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ORIGINAL RESEARCH

Implementation and initial validation of a multicentre obstetric airway management registry

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Background: In Africa, maternal mortality after caesarean delivery is 50 times greater than in high-income countries. In South Africa, more than 50% of anaesthesia-related maternal mortality is attributed to failure to protect the airway. We implemented an obstetric airway management registry, to facilitate future improvements in management and outcomes.
Methods: A prospective electronic registry was established at three obstetric sites in Cape Town, recording airway management for all general anaesthetics from 20 weeks gestation to seven days post-partum. Perioperative descriptive data are entered using a web-based smartphone-enabled platform. To quantify the reliability of capture, we compared the first 200 records in the registry to theatre logbooks. We used summary statistics to describe our obstetric anaesthesia population, and details relevant to airway management.
Results: The first 200 cases were recorded from September 2018 to January 2019. According to theatre logbooks, this represented 80% of cases performed. Major indications for general anaesthesia included severe fetal distress/bradycardia (21%), failed neuraxial technique (19%), coagulopathy (19%), and abnormal placentation (12%). A third of patients had hypertensive disorders of pregnancy, and 6% had imminent/confirmed eclampsia. Forty per cent were in active labour. On airway assessment, Mallampati grade was 3 or 4 in 29% of patients, and mouth opening, thyromental distance and mandibular protrusion limited in 10%, 8% and 8% respectively. Cormack-Lehane grade IIb and III views were encountered in 6% and 2% respectively, with no grade IV views. Desaturation below 90% occurred in 12% of patients. There were two cases (1%) of failed intubation with supraglottic airway rescue, and no emergency surgical airways performed.
Conclusion: An obstetric airway management registry was successfully implemented. Clinically significant hypoxaemia occurred commonly during general anaesthesia, with a high incidence of difficult intubation predictors and desaturation. The registry will guide research aimed at improving safety during general anaesthesia in obstetrics.

Keywords: airway management, general anaesthesia, hypoxaemia, obstetric anaesthesia, pregnancy, registry
Registry number: NHRD WC_201810_002

Introduction

The African Surgical Outcomes Study showed that maternal mortality after caesarean delivery is 50 times greater in Africa, predominantly from obstetric haemorrhage and anaesthesia-related hypoxaemia or pulmonary aspiration.[1,2] The South African Saving Mothers Report (2014–2016) showed that 61/87 (70%) of anaesthesia-related deaths were attributed to complications of airway management.[3] Lack of skilled doctors was recorded in 71% of these deaths, and a quarter of all anaesthetics were administered by non-physician anaesthesia providers.[3]

Obstetric airway management features increased difficulty and complications.[4] Anatomical and physiological changes that occur during pregnancy increase the likelihood of difficult or failed intubation,[5] which may be up to eight times higher than in the general surgical population.[6-9] Maternal deaths from difficult airway management have been highlighted in two reports of the Confidential Enquiries into Maternal Deaths in the United Kingdom (2006–2008 and 2000–2002).[10,11] The American Society of Anaesthesiologists' Closed Claims in obstetrics database revealed that maternal deaths were more frequently associated with general than regional anaesthesia, and that 16% of the anaesthetic claims were due to critical events involving the airway and respiratory system.[12]

We sought to describe the clinical characteristics, contributors to, and outcomes of obstetric airway management within our context, and to test an online data collection tool. We aimed to quantify the reliability of captured cases; hence, the primary outcome of this validation study was to establish the proportion of the total number of general anaesthetics (GAs) performed, which were captured in the registry. We therefore compared the first 200 patients in the registry with the number of theatre logbook entries for the corresponding period. The secondary outcome was a detailed description of our obstetric anaesthesia population requiring GA, including predictors of difficult airway management, and outcomes. The aim of this ongoing registry is to address the lack of data in our context, identify trends, and provide the basis for future quality improvement projects in airway management.

Method

A multicentre Obstetric Airway Management Registry (ObAMR) was established after approval by the Human Research Ethics Committee (HREC) of the Health Sciences Faculty of the University of Cape Town (UCT) (HREC Ref: R025/2018). The ongoing registry was approved for a duration of three years from 26 September 2018 to 30 September 2021. Perioperative data describing patient demographics, indications for GA, factors predictive of a

difficult airway, airway management techniques, complications and outcomes are collected at Groote Schuur (GSH), Mowbray Maternity (MMH) and New Somerset (NSH) Hospitals under the clinical supervision of the Department of Anaesthesia and Perioperative Medicine of UCT.

