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SPECIAL ARTICLE

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Failed tracheal intubation during obstetric general anaesthesia: a literature review

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ABSTRACT

We reviewed the literature on obstetric failed tracheal intubation from 1970 onwards. The incidence remained unchanged over the period at 2.6 (95% CI 2.0 to 3.2) per 1000 anaesthetics (1 in 390) for obstetric general anaesthesia and 2.3 (95% CI 1.7 to 2.9) per 1000 general anaesthetics (1 in 443) for caesarean section. Maternal mortality from failed intubation was 2.3 (95% CI 0.3 to 8.2) per 100 000 general anaesthetics for caesarean section (one death per 90 failed intubations). Maternal deaths occurred from aspiration or hypoxaemia secondary to airway obstruction or oesophageal intubation. There were 3.4 (95% CI 0.7 to 9.9) front-of-neck airway access procedures (surgical airway) per 100 000 general anaesthetics for caesarean section (one procedure per 60 failed intubations), usually carried out as a late rescue attempt with poor maternal outcomes. Before the late 1990s, most cases were awakened after failed intubation; since the late 1990s, general anaesthesia has been continued in the majority of cases. When general anaesthesia was continued, a laryngeal mask was usually used but with a trend towards use of a second-generation supraglottic airway device. A prospective study of obstetric general anaesthesia found that transient maternal hypoxaemia occurred in over two-thirds of cases of failed intubation, usually without sequelae. Pulmonary aspiration occurred in 8% but the rate of maternal intensive care unit admission after failed intubation was the same as that after uneventful general anaesthesia. Poor neonatal outcomes were often associated with preoperative fetal compromise, although failed intubation and lowest maternal oxygen saturation were independent predictors of neonatal intensive care unit admission.

Keywords: Obstetric anaesthesia; General anaesthesia; Failed intubation

Introduction

The first failed tracheal intubation guideline was developed by Michael Tunstall at Aberdeen Maternity Hospital in the 1970s.[1] Versions of this original guideline for obstetric anaesthesia spread through local adaptation, and simplified guidelines were also applied to non-obstetric cases. The American Society of Anesthesiologists produced an official national guideline on management of the difficult airway in 1992 (last updated in 2013)[2] and the Difficult Airway Society (DAS) produced an equivalent for the UK in 2004.[3] These and other non-obstetric guidelines do not address the problem that surgery (especially for caesarean section) is often performed to ensure the wellbeing of a different individual to the patient, furthermore, an individual who has no individual legal status before birth. On the other hand, developments in obstetric anaesthetic practice that have had an impact on modifications of Tunstall's guideline include the laryngeal mask and other supraglottic airway devices (SAD), antacid and oral intake protocols during labour, infrequent use of orogastric tubes for stomach emptying, rapid onset non-depolarising neuromuscular blocking drugs and rapid neuromuscular reversal agents. The patient population has changed with a growing prevalence of obesity. Finally, as the use of neuraxial anaesthesia for caesarean section has increased, up to one third of obstetric general anaesthetics are now administered after failed neuraxial anaesthesia.[4,5]

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The Obstetric Anaesthetists' Association (OAA) and DAS are producing stand-alone obstetric failed intubation guidelines to address the deficit in the DAS 2004 guidelines with respect to obstetric practice. The aim of this review was to search the relevant literature for evidence to support these guidelines, especially with regard to numerical information, management options and maternal and neonatal outcomes.

Methods

We performed an electronic literature search on Medline, Embase, PubMed and National Guidelines Clearinghouse from 1970 to the present. The search terms were: intubation, difficult airway, obstetric, airway problem, cricothyroidotomy, laryngeal mask airway, Proseal, Supreme, video laryngoscope, airway assessment, Mallampati, thyromental distance, physiology of airway in pregnancy, failed intubation, cricoid pressure, rapid-sequence induction, pregnant woman, general anaesthesia. We considered all sources including abstracts and correspondence, with no language restrictions. The resulting list was searched manually for relevant articles. Where appropriate, authors were contacted directly for details of management.

The incidence of failed intubation was calculated when the number of cases as well as the denominator of all obstetric general anaesthetics during a defined time period were reported. When the information was available, the proportion of cases where anaesthesia was continued after failed intubation, as opposed to the patient being awakened, was calculated. This process was repeated for publications where there was information available on case urgency.

For the purposes of analysis the middle year of the range was taken as representative of the data collection period pertaining to each report. Data were analysed using random effects meta-analysis with the Cochran Q statistic for heterogeneity and Clopper-Pearson exact 95% confidence intervals (CI). Forest plots are used to show the data and effect sizes are presented as proportion, odds ratio (OR) and incidence with 95% CI. Trends in proportions and OR over time were analysed using the chi-square trend test, trend in $\log_e$ (OR) and non-linear curve fitting. The software used included Prism 6.0 (GraphPad Software Inc., La Jolla, CA, USA), StatsDirect 2.8.0 (StatsDirect Ltd., Altrincham, UK) and Number Cruncher Statistical Systems 9.0 (NCSS Inc., Kaysville, UT, USA). A P value <0.05 (two-sided) was used to define statistical significance.

We identified reports of the management of single or multiple cases. Cases were also identified from publications that collect and analyse adverse outcomes in maternity care. These included prospective national or regional registry-based outcome collection, an example being the UK Confidential Enquiries into Maternal Deaths (CEMD). Other sources used included closed claims analyses from the USA and UK, anaesthetic critical incident reporting and publications reporting admissions to intensive care units (ICU). Information was abstracted when the paper contained enough detail to allow evaluation of individual cases.

Results

Definition

The definition of failed intubation is not standard. The lowest threshold for qualification is "*intubation that was not accomplished with a single dose of succinylcholine*".[6–8] McKeen et al. defined it as "*unsuccessful attempts at placement of an endotracheal tube into the trachea using either direct laryngoscopy or alternative intubating equipment, the need to proceed with surgery with a non-elective unsecured airway (e.g. bag-mask ventilation or laryngeal mask airway), or the need to abort intubation or surgery and awaken the woman prior to surgery*".[9] At the other end of the spectrum is "*inability to intubate during general anaesthesia*".[10]

Incidence of obstetric failed intubation

We found 33 sources providing an incidence for failed intubation at obstetric general anaesthesia, comprising 20 full journal publications, nine abstracts, three databases and one letter (Table 1).[4,7–9,11–40] Although there was a total of 142 560 women reported or estimated in the reports, it is not possible to exclude overlaps, replicate counting and estimation errors in the sources. As expected there was significant heterogeneity in reported incidences and effect sizes. Because of the use of differing definitions of failed intubation, we re-analysed the number of cases, based on the definition by McKeen et al, in order to provide more comparability between series.[9] There were 372 cases of failed intubation, giving an overall incidence for all obstetric cases of 2.6 (95% CI 2.0 to 3.2) per 1000 general anaesthetics (1 in 390).

There were 27 sources with data on failed intubation at caesarean section totalling 88 186 cases. The incidence of failed intubation ranged from zero to 1 in 98 in individual sources. There were 181 cases of failed intubation, giving an overall incidence of 2.3 (95% CI 1.7 to 2.9) per 1000 general anaesthetics for caesarean section (1 in 443; Fig. 1). There were two deaths reported in this number,[13,15] giving an incidence of 2.3 (95% CI 0.3 to 8.2) per 100 000 general anaesthetics for caesarean section (one death per 90 failed intubations). There were three cases reported from these sources where a front-of-neck airway access procedure (surgical airway) was attempted (see below),[7,15,29] giving an incidence of 3.4 (95% CI 0.7 to 9.9) per 100 000 general anaesthetics for caesarean section (one procedure per 60 failed intubations).

