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Clinical Investigation

CLINICAL INVESTIGATION

Difficult tracheal intubation in neonates and infants. NEonate and Children audiT of Anaesthesia pRactice IN Europe (NECTARINE): a prospective European multicentre observational study

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Abstract

Background: Neonates and infants are susceptible to hypoxaemia in the perioperative period. The aim of this study was to analyse interventions related to anaesthesia tracheal intubations in this European cohort and identify their clinical consequences.

Methods: We performed a secondary analysis of tracheal intubations of the European multicentre observational trial (NEonate and Children audiT of Anaesthesia pRactice IN Europe [NECTARINE]) in neonates and small infants with difficult tracheal intubation. The primary endpoint was the incidence of difficult intubation and the related complications. The secondary endpoints were the risk factors for severe hypoxaemia attributed to difficult airway management, and 30 and 90 day outcomes.

Results: Tracheal intubation was planned in 4683 procedures. Difficult tracheal intubation, defined as two failed attempts of direct laryngoscopy, occurred in 266 children (271 procedures) with an incidence (95% confidence interval [CI]) of 5.8% (95% CI, 5.1–6.5). Bradycardia occurred in 8% of the cases with difficult intubation, whereas a significant decrease in oxygen saturation (SpO_2<90% for 60 s) was reported in 40%. No associated risk factors could be identified among co-morbidities, surgical, or anaesthesia management. Using propensity scoring to adjust for confounders, difficult anaesthesia tracheal intubation did not lead to an increase in 30 and 90 day morbidity or mortality.

Conclusions: The results of the present study demonstrate a high incidence of difficult tracheal intubation in children less than 60 weeks post-conceptual age commonly resulting in severe hypoxaemia. Reassuringly, the morbidity and mortality at 30 and 90 days was not increased by the occurrence of a difficult intubation event.

Clinical trial registration: NCT02350348.

Keywords: airways; anaesthesia; difficult intubation; infants; morbidity; mortality; neonates; paediatric

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Editor's key points

- A study of a large European cohort was carried out to determine the incidence of difficult tracheal intubation, and the related complications in neonates and infants.
- Difficult tracheal intubation in children less than 60 weeks post-conceptual age commonly resulted in severe hypoxaemia.

Tracheal intubation is commonly performed in patients requiring mechanical ventilation, protection of the airway, or both. This procedure is potentially life-threatening, particularly in patients with low oxygen reserves, and it requires specific competencies[1] whereas failure to oxygenate and ventilate is strongly related to morbidity and mortality.[2]

Neonates are prone to hypoxaemia because of high oxygen consumption, low functional residual capacity, small closing capacity, and increased risk of airway collapse exacerbated after induction of general anaesthesia.[3] Desaturation rapidly occurs after cessation of spontaneous or assisted ventilation with two-thirds of neonates undergoing non-emergency nasotracheal intubation suffering from prolonged hypoxia.[4] Although previous reports provided some information on difficult intubation in children,[5,6] none of them targeted specifically the youngest population, from prematurity to early infancy.

The recently published prospective cohort study NECTARINE (NEonate and Children audiT of Anaesthesia pRactice IN Europe) collected incidences of acute critical events and related interventions occurring during anaesthesia management of neonates and infants less than 60 weeks post-conceptual age (PCA).[7] Airway management interventions were recorded as part of primary outcome, and difficult tracheal intubation was defined as more than two unsuccessful attempts of intubation by direct laryngoscopy and that required alternative strategies to achieve successful tracheal intubation. The primary aim of this analysis was to determine the incidence of difficult tracheal intubation in neonates and infants in this European cohort and the resulting cardiovascular and respiratory complications. As a secondary aim, we analysed the immediate post-anaesthesia, and 30 and 90 day morbidity and mortality.

Methods

This study is registered with ClinicalTrials.gov (NCT02350348). Detailed study design and data collection for the NECTARINE were previously published.[7,8] In summary, NECTARINE is a multicentre/multinational European, prospective, observational cohort study funded by the European Society of Anaesthesiology (ESA) through the Clinical Trial Network (CTN) grant and collected perioperative data that described the anaesthesia management of children aged from birth to 60 weeks PCA. Participating centres were selected through a 'call for centre' launched by the ESA, and after ethics approval recruited patients during a 3 month period between March 1, 2016 and January 31, 2017.

