a pressure up to 94 cm H₂O could be prevented from passing beyond the point of application. Sellick showed not only that this method effectively prevented regurgitated material from entering the pharynx, but also that "During cricoid pressure the lungs may be ventilated by intermittent positive pressure without the risk of gastric distension."

Cricoid pressure must be applied before loss of consciousness and, although not comfortable, is well tolerated by the majority of patients. Recent work has shown that a force of 44 N is required to protect the majority of adults from regurgitation (Wraith, Chamney and Howells, 1983). The same group also showed that there was an unacceptably wide variation in performance of anaesthetists and paramedical personnel familiar with the manoeuvre, and that 47% failed to reach a force of 44 N (Howells et al., 1983). The importance of correct application of the simple and effective procedure of cricoid pressure and its maintenance until the trachea has been sealed by a cuffed tube cannot be overstressed.

Because fatalities do still occur as a result of incorrect application of cricoid pressure, Lawes and colleagues (1986) have designed an instrument to provide consistent and reproducible cricoid pressure at a force of 44 N. In the initial studies it was shown that the skill required to use the instrument was easily learned, but that it did increase the incidence of poor intubating conditions, mainly from distortion of the larynx. It is difficult to see how an instrument such as this is going to replace the simple manoeuvre of manually applied cricoid pressure.

Failed Tracheal Intubation
When the Confidential Enquiries commenced, tracheal intubation was rarely performed during obstetric anaesthesia. It was after the work of Hodges and colleagues (1959) that routine intubation after thiopentone and suxamethonium
became accepted practice. It was in the report for the years 1964–1966 (Report, 1969) that technical difficulties with tracheal intubation were first mentioned and it is noteworthy that, in those years, the percentage of true maternal deaths from anaesthesia more than doubled. This is probably the time at which the thiopentone–suxamethonium induction sequence came into widespread use. Inability to intubate the trachea in an apnoeic patient is a life-threatening situation that demands immediate skilled action. Since that time, difficulty with tracheal intubation has been increasingly implicated as a factor contributory to maternal deaths.

There is little doubt that it is more difficult to intubate the trachea in obstetric patients than in their non-obstetric counterparts. For the years 1979–1981 (Report, 1986), eight of 22 deaths were directly related to difficulties with tracheal intubation, whereas the report of Lunn and Mushin (1982) cited only four problems with tracheal intubation of 58 anaesthetic deaths in non-pregnant patients. There are a number of reasons for this. The mothers usually have full dentition and the thorax has been lifted into an unusual position by a wedge. Some degree of laryngeal oedema may be present, particularly in the presence of pre-eclamptic toxaemia (Brock-Utne, Downing and Seedat, 1977; Mackenzie, 1978). Incorrect application of cricoid pressure may distort and displace the larynx, while the presence of large breasts and a hand applying cricoid pressure may make introduction of a laryngoscope difficult. As a result, cricoid pressure may be released, with possible regurgitation and aspiration.

In the haste to pass a tracheal tube, attempts at laryngoscopy may be made too soon, before the suxamethonium has taken its full effect, and might have the effect of precipitating vomiting or regurgitation. Carmie, Street and Kumar (1986) found that junior anaesthetists attempted laryngoscopy much earlier in relation to the observed degree of neuromuscular blockade in obstetric patients (mean time 29.8 s) than in ordinary surgical patients (mean time 63.5 s). They proposed...
that the junior anaesthetists, who were unaware of the degree of blockade, were either reluctant to wait or found it difficult to judge complete blockade clinically. Objectively, it has been shown by Donlon, Ali and Savarese (1974) that, although conditions were not perfect, tracheal intubation could be achieved easily by relatively inexperienced anaesthetists once the twitch height of the adductor pollicis has been depressed by 95% of its control value. Blackburn and Morgan (1978) found that the mean time to this point in lightly anaesthetized patients following suxamethonium 1.0 mg kg\(^{-1}\) was 49.2 s (SEM 1.68). It is imperative that sufficient time be given for the suxamethonium to exert its full effect. To achieve rapid paralysis, a minimum of suxamethonium 100 mg should be given, preceded by atropine. Anaesthetists should be reminded that administration of a small dose of a competitive neuromuscular blocking drug before the depolarizing drug, in the hope of preventing the increase in intragastric pressure or reducing the incidence of muscle pains after operation, will antagonize the effect of the suxamethonium and make intubation more difficult.