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Table 1 Case series providing incidence of obstetric failed tracheal intubation and management of cases at caesarean section

First author, year	Data collection	Centre	RSI GA; number	Failed intubations	Rate	Management at caesarean section
Lyons 1985[11]	1978–1983	Single	CS 2331	8	1 in 291	Awakened 8 (epidural 7, vaginal delivery 1) Continued 0
Samsoon 1987[12]	1982–1985	Single	Obs 1980	7	1 in 283	NR
Glassenberg 1990[13]	1980–1989	Single	CS 2142	6	1 in 357	Awakened 0 Continued 6 (FOI 2; blind nasal intubation 4). 1 death
Rocke 1992[14]	~1991	Single	CS 1500	2	1 in 750	Awakened 1 (epidural 1) Continued 1 (TT)
Hawthorne 1996[7]	1984–1994	Single	CS 3471	15	1 in 231	Awakened 10 (spinal 4, epidural 2, CSE 4) Continued 6 (TT 2, laryngeal mask 3, small-bore front-of-neck 1)
Tsen 1998[15]	1990–1995	Single	CS 536	1	1 in 536	1 front-of-neck; died
Shibli 2000[16]	1997	Multi (120)	CS 13 275	15	1 in 885	Awakened 10 (spinal 8, epidural 2) Continued 5 (TT 1, laryngeal mask 3, mask 1)
Barnardo 2000[8]	1993–1998	Multi (14)	Obs 8970	36 (CS 23)	1 in 249	Awakened 11 (spinal 9, epidural 2) Continued 12 (TT 6, laryngeal mask 3, mask 2)
Kan 2004[17]	2002–2003	Single	CS 732	0	0	NR
Rahman 2005[18]	1999–2003	Multi (12)	Obs 4768	20 (CS 13)	1 in 238	Awakened 1 (spinal 1) Continued 12 (TT 7, laryngeal mask 5)
Saravanakumar 2005[19]	1988–2004	Single	CS 5968	11	1 in 543	NR
Bloom 2005[4]	1999–2000	Multi (13)	CS 2527	2	1 in 1264	1 death (elective awake intubation, not RSI)
Bailey 2005[20]	~1998–2004	Multi (6)	NR	9	–	Awakened 0 Continued 9 (laryngeal mask 9)
Nze, 2006[21]	1993–2002	Single	CS 3710	14	1 in 265	Awakened 2 (spinal 2) Continued 12 (TT 3, mask 9)
McDonnell 2008[22]	2005–2006	Multi (13)	CS 1095	4	1 in 274	Awakened 1 (neuraxial anaesthesia 1) Continued 3 (laryngeal mask 1, LMA ProSeal® 2)
Bullough 2009[23]	2003–2004	Multi (187)	Obs 19 762	64	1 in 309	NR
Djabatey 2009[24]	2000–2007	Single	Obs 3430; CS 2960	0	0	NR
Pujic 2009[25]	2008	Single	CS 1196	3	1 in 399	NR
NOAD[26]	2009	Multiple (>120)	CS 10 283	18	1 in 571	NR
Kessack 2010[27]	2005–2008	Single	Obs 219; CS 180	2 (CS 1)	Obs 1 in 219 CS 1 in 180	Awakened 0 Continued 1 (laryngeal mask 1)

(*continued on next page*)

Table 1 (*continued*)

First author, year	Data collection	Centre	RSI GA; number	Failed intubations	Rate	Management at caesarean section
NOAD[26]	2010	Multiple (>100)	CS 8719	18	1 in 484	NR
Ajmal 2011[28]	1991–1999	Single	CS 2114	2[a]	1 in 211	NR
McKeen 2011[9]	1984–2003	Single	Obs 2633; CS 1005	2 (CS 0)	Obs 1 in 1317 CS 0	NR
Palanisamy 2011[29]	2000–2005	Single	CS 98	1[a]	1 in 98	Awakened 0 Continued 1 (surgical front-of-neck 1)
Keen 2011[30]	2009–2010	Single	CS 154	1	1 in 154	NR
NOAD[26]	2011	Multiple (>140)	CS 11 278	20	1 in 564	NR
Kirodian 2012[31]	2006–2011	Single	CS 708	6	1 in 118	Awakened 3 (spinal 2, awake FOI 1) Continued 3 (LMA Supreme® 3)
Teoh 2012[32]	2004–2011	Single	Obs 5065; CS 2772	12 (CS 6)	Obs 1 in 844 CS 1 in 462	Awakened 1 (spinal 1) Continued 5 (LMA ProSeal® 5)
Quinn 2013[33]	2008–2010	Multi (216)	Obs 12 800	57	1 in 224	Awakened 3 (spinal 2, local anaesthetic and sedation 1); Continued 52 (TT 6, SAD 43, mask 2, surgical front-of-neck 1)
Tao 2012[34]	2001–2006	Single	Obs 2158; CS 1636	10[a]; (CS 4[a])	Obs 1 in 359 CS 1 in 409	Awakened 0 Continued 4 (LMA Fastrach® 2, FOI via LMA Fastrach® 2)
Madsen 2013[35]	2008–2011	Multiple	CS 1969	12	1 in 164	NR
Dodds, 2013 (unpublished)	2013	Single	NR	4	–	Continued 2 (TT 2)
Davies 2014[36]	2008–2012	Single	Obs 1172	2 (3[a])	1 in 391	Awakened 0 Continued 3 (TT after delivery 1, laryngeal mask 2)
D'Angelo 2014[37]	2004–2009	Multiple (30)	CS 5332	10	1 in 533	NR
Nafisi 2014[38]	2007–2009	Multiple (2)	CS 465	1	1 in 465	NR
Swales 2014[39]	2013	Multi (144)	NR	55	–	Awakened 13 Continued 28
Thomas 2014[40]	2009–2013	Single	NR	10	–	Awakened 1 (spinal 1) Continued 9 (TT 8, LMA ProSeal® 1)

RSI: rapid sequence induction; GA: general anaesthesia; CS: caesarean section; Obs: obstetric; NR: not reported; FOI: fibreoptic intubation; TT: tracheal tube; LMA: Laryngeal Mask Airway; NOAD: National Obstetric Anaesthesia Database; SAD: supraglottic airway device.

[a]Failed intubation numbers adjusted based on redefinition (see text).

