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Original Research Article

Impact of two different head and neck alignment planes on glottic visualization at laryngoscopy in adults

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ABSTRACT

Background: Optimal head and neck positioning is key to rapid, successful tracheal intubation enabling circumvention of peri-intubation sequelae; thus, scientific search for definite anatomical landmarks to serve as reference points for favorable head and neck alignment during laryngoscopy is warranted.

Methods: Ethical approval obtained, 78 adults aged 18-60 years, of American society of anesthesiologists (ASA) class I and II, were randomized into groups A and B, of 39 each. All patients had general anaesthesia with oro-tracheal intubation. Group A had the suprasternal notch and external auditory meatus (SN-EAM) plane aligned horizontally, while group B had the sternal angle of Louis and external auditory meatus (SAL-EAM) plane horizontally aligned, for direct laryngoscopy. Glottic view achieved and external laryngeal manoeuvre with backward, upward, rightward pressure (BURP) application was assessed using Cormack-Lehane grading and four-point Likert scale respectively; intubation attempts, immediate post-intubation arterial oxygen saturation (SpO_2), and time to orotracheal intubation (TTOTI) defined as the period from removal of preoxygenating face mask to first capnographic evidence of correct tracheal intubation, were recorded.

Results: All 78 subjects completed the study. Groups A and B were similar in degree of glottic visualization (p=0.642) and TTOTI (33.38±5.09 versus 33.18±5.77, p=0.868); tracheal intubation attempts, BURP application and immediate post-intubation SpO_2 (98.25±0.72 versus 98.23±0.81, p=0.833) were also comparable.

Conclusion: Aligning the SN-EAM plane horizontally achieved degree of glottic visualization comparable to keeping horizontally the SAL-EAM plane, during direct laryngoscopy in adults.

Keywords: Glottic view, Head-neck alignment planes, Laryngoscopy

INTRODUCTION

Amongst airway management professionals, routinely, direct laryngoscopy for oro-tracheal intubation is the ranking technique.[1,2] This technique, though usually done with ease, is occasionally associated with difficulties, especially when a difficult airway is unanticipated.[3] Failure to accomplish a smooth, swift tracheal intubation at first attempt risks peri-intubation hypoxia, and predisposes to regurgitation and pulmonary aspiration. Researchers have documented increasing incidence of adverse events with increasing laryngoscopic attempts, including oro-pharyngeal trauma and significant haemodynamic derangements.[4-6] Bannister et al introduced the 'three axes alignment theory', concluding that aligning the vision of the intubator with the patient's oro-pharyngo-laryngeal axis was the main determinant of good glottic visualization, and could be achieved by head elevation with a pillow, resembling the 'sniffing the morning air' position. Subsequent researchers reported a superiority of the 'sniffing position' over simple head extension.[3,7,8] Greenland et al later observed that the oro-pharyngo-laryngeal axis was more favourably aligned for direct orotracheal intubation when the auditory meatus-sternal notch plane was kept horizontally, compared to head kept in the neutral position; thus, they provided specific anatomical reference points for the achievement of optimal positioning for layngoscopy.[9] However, there is paucity of reported studies on the comparison between the use of the auditory meatus-sternal notch axis and another anatomical plane with respect to glottic visualization. This study, therefore, is designed to determine the extent of glottic view achieved during direct laryngoscopy for oro-tracheal intubation in Nigerian adults, when head-neck alignment is done by keeping horizontally the SAL-EAM axis compared to head-neck alignment done by keeping horizontally the reported SN-EAM plane.

METHODS

Approval secured from the research ethics committee (UPTH/ADM/90/S.11/VOL.XI/1715) of the university of Port Harcourt teaching hospital (UPTH), Port Harcourt, Nigeria, for a prospective, randomized, double blind, comparative study, 78 consenting adults, aged 18-60 years, of ASA I and II, were randomized into groups A and B, of 39 each. All 78 subjects completed the study which was conducted from April to September, 2024, in UPTH, Port Harcourt, Nigeria.