All patients requiring GA after 20 weeks gestation and up to seven days post-delivery are included. Simple verbal consent for inclusion in the registry was approved by HREC. Preoxygenation to an end-tidal oxygen fraction > 0.8, followed by rapid sequence induction (RSI) and tracheal intubation with cricoid pressure is taught as standard practice at our centres.[4,13-16] However, the GA technique provided is ultimately at the discretion of the anaesthesiologist. All anaesthesia providers from the Department of Anaesthesia and Perioperative Medicine of UCT can enter data into the registry. Records are collected anonymously on REDCap (Research Electronic Data Capture, https://www.project-redcap.org/) during or immediately after the case by using an electronic link sent to their smartphones (www.tinyurl.com/ObAMR), or by scanning a QR code present in all obstetric theatres. The ObAMR is maintained on a secure password protected UCT server. Each electronic data capturing form is assigned a unique study number, with no personal identifying information.

The HREC of the Health Sciences Faculty of UCT approved the validation and initial description of the first 200 cases entered into the ObAMR (UCT HREC Ref: 341/2019). Data were collected from 26 September 2018 to 9 January 2019. Data were extracted from the REDCap server to an Excel spreadsheet (Microsoft, Redmond, Washington, USA). The primary outcome was assessed by establishing the proportion of general anaesthetics captured, by comparing the number of records in the registry and the total number of cases entered in the operating theatre logbooks over the same time period. For secondary outcomes, baseline patient characteristics were reported as mean (standard deviation [SD]) for continuous normally distributed variables, median (interquartile range [IQR]) for data not normally distributed, and number (percentage) for categorical variables. In addition, details relating to airway management were reported, including experience of anaesthesia provider, airway assessment, laryngoscopic view, and outcomes such as incidence of failed intubation and rescue, and nadir of oxygen saturation (< 90% defined as clinically significant). The detailed data capture sheet is available as Supplementary Material, Appendix 1.

Results

Cases were recorded at GSH (tertiary academic, 40%), MMH (regional obstetric, 39%) and NSH (regional, 21%). When compared to theatre logbooks, overall 80% of GAs were captured in the ObAMR (Table I). The obstetric GA rate at these centres was approximately 11% of all caesarean sections performed. At MMH there was a failure to record conversions from regional to general anaesthesia in the theatre logbooks, with one more GA case entered in the registry than recorded in theatre. This led to a falsely elevated capture rate of 101% at this institution. We excluded 32 patients requiring GA for infertility procedures (< 20 weeks gestation) at GSH, that had been entered in the theatre logbooks. Two incomplete records in the registry, with no location specified, were also excluded.

Table I: Validation data and location

	GSH	MMH	NSH	Total
Theatre logbooks	105*	76	66	247
ObAMR	80	77	41	198†
Capture rate	**76%**	**101%**	**62%**	**80%**

GSH – Groote Schuur Hospital, MMH – Mowbray Maternity Hospital, NSH – New Somerset Hospital, ObAMR – Obstetric Airway Management Registry
*32 ultrasound-guided oocyte retrievals at GSH were excluded (< 20 weeks gestation)
†2 incomplete records excluded; locations not specified

Patient demographic details are presented in Table II. Mean (SD) age was 29.5 (6.4) years, weight 77.2 (19.6) kg and body mass index (BMI) 29.3 (7.5) kg/m^2. Median (IQR) gestational age was 37 (33–39) weeks. Major indications for general anaesthesia included severe fetal distress/bradycardia in 21%, failed neuraxial technique in 19%, suspected or confirmed coagulopathy in 19%, and the presence of abnormal placentation (e.g. abruptio placentae/placenta praevia/accreta) in 12% of cases. Neuraxial anaesthesia was the primary anaesthetic strategy in 24% of cases who subsequently underwent GA. Hypertensive disorders of pregnancy were present in 33%, with 6% developing imminent or confirmed eclampsia. Forty per cent of patients were in active labour.

Table II: Patient demographic details

	Minimum	Maximum	Mean/ median	SD/IQR	*n*
Age (years)	15	44	29.5	6.4	200
Height (cm)	145	180	162.5	6.6	197
Weight (kg)	39	170	77.3	19.6	197
BMI (kg/m^2)	17.3	72.6	29.3	7.5	197
Gestation (weeks)	20	42	37	33–39	190
Parity	0	8	1	0–2	199
Gravidity	1	8	2	1–4	199

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

In this analysis, 89% of anaesthesia providers were medical officers and/or anaesthesia registrars with more than one year of experience of clinical anaesthesia. On airway assessment, Mallampati grade 3 or 4 was present in 29% of cases, and mouth opening, thyromental distance and mandibular protrusion were limited in 10%, 8% and 8% respectively (Table III).

