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ORIGINAL RESEARCH

Predictors of difficult tracheal intubation during general anaesthesia: an analysis of an obstetric airway management registry

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Background: Complications during airway management can be life-threatening. This study aimed to identify anatomical and physiological risk factors for hypoxaemia during tracheal intubation in obstetric general anaesthesia (GA).

Methods: A retrospective analysis was performed of data from an obstetric airway management registry (ObAMR) on tracheal intubation during GA in patients with a gestational age from 20 weeks, and until 7 days post-delivery. The primary outcome was arterial desaturation to < 90% during airway management. Logistic regression was performed to identify associations with hypoxaemia.

Results: Data were collected for 1 095 general anaesthetics in the ObAMR. Overall, 143/1 091 of patients (13.1%, 95% CI 11.1–15.4%) experienced arterial oxygen desaturation. Univariate analysis showed that 91/142 (64.1%) of patients who desaturated were obese (body mass index [BMI] > 30 kg/m^2), compared with 347/915 (37.9%) who were obese and did not experience desaturation (p < 0.001). A receiver operating characteristic curve was constructed post hoc, which showed a cut-off point for BMI of 29.76 kg/m^2, with a sensitivity of 0.66 and specificity of 0.62 for predicting hypoxaemia. Desaturation occurred in 17.0% of patients with hypertensive disorders of pregnancy, versus 11.0% without the condition (p = 0.005). Increasing Mallampati class was associated with an increased incidence of hypoxaemia. The incidence of hypoxaemia was 25.8% when intubation was performed by interns, compared with 8.0% for specialist anaesthetists (p = 0.005). In the multivariate analysis of factors associated with hypoxaemia, BMI (p < 0.001), room air saturation prior to preoxygenation (p = 0.008), and airway oedema (p = 0.027) were independently associated with hypoxaemia.

Conclusion: In this study, hypoxaemia was used as a composite indicator of anatomical and physiological difficulty. Using this concept, a predictive tool could be developed to identify a difficult airway in obstetrics. Further research is required to show whether simple interventions such as face mask ventilation and the use of high-flow nasal oxygenation during intubation reduce the incidence of life-threatening hypoxaemia.

Keywords: caesarean delivery, general anaesthesia, hypoxaemia, obstetric anaesthesia, airway management

Introduction

The airway of the pregnant patient presents unique challenges regarding pre-anaesthetic assessment, as well as safe, expeditious and definitive management. Management priorities include prevention of hypoxaemia and pulmonary aspiration during the induction of general anaesthesia (GA). Difficulties with airway management have been reported to be eight times more common in obstetric patients than in the general surgical population,[1,2] with the incidence of difficult or failed tracheal intubation approximately 1 in 390 for obstetric GA.[3] Maternal mortality remains at one death per 90 failed intubations,[3] and results from hypoxaemia secondary to airway obstruction or oesophageal intubation, and/or pulmonary aspiration.[3,4] This has resulted in a significant reduction in the use of GA for caesarean delivery, and a corresponding increased application of neuraxial techniques, thus avoiding airway management by the anaesthesia provider in a large proportion of patients.

However, there are still specific maternal conditions which require GA, such as significant haemorrhage, hypovolaemia, severe valvular stenosis, cardiomyopathy, and preeclampsia with systolic hypofunction or heart failure. In addition, there may be circumstances involving severe fetal compromise (including fetal bradycardia) such as abruptio placentae and cord prolapse, which necessitate rapid surgery most swiftly facilitated by urgent GA. In these patients, the risk of difficulty in establishing an airway (with concomitant maternal and fetal morbidity and mortality) is significant. A variety of difficult airway algorithms exist as training and memory aids to mitigate difficulty once a challenging airway is encountered.

In 2018, the Department of Anaesthesia and Perioperative Medicine of the University of Cape Town (UCT) established an obstetric airway management registry (ObAMR) to improve clinical governance and assess and monitor airway management during GA in this vulnerable group of patients. At all obstetrics facilities affiliated with the Department, standard clinical airway assessment forms an integral part of the pre-anaesthetic examination, whether a neuraxial or general anaesthetic technique is planned. Standard clinical airway assessment at our centres includes all the features as captured on the registry, namely: Mallampati class, dentition, thyromental distance, mouth opening (inter-incisor distance), neck mobility (atlanto-occipital extension) and mandibular protrusion. This is a validated tool in the non-obstetric population, but its performance has not been formally assessed in our parturients. The aim of this retrospective analysis of registry data is to identify common, clinical, pre-induction predictors of a difficult airway, allowing time for the anaesthesia provider to prepare adequately, and thereby reduce morbidity and mortality.