All neonates and infants up to 60 weeks PCA undergoing anaesthesia for surgical and non-surgical procedures, in the operating room, ICU, or diagnostic suite, were eligible for inclusion. Medical history, current physical medical status, and presence of co-morbidities at the time of anaesthesia were also documented.

Children were observed for the occurrence of intra- and postoperative medical intervention triggered by a predefined list of critical events. The definitions of the severe critical events were previously reported.[8] The occurrence of difficult tracheal intubation, defined as more than two unsuccessful attempts of intubation by direct laryngoscopy regardless of Cormack–Lehane grading and requiring alternative strategies or specific intervention, either expected or unexpected, was reported. A consensus was obtained among the members of the steering committee to use this definition for difficult tracheal intubation, retrieved from previously published reports. When a difficult tracheal intubation occurred, the alternative technique used, number of attempts, eventual concomitance of difficult face-mask ventilation, the bradycardia (defined as heart rate <80 min^{-1}), or both, and/or significant decrease in oxygen saturation (defined as SpO_2 <90% for at least 60 s, or severe oxygen desaturation when SpO_2 <85%) were also documented. The immediate outcome, defined as successful intubation or unsuccessful (patient woken from anaesthesia or surgical procedure carried out with face mask or laryngeal mask airway) were documented. As for the NECTARINE protocol, the *previous neonatal medical condition and congenital anomalies*, the *preoperative need for intensive care* support and the *current co-morbidities* at the time of anaesthesia were documented. All included children were followed up 30 days after anaesthesia for morbidity and mortality, and a second follow-up 90 days after anaesthesia for in- and out-of-hospital mortality. Detailed definitions of patient characteristics, medical history, and parameters related to the general anaesthesia are available in the study protocol (www.esahq.org/nectarine).

Statistical methods

Study size determination for NECTARINE was based on the estimation of approximately 5000 patients in order to provide the 95% confidence interval (CI) for the overall incidence of severe critical events with an acceptable confidence width assuming that the lowest incidence of severe critical events is 0.1% (i.e. the exact 95% CI is 0.065–0.147). An *a priori* statistical analysis plan for the primary and secondary analysis was defined in the initial protocol which is accessible online (www.esahq.org/nectarine).

Continuous variables are summarised as medians with first and third quartiles (Q1 and Q3, respectively), whereas absolute frequencies and percentages are presented for categorical variables. The incidence of difficult intubation was determined after excluding those whose tracheas were already intubated and is reported as a percentage with a 95% exact binomial CI.

Propensity score matching was performed to reduce the effects of confounding on the assessed 30 and 90 day outcomes between children with and without difficult intubation. Variables listed in Table 1 were selected to calculate propensity scores using a logistic regression model. One-to-one matched groups were created using nearest-neighbour (greedy) matching without replacement. Covariate balance between the resulting groups of children was assessed using the mean standardised difference (MSD), which compares the difference in means in units of the pooled standard deviation, with values <0.1 considered sufficiently balanced. McNemar's tests with continuity correction were performed for univariable comparisons between the matched cohorts, to correct the error introduced when a discrete distribution was approximated by a continuous distribution.

Univariable Poisson regression models with a robust error variance and age and gender adjustment were fitted to identify the potential risk factors associated with a significant reduction in oxygen saturation.

Statistical analyses were performed using R V4.0.2 (R Core Team [2020]; R Foundation for Statistical Computing, Vienna, Austria) with the ggplot2, lmtest, MatchIt, sandwich, and stats packages.

A *P*-value less than 0.05 was considered statistically significant.

Results

Participants

Peri-anaesthetic data included 5609 patients undergoing 6542 procedures, between March 1, 2016 and January 31, 2017, in the 165 centres of the NECTARINE network. A total of 2056 procedures had at least one intervention,[8] with 271 requiring an intervention for airway management (13.2%; 95% CI, 11.8–14.7%). Figure 1 displays the flow chart of included/analysed patients. The median age (inter-quartile range) of the included children in the present analysis was 58 (31–91) days, 38 weeks gestational age (34–39), with 17 patients (6%) less than 37 weeks PCA at inclusion, and 102 (38.4%) being born premature.