The incidence of failed intubation in obstetric anaesthesia is not known, but Lyons (1985) quotes a figure of 1:300 over a 6-year period. This high incidence is almost certainly because a failed intubation drill is advocated early in the course of a difficult intubation in that unit (Lyons and MacDonald, 1985). However, Samsoon and Young (1987) have also reported a similar incidence of failure to intubate the trachea of obstetric patients, namely 1 in 280 over a 4-year period, compared with 1 in 2230 in surgical patients.

Cormack and Lehane (1984) have classified difficulty of intubation into four grades according to the view obtained at laryngoscopy. They suggested that the main cause of trouble was grade 3, in which the epiglottis can be seen, but not the cords. Such cases are quite rare, but they calculated that each anaesthetist would encounter this problem about four times before becoming a consultant, while about 2% can expect to become consultants without having met the situation. They suggest a method whereby the problem can be simulated in routine anaesthesia so that a drill for managing it can be practised. This is recommended to all anaesthetists.

It is not always possible to predict from usual clinical observations whether tracheal intubation will be difficult. Mallampati and colleagues (1985) have suggested a relatively simple sign to predict difficulty in tracheal intubation, which involves the ability to visualize the pillars of the fauces, soft palate and base of the uvula when the patient opens the mouth and protrudes the tongue maximally whilst in the sitting position. They found that the degree of difficulty in visualizing these three structures was an accurate predictor of the ease of direct laryngoscopy.

As difficult intubation is therefore a relatively common occurrence in obstetrics, it is imperative that equipment necessary to deal with the problem is always immediately at hand. Skilled assistance is also necessary. Not only must laryngoscope blades of different sizes be available, but also those where the angle between the blade and the handle allow for easier introduction to the mouth in appropriate circumstances—for example the polio blade and that described by Jellicoe and Harris (1984). A new angled laryngoscope has recently been described by Bellhouse, which can accommodate a prism if it is required for difficult intubations (Tunstall and Sheikh, 1986). As yet, there are no reports of experience with this instrument in the U.K.

Everyone who practises obstetric anaesthesia is going to meet a patient whose trachea cannot be intubated. Thus it is essential that, under these circumstances, a failed intubation drill is instituted which is understood by all labour ward staff. There can be no hard and fast rule as to what form this should take, as it depends on individual circumstances, but that suggested by Tunstall (1976) and Tunstall and Sheikh (1986) would form a sound basis. The most important factor in this situation with an apnoic patient is a prompt decision that a tracheal tube cannot be passed and that the lungs must be ventilated. Scott (1986) has stressed that patients do not die from failure to intubate; they die from failure to stop trying to intubate. The mother at term is utilizing oxygen at a greater rate than when not pregnant (Archer and Marx, 1974), and this will be compounded if cardiac output is reduced by an element of inferior vena cava occlusion. All anaesthetists must be capable of ventilating the lungs using a mask, airway and bag; correctly applied cricoid pressure will prevent inflation of the stomach during the procedure. The failed intubation drill should be practised and it is true to say that the first time this is used should not be the first time when it is essential.
If ventilation with a face mask is difficult, then deliberate passage of a tracheal tube or some form of specially designed tube into the oesophagus may allow the lungs to be ventilated until spontaneous breathing returns. Both have been described, with successful outcomes, following failed intubation in obstetrics (Boys, 1983; Tunstall and Geddes, 1984). Anaesthesia with spontaneous ventilation should continue using a volatile agent with which the anaesthetist is familiar and in a concentration which allows safe completion of surgery.

Oesophageal intubation. The other cause of death following difficult tracheal intubation is undiagnosed oesophageal intubation. The signs of the latter should be obvious, but this is not always so and experienced anaesthetists can be misled into believing that an incorrectly placed tube is in the trachea, even after the appearance of cyanosis (Howells and Reithmuller, 1980). They recommended that ventilation should be carried out with a mask over the open tube, when relief of cyanosis would indicate misplacement of the tube. Presence of carbon dioxide in the exhaled gas, however, is the only absolute diagnostic test of correct placement of a tracheal tube.

A high level of suspicion of oesophageal intubation should be borne in mind, remembering that pre-oxygenation will delay the onset of cyanosis, possibly until after delivery of the baby. Gray (1985) has surveyed serious anaesthetic accidents and concluded with six very simple maxims, the first of which is "when in doubt, take it out."

OTHER CAUSES OF DEATHS

By far the largest number of deaths occur during, or as a result of mishaps occurring at, the induction of general anaesthesia. Of the other deaths, attempts have been made to classify them into distinct groups.