Sample size determination

Sample size (n) was determined using power analysis formula[10]

$n=(Z\alpha+Z_\beta)^2\, p(1\text{-}p)/d^2$

Where,

n=minimum sample size

$Z\alpha=1.28$, with power of 90% for this study; $Z_\beta=1.96$, using a significance level of 5%.

p1=proportion of outcome in group which received intervention; in a related study 85.9% (0.859) improved glottic view was achieved in the group which aligned the external auditory meatus and suprasternal notch horizontally.[11] p2=proportion of outcome in second group; from same study this was 43.7% (0.437).[11]

p=average proportion=(p1+p2)/2=0.859+0.437/2=0.648. d=effect size. For this study, the effect size is 26% (0.26).

Substituting,

$n=(1.96+1.28)^2\times0.648(1\text{-}0.648)/(0.26)^2=35.42$

Allowing for 10% attrition, adjusted sample size=35.42+3.54=39 per group.

Randomization and blinding were ensured via recruitment of research assistants (Registrar anaesthetists). Each subject, under supervision by first research assistant and a nurse, picked from a bag one out of 78 opaque sealed envelopes concealing alphabet A or B in an equal ratio of 39. The envelope picked was excluded from the rest and the patient allocated to the group designated. A second research assistant, blinded to the outcome of the study, undertook head-neck alignment according to group specification as well as assigned a different code for each subject's group against hospital number. The Lead Researcher who was blinded to the group allocations and head-neck alignments performed laryngoscopy and recorded the parameters.

The groups accordingly were, A: group which had head-neck alignment done by keeping the SN-EAM axis horizontally. B: group that had head-neck alignment done by keeping the SAL-EAM axis horizontally.

Preoperatively, all subjects were visited a day before surgery, for evaluation, preparation and assessment of eligibility for study; the inclusion criteria comprised adults aged 18-60 years scheduled to undergo general anaesthesia with direct laryngoscopy and oro-tracheal intubation for elective surgery, belonging to ASA class I or II, with BMI range of 18 to 29 kgm^{-2}, who gave consent for surgery, anaesthesia and study. Contrarily, refusal to give consent for surgery, anaesthesia and for study, age <18 or >60 years, BMI <18 or >29 kgm^{-2}, Mallampati grade >II, inter-incissor gap <4 cm, thyromental distance <5 cm, history of haemoglobinopathy, presence of cranio-facial, neck/chest wall deformities/arthritis, vertebral anomalies oropharyngeal/laryngeal masses, Down syndrome, Pierre Robbin, Goldehar/Treacher-Collins syndrome, plagiocephaly, microcephaly, megalencephaly, micrognathia, obstetric patients, emergency surgery, 2 unsuccessful oro-tracheal intubation attempts and those scheduled for nasotracheal intubation constituted exclusion criteria.

Details of anaesthesia

On morning of surgery, a multi-parameter monitor (Dash 4000®) was attached for recording baseline heart rate, temperature, non-invasive BP (NIBP) and SpO_2, and for continuous monitoring all through period of surgery. Prior to laryngoscopy, patients ramped up, by fixing linen under their trunks or heads as required, to keep either SN-EAM/SAL-EAM axis horizontally, in accordance with each subject's group allocation. Horizontal alignment was ascertained using small plumb rule.[9]

Laryngoscopy and tracheal intubation were performed by the lead researcher for homogeneity, using size 4 Macintosh blade (Orion) and appropriate size styletted tracheal tube, facilitated by intravenous 2 mg/kg propofol, 1μg/kg fentanyl and 0.5 mg/kg atracurium sequentially, following preoxygenation for 3 minutes via face-mask. The degree of glottic view achieved, TTOTI, tracheal intubation attempts, BURP application, and the immediate post-intubation SpO_2 were recorded; grade of BURP applied was assessed using a four-point Likert scale:[12] (0=none; 1=minimal; 2=moderate; 3=maximal); the degree of glottic view achieved at laryngoscopy was assessed using the Cormack-Lehane grading:[13] (grade 1=full view of rima glottidis; grade 2=partial view of rima glottidis; grade 3=only epiglottis seen, none of rima glottidis seen; grade 4=neither epiglottis nor rima glottidis seen). Subjects in whom oro-tracheal intubation was unsuccessful at the second attempt were to have tracheal intubation aided by Glidescope, and dropped from study. Adequate analgesia, anaesthesia, airway maintenance, reversal of anaesthesia and recovery were ensured in accordance with local standard operating protocol.