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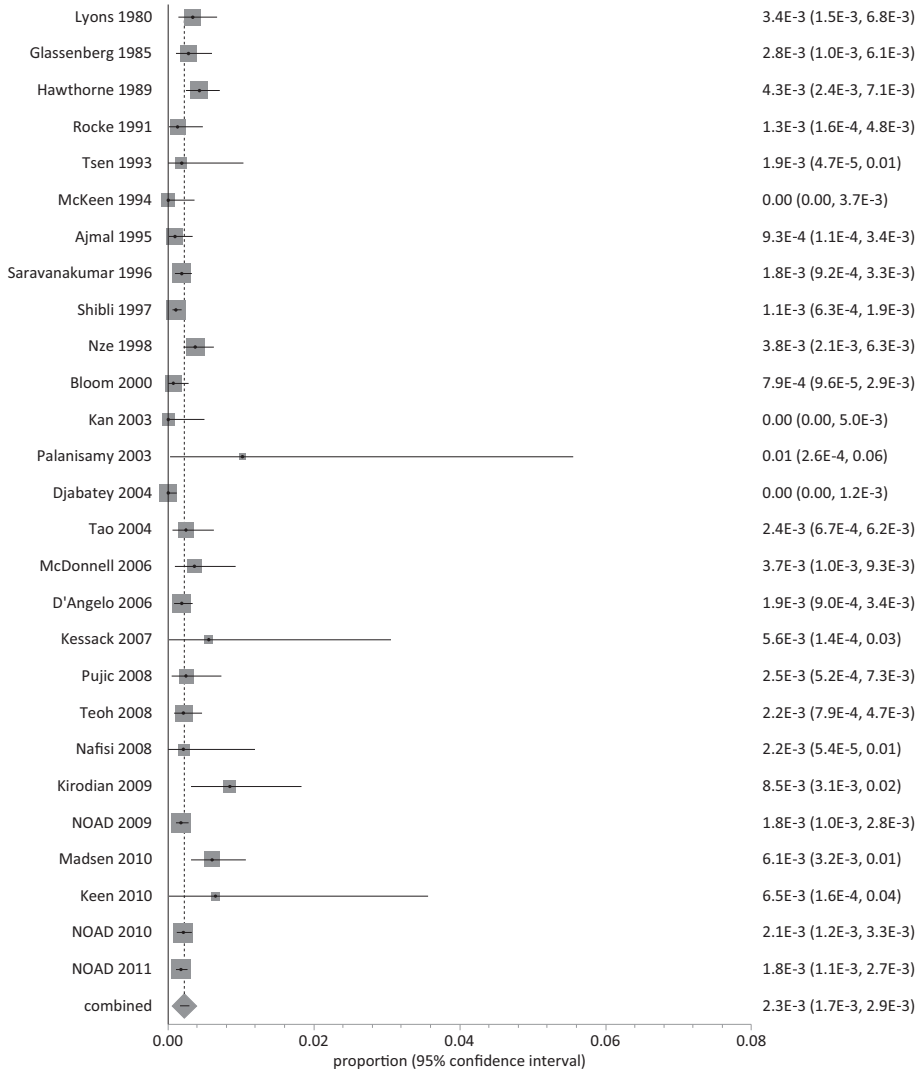

Fig. 1 Proportion meta-analysis plot (random effects) for incidence of failed tracheal intubation during caesarean section. Authors cited in Table 1; year=middle year of data collection. Error bars=95% confidence interval; diamond=summary statistic. E='×10 to the power of'

Management after failed intubation at caesarean section — awaken or continue general anaesthesia?

Information about whether general anaesthesia was continued or the patient awakened after failed intubation at caesarean section was not always available but was elicited from the published version or from the authors of 20 reports (Table 1). General anaesthesia was continued in 73.3% (95% CI 59.6 to 85.1) of all cases (Fig. 2). There was marked heterogeneity in the data over time so data were pooled in consecutive 5-year epochs for trend analysis. Overall there was a significant 1.8% per year (95% CI 1.1 to 2.4, P <0.0001) increase in the proportion of continuing general anaesthesia over the study period (Fig. 3).

Sixteen incidence studies included details of management as above, together with information on whether cases were emergency or elective. Ten of these were suitable for meta-analysis. Overall, there was no significant difference in the proportion of cases where general anaesthesia was continued during emergency compared with elective caesarean section (OR 1.5, 95% CI 0.60 to 4.22, P=0.35). However, there was a significant increasing trend over time (P =0.021) for general anaesthesia to be continued in emergency compared with elective cases (Fig. 4).

Nine series included data on category 1[41,42] cases. Data from one centre collected between 1978 and 1994 show nine category 1 cases of which two (22%) continued with general anaesthesia. Data from eight series from 2004 onwards include 46 cases of which 43 (93%) were continued (P <0.0001). These proportions were similar for category 1 cases where the indication for caesarean section was fetal compromise. In the period

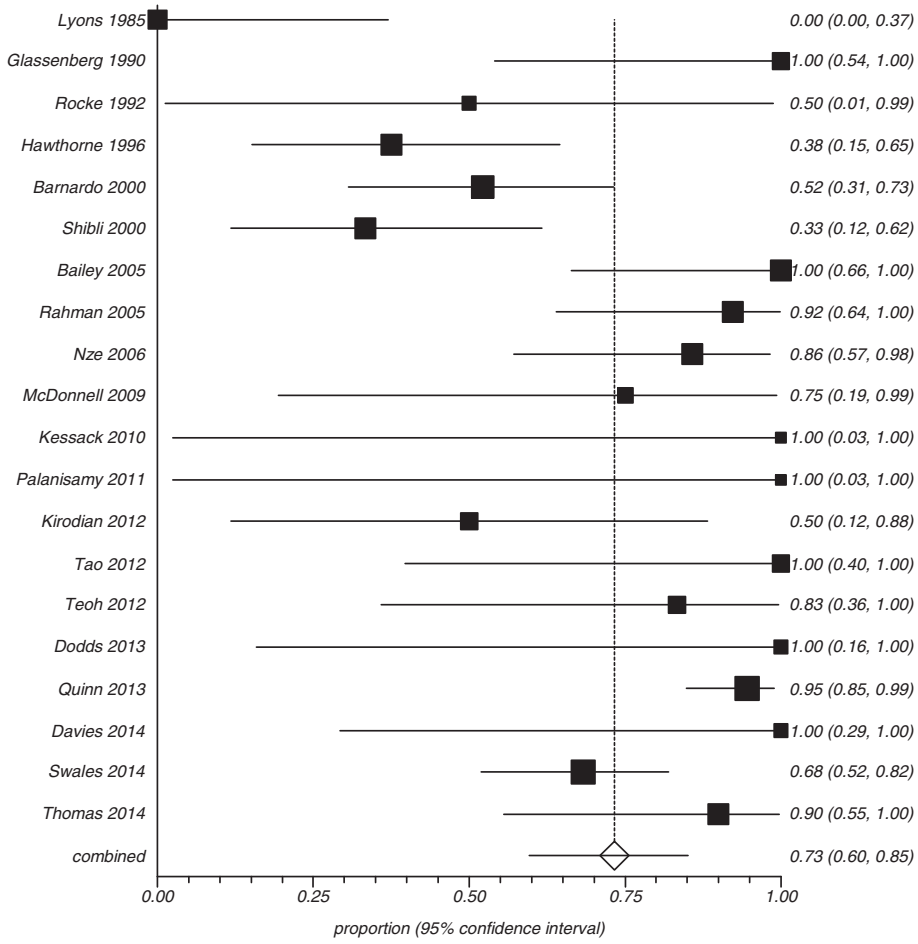

Fig. 2 Proportion meta-analysis plot (random effects) for continuation of general anaesthesia after failed tracheal intubation during caesarean section. Authors cited in Table 1; year=year of publication. Error bars=95% confidence interval; diamond=summary statistic

