Structured airway intervention improves safety of endotracheal intubation in an intensive care unit

Each year the Royal College of Anaesthetists undertakes a national audit project of procedures and practices within the specialty that have the potential to be associated with significant morbidity and mortality. The fourth National Audit Project (NAP4), endorsed by the Difficult Airway Society, audited advanced airway management and its complications in general theatres, labour wards, critical care units and emergency departments. The NAP4 data allowed the authors to benchmark their own practice against national standards. Using the recommendations in NAP4 they developed a quality improvement intervention to improve airway assessment and tracheal intubation procedures. The authors used a multidisciplinary team approach to training, improving resources and adopting new working practices, which resulted in improved endotracheal intubation technique, and embedded new practice and a new departmental training programme.

Airway management in the intensive care unit has a higher incidence of complications compared to theatre anaesthesia (Schwartz et al, 1995; Jaber et al, 2006). The complications include failed intubation, oesophageal intubation, hypoxia, need for cricothyroidotomy, hypoxic brain injury and death. The Fourth National Audit Project (NAP4) of the Royal College of Anaesthetists in conjunction with the Difficult Airway Society (Cook et al, 2011) was designed to identify the incidence of major complications of airway management within the theatre environment, the intensive care unit and the emergency department.

NAP4 project leads set up a network of local reporters in all anaesthetic departments and most intensive care units and emergency departments in UK NHS hospitals. The aim was to identify the nature of major complications of airway management in each of the three environments and develop a registry to collect and report on these cases over a 12-month period. A multi-speciality expert review panel examined the submitted reports and in each case the factors that potentially contributed to the event were identified.

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In total 184 airway incidents were included in the audit, 38 of which resulted in patient death. Importantly the authors estimated that up to 75% of incidents could have been missed by this audit as a result of poor reporting. Nearly 20% (36/184) of airway incidents occurred in the intensive care unit. Of the 36 cases, 18 resulted in the death of the patient and four resulted in significant neurological injury (61% of cases in total). This compares unfavourably with the outcome of major airway complications during anaesthesia in theatres, where 14% resulted in death or significant neurological injury.

The NAP4 project authors suggested factors that might contribute to the increased mortality and morbidity in the intensive care unit population and separated these into patient, equipment, staffing and training, and environmental factors.

Patient factors

Critically ill patients lack the normal physiological reserve, leading to very rapid hypoxaemia during induction of anaesthesia. Pre-treatment with high concentration oxygen is often ineffective or not tolerated, the stomach is generally full and the patient often requires urgent intubation in sub-optimal conditions. Patients frequently have complicated airways, e.g. trauma, burns, head and neck surgery. These patients require careful planning of any airway intervention. Accidental extubation is also a recognized complication of airway management in the intensive care unit. In NAP4 47% of those who suffered complication during airway management in the intensive care unit were obese, which increases the incidence of failed intubation and makes airway management more difficult (Juvin et al, 2003).

Equipment factors

The equipment available to assist in airway management is often not as comprehensive in intensive care units as in operating theatres. Most notably capnography, used for the identification of end-tidal CO_2 to confirm successful endotracheal intubation, is less routinely used in the intensive care unit. Four of the reported cases (three of which resulted in death or severe hypoxic brain injury) were caused by unrecognized oesophageal intubation and capnography was not used. Fourteen cases of death or significant brain damage were secondary to tube displacement where capnography was not in use, likely resulting in a delay in recognizing the problem.

Staffing and training factors

Owing to changes in training and staffing intensive care units are staffed by doctors who do not always possess advanced airway skills. The nursing staff who care for the patients are generally not as experienced in airway management as those who work in theatres. Airway incidents in the intensive care unit often occur out of hours where senior presence is frequently lacking because of working practices.

Environmental factors

Intensive care units are frequently not designed for the purpose of airway management, lacking space and having poor lighting.

The NAP4 authors issued a series of recommendations in light of these findings to guide ongoing management of airways in the intensive care unit. *Table 1* gives a brief summary of the recommendations and reasoning behind them.