Data analysis

Data were entered into Excel spreadsheet and exported to the statistical product and service solutions (SPSS) version 20.0 (Armonk, NY: IBM Corp.), for statistical analysis by a statistician not involved in study. Statistical significance was set at p<0.05.

RESULTS

Two groups were comparable in mean age (p=0.342), mean BMI (p=0.933), and ASA classification (p=0.812); there was female preponderance in 2 groups with a female to male ratio-30:9 in group A and 28:11 in B, however, difference was not significant, p=0.604 (Table 1).

Mastectomy was the ranking surgery undergone by the subjects, recording a total of 30 (76.93%); laparotomic huge ovarian cystectomy and lumbar/thoracic spine decompression, respectively, were the second and third leading surgeries, with the corresponding total values of 18 (23.08%) 9 and (11.54%); laparotomic abdominoperineal resection for sigmoid tumour and laparoscopic cholecystectomy were each 7 (8.97%), occupying fourth leading position, while diverting ileostomy for colonic tumour (5; 6.41%) and laparoscopic appendicectomy (2; 2.56%) ranked 5th and 6th correspondingly (Table 2).

Predictive airway assessments using Mallampati classification, inter-incissor gap and thyromental distance, showed no significant difference between the groups: 21 (53.8%) in group A, and 20 (51.3%) in group B were of Mallampati class I, while 18 (46.2%) and 19 (48.7%) in groups A and B respectively, belonged to Mallampati class II, p=0.821. Again, on t-test analysis of the mean inter-incissor gaps (5.87±0.23 versus 5.84±0.28) and mean thyromental distances (6.89±0.52 versus 6.94±0.41) the two groups were statistically comparable, p=0.595 and p=0.663, respectively (Table 3).

Tracheal intubation was successful at first attempt in all subjects, without any application of BURP; there was statistically similar mean TTOTI, in seconds, across the groups (33.38±5.09 versus 33.18±5.77, p=0.868); as well, immediate post-intubation SpO_2 values (98.25±0.72 versus 98.23±0.81) in the two groups were comparable, p=0.833. Peri-intubation assessment of degree of glottic visualization showed comparable Cormack-Lehane (C-L) grades between the two groups: 23 (59. 0%) in group A, and 25 (64.1%) in group B, had C-L grade I; the corresponding number of subjects who had C-L grade II were 16 (41.0%) versus 14 (35.9%), p=0.642; there was no occurrence of failed tracheal intubation, inadvertent oesophageal intubation or peri-intubation hypoxaemia in any of the groups (Table 4).

Table 1: Socio-demographic characteristics and ASA class of subjects in groups A and B.

Variables	Group						χ^2/t-test value	P value
	A, n=39		B, n=39		Total			
Age (in years)								
<20	1	(2.6)	1	(2.6)	2	(2.6)	2.97$^{\alpha}$	0.563
20-29	10	(25.6)	15	(38.5)	25	(32.1)		
30-39	13	(33.3)	13	(33.3)	26	(33.3)		
40-49	14	(35.9)	8	(20.5)	22	(28.2)		
50-59	1	(2.6)	2	(5.1)	3	(3.8)		
Total	39	(100.0)	39	(100.0)	78	(100.0)		
Sex								
Female	30	(76.9)	28	(71.8)	58	(74.4)	0.27$^{\alpha}$	0.604
Male	9	(23.1)	11	(28.2)	20	(25.6)		
Total	39	(100.0)	39	(100.0)	78	(100.0)		
BMI (kg/m^2)								
Healthy	26	(66.7)	26	(66.7)	52	(66.7)	0.0$^{\alpha}$	1.00
Overweight	13	(33.3)	13	(33.3)	26	(33.3)		
Total	39	(100.0)	39	(100.0)	78	(100.0)		
Age (in years)	35.03±9.28		33.08±8.70		34.05±8.99		0.96$^{\delta}$	0.342
BMI (kg/m^2)	23.50±2.86		23.55±2.45		23.52±2.65		-0.09$^{\delta}$	0.933
ASA								
I	25 (64.1)		26 (66.7)		51 (65.4)		0.06$^{\alpha}$	0.812
II	14 (35.9)		13 (33.3)		27 (34.6)			
Total	39 (100.0)		39 (100.0)		78 (100.0)			

χ^2=Chi-square; α=Chi-square value; δ=t test value; data are expressed as mean±SD/no. (%), ASA=American society of anesthesiologists.