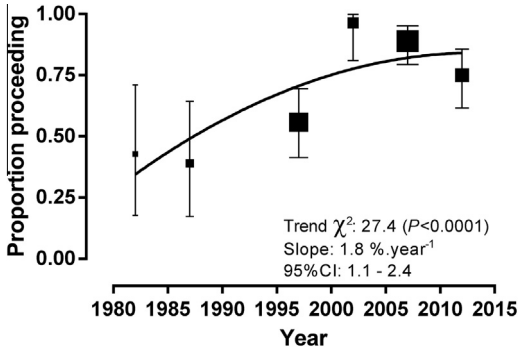

Fig. 3 Graph of proportion of cases in which general anaesthesia was continued after failed tracheal intubation at caesarean section; reports pooled into 5-year epochs. Error bars=95% confidence interval

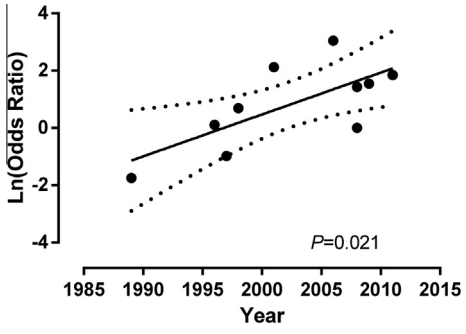

Fig. 4 Ratio of 'proportion of general anaesthesia continued after failed tracheal intubation at emergency caesarean section'/'proportion of general anaesthesia continued after failed tracheal intubation at elective caesarean', plotted by year of publication. Dotted lines=95% confidence interval

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1978–1994 there were six cases of which one (17%) was continued, and in the period from 2004 onwards there were 33 cases of which 30 (91%) were continued (P=0.0003).

Airway management

Appendix A (online only) gives details of management in case reports focussing on the airway device used after failed intubation at rapid-sequence induction of general anaesthesia for caesarean section.[43–85] The vast majority of cases were emergencies. Difficulty with intubation was not anticipated in two-thirds of those where an airway assessment was reported. There was a preponderance of non-consultant anaesthetists involved in the initial event. Suxamethonium was the only neuromuscular blocker used at induction of anaesthesia. The laryngoscopic view was usually Cormack and Lehane grade 3 or 4,[43] and the number of intubation attempts limited to two or three. Cricoid pressure was usually continued if not impairing ventilation. If mask ventilation was difficult, release of cricoid pressure did not affect this, but was also not associated with regurgitation upon release. Over time, there was a trend for reports to describe continuation of anaesthesia rather than awakening, and a move from facemask to laryngeal mask to second generation SAD.

History and airway assessment

A history of difficult or failed intubation was available in some cases.[40,48,49] In two of these, airway assessment was normal but a large epiglottis and anterior larynx[40] and large tonsils and oedematous pharyngeal tissues[49] impaired the view of the larynx. Preoperative airway examination is insensitive, as difficult intubation has been unanticipated in a half to two-thirds of cases.[7,32] The United Kingdom Obstetric Surveillance System (UKOSS) study on failed obstetric intubation found that Mallampati class was a univariate but not an independent predictor of failed intubation.[33] However, documentation of airway assessment was present in 60% of failed intubation cases and was an independent predictor of failed intubation. It is likely that the anaesthetic problem may have influenced subsequent recording of the airway assessment.[33] In other failed intubation series, an airway assessment was recorded from "less than half" of 26,[8] and six of 14,[24] down to none of 11 cases.[35] In some cases of anticipated difficulty, alternative equipment was made available,[86] or ear, nose and throat surgeons were on standby to perform a tracheostomy.[29,70]

Laryngoscopy, intubation and extubation

Specific causes for poor laryngoscopic view include skeletal abnormalities,[86] soft tissue anomalies (laryngeal oedema,[85] enlarged tonsils[49]) and neck haematoma.[87–89] However, the majority are "normal variations".[11] Barnardo and Jenkins recorded Cormack and Lehane grades of 1, 2, 3 and 4 in one, two, eight and six cases, respectively.[8] The causes for difficulty with intubation in spite of a good view of the glottis include excessive cricoid pressure,[31] technical problems with railroading the tracheal tube over an introducer or bougie,[31] or subglottic stenosis.[74] A deterioration in laryngoscopic view has been noted when reintubation was performed at the end of a case. Stridor[78] and 'can't intubate, can't oxygenate' (CICO)[90] have followed extubation after an earlier difficult intubation, in the latter case, mandating front-of-neck airway access (see below). An airway exchange technique has recently been used at extubation following difficult intubation at caesarean section.[91]

Supraglottic airway device

The laryngeal mask is the rescue device with the most extensive track record. The first descriptions recorded successful use, but these were soon followed by failures. The reason for failure to ventilate the lungs after insertion was rarely defined, although in one case it was related to laryngospasm relieved by a neuromuscular blocker.[62] Cricoid pressure was usually continued during surgery. Aspiration of gastric contents into the airway has been noted in one case of laryngeal mask use, with no mention of cricoid pressure application (F. Dodds, personal communication). The laryngeal mask has been used to provide a conduit for intubation after delivery.[61]

The use of second generation SADs has been described on a number of occasions. A bougie-guided technique has been used to aid correct placement of the LMA ProSeal®. †,[73] In most cases where a SAD with drain tube was used, a gastric tube was placed to decompress the stomach. In one case pulmonary aspiration occurred when a LMA Supreme® was positioned incorrectly, with no sequelae.[31] In the UKOSS study of obstetric failed intubations spanning 2008–2010, the LMA Classic® was used in 39, LMA ProSeal® in three, LMA Fastrach® in four and an i-gel® in three cases.[33] A UK national survey of failed intubation at caesarean section in 2013–2014 found that a laryngeal mask was used in 12 failed intubation cases and a second-generation SAD in 18; there was one failure of a second-generation device.[39]

'Can't intubate, can't oxygenate' and front-of-neck airway access procedure

The reported incidence of CICO at failed intubation during general anaesthesia for caesarean section ranges from 1 in 20 (5 per 100) to 5 in 18 (28 per 100).[7,26,35] Fixed (anatomical) causes of failed ventilation include high body mass index (BMI),[68] overgrown tonsils[49] and neck haematoma,[87–89] whereas

†LMA is a registered trade mark of The Laryngeal Mask Company Ltd, an affiliate of Teleflex Incorporated.

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laryngospasm may cause a fluctuating degree of upper airway obstruction.[62] We identified 13 cases of front-of-neck access procedures after failed intubation at induction of general anaesthesia for caesarean section, as well as one at extubation and one after an abandoned caesarean section (Table 2).[7,15,29,33,48,49,64,88,90,92–94] Six cases ended in maternal death and significant complications were reported in another that survived. There were eight cases of primary surgical tracheostomy and two performed after the failure of cricothyroidotomy. Four of 13 rescue cases followed failure to establish an airway using a laryngeal mask. Another front-of-neck procedure was performed in a non-surgical situation. A woman with placental abruption and coagulopathy suffered carotid artery puncture during attempts to site a central venous catheter. She developed complete airway obstruction and respiratory arrest. Front-of-neck airway access was gained with a 14-gauge cannula and trans-tracheal jet ventilation was performed for 10 min. A second attempt at intubation using a bougie was successful.[87]