Rapid sequence induction with an endotracheal tube (ETT) was the primary strategy in 72%. Suxamethonium was the muscle relaxant used in 97% of cases. First-pass intubation success was 87%, and an introducer was used in 21%. Traditional Macintosh laryngoscope blades were used in 73% of intubations. Videolaryngoscopes were available in 98%, but only used in 26% of intubations. Cormack-Lehane grade IIb and III laryngoscopic

views were encountered in 6% and 2% respectively, with no grade IV views.

Mild or severe airway oedema was encountered in 17%, as assessed clinically during laryngoscopy. Range (median; IQR) of saturation nadir was 15 to 100% (98; 95–99), with 12% of patients below 90%. Desaturation was more common in patients with pregnancy-related hypertension (22% versus 7%, $p = 0.0021$). There were two cases (1%) of failed intubation with supraglottic airway rescue, no emergency front of neck surgical access was required, and there were no deaths.

Table III: Airway assessment and management

Provider demographic details:	Frequency	Percentage (%)	*n*
Level of qualification			
Intern	4	2	
Community service doctor	7	3.5	
Medical officer	66	33	200
Registrar	111	55.5	
Consultant	12	6	
Years of experience			
< 1 year	21	10.5	
1–5 years	130	65	200
> 5 years	49	24.5	
Airway assessment:			
Mallampati			
I	44	22	
II	95	47.5	
III	48	24	200
IV	9	4.5	
Not assessed	4	2	
Dentition			
Full	155	77.5	
Partial present	36	18	200
Partial absent	7	3.5	
Edentulous	2	1	
Thyromental distance			
≥ 6.5 cm or 4 fingers	150	75.4	
< 6.5 cm or 4 fingers	15	7.5	199
Not assessed	34	17.1	
Inter-incisor gap			
≥ 5 cm or 3 fingers	170	85	
< 5 cm or 3 fingers	19	9.5	200
Not assessed	11	5.5	
Neck mobility			
≥ 35 degrees	171	85.5	
< 35 degrees	1	0.5	200
Not assessed	28	14	
Mandibular protrusion			
Class A	89	44.7	
Class B	12	6	199
Class C	3	1.5	
Not assessed	95	47.7	
Airway management:			
Primary strategy			
GA + ETT	144	72	
GA + SGA	4	2	200
Neuraxial	48	24	
Other	4	2	
Muscle relaxant			
None	4	2	
Suxamethonium	194	97	
Rocuronium	2	1	200
Cisatracurium	-	-	
Other	-	-	
Laryngoscope blade			
Macintosh 3	122	61.3	
Macintosh 4	24	12.1	
CMAC 3	27	13.6	199
CMAC 4	19	9.5	
CMAC D	4	2	
None	3	1.5	
Direct C-L view			
Grade I	155	77.5	
Grade IIa	25	12.5	
Grade IIb	12	6	200
Grade III	4	2	
Grade IV	-	-	
Not assessed	4	2	
Airway oedema			
Absent	167	83.5	
Mild	28	14	200
Severe	5	2.5	
Intubation attempts			
1	174	87	
2	25	12.5	200
3	1	0.5	
4	-	-	
Introducer			
Yes	41	20.5	200
No	159	79.5	
Videolaryngoscope used			
Yes	56	28	200
No	144	72	
Supraglottic device used			
Yes	2	1	200
No	198	99	
Front of neck access			
Yes	-	-	200
No	200	100	
SpO_2 nadir			
< 90%	23	11.5	200
> 90%	177	88.5	

GA – general anaesthesia, ETT – endotracheal tube, SGA – supraglottic airway, C-L – Cormack-Lehane

Discussion

The primary outcome of this analysis showed that 80% of obstetric GA cases performed during September 2018 and January 2019 at GSH, MMH and NSH were captured in the ObAMR by means of an online data-capturing tool. This begins to address the scarcity of airway-specific registry data for obstetric GA in the literature.