Historically, studies assessing difficulty of intubation in obstetrics have focussed primarily on the physical and anatomical challenges associated with insertion of an endotracheal tube. However, increasing recognition of the concept of a physiologically difficult airway (rapid onset of hypoxaemia during airway management), prompted the present analysis of hypoxaemia as a composite indicator of both anatomical and physiological difficulty during intubation.

Methods

This was a retrospective observational study of data pertaining to tracheal intubation, obtained from the ObAMR. The registry was approved by the Human Research Ethics Committee of the Faculty of Health Sciences of UCT (HREC R025/2018). Data are collected at all sites performing obstetric anaesthesia under the supervision of the UCT Department of Anaesthesia and Perioperative Medicine, namely Groote Schuur- (GSH), New Somerset- (NSH), and Mowbray Maternity (MMH) Hospitals, in Cape Town, South Africa. The registry contains data from all pregnant patients requiring GA for both elective and emergency surgery, from a gestational age of 20 weeks and until 7 days after delivery. Standard practice for GA for caesarean section taught at our centres includes preoxygenation using high-flow oxygen via a circle system and snug fitting anaesthetic mask until an end-tidal oxygen fraction of at least 0.8 is achieved, followed by rapid sequence induction and tracheal intubation with cricoid pressure. Data are entered by the anaesthesia provider involved in the case into a secure password protected UCT database (Research Electronic Data Capture, REDCap 9.5.36, © 2022 Vanderbilt University). Clinicians can enter data using their mobile devices via a designated uniform resource locator (URL) or quick reaction (QR) code displayed in the obstetric theatres. All data collected for the purposes of the study had been documented as part of the routine anaesthesia management. Anonymity was maintained, since access to the entire database was restricted to the investigators. The registry had previously been validated and the findings published.[5]

For this study, we conducted a retrospective analysis of this registry, extracting data recorded from 1 095 obstetric general anaesthetics during the period 2018–2020 into a Microsoft Excel spreadsheet. The details of the recorded data included patient-, pregnancy- and airway characteristics, details of airway management, and operator experience.

The primary aim of the study was to identify anatomical and physiological risk factors for hypoxaemia. The primary outcome was defined as arterial desaturation to < 90% during obstetric airway management from the time of induction of anaesthesia until the establishment of maintenance anaesthesia. For this purpose, multivariable binary logistic regression was performed for categorical variables expected to be independently associated with desaturation to < 90% (provider training < 5 or ≥ 5 years; mother "in labour" vs "not in labour"; Mallampati class I or II [easy] vs III or IV [difficult]; mouth opening limited to < 3 finger-breadths or 5 cm vs not limited; neck mobility < 35 degrees from neutral head position vs not limited; upper airway oedema assessed by the anaesthesia provider as present or absent; BMI < 30 or ≥ 30 kg/m^2; oxygen saturation on room air prior to pre-oxygenation < 94% or ≥ 94%; hypertensive disorder of pregnancy present or absent). "In labour" was defined as being in the first to third stage of labour, whereas "not in labour" was defined as prior to onset of labour or after delivery. Room air oxygen saturation was dichotomised to abnormal (< 94%) and within normal range (94–100%). Hypertensive disorders of pregnancy (HDP) were classified as in our previous work, wherein patients with no hypertension or chronic hypertension alone were classified as non-HDP, and patients developing gestational hypertension, preeclampsia, preeclampsia superimposed upon chronic hypertension, and eclampsia were defined as having HDP.[5]