Misuse of drugs

The two main groups of drugs involved are central sedatives and neuromuscular blockers. The effects of the former on ventilation, particularly when used in combination, are repeatedly stressed in the reports. Use of opioids with i.v. anaesthetics such as methohexitone, and often with a benzodiazepine, would appear to be relatively common for minor procedures such as termination of pregnancy. The situation is compounded by the use of opioid premedication. Benzodiazepines have little effect on ventilation in healthy adults, but potentiate the central effects of other sedatives. Such drug combinations are potent central depressants and the development of any element of ventilatory obstruction in a heavily sedated patient whose ventilation is already depressed can have disastrous consequences.

Inadequate antagonism of neuromuscular blockade is another aspect mentioned in the reports. Caesarean section is a relatively rapid procedure and antagonism of blocking drugs may be required quite soon after their administration, particularly as tracheal intubation has been achieved with the aid of suxamethonium. With the availability of shorter acting agents such as atracurium, the use of pancuronium and tubocurarine for Caesarean section must now be questioned. Initially, reversal of these drugs might appear clinically to be adequate, but this can be difficult to judge in a patient who is drowsy from the effects of an anaesthetic, which has probably included an opioid with its accompanying ventilatory depressant effects. With the considerable amount of stimulation that occurs at the end of surgery, the patient's tidal volume and colour might well appear adequate. However, on moving to the quieter environment of a possibly inadequately staffed recovery room or a general ward, the patient might lapse back into sleep. If there is any residual weakness from the effects of the blocking drug, muscle power could be inadequate to overcome any ventilatory obstruction, and death ensue. The only objective signs of adequate neuromuscular transmission are provided by a nerve stimulator, use of the train-of-four stimuli indicating adequate motor power even in the absence of a control response.

Frequent mention is made of the difficulty in identifying cyanosis in dark-skinned patients, whose deaths are often quoted as being associated with the above drugs. Great care must be taken when any ventilatory depressant drug is used in these patients. It is also pertinent to remember that hypoxia is a cause of restlessness, and after operation this must be excluded before administration of an opioid.

Several drugs used in anaesthesia have a tendency to cause bradycardia, including suxamethonium, fentanyl and halothane. Recent reports have linked the use of vecuronium to the development of bradyarrhythmias and even asystole (Kirkwood and Duckworth, 1983; Milligan...
This is most likely to occur in patients already at risk of bradycardia or during parasympathetic stimulation by peritoneal stretching. Routine use of atropine i.v. is, therefore, advocated during induction of anaesthesia for Caesarean section.

Ergometrine has been implicated in causing inhalation of vomitus in a patient during Caesarean section under extradural analgesia. The drug should not be used in this way i.v. in conscious patients because of the high incidence of nausea and vomiting.

Any death from misuse of drugs is avoidable. Basic anaesthetic training requires a detailed knowledge of pharmacology, complications of drug therapy and drug interactions, but obstetricians must also be aware of all the actions of the drugs that they use and, in particular, of the dangers of sedative drugs and the drug combinations mentioned above. Operator–anaesthetists, alluded to more than once in the enquiries, can only be condemned. A much wider question, of course, is why the person involved did act as operator–anaesthetist.

Extradural analgesia

Since extradural analgesia became popular in 1968, use of the technique has been associated with eight deaths. On two occasions, the extradural was performed by an obstetrician.

Extradural analgesia is associated with potentially lethal complications, the signs of which must be recognized by all who practise the technique. Constant monitoring of a mother in receipt of an extradural is mandatory. All attendants must be familiar with the symptoms, signs and management of hypotension, and the importance of avoiding aortocaval compression cannot be over-stressed. More difficult to recognize is the accidental intrathecal injection of local anaesthetic, particularly by those who do not regularly perform spinal anaesthesia. Similar remarks apply to the systemic toxic effects of local anaesthetics. It is therefore obvious that someone who is versed in the management of all these complications, and of cardiac arrest, must be immediately available to attend the labour ward at all times.

In fact, serious complications of extradural analgesia are rare, Crawford (1985) detailing only nine potentially life-threatening events in 27,000 extradurals provided for pain relief in labour. Corresponding figures are not available for Caesarean section under extradural analgesia. As most of the anaesthetic–related maternal mortality is associated with general anaesthesia for Caesarean section, it is not surprising that a change to extradural anaesthesia has been advocated. Davis (1982) suggested that the general anaesthetic rate for Caesarean section could be reduced to as little as 22% by making maximum use of extradurals. Corall (1982) however, queried if adoption of this policy would reduce maternal mortality, as the problems of induction of general anaesthesia would be replaced by the equally potentially serious, although different, ones of the extradural analgesia. There can be little doubt that increasing use has been made of regional anaesthesia for Caesarean section in the past 10 years, but it is too early yet to comment on whether or not this has resulted in a reduction in maternal mortality. It is heartening to know that in the last enquiry, covering the years 1979–1981, there were no deaths associated with extradural analgesia. Anaesthetists should not lose sight of the fact, however, that general anaesthesia will always be required for some Caesarean sections, and they must strive to maintain high standards.