Primary outcomes

Three or more attempts for tracheal intubation were necessary in 266 children (271 procedures) included in this cohort with an incidence of 5.8% (95% CI, 5.1–6.5). Table 2 summarises the patient characteristics and anaesthesia procedures of those with difficult intubation. Almost half of the children had a congenital abnormality and 40% of the cohort had an ASA physical status ≥3. In 13% of those cases with difficult intubation, a difficult face-mask ventilation was reported. Successful intubation was achieved in 98% of the cases. A switch towards laryngeal mask airway was performed in three patients, whereas three other patients were woken up from anaesthesia. There were no incidences of impossible mask ventilation. Morbidity and mortality of children with difficult intubation are summarised in the Supplementary table.

Secondary outcomes

The majority of tracheal intubations (85%) were performed orally, and the use of cuffed *vs* uncuffed tubes was equally distributed. Difficult intubation was expected in 31% of the cases, whereas in the remaining it was unanticipated. A complication during the procedure occurred in 164 cases

Table 1 Comparison of matched samples (*n* [%] for categorical, mean [95% confidence interval] and median [Q1–Q3] for continuous variables). *McNemar's test with continuity correction. SMD, standardised mean difference.

The control group is defined as:
- Only those children in whom there were no interventions at all during any of their procedures: 3821 procedures on 3535 children
- Only the last procedure for each child: 3535 procedures
- Only those procedures where status at day 30, the presence of brain, respiratory, and cardiovascular complications is known: 3117 procedures
- Only those procedures where tracheal tube was used: 1876 procedures
- Only those procedures where the values of all the matching variables is known: 1871 procedures

The difficult airway group is defined as:
- Intervention for difficult intubation occurred in 271 procedures on 266 children
- Only those procedures where status at day 30, the presence of brain, respiratory, and cardiovascular complications is known: 243 procedures on 240 children.

	Intervention for difficult tracheal intubation		SMD
	No (*n*=243)	**Yes (*n*=243)**	
Covariates used for matching			
Gestational age at birth (weeks)	35.8 (35.3–36.4) 38 (34–39)	36.19 (35.6–36.7) 38 (34–39)	0.068
Age at inclusion (days)	63.8 (57.8–69.9) 54 (26–96.5)	63.72 (58.5–68.9) 58.00 (32–91)	0.003
Weight at inclusion (kg)	4.1 (3.9–4.2) 4 (3–5.1)	4.11 (3.9–4.3) 3.9 (3.2–5)	0.032
ASA physical status (≥3)	96 (39.5)	100 (41.1)	0.034
Use of neuromuscular blocking agent (yes)	190 (78.2)	180 (74.1)	0.097
Anaesthesia induction (intravenous)	95 (39.1)	99 (40.7)	0.034
Degree of urgency (urgent/emergency)	115 (47.3)	111 (45.6)	0.033
Outcome			**P-value***
Overall morbidity at day 30	36 (14.8)	43 (17.7)	0.464
Brain complication at day 30	5 (2.1)	4 (1.6)	1
Respiratory complication at day 30	19 (7.8)	28 (11.5)	0.212
Cardiovascular complication at day 30	6 (2.4)	14 (5.7)	0.118
Mortality at 30 and 90 days	5 (2.1)	5 (2.1)	0.724

