Resuscitation 105 (2016) 41–44

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Time without ventilation during intubation in neonates as a patient-centred measure of performance☆

Izhak Nadler[a,1], Mia McLanders[b,*,1], Penelope Sanderson[a,b,c], Helen Liley[c,d]

[a] School of Information Technology and Electrical Engineering (ITEE), The University of Queensland, St Lucia, QLD 4072, Australia
[b] School of Psychology, The University of Queensland, St Lucia, QLD 4072, Australia
[c] School of Medicine, The University of Queensland, St Lucia, QLD 4072, Australia
[d] Mater Research Institute - The University of Queensland, South Brisbane, QLD 4101, Australia

ARTICLE INFO

Article history:
Received 29 November 2015
Received in revised form 11 March 2016
Accepted 14 April 2016

Keywords:
Endotracheal intubation
Teamwork
Neonatal resuscitation
Neonate
Team co-ordination

ABSTRACT

Aims: Time without ventilation is often much longer than an intubation attempt, yet patient stability relies on effective gas exchange. We argue that in addition to existing performance criteria, intubation performance measures should include interruption to effective ventilation.
Methods: We reviewed video recorded resuscitations of 31 term and preterm newborns that included at least one intubation attempt. Time stamps were recorded at the end of mask ventilation, laryngoscope insertion and removal (laryngoscope duration), and re-commencement of ventilation via mask or endotracheal tube (ETT). Intubation attempts were defined as Successful (subsequent ventilation via ETT), or Failed (ETT incorrectly placed) or Withdrawn (laryngoscope removed before ETT insertion attempt).
Results: During intubation, total time without ventilation varied from 31 to 273 s, compared to laryngoscope duration of 12–149 s. Time without ventilation as Median [min–max] was greater for failed attempts 64 [48–273] s, yet laryngoscope duration was shortest for failed attempts 33 [21–46] s. Time between ceasing ventilation and commencing intubation was 5 [1–46] s suggesting room for improvement during transitions within the procedure.
Conclusions: Time without ventilation is a more physiologically important measure of a resuscitation team's intubation expertise than laryngoscope duration. Since successful attempts took longer than failed attempts, emphasising haste during vocal cord visualisation and tube insertion may reduce success rates. Reducing the time without ventilation at either end of the procedure may be achievable with better team coordination and could be just as important to patient wellbeing as technical precision.

Introduction

Endotracheal intubation can be one of the most difficult procedures during neonatal resuscitation. It is usually performed to improve how effectively the lungs are ventilated, which can be critical to effective resuscitation.[1,2] There is no standard definition of intubation competence.[3–5] Previous studies have focused on two measures of intubation performance: (1) laryngoscopy duration from blade insertion to blade removal, and (2) intubation success (correct endotracheal tube (ETT) placement as a proportion of all attempts).[6,7] We propose that these measures incompletely characterise intubation performance, because they do not address other potentially critical delays in providing ventilation.

Neonates are at risk of physiological deterioration during intubation, with increasing risk of bradycardia and desaturation with increasing duration of the attempt,[5,6,8] so timeliness and precision are critical. The time from laryngoscope blade insertion to removal is frequently longer in duration[6,7,9] than the 20 s recommended in earlier resuscitation guidelines,[10] although attempts that exceed 40 s have been associated with increased complications.[11] In previous studies, the correct placement of an ETT occurred on approximately half of observed attempts, and even less often for inexperienced clinicians. Considerable experience is required to perform intubations successfully,[4,5,7,12,13] where observed success rates have been as low as 25% for pediatric interns,[7] and depending on experience, 24–63% for pediatric residents,[5–7,13] 43–78% for neonatal fellows,[5–7,13] and 86% for neonatal consultants.[6] Extremely low birth weight infants are at high risk of needing intubation, and among them, failed attempts at intubation are

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2016.04.016.

* Corresponding author at: School of Psychology, McElwain Building, The University of Queensland, St Lucia, QLD 4072, Australia.
E-mail address: m.mclanders@uq.edu.au (M. McLanders).

[1] Joint first authors.

http://dx.doi.org/10.1016/j.resuscitation.2016.04.016
0300-9572/

Table 1
Average duration of each key step of the intubation procedure across each intubation attempt. All values are median 95% CI lower limit, upper limit (LL–UL [min–max]) duration in seconds.

	End of mask ventilation to laryngoscope insertion	Intubation: laryngoscope in-out duration	Laryngoscope removal to mask or ETT ventilation	Total time not ventilated	Total time not ventilated pre- and post-laryngoscopy
1st Attempts (n = 30)	5 (4–8 [1–31])	40 (32–49 [16–114])]	5 (4–8 [2–49])	57 (50–71 [31–136])	13 (9–22 [6–61])
2nd Attempts (n = 18)	3 (3–5 [1–46])	40 (33–57 [12–149])	10 (4–19 [2–56])	62 (49–87 [33–163])	12 (8–24 [6–65])
3rd Attempts (n = 6)	3 (2–7 [2–7])	33 (21–44 [21–44])	6 (4–223 [4–223])	49 (36–273 [36–273])	8 (7–230 [7–230])
4th Attempts (n = 1)	3 ([N/A])	55 ([N/A])	11 ([N/A])	69 ([N/A])	14 ([N/A])

especially common and are associated with increased risks including adverse neurodevelopmental outcome.[14] Collectively, evidence to date highlights the technical difficulty of intubation, compounded by limited opportunities for practice,[3,13] and the need to improve processes for the well-being of the neonate.