Data analysis

Patient details and pregnancy characteristics were reported as mean (standard deviation [SD]), if variables were normally distributed, median (interquartile range [IQR]) if not normally distributed, and count (%) for categorical variables. Normality was tested using the D'Agostino-Pearson test. Normally distributed data were compared using Student's t-test, and for data not normally distributed, the Mann–Whitney U test was used. Categorical data were analysed using the chi-square test. In a recent study analysing data from the first 402 patients in the registry,[6] the overall incidence of hypoxaemia during tracheal intubation in obstetrics was 12.3%. Assuming a similar incidence in the approximately 1 000 patients recorded in the registry for the present study, if we allowed for 10 events per predictor of hypoxaemia, 10 variables could be included in a multivariable logistic regression. For all data analysed, statistical significance was defined by a *p*-value of 0.05, and 80% was accepted as adequate statistical power. A post hoc decision was taken to conduct a sensitivity analysis of the multivariable logistic regression excluding the saturation on room-air, as this variable had not been part of the original dataset, resulting in 206 missing data points.

Data analysis and summary statistics were performed with MedCalc (MedCalc® Statistical Software version 19.6, MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2020), and logistic regression was performed in SPSS. We conducted a post hoc receiver operating characteristic (ROC) curve to determine the optimal cut-off point for BMI associated with desaturation to less than 90%.

Results

The data for 1 095 obstetric general anaesthetics from the registry were examined. Patient characteristics are reported in Table I.

Table I: Patient characteristics

	n	Mean (SD) or median [IQR]
Age (years)	1 093	29.1 (6.7)
Height (cm)	1 070	162.2 (6.9)
Weight (kg)	1 070	78.3 (21.1)
BMI (kg/m²)	1 063	29.6 (8.0)
Gestational age (weeks)	1 016	35.9 (4.2)
Gravidity	1 085	2 [1–3]
Parity	1 083	1 [0–2]

SD – standard deviation, IQR – interquartile range, BMI – body mass index

Data for the primary outcome (arterial desaturation below 90%) was available for 1 091 patients. Overall, 143/1 091 (13.1%, 95% CI 11.1–15.4%) patients experienced hypoxaemia during induction of anaesthesia. Of the cases analysed, 99.5% were undertaken in maternity theatres at the three contributing hospitals, with the remaining five patients receiving their operations in the main theatre complex for specific indications. The overall rate of desaturation at GSH, NSH, and MMH was 15.8%, 15.5%, and 8.6% respectively. The incidence of hypoxaemia was 25.8% when interns managed the airway, compared with 8.0% for specialist anaesthetists. The incidences of hypoxaemia for medical officers and registrars were 13.4% and 13.0% respectively. The incidence of hypoxaemia was not associated with the number of years of anaesthesia experience. There was no difference in the incidence of hypoxaemia related to gravidity, parity, duration of labour, primary anaesthesia strategy (GA versus neuraxial), or the presence of partial dentition.

Multivariable analysis showed that saturation < 94% on room air, the presence of airway oedema as assessed by the anaesthesia provider, and raised BMI were associated with hypoxaemia (Table II). Overall, of patients who desaturated, 91/142 (64.1%) were obese, whereas amongst those who did not experience desaturation, 347/915 (37.9%) were obese ($p < 0.001$). A ROC curve constructed post hoc showed a cut-off point for BMI of 29.76 kg/m², with a sensitivity of 0.66 and a specificity of 0.62 for the prediction of hypoxaemia.

The sensitivity analysis is shown in the supplementary material. The findings of the sensitivity analysis were consistent with the main analysis (Supplementary Table I).

Overall, 31.4% of patients had preeclampsia or eclampsia. Desaturation occurred in 17.0% of patients with HDP, versus 11.0% without HDP ($p = 0.005$). In patients with preeclampsia superimposed upon chronic hypertension, and those with severe preeclampsia or eclampsia, hypoxaemia occurred in 25% and 28.2% respectively. Desaturation was found in 19.5% of patients with chronic hypertension, compared with 12.8% of those with gestational hypertension.