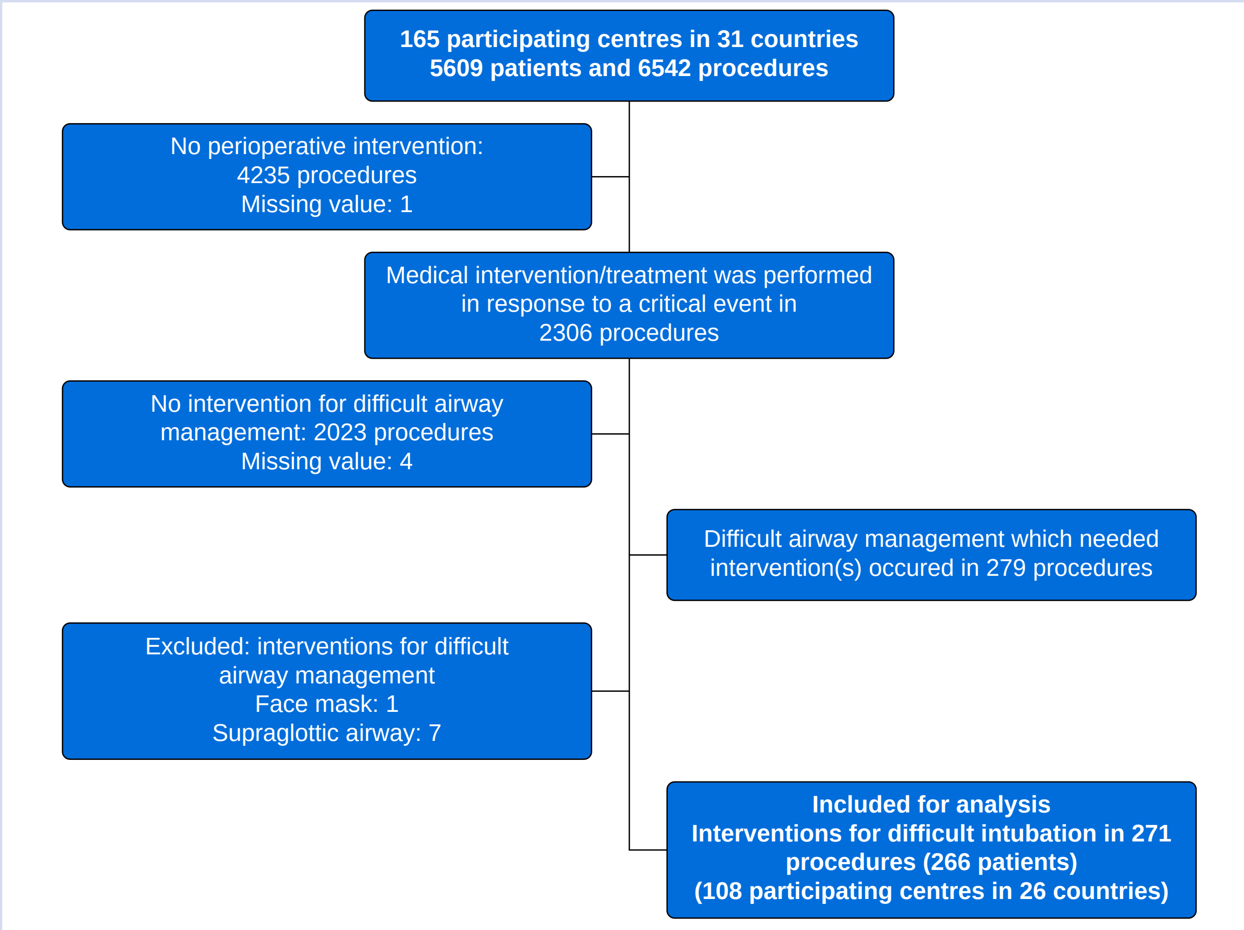

Fig 1. Flow chart of patients included/analysed in the study.

(60%). In particular, a significant decrease in oxygen saturation for longer than 60 s occurred in approximately 40% of cases with SpO_2 threshold reported in 66 patients (26% of patients reaching a SpO_2 of less than 90%, 9% less than 80%, and for 65% of them, SpO_2 decreased to less than 80%). Moreover, bradycardia occurred in 8% of the cases mostly as a result of severe hypoxaemia (90% of the cases). All the above results are summarised in Table 2, including morbidity and mortality at 30 and 90 days (Supplementary table). Successful intubation was achieved in 265 cases (97.8%) with an average of three attempts (Fig. 2), whereas for the remaining cases four to seven attempts were required. In one patient, 10 attempts were needed to achieve successful intubation.