We propose that previous research has focused on the technical skills of the person performing the intubation, whereas well-performed intubation also requires good teamwork. The complexity of the procedure requires one person to intubate and at least one assistant whose roles include final preparation and presentation of equipment, monitoring the patient physiology, assisting with re-commencement of ventilation and securing the ETT once in place.[10] Moreover, recognizing whether an ETT is correctly placed can be difficult. Even after the airway is stabilized, the more depressed the baby, the slower the improvement in oxygenation and heart rate is likely to be. When the initial response is unsatisfactory, a decision must be made as to whether to persist with ventilation, perhaps adjusting pressures and oxygen, or to extubate and recommence mask ventilation with or without a further intubation attempt. A strategy that involves prompt independent observation followed by agreement between the intubating clinician and the assistant on signs of correct insertion could lead to fewer errors, fewer delays in establishing effective ventilation, and better resuscitation outcomes.

We propose that a comprehensive evaluation of performance should encompass the entire procedure as it affects the patient, from ceasing mask ventilation to re-establishing ventilation via mask (if the intubation is unsuccessful) or via ETT. We examined a nested sample of video-recorded resuscitations (made during a previous project) in which intubation was attempted, in order to explore whether improved team co-ordination could improve patient outcomes, specifically by avoiding unnecessary interruptions to ventilation of the neonate's lungs.

Method

We reviewed video recordings of neonatal resuscitations that were performed in the resuscitation room adjoining two obstetric theatres at Mater Mothers' Hospital (MMH) in Brisbane, Australia, a large teaching hospital with a tertiary neonatal/perinatal service. Recordings were taken from November 2008 until November 2009 as part of an investigation into the use of debriefing to improve clinical practice, using motion activated cameras that did not require a researcher to be present.[15] The current study and the previous study were approved by the Human Research Ethics Committees of Mater Health Services and The University of Queensland.[15] Of 122 recorded resuscitations 31 were considered eligible because the infant survived to neonatal unit admission and parental consent was obtained, and there was at least one attempt to intubate. The resuscitation team comprised two to five clinicians, and in the case of the infants for whom intubation was attempted, the team always included at least one doctor and one nurse or midwife. Analyses were conducted on 55 intubation events in 30 of the 31eligible neonates. One case was excluded because mask ventilation was not reinstated between intubation attempts due to the neonate's spontaneous breathing.

Time stamps were marked at five points: (1) ceasing face mask ventilation, (2) laryngoscope entering mouth, (3) laryngoscope exiting mouth, (4) decision of correct or incorrect ETT placement, and (5) re-commencing ventilation via ETT for successful attempts or via face mask for failed attempts. Successful attempts were defined as ETT tube placement and subsequent continuous ventilation via ETT. Withdrawn attempts were laryngoscope insertion and removal without ETT insertion, and failed attempts were incorrect ETT placement, requiring removal of the ETT and subsequent mask ventilation. Ventilation was not re-established between attempts for two neonates, so the total time without ventilation was divided equally between attempts. It was not routine practice at MMH to perform laryngoscopy only for upper airway suction under direct vision, so all laryngoscopies were presumed to be for the purpose of intubation.

Results

The overall intubation success rate of intubation was 51%, (number of successful intubations divided by total attempts). The success rate was lowest for first attempts (37%), and was higher on second (67%) and third (67%) attempts. The single case involving a fourth attempt was successful. As data were not normally distributed, medians and non-parametric 95% confidence intervals lower limit and upper limit (LL, UL) are presented throughout. Average laryngoscope duration, and the total time pre- and post-laryngoscopy without ventilation across all attempts are presented in Table 1. Failed attempts had the shortest laryngoscopy duration in seconds, 33 (28–44 [21–46]), compared to successful attempts, 40 (32–50 [12–149]) and withdrawn attempts, 49 (34–57 [16– 114]). Moreover, the average time to determine ETT placement was much longer for failed attempts, 61 (47–85 [8–267]), than for successful attempts, 47 (37–55 [28–160]). The median time to recommence ventilation after intubation was similar for successful attempts, 5(4–8 [2–21]), and withdrawn attempts, 5 (3–5 [2–38]), but much longer for failed attempts, 28 (17–56 [8–223]).

Across all attempts, the median time taken from stopping ventilation to laryngoscope insertion was 5 s (3–5 [1–46]) and the median time from laryngoscope removal to recommencement of ventilation was 6 s (5–10 [2–223]). Failed attempts had the longest proportion of time without ventilation[16] (see Fig. 1). For 1st, 2nd, 3rd and 4th failed attempts, a range of 46–80% of the total time without ventilation was pre- and post- laryngoscopy, compared to ranges of 20–26% for successful attempts and 10–21% for withdrawn attempts.

Discussion

The intended purpose of endotracheal intubation during neonatal resuscitation is to achieve effective ventilation of the lungs. Whereas previous research has assessed intubation performance by measuring laryngoscopy duration and correct ETT placement,[6,7] the patient's physiological improvement relies on minimising the