Table II: Multivariable analysis of factors associated with hypoxaemia (*n* = 678)

Binary variable	OR	95% CI	*p*-value
Training years (< 5 vs ≥ 5)	1.36	0.78–2.35	0.28
Presence vs absence of labour	0.98	0.62–1.56	0.94
Presence vs absence of hypertensive disorders of pregnancy	0.89	0.54–1.47	0.65
Mallampati class (III/IV vs I/II)	1.33	0.78–2.26	0.29
Mouth opening (limited vs normal)	1.25	0.46–3.39	0.66
Neck mobility (limited vs normal)	0.88	0.15–5.18	0.88
Body mass index (≥ 30 kg/m² vs < 30 kg/m²)	3.02	1.87–4.89	< 0.001
Saturation on room air < 94% vs ≥ 94%	3.98	1.43–11.13	0.008
Presence vs absence of airway oedema	1.86	1.07–3.22	0.027

OR – odds ratio, CI – confidence interval

Data describing the indication for GA showed no association between hypoxaemia and abnormal placentation, cardiac disease, coagulopathy, fetal distress, failed spinal anaesthesia or prolonged surgery, or postpartum haemorrhage. Hypoxaemia occurred in 33.3% of patients in whom the indication for GA was a decreased level of consciousness, compared with 12.5% of those with a normal level of consciousness ($p < 0.001$).

The Mallampati class was assessed in 1 056 patients (96.8%). Classes III and IV comprised 17.8% and 4.6% respectively. There was a significant progression in proportion of patients with a saturation nadir < 90% with increasing Mallampati class. The mean incidences for classes I and II were 8.1% and 12.9%, and 17.5% and 26.0% for classes III and IV, respectively ($p = 0.002$). This is illustrated in Figure 1.

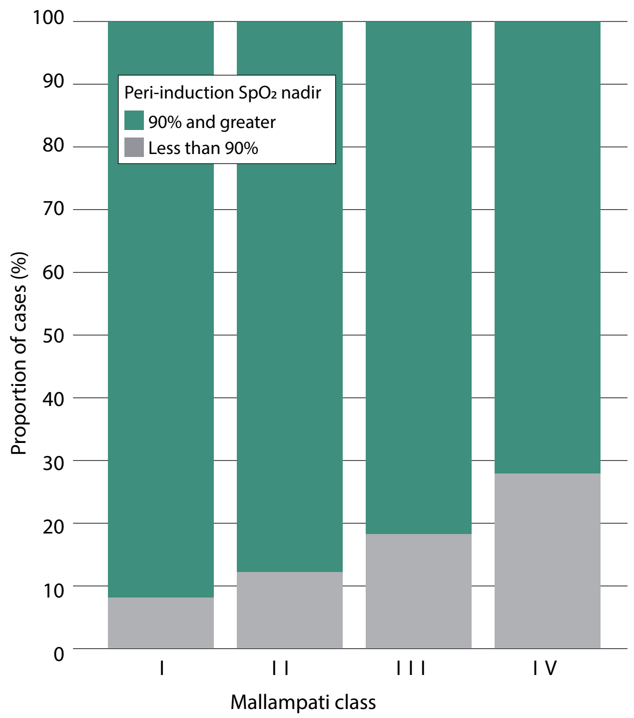

Figure 1: Proportions of patients experiencing hypoxaemia by Mallampati class

A thyromental distance of less than 6.5 cm (or four fingers) was associated with an increased incidence of hypoxaemia (21.2% vs 13.2%, $p = 0.028$). Mandibular protrusion was assessed in 539/1 089 (49.5%) of cases. Limited protrusion (Class B or C) was associated with increased hypoxaemia (24.0% or 25.0%, compared to 10.7% in cases in whom protrusion was normal, $p = 0.013$). Limited mouth opening was described in 65/ 1 090 patients. Desaturation occurred in 21.5% of these cases, compared to 12.3% in those with mouth opening of at least 5 cm ($p = 0.66$). Of the ten patients who had limited neck mobility, three experienced hypoxaemia.

In this study, video laryngoscopy (VL) was available in 97% (1 058/1 091) of patients. VL use was associated with peri-induction hypoxaemia (21.0% vs 9.0%, $p < 0.001$). After the initial validation study,[5] we introduced a question documenting whether the VL was used as the primary strategy or was introduced as a rescue strategy after failed direct laryngoscopy. When VL was used on the first attempt, there was no association with hypoxaemia ($p = 0.25$). Overall, the use of an introducer in the endotracheal tube was associated with hypoxaemia ($p < 0.001$). Later data documenting whether the introducer was used on the first attempt showed no association with desaturation ($p = 0.65$) when this was the case.