On airway assessment, we encountered a high prevalence of factors predicting difficult tracheal intubation. Clinically significant hypoxaemia (saturation nadir < 90%) occurred in approximately one in eight patients (12%) and was more common in patients with hypertensive disorders of pregnancy. The overall incidence of hypoxaemia is similar to that described in a recent observational study conducted elsewhere in South Africa (16.8%).[17]

Neuraxial anaesthesia offers advantages in obstetric patients in terms of avoidance of airway management.[18] Over the past 20 years, there has been a significant reduction in the use of GA for caesarean section, with corresponding increased use of neuraxial techniques.[19] The challenges surrounding safe and timely securing of the airway in the obstetric patient are a major cause of morbidity and mortality in any setting.[19] In 38 (19%) patients in our study, the primary indication for GA was failed neuraxial anaesthesia. This highlights an area for quality improvement in our setting.

Airway difficulty has been reported to be eight times more common in obstetric patients compared to the general surgical population,[7] with the incidence of difficult or failed tracheal intubation remaining at 2.6 (95% CI 2.0–3.2) per 1 000 anaesthetics (1 in 390) for obstetric general anaesthesia.[7] Maternal mortality from failed intubation is 2.3 (95% CI 0.3–8.2) per 100 000 of all GAs for caesarean section (one death per 90 failed intubations),[7] and occurs from hypoxaemia secondary to airway obstruction or oesophageal intubation, or pulmonary aspiration.[4,7] In this analysis, there were two cases of failed intubation (1%) with successful supraglottic airway rescue, and no emergency front of neck surgical access was required. There were no maternal deaths recorded in the registry.

Most airway catastrophes occur when airway difficulty is not anticipated prior to induction of anaesthesia.[5] Timely evaluation of the parturient's airway and adequate preparation to deal with potential complications are helpful in avoiding airway disasters. There are a few simple preoperative bedside clinical tests that can be performed to evaluate the airway, including the Mallampati score, mouth opening (inter-incisor gap), thyromental distance, neck mobility (atlanto-occipital extension), and ability to protrude the mandible.[5,20,21] The relationship between increased grades of airway classification and relative difficulty of intubation in parturients undergoing caesarean delivery during GA, has been studied by Rocke et al.[22] They found that the relative risk of difficult intubation in a parturient with a Mallampati class 3 airway was 7.58 times higher than in a parturient with a class 1 airway. This relative risk increased to 11.3 in patients with a class 4 airway.[22] We encountered Mallampati grade 3 or 4 in 29% of cases, and mouth opening, thyromental distance and mandibular protrusion were often limited.

Maternal, fetal, surgical and situational factors contribute to the increased incidence of failed intubation. Many physiological changes occur during pregnancy, including physical characteristics such as increased BMI, breast enlargement, and generalised oedema. The mucosa of the upper respiratory tract also becomes more vascular and oedematous, especially during labour,[23] leading to increased risk of airway bleeding and swelling.[20] Fluid retention in head and neck tissues during pregnancy potentially narrows the upper airway and reduces compliance, making laryngoscopy more difficult.[19] Clinical teaching is that pharyngeal oedema may be exacerbated by preeclampsia and eclampsia, although there is limited literature to support this statement. In this analysis mild or severe airway oedema was encountered in 17% of patients. Videolaryngoscopy (VL) has been suggested as a useful adjunct for both anticipated and unanticipated difficulty in obstetric GA. The low rates of usage of VL and tracheal tube introducers in our registry (despite near-ubiquitous availability) is cause for concern, and an obvious target for quality improvement.

There were several limitations of our study. The overall rate of capture of approximately 80% into the registry reflects that at least 20% of general anaesthesia cases were omitted. However, if the elevation of the capture rate due to the documentation practice at MMH is excluded, the rate may have been only 71%. It is unlikely that any category of airway challenge would have had a higher likelihood of reporting or omission, so that selection bias probably did not influence the outcome**.** Although the registry is rapidly completed by the attending anaesthetist, it is possible that periods of high case load may have reduced reporting. The ethical considerations concerning anonymity precluded our establishing the clinical circumstances of the cases not captured. Every attempt will be made to increase the capture rate, by emphasising the long-term benefits to patient safety of maintaining a complete registry. The anaesthesia provider during the GA was responsible for capturing the data onto the ObAMR, and data entry errors may have occurred. The online data capturing tool included definitions and pictures as a guideline, but certain data fields including preoperative airway assessment are subject to inter-observer variability. As clinicians were ultimately responsible for the GA technique, there may have been non-standardised performance. It was therefore often difficult to identify the contributing factors for the high incidence of hypoxaemia in our study.