The univariate analysis indicated no specific risk factors associated with the significant decrease in oxygen saturation during difficult intubation in this cohort of patients (Table 3). The most frequent intervention used to achieve a successful tracheal intubation consisted in changing the laryngoscope blade (43%) and calling for help (32%). Advanced techniques such as video-assisted intubation or fibreoptic intubation were adopted in 12% and 4% of cases, respectively. All the interventions performed in case of difficult intubation are summarised in Table 4. In patients in whom difficult intubation was expected, video-assisted intubation was used in 16% of the planned difficult intubation, whereas the use of fibreoptic bronchoscopy was reported in only 12% of the cases. There was no surgical airway access reported.

Table 1 describes the matched samples that were obtained after adjusting for gestational age, age and weight at inclusion, ASA physical status (PS) 1–4, the use of neuromuscular blocking agent, anaesthesia induction, and degree of urgency. Difficult intubation did not result in a difference in 30 day morbidity and in 30 and 90 day mortality (Table 1).

Discussion

The current analysis of NECTARINE, a prospective European multicentre observational study, indicated a high incidence of difficult tracheal intubation in the studied population, which was not anticipated in more than two-thirds of patients. Difficult tracheal intubation was frequently associated with a significant decrease in oxygen saturation. However, potential risk factors such as previous neonatal medical condition and congenital anomalies, presence of medical comorbidities, surgical plan, or anaesthesia management were not associated with a decrease in oxygen saturation. Moreover, using propensity score to adjust for confounders (Table 1) a difficult intubation did not lead to an increased

Table 2 Patients characteristics and anaesthesia procedures (n [%] for categorical, median [Q1–Q3] for continuous variables).

Gestational age at birth (weeks)	n=266	38 (34–39)
Birth weight (kg)	n=264	2.9 (1.9–3.3)
Age on day of anaesthesia (days)	n=271	58 (31–91)
Weight on day of anaesthesia (kg)	n=271	3.9 (3.1–4.9)
Sex (male)		187 (70)
Congenital abnormality	Yes	127 (47.7)
Congenital heart disease (among children with any congenital abnormality)	Yes	29 (22.8)
Physical condition at anaesthesia	ASA physical status ≥3	110 (40.5)
	Respiratory problems	62 (22.8)
	Cardiovascular problems	48 (17.7)
	Metabolic problems	25 (9.3)
	Neurological problems	43 (15.9)
	Renal problems	19 (7.0)
Degree of urgency	Elective	152 (56.0)
	Semi-elective/urgent	86 (31.7)
	Emergency	33 (12.1)
Type of procedure	Surgical	237 (87.4)
	Non-surgical	34 (12.5)
Anaesthesia induction	Inhalational	164 (60.5)
	Intravenous	107 (39.4)
Neuromuscular blocking agent used	No	74 (27.3)
	Yes	197 (72.6)
Tube type	Uncuffed	154 (57.2)
	Cuffed	115 (42.7)
Intubation route	Oral	229 (85.1)
	Nasal	40 (14.8)
Cormack–Lehane score	1	56 (20.8)
	2	85 (31.6)
	3	83 (30.8)
	4	29 (10.7)
Difficult intubation	Planned	85 (31.3)
	Unplanned	186 (68.6)
Complication during intubation	Difficult face-mask ventilation	36 (13.2)
	Decrease in oxygen saturation	107 (39.4)
	Bradycardia	21 (7.7)
Outcome of event	Successful intubation	265 (97.7)
	Unsuccessful intubation, procedure performed under face or laryngeal mask	3 (1.1)
	Unable to intubate, patient woken up from anaesthesia	3 (1.1)