Our data showed an association between hypoxaemia and Cormack–Lehane (CL) grade. Grade 1 views were associated with an incidence of hypoxaemia below the overall rate (11.2% vs 13.1%), Grade IIa – 15.1%, Grade IIb – 25.9%, Grade III – 26.7%, and Grade IV – 50% (1 of 2 patients) ($p = 0.003$).

Where patients in our study were graded based on a practitioner's impression of the degree of airway oedema (absent, mild or severe), the presence of any airway oedema was associated with hypoxaemia ($p < 0.001$). Of patients assessed to have severe oedema, 47% (8/17) had hypoxaemia.

Patients who required multiple attempts at intubation had a higher incidence of hypoxaemia ($p < 0.0001$). When intubation was accomplished on the first attempt, the incidence of hypoxaemia was 9.7%. If multiple attempts were required, desaturation ranged from 46% (two attempts) to 60% (three attempts). No patient required more than three attempts at intubation. In the registry, there were four cases of rescue using a supraglottic airway (SGA), and none required emergency front of neck access. Two of four patients requiring an SGA had hypoxaemia. In the other two, an SGA was used before onset of hypoxaemia.

Discussion

In this analysis of tracheal intubation for GA in over 1 000 parturients, there was an overall incidence of hypoxaemia of 13.1%. This rate of desaturation occurring in approximately 1 in 8 patients is in keeping with numerous previous studies, and highlights the significance of the problem. Obesity, room air peripheral saturation < 94% prior to preoxygenation, and the presence of airway oedema were found to be independent predictors of hypoxaemia during airway management. These findings serve as an alert to anaesthesia providers managing this challenging and vulnerable group of patients, and could assist in the generation of a difficult intubation score.

Most airway catastrophes occur when airway difficulty is not anticipated prior to induction of anaesthesia.[7] Many physiological changes occur during pregnancy, including physical characteristics such as increased BMI, breast enlargement, and generalised oedema.[4,8] The mucosa of the upper respiratory tract also becomes more vascular and oedematous, leading to increased risk of airway bleeding and swelling.[9] Fluid retention in head and neck tissues during pregnancy, particularly in preeclampsia, potentially narrows the upper airway and reduces compliance, making laryngoscopy more difficult.[8] The term parturient is also more susceptible to gastro-oesophageal reflux, due both to progesterone-mediated effects and anatomical changes due to the gravid uterus.[7]

Rocke et al. studied the relationship between increased airway classification scores and relative ease or difficulty of intubation in 1 500 pregnant patients undergoing elective or emergency caesarean delivery.[10] A strong correlation was found between difficulty in identifying oropharyngeal structures, and difficult tracheal intubation. The authors found that the relative risk of encountering difficult intubation in a gravid parturient with a Mallampati class III airway was 7.6 compared with class I, increasing to 11.3 in those with class IV.[10] Using a combination of risk factors, they showed that the presence of a class III or IV airway together with protruding maxillary incisors, a short neck, and a receding mandible, increased the probability of difficult laryngoscopy to > 90%. Our study showed that there was a significant progression in incidence of hypoxaemia with increasing Mallampati class.

Pilkington et al. demonstrated that airway oedema may increase during the course of pregnancy and result in an increased Mallampati score.[11] Kodali et al. observed airway changes during labour and delivery.[12] There was a significant increase in airway class from the pre-labour period to after delivery. The Mallampati score increased by one class in 20/61 patients (33%), and by two classes in three women (5%). At the end of labour there were eight patients with a class IV-, and 30 women with a class III or IV airway ($p < 0.001$). Oral volume and pharyngeal area and volume also decreased significantly after labour. In a further case-control study, changes in Mallampati class were compared in healthy women and those with preeclampsia. In addition, sonographic measurements were made of tongue thickness, anterior neck soft tissue, thyromental distance and neck circumference. Mallampati score was found to increase from the pre-labour period in both groups. In addition, there was a significant between-group difference in tissue thickness at the hyoid level before and after labour and postpartum.[13]