Maintaining general anaesthesia after failed intubation

In recent UK practice, facemask anaesthesia has only been continued after failed laryngeal mask attempts.[40] There were no reports of regurgitation or pulmonary aspiration during or at the end of established facemask anaesthesia after failed intubation. Swales et al. noted that, in 28 women who had anaesthesia continued after failed intubation, 10 breathed spontaneously, eight had positive pressure ventilation without and 10 had positive pressure ventilation with additional non-depolarising neuromuscular blocker after an initial dose of suxamethonium.[39] All but one case had anaesthesia continued with an inhalational agent. Nitrous oxide and halothane were the usual agents in early case reports but current practice shows a 2:1 distribution between sevoflurane and isoflurane,[39] similar to routine general anaesthesia for caesarean section.[95]

Management after waking

There were 51 cases who were awakened after failed intubation (Table 1). These were usually managed with neuraxial anaesthesia for surgery (spinal n=30, epidural n=14, combined-spinal epidural n=4), but one had local anaesthetic infiltration with sedation and two had repeat general anaesthesia after the airway was secured while awake. Only one report recorded repeat general anaesthesia with an unsecured airway, using inhalational induction and facemask anaesthesia.[44] There were two occasions in which significant maternal morbidity was recorded after awakening following failed intubation, related to difficulties with the subsequent anaesthesia. In the first, total spinal anaesthesia after attempted epidural anaesthesia led to apnoea, oesophageal intubation and death.[48] In the second, caesarean section had been abandoned, awake fibreoptic intubation attempted but failed and the patient had a delayed cardiorespiratory arrest. Afterwards it was reported that she might have had a cardiac event during the period of hypoxaemia.[90]

Maternal adverse outcomes

The most important life-threatening risk during management of failed intubation is hypoxaemia, occurring during intubation attempts, unrecognised oesophageal intubation or attempted but ineffective ventilation. This led to immediate death in many cases, with a few patients surviving for several days on ICU with hypoxic brain damage.[48,96] Late deaths, defined as >42 days but <1 completed year after delivery,[97] have occurred after unrecognised oesophageal intubation.[48,98] Non-fatal cardiac arrest has been described after airway problems that resulted in hypoxaemia, although it is unclear whether this was neurogenic (vagal) or from cardiac hypoxia.[99] Hypoxaemia may also have caused cardiac damage.[90]

The UKOSS study found that the incidence of hypoxaemia in cases of failed intubation was much higher than in a control population who had uneventful general anaesthesia (71% and 2% respectively); the severity was also greater (lowest saturation 40% and 84%, respectively), although there were no identified sequelae. Of note there was a high incidence of admission to ICU in both groups (12% and 14%, respectively).[33]

Pulmonary aspiration of stomach contents at uncomplicated obstetric general anaesthetic induction is rare.[22,100] The CEMD reports covering several decades suggest that fatal aspiration presents at tracheal extubation, in recovery or in the postoperative period more often than during induction or maintenance.[98] Fatal aspiration at failed intubation still features in the CEMD reports.[98] There are few data on the incidence of non-fatal aspiration in relation to difficult or failed obstetric intubation. The UKOSS study recorded an 8% incidence of aspiration at failed intubation, versus 1% in controls. In the former group, all cases were admitted to ICU for 2–7 days, although none were purely for airway management.[33] Rahman and Jenkins noted one case of aspiration in 16 cases of failed intubation.[18]

Rapid-onset pulmonary oedema after failed intubation without a record of regurgitation has been noted, either at the start of surgery[40] or after post-extubation CICO (F. Dodds, personal communication); these may have been cases of negative-pressure pulmonary oedema.

Trauma during difficult intubation has resulted in perforation of the piriform fossa with subsequent mediastinitis and permanent alteration of the voice,[101] and

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Table 2 Cases requiring a front-of-neck airway access procedure after failed tracheal intubation at caesarean section

Author, Year	Urgency	Management	Outcome
CEMD 1982–84, 1989[92]	Elective	Failed epidural. Multiple intubation attempts, failed tracheostomy	Death; abnormally small larynx and trachea at post-mortem
CEMD 1982–84, 1989[92]	Emergency	Grade 4 laryngoscopy. Suxamethonium wore off, failed tracheostomy and significant haemorrhage into trachea and lungs	Death
CEMD 1985-87, 1991[48]	Emergency, fetal distress, preeclampsia	Epidural topped up but inadequate. Intubated, breath sounds heard but cyanosis developed, cardiac arrest, attempted tracheostomy by obstetrician	Death
Stephens 1991[93]	NR	Grade 4 laryngoscopy (tonsillar tissue). Failed mask ventilation; tracheostomy by obstetrician. Blind tracheal intubation using bougie after airway controlled	Tracheostomy closed immediately after surgery, extubated at 24 h
Stephens 1991[93]	Preterm, preeclampsia	Oedema from preeclampsia. Laryngoscopy showed oedematous larynx, failed intubation and mask ventilation. Size 3.5 mm tracheal tube lodged in larynx with limited ventilation, SpO_2 60%. ENT surgeon performed tracheostomy with 5.0 mm tube	Mother and neonate neurologically intact
Fuhrman 1995[49]	Emergency	Failed neuraxial anaesthesia. CICO. Failed cricothyroid catheter, failed tracheostomy	Death soon after, complications secondary to cerebral hypoxia
Hawthorne 1995[7]	NR	Failed mask ventilation, CICO, failed mini-tracheostomy, spontaneous ventilation resumed and managed with mask and airway	NR
CEMD 1991–93, 1996[88]	Emergency during labour	Oedema, obesity, preeclampsia. Uneventful induction of general anaesthesia. Developed airway obstruction after tracheal extubation, two attempts at laryngeal mask insertion plus repeated intubation attempts, suxamethonium given, two attempts at mini-tracheostomy with some improvement after the second, but cardiac arrest ensued. Trachea finally intubated but circulation not re-established	Death; post mortem found no evidence of tracheostomy entry site in the larynx (sic) or trachea
Biswas 1997[94]	Emergency – fetal bradycardia	Mallampati 2. Grade 3 laryngoscopy, one intubation attempt, failed bag-mask ventilation. Unsuccessful cricothyroidotomy with 14-gauge cannula, SpO_2 7%, successful cricothyroidotomy with TracheoQuick. Intubated with bougie after delivery, then ENT surgeon performed tracheostomy	Bilateral pneumothoraces and pneumoperitoneum. Tracheal decannulation after one day
Tsen 1998[15]	Elective	Failed spinal, Mallampati 2, five intubation attempts with different blades, failed mask ventilation, failed Combitube™ placement, unsuccessful cricothyroidotomy, cardiopulmonary arrest. Surgical tracheostomy successful	Hypoxic cardiopulmonary arrest, return of circulation. Death after seven days

(*continued on next page*)

Table 2 (*continued*)

Author, Year	Urgency	Management	Outcome
Ezri 2001[64]	Emergency – fetal bradycardia	Three intubation attempts, failed mask ventilation, failed, failed Combitube™. SpO_2 70%. Successful cricothyroidotomy with 14-gauge cannula and ventilation using jet injector for 10 min. Successful fibreoptic intubation after delivery	NR
NAP4 2011[90]	Emergency – haemorrhage	Grade 4 laryngoscopy, three intubation attempts, successful laryngeal mask placement. Tracheostomy by ENT surgeon for planned ventilation on ICU	Full recovery
NAP4 2011[90]	Emergency – labour and neuraxial anaesthesia contraindicated	Failed intubation, patient awakened. Fibreoptic intubation failed. Allowed to labour, cardiorespiratory arrest, bag-mask ventilation failed, laryngeal mask rescue failed, two cricothyroidotomy attempts with 13-gauge cannula unsuccessful, LMA Fastrach® inserted with successful ventilation, tracheal intubation through LMA Fastrach®, lowest SpO_2 30%	Transferred to ICU, extubated the next day
Palanisamy 2011[29]	Emergency – fetal distress	HELLP syndrome, Mallampati 3, surgeon on standby. Grade 3 laryngoscopy, three intubation attempts, contact bleeding. Size 4 laryngeal mask placed, CICO due to laryngospasm. Surgical cricothyroidotomy, size 7.0 mm tracheal tube, easy ventilation. Time from induction to securing airway <5 min	Uneventful tracheal decannulation after five days
Quinn 2012[33]	Category 1	Stable airway using laryngeal mask. Tracheostomy for planned prolonged ventilation on ICU	NR