Table 2: Distribution of surgical procedures for tracheal intubation across the two groups.

Type of surgery	Group			Rank
	A, n=39 (%)	B, n=39 (%)	Total, N (%)	
Mastectomy	16 (41.03)	14 (35.90)	30 (38.46)	1
Laparotomic huge ovarian cystectomy	10 (25.64)	8 (20.51)	18 (23.08)	2
Lumbar/thoracic spine decompression	4 (10.26)	5 (12.82)	9 (11.54)	3
Laparotomic abdomino-perineal resection for sigmoid tumour	3 (7.69)	4 (10.26)	7 (8.97)	4
Laparoscopic cholecystectomy	3 (7.69)	4 (10.26)	7 (8.97)	4
Diverting ileostomy for colonic tumour	2 (5.13)	3 (7.69)	5 (6.41)	5
Laparoscopic appendicectomy	1 (2.56)	1 (2.56)	2 (2.56)	6
Total	39 (100.0)	39 (100.0)	78 (100.0)	-

Table 3: Inter-incissor gap, thyromental distance, and Mallampati classification between the two groups.

Variables	Group			χ^2/t-test value	P value
	A, n=39	B, n=39	Total		
Inter-incisor (I - I) gap (cm)	5.87±0.23	5.84±0.28		0.53^{δ}	0.595
Thyromental distance (cm)	6.89±0.52	6.94±0.41		-0.44^{δ}	0.663
Mallampati classification					
I	21 (53.8)	20 (51.3)	41 (52.6)	0.05^{α}	0.821
II	18 (46.2)	19 (48.7)	37 (47.4)		
Total	39 (100.0)	39 (100.0)	78 (100.0)	-	-

χ^2=Chi-square test; α=Chi-square value; δ=t test value; **d**ata are expressed as mean±SD or number (%)

Table 4: Cormack-Lehane grading, TTOTI, tracheal intubation attempts, application of BURP, post intubation SpO_2 and peri-intubation complications across the groups.

Variables	Group			χ^2/t-test value	P value
	A, n=39	B, n=39	Total		
Cormack-Lehane grading					
1	23 (59.0)	25 (64.1)	48 (61.5)	0.22^{α}	0.642
2	16 (41.0)	14 (35.9)	30 (38.5)		
Number of attempts at tracheal intubation					
1	39 (100.0)	39 (100.0)	78 (100.0)		
>1	0 (0.0)	0 (0.0)	0 (0.0)		-
Application of BURP					
No	39 (100.0)	39 (100.0)	78 (100.0)		
Yes	0 (0.0)	0 (0.0)	0 (0.0)		-
Time to oro-tracheal intubation (Sec)	33.38±5.09	33.18±5.77		0.17^{δ}	0.868
Immediate post intubation SpO_2 (%)	98.25±0.72	98.23±0.81		0.15^{δ}	0.833
Failed tracheal intubation					
No	39 (100.0)	39 (100.0)	78 (100.0)		
Yes	0 (0.0)	0 (0.0)	0 (0.0)		
Inadvertent oesophageal intubation					
No	39 (100.0)	39 (100.0)	78 (100.0)		
Yes	0 (0.0)	0 (0.0)	0 (0.0)		
Peri-intubation hypoxaemia					
No	39 (100.0)	39 (100.0)	78 (100.0)		
Yes	0 (0.0)	0 (0.0)	0 (0.0)		

χ^2=Chi-square test; α=Chi-square value; δ=t-test value; data are expressed as mean±SD or mumber (%), TOTTI=Time to oro-tracheal intubation and BURP=Backward upward rightward pressure.

DISCUSSION

In adults possessing similar demographic and predictive airway parameters, head-neck alignment done by keeping the SAL-EAM axis in a horizontal plane, achieved degree of glottic view comparable to head-neck alignment done by keeping the SN-EAM axis horizontally, during direct rigid laryngoscopy for oro-tracheal intubation; the TTOTI, number of attempts at tracheal intubation and immediate post-intubation SpO_2 were, as well, statistically similar, without the occurrence of peri-intubation complications.