Table 1. Summary of Fourth National Audit Project of the Royal College of Anaesthetists recommendations into airway complications that apply to intensive care units

Category	Reasoning	Specific intervention
Capnography	Failure to use capnography lead to avoidable deaths (oesophageal intubation, tube displacement)	Universal availability for intubation in the intensive care unit
	Failure to interpret the capnography trace correctly in a cardiac arrest situation	Continuous use in patients with tracheal tubes
		Training in interpretation for all staff
Intubation	Several cases identified where problems arose that were not dealt with in a logical or recognized manner	Development of pre-intubation checklists
Prediction and planning for difficult intubation or ventilation	Avoidable harm came to patients who had complex airway management problems because of lack of airway planning and availability of suitable equipment or staff	Development of algorithms for use in difficult intubation
		Identification of the high-risk patient
		Development of specific plans for the patient with a predicted difficult airway
Airway displacement	More frequent in obese patients and those with tracheostomy; most likely to occur during patient movement or sedation holds	Training in the recognition of the displaced airway
Obesity	Increased risk of airway complications	Recognition of the high risk obese patient
Equipment	Avoidable harm to patients in the audit because of lack of equipment	Development of dedicated difficult airway trolleys for use in intensive care unit
		Ongoing systems for maintenance and restocking
Staff/training	Staff caring for patient do not have knowledge or experience of basic or advanced airway skills	The availability of appropriately skilled staff at all times
		Training in the recognition of the potentially high risk airway
		Multidisciplinary team training
		Ongoing audit
		Training of all staff in basic airway management

From Cook et al (2011)

Initial audit

The authors conducted an initial audit benchmarked against NAP4 recommendations in their 35-bed adult general intensive care unit. Data collection took place over a 6-week period attempting to capture every intubation undertaken through structured interview and questionnaire in order to ensure high quality data collection (*Table 2*).

Table 2. Data collected for each intubation

Time of intubation: in hours (0800–1800) or out of hours (1800–0800)
Presence of consultant supervision
The primary specialty and level of seniority of the clinician(s) involved in the intubation
Whether the case was an intubation or re-intubation
Use of pre-oxygenation
Use of appropriate monitoring equipment (end-tidal CO_2, electrocardiography, blood pressure, arterial oxygen saturations)
Availability of standard equipment for the management of unanticipated difficult intubation (gum elastic bougie, second generation laryngeal mask airway, oropharyngeal suction, Ambu Bag or Mapleson C circuit)
Advance preparation of drugs to facilitate intubation, sedation and cardiovascular management
Use of cricoid pressure
Number of attempts at intubation
Any major complications (arterial oxygen saturation <90% for >1 min, systolic blood pressure<90 mmHg unresponsive to fluid bolus, failed intubation or ventilation, death)

Their findings were similar to those of the NAP4 project: intubation was frequently undertaken by inexperienced trainees or by trainees whose primary speciality was not anaesthesia, and appropriate monitoring and airway management equipment was often unavailable (*Table 3*).

Guided by these baseline data, a multidisciplinary team training intervention was implemented based on the NAP4 recommendations. Bedside nurses and doctors in training were recruited into teams with nurse educators and a consultant supervisor to develop a programme of improvement within the department (*Table 4*).

These interventions were rolled out, and after a period of training the authors undertook prospective re-audit of data earlier described. The results of the pre- and post-intervention data sets were compared using the Chi^2 test for comparison of proportions (*Table 3*).

Results

Data were collected on 30 consecutive intubations before the intervention and 31 consecutive intubations after implementation of the intervention. Data collection was

complete in 95% of cases; in the remaining cases only one component was missing.

Following the introduction of the intervention the authors could demonstrate a highly significant improvement in equipment availability (one piece of equipment missing in 35% *vs* 67%, $P<0.001$), most importantly the availability of capnography (missing in 29% *vs* 67%, $P=0.0046$). Through the increased education and awareness of failed successful extubation, the re-intubation rate of patients in the intensive care unit was significantly reduced (7% *vs* 26%, $P=0.002$). There were also significant improvements in the frequency of senior clinician attendance (100% *vs* 77%, $P=0.047$) and anaesthetic team presence (81% *vs* 40%, $P=0.0012$) during airway intervention.

In this small data set the authors were unable to demonstrate a significant difference in the use of cricoid pressure, availability of essential drugs and multiple intubations, but there was a trend to improvement with all. The major complication rate was low in both data sets.

Table 3. Comparison of compliance with the Fourth National Audit Project of the Royal College of Anaesthetists standard pre- and post-intervention

Observation	Pre-intervention n (%)	Post-intervention n (%)	*P* value
Anaesthesia as primary specialty of senior clinician present	12 (40)	25 (81)	0.0012
Senior clinician present ST5+ or consultant	27 (77)	31 (100)	0.047
At least one essential piece of monitoring equipment missing	20 (67)	11 (35)	<0.001
End-tidal CO_2 missing	20 (67)	9 (29)	0.0046
At least one essential drug unavailable	6 (20)	4 (13)	NS
Cricoid pressure used	19 (63)	23 (74)	NS
More than three attempts at intubation	4	0	0.0525
Reintubation	8 (26)	2 (7)	0.002
Major complication	2	1	NS