CEMD: Confidential Enquiries into Maternal Deaths; NR: not reported; ENT: Ear, nose and throat; CICO: 'can't intubate, can't oxygenate'; NAP4: National Audit Project 4; ICU: intensive care unit; LMA: Laryngeal Mask Airway; HELLP: Haemolysis, elevated liver enzymes and low platelets.

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bleeding with pulmonary aspiration of blood requiring ICU observation.[39] Bilateral glossopharyngeal and unilateral hypoglossal nerve dysfunction has followed use of a Combitube™ for airway rescue.[68] Two cases of intraoperative awareness in paralysed patients that led to a new anxiety state were identified in the UK 5th National Audit Project.[102]

Neonatal outcome

Many case reports of failed intubation at caesarean section note good neonatal status or do not comment. Table 3 summarises cases of failed intubation where both details of maternal compromise and poor neonatal outcome (1 min Apgar <7 or other adverse events) were reported.[45,46,48–50,56,64,66,68,70,82,93,101,103] Among 14 cases in which women were awakened after failed intubation at caesarean section, two had poor neonatal outcomes.[45,50] Hawthorne et al. reported one poor neonatal outcome in 23 failed intubations at caesarean section, seven of which were for fetal distress. In this case, twins suffered cerebral damage although there was no evidence that the woman was hypoxic.[7] Extremely low maternal oxygen saturations have been noted with good neonatal outcome.[7,94]

A secondary analysis of UKOSS study data noted 17 neonatal ICU admissions out of 50 (34%) cases of failed intubation at caesarean section. This, however, was not significantly different from the control group with 19 admissions in 94 (20%) cases. Neonatal deaths were also comparable with 0 versus 3 (3%), respectively. In the index cases 27 of 50 (54%) were category 1 urgency, with the controls having a similar distribution of 57 out of 94 (61%). There was no correlation between lowest maternal oxygen saturation and Apgar score, but failed intubation and lowest oxygen saturation were independent predictors of neonatal ICU admission.[33]

Guidelines

Rahman and Jenkins noted features common to failed intubation guidelines in the UK South-West Thames region in the period 1999–2003. These included: if ventilation was possible, a decision on awakening or continuing mask anaesthesia with spontaneous ventilation in the presence of an urgent obstetric need to continue should be made; and, if ventilation was impossible, perform a sequence of easing cricoid pressure/ laryngeal mask/ cricothyroidotomy.[18] During the study period, five of 14 cases of failed intubation with continued general anaesthesia were managed with a laryngeal mask, arguably reflecting a changing approach to the use of the laryngeal mask that preceded formal ratification in guidelines.[18] Soon after, the 2004 DAS non-obstetric guideline for management of unanticipated difficult tracheal intubation during rapid-sequence induction of anaesthesia suggested that urgent surgery was allowable with a laryngeal mask to maintain the airway.[3]

Many local obstetric failed intubation guidelines from the UK follow the DAS approach of minimising the number of decision points,[10] in contrast to some other algorithms.[64] Current UK algorithms, available on the OAA website, suggest that mask ventilation is only carried out *after* failed intubation and that the laryngeal mask is the SAD of choice.[10] The stated indications for continuing general anaesthesia vary; maternal life-threatening conditions are always an indication, but in some cases fetal compromise alone is not. Elective surgery may be given as an absolute reason to awaken the mother.[10]

Discussion

We have been comprehensive in inclusion of source material for this review, including accessing unpublished details. The papers that include an incidence of obstetric failed tracheal intubation show considerable heterogeneity, and a number of these are published in abstract form only. The limitation of this approach is that the data from abstracts and databases are potentially less reliable. Furthermore many case reports of failed intubation and airway devices are in the form of journal letters, and there is potentially a strong element of publication bias with these sources.

Incidence of obstetric failed intubation

Samsoon and Young first highlighted an increased incidence of failed intubation in obstetric compared with non-obstetric general anaesthesia.[12] The Australian Incident Monitoring System also noted that difficult and failed intubation incidents in obstetric practice were more frequent than in non-obstetric practice, especially in emergency cases.[104] Our analysis supports a high incidence of failed intubation during obstetric general anaesthesia (1:390), based on a sample of 142 560 cases.

The incidence of failed intubation at caesarean section (1:443), from the smaller denominator of 88 186, was apparently lower than for all obstetric cases. Unfortunately, a number of reports of obstetric failed intubation do not identify the number of caesarean sections within the total cases. However, we have identified five studies in Table 1 that do distinguish between caesarean and other cases within their total.[9,24,28,32,34] These give a higher rate of failed intubation for the former than the latter, in contrast to the impression from the complete dataset. We suggest that, given the heterogeneity of results from different sources, firm conclusions cannot be drawn on differences in failed intubation incidence between caesarean and non-caesarean surgery. However, we can say that failed intubation at caesarean section carries additional risks compared to other obstetric surgery because this operation involves the highest considerations for fetal wellbeing as well as intrinsic maternal physiological stress, and

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Table 3 Poor neonatal outcomes in cases of failed intubation at caesarean section

Author, year	Urgency/indication for surgery	Maternal management	Neonatal outcome
Edwards 1982[45]	Emergency, late decelerations to 80 beats/min, meconium[a]	Retroplacental clot found at delivery	Apgar scores 3 at 1 min, 7 at 5 min, jaundice on day 3
Tunstall 1984[82]	Emergency, in labour, preeclampsia[a]	[a]	Apgar scores 4 at 1 min, 8 at 5 min
Coleman 1987[46]	Emergency, fetal distress[a]	[a]	Apgar scores 6 at 1 min, 9 at 5 min
McClune 1990[56]	Emergency, sustained fetal bradycardia[a]	[a]	Apgar scores 3 at 1 min, 8 at 5 min; bradycardia 50–60 beats/min, tracheal intubation and ventilation with 100% oxygen; extubated "minutes later"
CEMD 1985–87, 1991[48]	Elective, no compromise[a]	[a]	Stillbirth
Stephens 1991[93]	Emergency, 32/40 preterm, preeclampsia[b]	Lowest SpO_2 60%[b]	Neonate severely hypoxic with umbilical vein pH 6.8, neurologically intact; bronchopulmonary dysplasia
Fuhrman 1995[49]	Emergency	CICO. Inadequate oxygenation with cricothyroid catheter, tracheostomy; maternal death from hypoxia	Depressed but viable
Fuhrman 1995[49]	NR	Induction-incision time 10 min[a]	Apgar scores 3 at 1 min, 6 at 5 min
Couzon 1995[101]	Emergency – acute fetal distress	Intubation attempts (unspecified) lasted 30 min	Cerebral palsy at 2 years old
CESDI 2000[103]	Emergency – placental abruption, severe fetal distress	Failed intubation, grade 3 but laryngeal oedema. Laryngeal mask; SpO_2 maintained throughout	Death. Large retro-placental clot
CESDI 2000[103]	Emergency – severe fetal distress	Decision–induction time 5 min. Failed intubation, mask ventilation. Significant period of SpO_2 60–70%. Decision–delivery interval 23 min	Death. Major placental abruption
Ezri 2001[64]	Fetal bradycardia <80 beats/min[b]	Lowest SpO_2 70%[b]	Apgar scores 6 at 1 min, 9 at 5 min
Ezri 2001[64]	Emergency, ruptured uterus, fetal bradycardia <50 beats/min[a]	[a]	Apgar scores 1 at 1 min, 1 at 5 min
Hinchliffe 2002[50]	Emergency, chorioamnionitis, 33/40 gestation[a]	Lowest SpO_2 80%[a]	Apgar scores 5 at 1 min, 9 at 5 min; umbilical vein pH 6.96, base deficit 15.9; neonatal ICU for observation, good recovery
Keller 2004[70]	Emergency, fetal bradycardia, intrauterine growth retardation[a]	Lowest SpO_2 93%[a]	Apgar scores 3 at 1 min, 5 at 5 min; 1800 g; Neonatal ICU, full recovery