During direct laryngoscopy, glottic visualization is the most important denominator, not only of a successful tracheal intubation, but also of the rapidity of achieving such success; in this regard, a prior anatomical alignment of the head relative to the neck, to enhance an optimal view of the rima glottidis at laryngoscopy is a critical necessity. Recognizing this, the difficult airway society United Kingdom (DAS UK) in a 4-step (A-B-C-D) difficult airway management algorithm for adult patients, had since 2004 retained its recommendation of the patient's head or neck repositioning, as the first of the constituent techniques under plan A, ab initio, or following a failed initial intubation attempt.[14,15] A proper and favourable head-neck alignment prior to laryngoscopy, being given recognition and recommendation by the DAS UK thus, warrants that it is considered a prerequisite to successful tracheal intubation.[14,15]

As observed, in this study, keeping in one group of subjects the SN-EAM on same horizontal plane at laryngoscopy, achieved a glottic view of Cormack-Lehane grade 1 in 23 (59.0%), and in 16 (41.0%) Cormack-Lehane grade 2, comparable to Cormack-Lehane grade 1 in 25 (64.1%), and grade 2 in 14 (35.9%) in the group that had the SAL-EAM axis kept horizontally, p=0.642; thus, there was an achievement of confinement of glottic view to Cormack-Lehane grades 1 and 2, with 100% exclusion of grades 3 and 4 in each group. Based on classification, Cormack-Lehane grades 3 and 4 represent poor glottic visualization that conveyed an association with difficult tracheal intubation; analyzing this finding further against the background of the interpretation of Cormack-Lehane grading, keeping the SAL-EAM plane horizontally was comparable to aligning the SN-EAM in horizontal axis, in the demonstrated considerable positive impact on glottic visualization, with consequent enhancement of easy laryngoscopy and tracheal intubation.[13] Empirically, this finding lends support to Greenland et al who earlier documented that their 'ramped position' effected a better alignment of the oro-pharyngo-laryngeal axis, favorable to direct oro-tracheal intubation, when the auditory meatus-sternal notch (SN-EAM) plane was kept horizontally, compared to head kept in the neutral position.[9] Inferentially, therefore, the oro-pharyngo-laryngeal axis, described by Bannister et al in 1944, in their 'three axes alignment theory', was brought into a favourable alignment with the vision of the laryngoscopist in this study, with the degree of favorableness achieved being statistically similar, between horizontally aligning the SAL-EAM plane and keeping horizontally the SN-EAM axis.[3]

Indeed, a swift, smooth and successful tracheal intubation at first attempt is all-time desirable. In this study, there was 100% first-pass success at tracheal tube placement in each of the two groups, depicting demonstration of parallel effectiveness of the two axes (SN-EAM versus SAL-EAM), in the conferment of an anatomical advantage of improved glottic view, favourabe to achieving first-attempt intubation success. Goto et al in their retrospective analysis of multicentre data, observed that in 1,151 rescue intubations, the success rate on the first attempt declined as the number of preceding failed attempts increased, with the corresponding values of 81%, 71%, and 67%, after the first, second and third failed attempts.[16] For a practicing airway management professional, therefore, it is far saner, and for the patient far safer, to employ such alignment of the head, relative to the neck, prior to the very first attempt rather than relegate such aligning to a second or third place, after a failed first or second attempt at tracheal intubation. A failure to secure successful tracheal intubation at first attempt not only necessitates multiple intubation attempts, but also predisposes to an occurrence in the patient of associated adverse airway-related consequences. The causative association of poor/difficult laryngoscopy with failed tracheal intubation leading to multiple attempts at intubation, resulting in airway trauma, oedema and grave hypoxia had been documented, and agrees with the earlier finding of an association of corresponding increase in the incidence of adverse effects with increasing tracheal intubation attempts.[4-6,17]

