CHAPTER 15

Major airway events in patients with a tracheostomy


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Headline

Critical incidents can occur during the initial placement of a tracheostomy, during the care of patients with a pre-existing tracheostomy, or as a consequence of having a tracheostomy. Many patients have tracheostomies performed and managed on intensive care units (ICUs) so this chapter should be read in conjunction with the ICU chapter (Chapter 9).

There were two reports of difficulty in insertion of tracheostomy, with one death. Capnography did not appear to be used during the performance of this tracheostomy.

Displacement of tracheostomies led to several deaths. Tracheostomies were often displaced on movement or during routine care. Continuous capnography was rarely used. The method of fixation of tracheostomies was not consistent. Often, patients whose tracheostomies became displaced were obese, leading to the inference that tracheostomy tubes are not always long enough or of appropriate design for these patients' anatomy. When patients were accidentally decannulated there was an evident lack of a systematic approach, highlighting the importance of having an extubation plan and of training and education of all staff in attending these patients.

Tracheal stenosis after tracheostomy decannulation provided challenges when patients need re-intubation, requiring team working between anaesthetists and/or intensivists and ENT surgeons.

What we already know

Tracheostomies are inserted electively during, for example, laryngectomy, in patients in whom major airway swelling is anticipated, or to facilitate weaning from mechanical ventilation. They are also inserted in emergency situations, either to rescue a critically compromised airway, e.g. secondary to tumour, or as part of an airway rescue procedure in the 'can't intubate, can't ventilate' (CICV) situation. There were 75 cases reported to NAP4 of emergency surgical access for airway rescue; most of these are dealt with in the 'can't intubate, can't ventilate' chapter (Chapter 13).

A substantial minority of patients in ICUs have tracheostomies placed and on the day of the EPIC survey 16% of UK ICU patients had a tracheostomy.[1] In ICU intensivists perform the majority of these tracheostomies when placed to aid weaning from mechanical ventilation. In one survey, 97% of responding units performed some type of percutaneous technique for tracheostomy placement.[2] Rates of complications for both surgical and percutaneous tracheostomies are reported to be as high as 5% during insertion, and include displacement, bleeding, pneumothorax and, later, infection. However, systematic reports of the rates and consequences of these complications are lacking, and what metanalyses there are in the literature, have conflicting conclusions.[3,4] Similarly, there are reports in the literature comparing the incidence of tracheal stenosis after surgical and percutaneous tracheostomies but these are sometimes contradictory and patient numbers are generally small. The true incidence of clinically significant stenosis after tracheostomy, however performed, is unclear.

The incidence of complications from tracheostomy in obese patients is greater than those with normal body habitus. El Sohl and Jaafar[5] found that life-threatening complications were attributed to tube obstruction and extra-tracheal positioning of the tracheostomy after becoming dislodged; morbid obesity was associated with an increased risk of tracheostomy-related complications with an odds ratio of 4.4 (95% CI 2.1–11.7). Mallick and colleagues[6] studied 50 non-obese patients undergoing percutaneous tracheostomy: they found that standard-length tracheostomy tubes commonly used in the UK were often too short even for patients with normal anatomy, and that the angle between the part of the tracheostomy which

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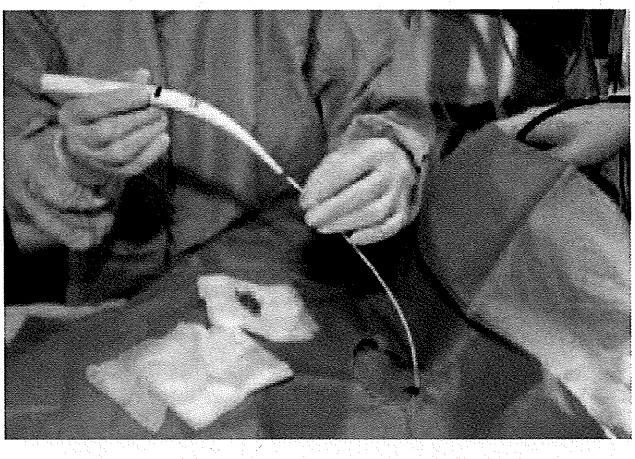

would sit in the stoma and the length which would sit in the trachea varied between manufacturers (see Table on page 124). The authors recommended that tubes be redesigned to increase both stomal and intra-tracheal lengths and that tracheostomies should be formed with an angle between intra-stomal and intra-tracheal sections of 110–120°.