Strengths of our study include the successful establishment of the ObAMR, which we believe to be the first online database collecting information on airway management in the pregnant population in our setting. The aims of this registry are to enhance quality control and clinical governance, and to monitor and assess airway management trends during GA in this high-risk group of patients.

The results of this initial analysis show that our online data-capturing tool is valuable for collecting information on airway management in the obstetric population. Hypoxaemia during GA for obstetric patients is still common. This registry will allow for broader analysis to be conducted on larger datasets and serve as the basis for the performance of future interventional studies.

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Conflict of interest

The authors declare that they have no conflicts of interest.

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Ethics approval

A multicentre Obstetric Airway Management Registry (ObAMR) was established after approval by the Human Research Ethics Committee (HREC) of the Health Sciences Faculty of the University of Cape Town (UCT) (HREC Ref: R025/2018).

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Appendix 1 on next page

Confidential

Obstetric Airway Management Registry

Thank you for completing this Obstetric Airway Management Registry (ObAMR). The data below should form part of your standard pre-operative assessment and peri-induction anaesthetic documentation, and should take 1-2 minutes per case to complete. Should you have questions, please contact Dr Maretha Smit (76177) or A/Prof Ross Hofmeyr (77392).

Please complete the survey below.

Case information

1) Location
- ◯ GSH MK (Maternity Centre)
- ◯ GSH (Main Theatres)
- ◯ MMH (Mowbray Maternity)
- ◯ NSH (Somerset Hospital)
- ◯ MPH (Mitchells Plain Hospital)

2) Date _____

3) What is your level of qualification?
- ◯ Intern
- ◯ Community service
- ◯ Medical Officer
- ◯ Registrar
- ◯ Consultant

4) Years of anaesthesia experience?
- ◯ < 1 Year
- ◯ 1 - 5 Years
- ◯ > 5 Years

5) Consent for use of data in registry
- ◯ Simple verbal consent obtained
- ◯ Patient unable* to provide sufficient verbal consent. Please flag for follow-up.

(*Decreased level of consciousness etc)

Patient demographics

6) Age of patient in years _____

7) Height of patient in centimeters (actual or estimated) _____

8) Body weight of patient in kilograms (actual or estimated) _____

Obstetric history

9) Gravidity of patient _____

10) Parity of patient _____

11) Current gestational age in weeks _____

12) Hypertensive disease
- ◯ None
- ◯ Chronic hypertension
- ◯ Pregnancy induced hypertension
- ◯ Pre-eclampsia
- ◯ Pre-eclampsia superimposed on chronic hypertension
- ◯ Eclampsia

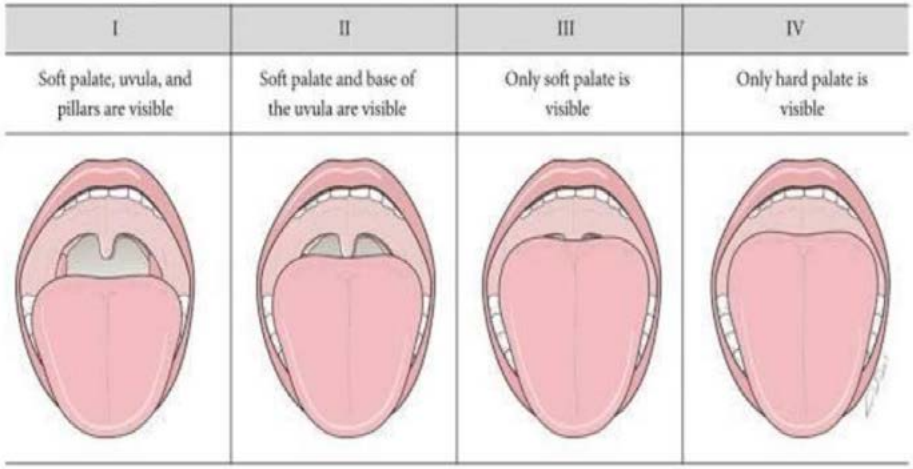
13) Duration of labour
- ◯ Not in labour
- ◯ First stage (latent phase): from the onset of contractions to 3cm dilatation of the cervix
- ◯ First stage (active phase): from 3cm to full cervical dilatation
- ◯ Second stage: from complete dilation and effacement to delivery of the baby
- ◯ Third stage: from delivery of baby to delivery of placenta
- ◯ Fourth stage: the first hour after delivery
- ◯ Within 48 hours post delivery
- ◯ More than 48 hours post delivery