In all the 78 direct rigid laryngoscopies, followed by endotracheal tube placements performed in this study, there was zero (0.0%) application of BURP; the observed comparable absence of its application, in the two groups, is a further corroboration of the parallel effectiveness of the two different head-neck alignment axes, used in this study, in achieving improved glottic visualization to the exclusion of necessitation of any BURP application. External laryngeal manoeuvre, through the application of BURP of varying degrees on the thyroid cartilage, as described by Knill, is often required to improve poor glottic visualization (Cormack-Lehane grades 3 and 4) for successful tracheal intubation, with the degree of BURP needed bearing a direct correlation with the level of poorness of glottic view.[18] The effectiveness and reliability of BURP manoeuvre in achieving improved glottic view, toward a favorable management of complex laryngoscopic procedures had, as well, been reported.[19] In their retrospective comparative study of the effects of BURP manoeuvre for tracheal intubation, using the Optiscope™ in 68 adults, Oh et al also observed a decreased intubation time by 6.089 seconds (95% confidence interval 1.303-10.875, p=0.014), in association with the group which had BURP manoeuvre, relative to control, owing to better glottic visualization.[20] However, according to Yu et al BURP application is not necessitated when there is satisfactory visualization of the rima glottidis, classifiable as Cormack-Lehane grade 1 or 2, during laryngoscopy; this documentation agrees with the empirical findings in the current study.[21]

Peri-intubation hypoxaemia/hypoxia is a time-dependent sequelae following apnoea or significant depression in respiration, that entails a risk for the development of hypoxic brain injury or death, if SpO_2 values decrease below 70%, especially in patients with preexisting haemodynamic compromise.[22] There was zero (0.0%) occurrence of peri-intubation hypoxaemia in the two groups (SpO_2=98.25±0.72 versus 98.23±0.81, p=0.15), in this study, as a result of rapidly successful tracheal intubation accomplished at first attempt in all subjects, made possible by favourable head-neck alignments; the rapidity of first-attempt success was made evident by the short mean duration (in seconds) from removal of preoxygenating face-mask to first capnographic evidence of correct tracheal intubation, being 33.38±5.09 in group A, and 33.18±5.77 in group B, p=0.17. Cook et al had identified hypoxia as the commonest airway-related complication cascading to death.[17] While agreeing with consensus view, upheld by airway management experts, that the occurrence of significant peri-intubation hypoxaemia/hypoxia is a direct consequence of delayed or failure of oxygen delivery to the alveoli, and not due to delayed or failed tracheal intubation, it is also very important to note that a rapidly successful tracheal intubation, achieved at first attempt, secures the anatomical channel for controlled oxygenation and ventilation, as well as ensures total circumvention of the necessity for rescue oxygenation and ventilation, via the use of face-mask, supraglottic or other device.[14,15]

As a note, the DAS UK recognizes that encountering a "can't intubate can't oxygenate" ("CICO") scenario, which is a most dreaded and life-threatening sequelae, remains a possibility during management of an unanticipated difficulty airway; however, more importantly, it is a certainty that the chances of encountering a "CICO" scenario, the occurrence of which demands an immediate life-saving needle cricothyrotomy, or a surgical cricothyrodotomy, can only become >0.0%, if a first-pass success at tracheal intubation is not achieved.[14,15] Inferentially, therefore, from the empirical findings in the current research, an optimal head-neck alignment conveyed an anatomical advantage of improved glottic exposure, with a physiological benefit of circumvention of peri-intubation arterial haemoglobin desaturation and a "CICO" scenario.

The mean values of TTOTI observed in the two groups of this study agree with those of Oh et al in their documented mean intubation time of 36.23±8.98 versus 38.92±10.97 for group A versus B, respectively.[20] Importantly, while Oh et al used BURP application in conjunction with a rigid video laryngoscope (Optiscope™), such were not used in this study.[20] On a critical analysis, a head-neck alignment done by keeping in horizontal plane, the SN-EAM or the SAL-EAM axis was effective in achieving a mean TTOTI that was similar to that achieved using a combination of Optiscope™ and BURP application. There was also no occurrence of failed tracheal or inadvertent oesophageal intubation noted in the groups. The findings in this study, thus, would be conveying an important fact of remarkable clinical significance to practicing anesthesiologists and airway professionals, especially those in institutions located in low- and middle-income countries with poor resource setting, on the critical usefulness of ensuring a horizontal alignment of either the SN-EAM or SAL-EAM axis, preliminary to direct rigid laryngoscopy for oro-tracheal intubation in adults.

CONCLUSION

During direct rigid laryngoscopy for oro-tracheal intubation in adults, keeping in horizontal axis the SAL-EAM plane was found comparable to aligning the SN-EAM plane horizontally, in the degree of achieved glottic visualization, TTOTI, intubation attempts and BURP application, without associated peri-intubation hypoxaemia.

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