In our study, even when intubation was accomplished on the first attempt, the incidence of hypoxaemia was still approximately one in ten. Predictably, patients who required multiple attempts at intubation experienced a higher incidence of hypoxaemia, ranging from 46% (two attempts) to 60% (three attempts). In keeping with modern difficult airway management guidelines, no patient in our cohort of > 1 000 required more than three attempts at intubation. In our registry, there were four cases of rescue using an SGA and none requiring emergency front of neck access. Although two of the four cases of supraglottic rescue experienced profound desaturation, the other two patients had an SGA placed rapidly, and hypoxaemia was avoided. This may indicate increasing acceptance of the practice of early placement of an SGA, with the emphasis on oxygenation rather than intubation as an airway management goal. Increased use of high-flow nasal oxygenation should become more widely accepted as familiarity with the technique improves. Various difficult airway algorithms exist as training and memory aids to mitigate risk once a difficult airway is encountered.[4,14]

In a recent study which focussed on patients who had an anticipated difficult airway in obstetric GA, previous difficulty with airway management was noted in 14/158 patients.[14] Unfortunately such records are often unavailable, as was the case in the present study. In the investigation by Mushambi et al., an airway assessment was only reported in 102/158 cases.[14] The Mallampati score was noted in 82 of these women, of whom seven were class I, 17 class II, 33 class III, and 30 class IV. All the women with class I and II airways had other predictors of difficulty. Other features or tests were limited neck movement in 75, mouth opening in 68, thyromental distance in 36, and jaw protrusion or micrognathia in 24 patients. In one patient the neck was assessed for front of neck access, and in two cases there were obstructive sleep apnoea. No studies described the use of a combined score. In the presence of specific airway pathology, respiratory investigations were performed, including computerised tomography. In 15/158 patients, awake laryngoscopy or nasal endoscopy was performed to guide the choice of anaesthesia technique. Fifty-two women required awake intubation using flexible bronchoscopy, of whom three had this procedure after an initial poor direct laryngoscopic view, and five after failed regional anaesthesia. Most of the women had congenital abnormalities, but other indications included morbid obesity, goitre, mediastinal mass, HELLP syndrome, a swollen tongue in a woman with eclampsia, and reduced mouth opening. A strength of our study was that the Mallampati class was assessed in 97% of 1 056 patients.

Historically, as indicated above, studies assessing difficulty of intubation in obstetrics have focussed primarily on the physical and anatomical challenges associated with insertion of an endotracheal tube. However, there is increasing recognition of the concept of a physiologically- or pathophysiologically difficult airway, which uses hypoxaemia as a composite indicator of anatomical and physiological difficulty. There are a limited number of studies in the literature exploring this concept. Smit et al. compared the prevalence and risk factors for hypoxaemia (SpO_2 < 90%) during induction of GA in parturients with and without HDP.[6] They hypothesised that hypertensive disorders of pregnancy are associated with desaturation during tracheal intubation. In a cohort of 402 cases, hypoxaemia occurred in 19% with- and 9% without hypertension ($p = 0.005$). Quantile regression demonstrated a lower SpO_2 nadir associated with HDP as BMI increased. Room-air oxygen saturation, Mallampati class, and number of intubation attempts were associated with the relationship. In the present study, involving a much larger sample size from the ObAMR, the significantly higher rate of desaturation demonstrated by Smit et al. in patients with HDP than in those without the condition,[6] was again shown in univariate analysis. This did not prove to be an independent predictor of hypoxaemia, due to the greater risk of hypoxaemia shown to be associated with obesity. However, this present further study enforces the contention of Smit et al. that a BMI of ≥ 30 kg/m^2 in conjunction with HDP should alert the practitioner to a high risk of peri-intubation hypoxaemia.