Anaesthetic Preassessment

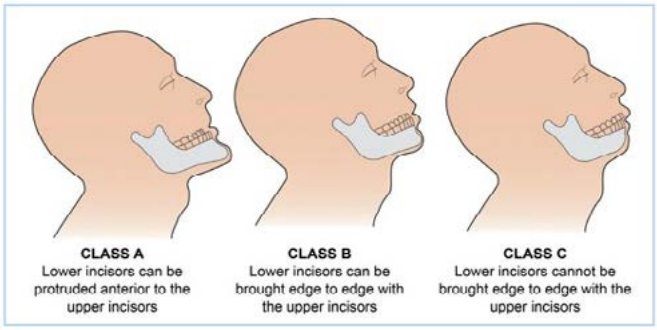
14) Primary anaesthetic strategy
- ◯ Neuraxial
- ◯ GA + mask ventilation
- ◯ GA + mask + supraglottic device
- ◯ GA + mask + endotracheal tube
- ◯ Other

15) Indication for general anaesthesia
- ☐ Coagulopathy
- ☐ Inadequate neuraxial anaesthesia
- ☐ Prolonged case
- ☐ Decreased level of consciousness
- ☐ Other

16) Mallampati score
- ◯ Class I
- ◯ Class II
- ◯ Class III
- ◯ Class IV
- ◯ Not assessed

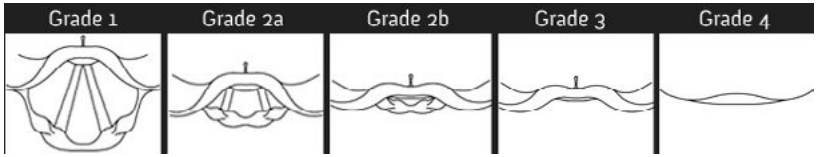


17)	Dentition	◯ Full ◯ Partial - Most teeth present ◯ Partial - Most teeth absent ◯ Edentulous
18)	Thyromental distance*	◯ ≥ 6,5cm or four fingers ◯ < 6,5cm or four fingers ◯ Not assessed (*The distance from the chin to the notch of the thyroid cartilage)
19)	Mouth opening (inter-incisor gap)	◯ ≥ 5cm or three fingers ◯ < 5cm or three fingers ◯ Not assessed
20)	Neck mobility* (atlanto-occipital extension)	◯ ≥ 35 degrees from neutral head position ◯ < 35 degrees from neutral head position ◯ Not assessed (*The range of extension of the head over the neck)
21)	Mandibular protrusion	◯ Class A - the lower incisors can be protruded anterior to the upper incisors ◯ Class B - the lower incisors can be brought edge to edge with the upper incisors but not anterior to them ◯ Class C - the lower incisors cannot be brought edge to edge with the upper incisors ◯ Not assessed



Airway Management

22)	Muscle relaxant used?	◯ None ◯ Suxamethonium ◯ Rocuronium ◯ Cisatracurium ◯ Other
23)	Video laryngoscope immediately available?	◯ Yes ◯ No
24)	Video laryngoscope used for intubation?	◯ Yes ◯ No
25)	Intubation recorded on CMAC?	◯ Yes ◯ No
26)	Patient positioning optimal* for intubation	◯ Yes ◯ No (*Ramped/sniffing/ear-to-sternal notch positioning)
27)	Laryngoscope blade used	◯ Macintosh 3 ◯ Macintosh 4 ◯ CMAC 3 ◯ CMAC 4 ◯ CMAC D-blade
28)	Direct Cormack-Lehane view of the glottis	◯ Grade I - 50% or more of vocal cords visible ◯ Grade IIa - Less than 50% of vocal cords visible ◯ Grade IIb - Only arytenoid cartilages visible ◯ Grade III - Only the epiglottis is visible ◯ Grade IV - Epiglottis not visible ◯ Not assessed



29) Upper airway oedema?
- ◯ Absent
- ◯ Mild
- ◯ Severe

30) Intubation attempts
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ > 5

31) SpO2 nadir*

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(*lowest oxygen saturation during induction and airway management (%))

32) Introducer (bougie or stylet) used?
- ◯ Yes
- ◯ No

33) Supraglottic rescue (LMA or other) required?
- ◯ Yes
- ◯ No

34) Surgical airway rescue (front-of-neck access) required?
- ◯ Yes
- ◯ No