NS = not significant

Table 4. Technical and non-technical interventions undertaken

Technical	*Portable end-tidal CO_2 available for all intubations	
	End-tidal CO_2 for all ventilated patients	
	*An airway management trolley (*Figure 1*)	Equipment to facilitate both routine and unanticipated difficult intubation
	Pre-intubation checklists confirming	Pre-oxygenation
		Drug preparation
		Equipment availability
		Confirmation of tracheal intubation
	*Written bedside airway management plan for every intensive care patient (ABC approach)	
Non-technical	Daily 'airway round' – identifying potential difficulties	
	Daily discussions with on call anaesthetic team regarding potentially difficult cases	
	*Regular structured training for nursing and medical staff regarding:	Rapid sequence intubation drills
		Cricoid pressure
		Difficult intubation drills
	Ongoing audit and team satisfaction survey	

* Those implementations that were successfully achieved

There were no significant differences between the number of patients intubated out of hours (31% *vs* 58%, $P=0.126$). The results of the intervention are summarized in *Table 3*.

Discussion

Airway management in the intensive care unit remains challenging, with patient factors contributing to the majority of difficulties encountered. As a result airway intervention is often associated with increased morbidity and mortality compared with other clinical areas in the hospital. The NAP4 audit project offered the authors the opportunity to review and improve their practice using a national standard to drive the implementation of change.

These data show a reduction in the re-intubation rate within the unit and the authors believe the introduction of an 'airway plan' contributed to this. It mandated the evening ward-round team to consider each and every individual patient and propose a written A, B, C style plan in the event of the need to intubate or re-intubate. Anecdotally, this worked well, particularly where complex airways were being considered, allowing a tailored approach to intubation that saved valuable time. For those patients deemed to have a difficult airway, improved awareness among the medical and nursing staff regarding the requirements and hazards of intubation and airway management better prepared them. This resulted in a more productive

Figure 1. Airway trolley intervention.

dialogue with anaesthetic colleagues, particularly out of hours, and made the at-night team better informed and prepared. The authors believe this increased senior clinician supervision and anaesthetic team presence during airway interventions.

In keeping with the small study sample size the authors were unable to demonstrate a significant morbidity or mortality benefit associated with these interventions; there were reductions in the absolute number of multiple attempts at intubation, and in the number of major complications following airway intervention but these did not reach statistical significance. The authors suspect that the true incidence of airway interventions during the time of this audit was under-reported. In spite of attempts to collect comprehensive data, in keeping with the observations of NAP4, the sample is smaller than anticipated for the study time period and as a result this under-reporting may have influenced the data presented. In areas of reduced performance of both technical and non-technical skills significant improvements were demonstrated. Airway adjunctive equipment and comprehensive monitoring became readily available and familiar to staff, by a process of education and training. Additionally, the introduction of education sessions for intensive care unit staff increased awareness of the hazards, increased confidence and developed team building. This process was met with a high degree of satisfaction and has allowed the development of an ongoing programme of audit and quality improvement to sustain the interventions beyond the life of the study.

In spite of training the uptake of use of the new airway trolley intervention was slow and may have contributed to some of the non-significance in morbidity benefit. There were challenges in communication given the size of the unit and the number of nursing and medical staff who are employed within it (>200). There was initial confusion over differences between the 'intubation trolley', the 'difficult intubation trolley' and the 'cardiac arrest trolley', within which intubation equipment was also contained. Ultimately the process was streamlined to encompass one airway trolley on the intensive care unit, with a more sophisticated airway trolley being available close by in the theatre department.

LEARNING POINTS

- Endotracheal intubation in the intensive care unit is high risk and associated with significant morbidity and mortality.
- Large scale audit informs projects designed to improve quality of care.
- Development of a multidisciplinary team training programme coupled with technical innovation engaged the whole workforce, which may have improved compliance.
- Multidisciplinary interventions based on the Fourth National Audit Project of the Royal College of Anaesthetists recommendations are successful, popular and sustainable.

Conclusions

By introducing a high-impact yet simple intervention to increase awareness and the availability of equipment during airway interventions, combined with multidisciplinary team training, the authors have demonstrated a benefit in the technical and non-technical aspects of airway management in their intensive care unit. The unit is better prepared for the unexpected airway incident and they have developed processes by which the right people are available to attend the right patients with the right equipment at the right time. Embedding the equipment checks, airway drills and airway safety culture into routine practice will be the ongoing challenge and is considered central to sustaining this improved practice. **BJHM**

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