It should also not be forgotten that, with the improvement in resuscitation services, some mothers who have had life-threatening complications have been resuscitated and have survived with extremely serious complications. Morbidity is outside the scope of the Confidential Enquiries.

Misuse of apparatus

Occasional deaths still occur from accidents with anaesthetic apparatus. Despite the fact that familiarity with apparatus and methods of checking its correct function are repeatedly stressed during training and represent frequent questions in examinations, it is evident that such advice is sometimes ignored. There is no need for sophisticated ventilators in a delivery suite, or for complicated alarm systems. All that is required is that the anaesthetist devotes all his attention to the mother and makes simple observations of her heart rate, arterial pressure and colour. Continuous display of the ECG should be a mandatory feature of all anaesthetics and the arguments for a capnograph on all labour wards are strong.

A responsible person should be designated to check all anaesthetic and related equipment daily and to ensure that spares are available for such items as tracheal tubes, laryngoscope bulks and batteries, etc. Regular servicing is essential.
ASSOCIATED FEATURES

The foregoing has concentrated on the causes of maternal death that can be gleaned from the triennial enquiries, but there are a number of other factors that have a bearing on anaesthetic-related maternal deaths.

Experience of the anaesthetist

The most important single factor associated with anaesthetic mortality is the experience of the anaesthetist in obstetric anaesthesia, which does not necessarily equate with status. In many instances the assessor is moved to comment that the skill and knowledge of the anaesthetist were inadequate for the task in hand. This is illustrated in the most recent report, in which it was obvious that the serious anaesthetic problems presented by patients with kyphoscoliosis were not familiar to the anaesthetist. Not only is an experienced anaesthetist more likely to anticipate potential problems, but (s)he would also be more likely to insist on appropriate equipment and help and correct resuscitation of the mother, where necessary, before starting the anaesthetic.

The importance of the experience of the anaesthetist is attested by reports from two large obstetric units. Morgan (1980) reported that anaesthesia was the commonest cause of death over a 20-year period, all the anaesthetics being given by junior staff with varying degrees of experience. This contrasts to the report of Breheny and McCarthy (1982) that, over a similar period, anaesthesia contributed to only two maternal deaths in high-risk mothers, the vast majority of the anaesthetics being given by consultants. It is the recommendation of the Obstetric Anaesthetists' Association that no one should give an anaesthetic unsupervised on the labour ward until they have had at least 1 year's experience.

There is also some indirect evidence to support the fact that obstetric anaesthetics should be given by experienced personnel. Maternal mortality in England and Wales in 1982 was 7 per 100000 live births, compared with 18 in Japan (Rosen and Fujimara, 1985). The prevalence of obstetricians and paediatricians is similar in the two countries, but that for anaesthetists is five times less in Japan. Although the maternal anaesthetic mortality rate is not known in Japan, it is known that 50% of anaesthetics for Caesarean sections in district general hospitals are given by obstetricians.

Haemorrhage

This is not an anaesthetic cause of death, but the anaesthetist is in the ideal position to cope with the problem. Any anaesthetist should be able to recognize the presence of hypovolaemia and be adept at central venous pressure monitoring and its interpretation. A drill is necessary for the management of severe haemorrhage, which should include the provision of additional staff to help with the emergency. Blood and blood substitutes must be readily available and help from a haematologist is required when disorders of coagulation are suspected and to resolve problems resulting from replacement of the circulating volume. Guidelines have been documented for the management of major obstetric haemorrhage (Report, 1986).

Administrative responsibility

Form MCW 97 has now been modified so as to obtain information regarding any administrative failures that have resulted in substandard care and, ultimately, maternal death. That anaesthetic services are giving cause for concern is highlighted by a recent survey in the Yorkshire region (MacDonald and Webster, 1986). This showed that a 24-h extradural service was available in only nine of 19 consultant units, and that in approximately seven units, mothers may have to wait up to 30 min for an anaesthetist to be available for an obstetric emergency. The authors point out the serious implications of lack of cover at consultant level; junior anaesthetists will not receive adequate training in obstetric anaesthesia, and neither midwives nor obstetricians will be educated to appreciate the benefits of modern obstetric anaesthesia.

This survey provoked an editorial on the subject (Reynolds, 1986). She has pointed out that similar problems exist in other regions and that obstetric anaesthesia may be occasional, unpredictable, urgent and difficult.