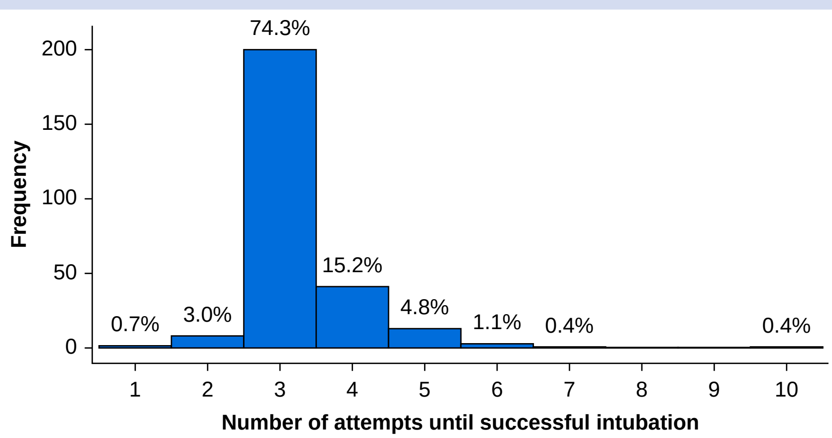

Fig 2. Number of attempts until successful intubation.

Table 3 Relative risk and non-adjusted 95% confidence interval (CI) for the risk factors associated with a significant hypoxaemia. Exposed and unexposed refer to the number of cases exposed and unexposed to the examined risk factor. For continuous variables, the table shows the mean and standard deviation when hypoxaemia occurred or not. *Univariable robust Poisson regression controlling for chronological age at inclusion and sex. [†]Controlling for age at inclusion. [‡]Controlling for sex. GA, general anaesthesia; RR, relative risk; SD, standard deviation.

Risk factor	Incidence of hypoxaemia		RR (95% CI)*
	Exposed to the examined risk factor	Unexposed	
Sex (male *vs* female)[†]	74/187 (39.6%)	33/84 (39.3%)	1.03 (0.75–1.43)
Chronological age at inclusion in days,[‡] mean (SD)	61.2 (43.3)	67.0 (43.1)	0.99 (0.99–1.00)
Weight at birth in kg, mean (SD)	2.6 (1.1)	2.7 (0.9)	0.87 (0.74–1.03)
Weight at inclusion in kg, mean (SD)	3.9 (1.4)	4.2 (1.3)	0.89 (0.78–1.01)
Premature birth (<37 weeks GA)	46/104 (44.2%)	61/167 (36.5%)	1.32 (0.98–1.78)
Congenital abnormality	52/132 (39.4%)	55/139 (39.6%)	0.98 (0.73–1.32)
Congenital heart disease	13/30 (43.3%)	94/241 (39.0%)	1.11 (0.72–1.72)
Admission from ICU	34/69 (49.3%)	73/202 (36.1%)	1.36 (0.99–1.88)
ASA physical status 3–5	48/110 (43.6%)	59/161 (36.7%)	1.20 (0.89–1.62)
Neonatal medical history and congenital anomalies			
Presence of respiratory problems	26/62 (41.9%)	81/209 (38.8%)	1.12 (0.79–1.57)
Presence of cardiovascular problems	15/48 (31.3%)	92/222 (41.4%)	0.76 (0.48–1.18)
Presence of metabolic problems	13/25 (52.0%)	94/243 (38.7%)	1.31 (0.86–2.00)
Presence of neurological problems	22/43 (51.2%)	85/226 (37.6%)	1.49 (1.04–2.12)
Presence of renal problems	11/19 (57.9%)	95/251 (37.9%)	1.50 (1.00–2.26)
Current co-morbidities			
Urgent/emergency *vs* elective	55/119 (46.2%)	52/152 (34.2%)	1.32 (0.97–1.8)
Surgical *vs* non-surgical procedure	90/237 (38.0%)	17/34 (50.0%)	0.75 (0.52–1.09)
Night-time (18:00–6:59)	8/17 (47.1%)	99/253 (39.1%)	1.16 (0.67–2.00)
Surgical plan			
Team in charge			
At least one senior *vs* at least one junior without a senior	90/225 (40%)	14/42 (33.3%)	1.21 (0.77–1.9)
Anaesthesia induction (i.v. *vs* inhalation)	48/107 (44.9%)	59/164 (36%)	1.24 (0.92–1.65)
Use of neuromuscular blocking agent	77/197 (39.1%)	30/74 (40.5%)	0.96 (0.69–1.33)
Presence of vasopressors or inotropes as part of anaesthesia management	5/15 (33.3%)	102/256 (39.8%)	0.77 (0.36–1.65)
Anaesthesia management			

morbidity and mortality at 30 and 90 days or increased mortality at 90 days.