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Lan 2007[66]	Emergency, twins 32/40 gestation, pre-eclampsia[a]	Sustained hypoxaemia from pulmonary oedema, lowest SpO_2 70%[a]	Twin 1 Apgar scores 1 at 1 min, 7 at 5 min; 1510 g Twin 2 Apgar scores 4 at 1 min, 8 at 5 min; 1698 g
Zamora 2008[68]	Emergency, 34/40 gestation, pregnancy-induced hypertension[a]	Ventilation only established 5 min after induction, lowest SpO_2 65%[a]	Apgar scores 5 at 1 min, 9 at 5 min

CEMD: Confidential Enquiries into Maternal Deaths; CICO: 'can't intubate, can't oxygenate'; NR: not reported; CESDI: Confidential Enquiry into Stillbirths and Deaths in Infancy.
[a]Further details see Appendix – Supplementary Table (on-line only).
[b]Further details see Table 2.

our review therefore concentrates on this operation. There was no change in the incidence of failed intubation at caesarean section over the period from 1985 to 2014, both overall as well as in individual units.[7,9,105]

A low rate of failed intubation has been attributed by different authors to a liberal attitude to the use of general anaesthesia at caesarean section,[24] a high rate of neuraxial anaesthesia for caesarean section with early siting of epidural catheters during labour,[9] training and regular use of the gum-elastic bougie as a tracheal tube guide,[106] senior specialist-level care,[32,38] or the frequent resort to awake fibreoptic intubation for cases predicted to be a difficult intubation.[13,105] However, an alternative explanation may relate to the use of different definitions for failed tracheal intubation.[107] Suxamethonium, the standard neuromuscular blocker for rapid-sequence induction used in all the reported cases of failed intubation, has a short duration of action compared to other agents. A narrow definition of failed intubation as one not accomplished with a single dose of suxamethonium,[7] introduced in Leeds to ensure that intubation attempts were not dangerously prolonged in the event of difficulty (G. Lyons, personal communication), leads to a higher number of cases. On the other hand, a definition of failure as occurring only when tracheal intubation is not achieved, at any stage and by any means, reduces cases that are registered. However, an emphasis on intubation as an end-point to be achieved at all costs may encourage repeated efforts to intubate but with the risk of accompanying morbidity.[31,108] This was highlighted in the 2006–2008 CMACE report that stated "An anaesthetist may perceive failed intubation as failed performance, which creates pressure to persist."[79]

Death rate

During the early part of the 60-year period covered by the CEMDs, airway problems and aspiration were the leading causes of maternal deaths due to anaesthesia in the UK.[98] However, fatalities from airway problems related to obstetric general anaesthesia are now less prominent in comparison to other disparate causes; this holds true for the UK[79,109] as well as the USA.[110] The death rate from our series of incidence studies for failed intubation at rapid-sequence induction of general anaesthesia for caesarean section is 2.3 per 100 000. This is in line with a calculation based on cases reported through the UK CEMDs. We estimate a mortality rate of airway deaths at induction of general anaesthesia for caesarean section to be 2.0 per 100 000 based on 812 970 births in 2012,[111–113] a 25% rate of caesarean section,[114] a general anaesthetic rate of 8.2%,[26,115] and four deaths in the past four CEMD reports (12 years) from oesophageal intubation or aspiration.[79,98,109,116] These suggest a fatality rate at failed intubation of 1 per 90 (from incidence studies) to 1 per 102 (from CEMDs),

consistent with the calculation by Glassenberg of 1 per 87 based on data from the 1970s and 1980s.[117] An interesting contrast can be made between two reports from Nigeria. One hospital described a 1 in 505 rate of fatal airway problems at caesarean section with general anaesthesia;[118] the other unit, with a strong emphasis on a locally-developed failed intubation drill, recorded a 1 in 265 rate of successfully managed failed intubation with no adverse maternal outcomes.[21]

Management after failed intubation at caesarean section — awaken or continue general anaesthesia?

Tunstall's original guideline suggested continued general anaesthesia after failed intubation if mask ventilation was easy.[1] However, in the 1980s there was a move in the UK to awakening and providing neuraxial anaesthesia wherever possible.[7,8] In 1997, Harmer proposed a scoring system based on maternal and fetal compromise to aid the decision to proceed or discontinue with general anaesthesia.[119] Elective surgery, as well as long standing fetal distress with good recovery between contractions, were considered to be indications to awaken the woman. He acknowledged acute severe fetal distress as a situation where there were conflicting priorities and advice.[119]

The available data from incidence studies dating from the early 1980s indicate that the majority of cases were awakened during the earlier years, with a change around the late 1990s to continuing the anaesthetic in the majority of cases. This change included both elective and emergency cases. Fifty percent of respondents to a survey of UK lead obstetric anaesthetists in 2009 said they would continue general anaesthesia for caesarean section after failed intubation in the presence of maternal haemorrhage, but only 23% would continue if the indication was fetal bradycardia.[120] Another survey presented OAA members with a hypothetical case of category 1 caesarean section for fetal bradycardia undergoing failed intubation but with acceptable ventilation; there was a 53:47 split between those who said that they would continue anaesthesia and those who would awaken the woman.[121] However, in case series in the literature from 2004 onwards, general anaesthesia was continued in 91% of category 1 caesarean sections for acute fetal compromise. There is thus a discrepancy between how anaesthetists say they would behave and published data.