In a multicentre investigation, Bonnet et al. studied the incidence and risk factors for maternal hypoxaemia during tracheal intubation for non-elective caesarean section.[15] Hypoxaemia occurred in 172/895 women (19%). Multivariate analysis showed that risk factors associated with hypoxaemia were difficult or failed intubation, and BMI > 35 kg/m^2. Intubation was found to be difficult in 40 patients (4.5%), and five women (0.56%) had failed intubation. Propofol was found to be associated with a significantly lower risk of failed intubation. In a further recent publication from South Africa, the authors performed a prospective, observational, dual-centre cohort study, aiming to establish the incidence of hypoxaemia (defined as SpO_2< 90%) during induction of GA for caesarean section.[16] Factors investigated as potential predictors of hypoxaemia were BMI, the level of experience of the operator, predicted difficult airway, CL grading, and the absence of planned mask ventilation. They also reported on complications related to tracheal intubation. The incidence of hypoxaemia was found to be 61/363 (16.8%). BMI > 30 kg/m^2 and CL grade IV predicted hypoxaemia. The failed intubation rate was 1.4%, and the regurgitation rate 0.8%. No patients experienced pulmonary aspiration or required surgical intervention to secure the airway.

Limitations of our study include possible reporting bias based upon the perception of the anaesthesia provider that tracheal intubation might be difficult, but we believe that this was unlikely. The body mass captured in the notes may have been transcribed from notes made earlier in pregnancy, so that the recorded BMI may have been an underestimate of the true BMI. Furthermore, as demonstrated in the earlier ObAMR validation study, the data capture rate may have been 80% or less,[5] and there may have been errors in some entries, as well as some degree of inter-observer variability. Some aspects of the airway assessment were not completed by all anaesthesia providers. For example, documentation of assessment of mandibular protrusion was only provided in 50% of cases.

Strengths of the study included the use of a previously validated airway registry specifically focussed on obstetric anaesthesia, and the considerable sample size. The study also provided valuable data on the use of VL in obstetric anaesthesia and provides a basis for focussed future studies in this area. A pragmatic interpretation of our data is that VL was frequently used as a rescue strategy where difficult intubation has already been encountered, explaining the early high incidence of desaturation associated with VL use. However, when VL was selected as the primary strategy, desaturation was not a significant occurrence despite anticipated airway difficulty. Similarly, whilst early in the study the use of an introducer was found to be associated with difficult intubation, additional data included later in the study, documenting whether the introducer was used on the first attempt, shows no such association when this was the case. "Introducer" is a group term which includes both stylets (devices used to shape the tube) and bougies (coude-tipped devices used to guide the tube). As both are used in our clinical settings, and the registry does not distinguish between them, we cannot make specific recommendations on the ideal type from these data. A pragmatic interpretation is that an introducer is often used when difficulty is encountered, but when it is used from the outset, peri-induction hypoxaemia can be prevented. Where predictors of anatomical or physiological difficulty exist, the prudent practitioner may opt for the combined use of VL and introducer as a primary strategy.[17]

In this study, which contributes to the limited literature on the use of hypoxaemia as a composite indicator of difficult intubation in obstetrics, both anatomical and physiological predictors of hypoxaemia were identified. Using this concept, a predictive tool could be developed to aid in the identification of a difficult airway in obstetrics. This could also guide the choice of anaesthesia for urgent caesarean section in women with anticipated difficult tracheal intubation, including the use of simple decision analysis.[18] Further research is required to show whether simple interventions such as face mask ventilation and the use of high-flow nasal oxygenation could be introduced to protect the parturient from the consequences of life-threatening hypoxaemia.

Conflict of interest

The authors declare no conflict of interest.

Ethical approval

The registry was approved by the Human Research Ethics Committee of the Faculty of Health Sciences of UCT (HREC R025/2018).

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Supplementary Table 1: Sensitivity analysis of factors associated with hypoxaemia, excluding room-air peripheral saturation ($n = 843$)

Binary variable	OR	95% CI	*p*-value
Training years (< 5 vs ≥ 5)	1.29	0.78–2.13	0.32
Presence or absence of labour	0.96	0.63–1.47	0.86
Hypertensive disorders of pregnancy	1.09	0.69–1.71	0.71
Mallampati class (I/II vs III/IV)	1.23	0.79–2.03	0.35
Mouth opening (limited or normal)	1.34	0.59–3.06	0.49
Neck mobility (limited or normal)	1.33	0.29–6.22	0.72
Body mass index (< 30 or ≥ 30 kg/m²)	3.07	1.99–4.76	< 0.001
Presence of airway oedema	2.36	1.44–3.86	< 0.001

OR – odds ratio