The results of the present study are consistent with the current evidence demonstrating that young children are at higher risk for difficult intubation.[5,6,9] However, the overall incidence for difficult intubation is much higher than that reported by the Pediatric Difficult Intubation (PeDI) registry, which may be partially explained by the fact that registries are based on voluntary reporting[5] in contrast to the prospective reporting and data collection of the current study.

Table 4 Specification of intervention for difficult intubation.

	n (%)
Change of laryngoscope blades	117 (43.2)
Help from otolaryngologist or second senior anaesthesiologist	89 (32.8)
Use of stylets or bougie	87 (32.1)
Use of video-assisted intubation	35 (12.9)
Use of fibreoptic bronchoscopy	13 (4.8)
Blind intubation	12 (4.4)
Rigid bronchoscopy	3 (1.1)
Use of air-track	3 (1.1)
Other	10 (3.7)

The second relevant finding is that decrease in oxygen saturation rapidly occurs during attempts to secure airways in neonates and infants, especially when difficulties are encountered after cessation of spontaneous or assisted ventilation.[3] The younger the child, the shorter the apnoea time before a desaturation occurs.[10] The lack of identified risk factors associated with significant reduction in oxygen saturation during difficult intubation provides additional evidence that physiological characteristics of neonates and infants such as high oxygen consumption, low functional residual capacity, a small closing capacity, and increased risk of airway collapse are the prominent factors.[3] This may explain in part the reasons for multiple attempts despite reporting a Cormack–Lehane grade of 1–2 in most patients.

Multiple attempts can be related to the lack of glottic visualisation and subsequent failure in tracheal intubation, or to the decrease in oxygen saturation because of the prolonged apnoea time generated by the airway instrumentation. Adequate visualisation of the vocal cords is a mandatory step for successful intubation and may reduce the number of intubation attempts.[11,12] The small anatomy of the mouth and airway and the large tongue, epiglottis, and arytenoids makes neonatal tracheal intubation more challenging. Therefore, techniques that improve glottis visualisation facilitating tracheal intubation such as videolaryngoscopy are desirable. In this regard, the Videolaryngoscopy in Small Infants (VISI) trial demonstrated that the use of videolaryngoscopy with a standard blade improves the first-attempt success rate and reduces complications in anaesthetised infants[11,12] Recent reports demonstrated the beneficial use of apnoeic oxygenation to prolong the safe apnoeic oxygenation period.[13–15] The findings of the present study provide further evidence for the administration of oxygen during airway manipulation as a preventive measure to reduce the incidence of oxygen desaturation and promote the implementation of systematic administration of oxygen during airway manipulation in infants. In particular, the use of nasal oxygen – either as warmed and humidified high-flow nasal oxygen or as normal low-flow oxygen[16] – or the concurrent administration of oxygen via nasopharyngeal prongs should be encouraged because of the potential to significantly prolong the safe apnoeic period allowing an intubation with reduced risk for critical events, especially in case of difficult management.

Although NECTARINE was not designed to investigate techniques used for tracheal intubation in neonates and infants, information on the applied intervention, device used to achieve a successful intubation, or both was provided. The change of blade, or the use of a stylet or bougie were the most commonly interventions used to secure the airway rather than more advanced techniques such as video-assisted intubation (videolaryngoscope or Glidescope®). Considering the increased evidence that these modern devices, when applied judiciously, are helpful in achieving successful tracheal intubation with fewer attempts and complications,[17–21] their systematic use in this population should be encouraged. Surprisingly, the use of fibreoptic bronchoscopy, video-assisted intubation, or both for securing the airways of patients known for difficult intubation was infrequent. This finding should be considered in the development and update of guidelines for the management of the difficult paediatric airway, recommending an early use of videolaryngoscopy in neonates and infants especially when difficult is highly expected.