Airway management

Airway assessment

Airway assessment to predict difficult intubation is unreliable,[122] although the non-obstetric literature suggests that there are common features in predicting difficulties with mask ventilation, SAD placement and tracheal intubation. These include Mallampati class 3 or 4, raised BMI and small interdental distance.[123,124] Failed tracheal intubation carries a much greater risk to the patient if ventilation is not easily achievable with mask or SAD. Findings from history or examination that suggest glottic and/or tracheal oedema are of significant concern as they predict not only poor laryngoscopic views, but also difficulty in placing a tracheal tube in spite of adequate laryngoscopy, potential for rapid worsening of the oedema with trauma, and structural CICO problems not relieved with neuromuscular blockers. Significant concern over predicted difficulty with airway management (mask ventilation ± SAD placement ± intubation) may lead the anaesthetist towards performance of neuraxial anaesthesia or awake intubation for general anaesthesia. Glassenberg calculated that an awake intubation rate of 15% of general anaesthetics would be needed to halve the failed intubation rate.[105]

Supraglottic airway device

The introduction of the laryngeal mask has clearly been the main advance in management of failed intubation since the first drill was introduced, as shown by its almost global incorporation into guidelines. The change in use of first- to second-generation SADs in individual case reports reflects publication bias. However, there is a continuing shift in practice in the UK; a second-generation SAD was used at obstetric failed intubation in 32% of cases in 2008–2010[33] and at failed intubation during caesarean section in 60% of cases in 2013–2014.[39]

The effectiveness of a SAD in preventing pulmonary aspiration is complex, as ability to block the oesophagus, direct gastric contents away from the glottis and the function of a drain tube if present must all be considered. In a cadaver study, Bercker et al. found that the laryngeal mask was effective at directing fluid away from the lungs.[125] However they concluded that the LMA Fastrach®, which occluded the oesophagus completely and the LMA ProSeal®, which combined intermediate oesophageal occlusion with a drain tube, were likely to function better. In clinical use, the drain tube of the LMA ProSeal® functions effectively during obstetric failed intubation; gastric contents were obtained on suction in a number of cases. Entry of gastric contents into the airway has been observed with a laryngeal mask (F. Dodds, personal communication) and a LMA Supreme®,[31] with no reported sequelae.

Can't intubate, can't oxygenate and front-of-neck airway access procedure

A recent large study of impossible mask ventilation reported an incidence of 0.15% in non-obstetric general anaesthetics. The only independent risk factor relevant to the obstetric patient was Mallampati class 3 or 4.[126] There may be anatomical reasons for fixed airway obstruction that importantly include airway oedema, but variable factors within the anaesthetist's control include cricoid pressure,[127,128] laryngospasm[29,68] and malpositioned SAD.[78] We found only a few sources that

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provide an incidence of CICO in obstetrics, which spanned a range from 1 in 20 to 1 in 4 failed intubations. The CICO situation as reported is usually a transient or partial situation during a dynamic management process, as front-of-neck airway access does not usually follow CICO.

Many failed intubation guidelines state that a second dose of suxamethonium should not be given, as this prevents the return of muscle activity required before awakening. More recent advice suggests that full paralysis should be ensured before a front-of-neck procedure.[90] There is a fine line between the benefit of reducing upper airway and abdominal/chest muscle tone by administration of further neuromuscular blocker, versus the risk inherent in re-paralysing a patient with CICO unrelated to laryngospasm.

The incidence of front-of-neck procedures after failed intubation at caesarean section is low at 1 per 60. Outcomes were poor, especially in the earlier years. It is likely that unfamiliarity with equipment and techniques is an important contributing feature. Some cases of failed intubation record multiple attempts at placement of airway equipment that should have triggered front-of-neck access if a strict protocol had been followed; eventual successful management was achieved without front-of-neck access.[68,78] A paradox is apparent: front-of-neck procedures are rarely necessary with modern management, yet if performed in extremis are likely to be more difficult or to fail. The indication and threshold for front-of-neck airway access after failed intubation at caesarean section should be made as clear as possible.

Maintaining general anaesthesia after failed intubation

Since the advent of the SAD, the prime indication for tracheal intubation at obstetric general anaesthesia is to protect the lungs from gastric contents, especially during emergency anaesthesia. In a situation where tracheal intubation skills were not available, there were only two cases of non-fatal aspiration pneumonitis in 940 emergency caesarean sections managed using facemask anaesthesia.[129] Although it is not possible to draw a strict comparison with anaesthesia continued after failed intubation, this figure provides some reassurance that the risk of aspiration may decline once stable anaesthesia has been established.[33] Although cricoid pressure was continued for the duration of surgery in most cases where a laryngeal mask or LMA ProSeal® was used, its effectiveness is questionable. Experimentally, cricoid force can only be sustained at 30–40 N for a few minutes.[130]

Maternal adverse outcomes

In recent years there have been three reported deaths in the UK from unrecognised oesophageal intubation. In two cases there was no explanation as to why the anaesthetist did not act on the information from the capnograph.[79,98] In the third, the patient had regurgitated, and the flat capnograph trace was attributed to a blocked sampling line.[98] Profound bronchospasm has been noted as a cause of a flat capnograph trace,[90,116] but oesophageal intubation must be excluded before another reason can be accepted.

Neonatal outcome

When considering case reports of failed intubation, it is difficult to separate the effects of this event from the underlying compromise necessitating the caesarean section.[103] There may also be considerable publication bias. In a large series from the USA, Bloom et al. noted that general anaesthesia was used more frequently than neuraxial anaesthesia in cases with decision–incision time <15 min; the odds ratios for 1-min and 5-min Apgar score $\leqslant 3$ and umbilical artery pH <7.0 were 2.7–2.9 after general compared with neuraxial anaesthesia.[4] In the UKOSS study, there was a 20% rate of neonatal ICU admission in control cases who underwent uncomplicated general anaesthesia for caesarean section.[33] After failed intubation there was a 34% neonatal ICU admission rate, although this difference did not reach statistical significance. However, multivariate analysis showed failed intubation as well as lowest maternal oxygen saturation to be independent predictors of neonatal ICU admission.[33] Possible mechanisms that might explain the requirement for neonatal ICU include maternal hypercapnia, acidaemia and catecholamine release. Delay in delivery during management of a difficult airway at caesarean section might further potentiate the effects of maternal physiological derangement. The greatest delay in delivery will be incurred if the woman is awakened after failed intubation, but we have not found evidence to support either awakening or continuing anaesthesia with respect to neonatal outcome. Leung et al. found that the majority of cases of caesarean section for fetal bradycardia did not show a correlation between the bradycardia onset-to-delivery interval and neonatal acidaemia.[131] Therefore, we conclude that maternal safety should be the primary consideration in awakening or continuing anaesthesia at caesarean section for fetal distress in the absence of a sentinel event such as placental abruption.[132]

Conclusions

We have identified a wide range of sources to provide estimates of failed tracheal intubation, death and front-of-neck airway access procedures at general anaesthesia for caesarean section. We acknowledge that there is a large amount of heterogeneity in these reports. However, with respect to the risk of death, an alternative approach to the calculations using UK national

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birth registry statistics provides a similar figure to that from the literature. The details of management of failed intubation obtained from case reports and series vary widely. Continuation of general anaesthesia is now more common, with variants of the laryngeal mask for airway control; there is growing use of second-generation SADs, especially the LMA ProSeal®. The presence of underlying pathology and compromise at the time of caesarean section under general anaesthesia means that it is difficult to attribute causation of adverse outcomes to the failed intubation. However, in this respect the case-control methodology of the UKOSS study is an important resource, showing a high background rate of maternal and neonatal complications and requirement for high dependency support.

Disclosure

This work was performed by a joint OAA/DAS working party who are writing guidelines for failed obstetric intubation. These two organisations have provided financial support but have had no role in the preparation of this manuscript. None of the authors have conflicts of interest to declare.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.ijoa.2015.06.008.

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