The existence of isolated maternity units without full back-up facilities and often without an experienced anaesthetist on site at all times can only be condemned, and every effort must be made to close such units, despite public opinion to the contrary. The small unit remains a liability (Reynolds, 1986). In addition to being responsible for the supply and maintenance of equipment and for all other facilities such as operating theatres and recovery rooms, the hospital authorities are responsible for ensuring that these specialist
rooms are adequately staffed by appropriately trained personnel. Trained help for the anaesthetist must be available in all units, but is frequently absent (Mehta, 1981).

The second report from the Social Services Committee (Report, 1980) recommends that “health authorities should make every effort to provide an anaesthetic service that is available within a few minutes of receiving a call for all consultant obstetric units.” The authorities are indeed being slow to implement these recommendations. Clearly, it is the responsibility of consultant anaesthetists to ensure that adequately trained anaesthetists are rostered to be immediately available for obstetric anaesthesia, but it is the health authorities’ responsibility to ensure that such staff are available, with sufficient consultants to train them.

Obstetricians’ responsibilities

Liaison between obstetricians and their anaesthetic colleagues has been criticized in more than one report. The main problem lies in the failure of obstetricians to give the anaesthetist appropriate time for adequate preoperative assessment. Sufficient time will allow institution of appropriate preventative measures in patients with pre-existing medical conditions. Such patients have often been in hospital for some time, and indeed the author was once given 30 minutes’ notice of an impending Caesarean section in a patient with a prolonged Q-T syndrome who had been in hospital for the previous 16 weeks. There can be no excuse for lack of consultation concerning these patients, and failure to do so has contributed to maternal deaths.

Again, there is evidence of obstetricians imposing their will on junior anaesthetists to anaesthetize urgently patients having problems with which the junior staff were manifestly ill-equipped to deal in terms of knowledge, skill and experience. Nowadays, senior help is invariably available and early consultation will ensure the presence of a more experienced anaesthetist. It is to be hoped that such comments will disappear from the reports.

CONCLUSIONS

During the 30-year period so far covered by the Confidential Enquiries, maternal mortality has decreased by more than 90%, from 98.9 to 8.9 per 100000 total births, roughly halving in each decade. From table I, however, it would appear that no such reduction is occurring in deaths from anaesthesia, the percentage of true maternal deaths having gradually increased since 1952, although there has been a small decrease in the last reported triennium. At the moment, deaths from anaesthesia comprise 9.0 per million maternities or 12.2% of direct maternal deaths. Anaesthesia is the third commonest cause of death after hypertensive disease and pulmonary embolism. Such an outlook, however, is misleading, as what should be examined is the number of anaesthetic deaths in relation to the number of anaesthetics given, which includes extradural analgesia for pain relief. Such figures are not available, but it can be stated that there has been a marked increase in anaesthetic interventions in the past 10–15 years. Extradural analgesia became popular only in 1968. There were 1.4 million legal abortions, each requiring an anaesthetic, between 1968 and 1981, while the number of Caesarean sections has increased from 103 310 in 1970–1972 to 157 850 in 1979–1981. The actual number of deaths from anaesthesia has gradually decreased from 1970–72 to 1978–81. Using number of anaesthetics given as the denominator, there has been an enormous reduction in anaesthetic-related maternal mortality.

In 1970, Crawford drew attention to the anaesthetist’s contribution to maternal mortality, basing his comments on the report for the years 1964–66 (Report, 1969). He concluded that the major share of the blame must lie with consultant anaesthetists for failing to ensure that appropriate standards were maintained. That his views have been heeded is indicated by the reduction in mortality that has been achieved.

The number of deaths is now very small and, under these circumstances, it is difficult to devise effective indices of quality control (Adams, 1983). Nevertheless, deaths still occur and it has been pointed out that a surprisingly common feature of mortality studies is that mishaps seem to occur, not from lack of knowledge, but rather from failure to apply such knowledge, from inattention or even from carelessness (Adams, 1983).

Lord Platt stated, in his 1967 Harveian oration “In the enthusiasm for teaching principles, the fact that much of medicine depends on the acquisition of technique is sometimes overlooked. Technique can be critical when academic knowledge is useless.” These views are echoed by Dykes (1980) who stated “...current evidence,
including that accumulating in our speciality, supports the importance of shifting from a knowledge-based to a performance-based educational and assessment system.‖ In other words “It is sheer lack of skill that kills” (Rosen, 1984).

REFERENCES


ANAESTHETIC CONTRIBUTION TO MATERNAL MORTALITY