It is reassuring that help from another experienced colleague was requested when a difficult tracheal intubation was encountered. The fact that clinicians involved are from different medical and cultural backgrounds underscores the importance of teamwork, especially in critical situations such as the circumstances required for mastering the challenge posed by a difficult airway management in a neonate.[22] This supports the specificity of neonatal anaesthesia and the need for advanced training on airway management by an experienced team when taking in charge these children.

Although most recent studies focus on the incidence of intubation-related complications, such as reduction in oxygen saturation, cardiac arrest, airway trauma, and oesophageal intubation,[23,24] the present study also provides information on morbidity and mortality at 30 and 90 days in infants with difficult intubation. As previously demonstrated, intervention for difficult airways was not associated with increased morbidity at 30 days.[8] This finding was further confirmed in the present analysis after using propensity score to adjust for confounders, with no evidence for increase morbidity and mortality in children with difficult airways. This is not surprising as successful intubation was achieved in almost all children despite a significant decrease in oxygen saturation, and without major trauma on airways.

Considerable efforts were made to reduce the incidence of airway complications,[24,25] by implementing education, establishing nationwide simulation training programmes,[26] and promoting guidelines by national and regional societies. Although a surgical airway in neonate seems feasible at least on a cadaveric model,[27] it is reassuring that none of the children required a surgical airway. However, a Cormack–Lehane score <3 was reported in half of cases, but the child was classified as difficult to intubate and the situation required a change in device or a specific intervention to achieve a successful intubation. This finding can be interpreted as surrogate evidence for insufficient expertise in the treatment of neonates and infants or indeed. Authors suggest that neonates should be considered as potentially at high risk for difficult intubation. Thus, efforts should be reinforced to minimise the number of attempts and the incidence of intubation-related complications by considering continuous administration of oxygen during laryngoscopies and airway manipulations via nasal cannulas or prongs, the early use of videolaryngoscopy and the readily available second experienced help.

Most tracheal intubations were achieved using a maximum number of three attempts. However, more than one in five required more than three attempts. We know that the higher the number of attempts, the more frequent are critical events and post-anaesthesia complications.[5] It must be stressed that a task fixation must be avoided as this can make a child with a difficult airway into a 'cannot intubate, cannot ventilate' child.[28] It is desirable to quickly move on to an alternative advanced intubation technique, when difficulty is encountered, and reassess the clinical situation at any attempt.

This analysis of NECTARINE dataset is subject to several limitations. Although this prospective report provides a good insight of airway instrumentation in very young patients with difficult intubation, the results may not necessarily be generalised to infants in whom tracheal intubation was successfully performed. Nevertheless, the results of the present study are more informative than those reported by the registries that are voluntary based and are subject to underreporting.[5,29] The second limitation is attributable to the nature of the study itself as information was gathered from 165 centres that were willing to participate, and thus, a selection bias may be perceived as most centres are specialised and the overall incidence of difficult intubation could be underestimated for non-participating or non-dedicated paediatric centres.[6,9] The (non-)availability of videolaryngoscopes or fibreoptic endoscopes in the participating centres may also have affected the final results.

In conclusion, the present study reports the incidence of difficult intubation in neonates and infants in their early life undergoing anaesthesia in 31 different European countries. The high incidence of difficult airway management and immediate related complications prompt urgent actions from National and Regional Societies to improve education and training in the field of airway management in this population. New and updated airway management algorithms should include correct choice of tools, devices, or both for airway instrumentation and potentially consider the use of continuous oxygen delivery during tracheal intubation in this vulnerable population.

Authors' contributions

Overall coordinating investigators: ND, WH
Study design: ND, WH
Literature search: ND, WH
Data cleaning: ND, WH, KV (statistician)
Data analysis: ND, WH, KV
Data interpretation: ND, WH, KV, TR, JK, TE
Coordination of team: ND, WH
Writing of the manuscript writing: ND, WH, KV
Review, approval, and language editing of the manuscript: TR, JK, TE
Weblink for the documents related to NECTARINE: https://www.esahq.org/research/clinical-trial-network/completed-trials/nectarine/

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Declarations of interest

The authors declare that they have no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.bja.2021.02.021.

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