In a survey of UK intensive care units conducted in 2004, 85% of respondents were aware of clinically significant incidents of blocked tracheostomies, more than half of which occurred in normal ward areas, i.e. after discharge from ICU. Few of these events were formally reported as critical incidents.[7] McGrath and Thomas[8] examined critical incidents related to airway events from ICUs as reported to the National Patient Safety Agency over a two-year period (2005-07): there were 453 incidents where patients were directly affected, 338 that led to harm and 15 that may have contributed to death. Of these 453 incidents, 276 (60%) involved tracheostomies becoming blocked or displaced.

The NAP4 census identified that approximately one in 300 anaesthetics in the UK is delivered via a tracheostomy.[9] A recent analysis of litigation in the UK related to airway events during anaesthesia identified that a disproportionate number of cases involved tracheostomy, at least one in ten of all cases and one fifth of cases of airway trauma.[10]

In theatre and during anaesthesia, continuous capnography is a minimal monitoring requirement for patients with artificial airways. However, in the ICU and on the wards, capnography is rarely used for such patients, for reasons of cost, of monitor malfunction due to blockage with water or airway secretions and of culture. In one survey of 169 intensive care units in the UK, only 35% of units used capnography for monitoring at any stage, and only 22% used continuous capnography for patients with intracranial pressure monitoring devices in place. Capnography was not used during 27% of tracheal intubations and 53% of tracheostomy insertion procedures. Only 55% of units responding had facilities to monitor end-tidal carbon dioxide at all bedspaces.[11]

In view of the available evidence of the 'high-risk' nature of the tracheostomy as an airway, one might anticipate that well-established protocols are available for monitoring and management of complications of their use. A survey of ICUs in the northwest of England showed that only two of 16 units had tracheostomy guidelines for trainees and nurses to refer to.[12] In 2006, Mace et al found that of 103 NHS trusts providing a tracheostomy service in the UK, 14.6% had no tracheostomy care policy, only 31% had a dedicated tracheostomy care team and only 12.5% had ENT input to tracheostomy care.[13] The northwest group has set up a website to help address this, www.tracheostomy.org.uk, which provides educational advice and algorithms for emergency airway management.

Case review

Cases reported to the project can be divided into three areas – problems during the insertion of a tracheostomy, problems during the care of a patient with a tracheostomy and problems encountered as a sequela of having had a tracheostomy.

Problems during tracheostomy insertion

There were two cases of significant brain damage after failure to insert a tracheostomy that was planned and performed to assist weaning from mechanical ventilation. One occurred during a percutaneous tracheostomy when the tracheostomy tube went into a false passage; it was not clear whether capnography was in use during the procedure or not, or whether a bronchoscope was used to confirm position. In the other, a surgical tracheostomy was being carried out by a non-ENT surgical registrar who was used to performing tracheostomies but who was unable to insert a tube despite multiple attempts. Reintubation was not attempted, nor was transtracheal jet ventilation.

There were cases when a tracheostomy was inserted because the patient had a difficult airway that could not be managed by intubation. These patients were reported

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to the NAP4 project because they had unplanned surgical airways or had an unplanned admission to ICU. In some cases there was careful planning and tracheostomy was performed as part of an accelerating plan of airway intervention. However in other cases, insertion of the tracheostomy was not part of the initial plan and equipment was not immediately available or a plan 'B' was not evident. Many of these cases are discussed in the 'can't intubate, can't ventilate' (Chapter 13).

Lesser degrees of harm occurring during formation of tracheostomy were also reported.

Case 1
A young patient with previous airway trauma pulled out his tracheostomy at home. It was not possible to insert a small tracheal tube through the stoma, so a Cook airway exchange catheter was inserted and the patient transferred to theatre. The patient developed bilateral tension pneumothoraces and surgical emphysema after a test Manujet ventilation, despite using pressures in the lowest range; the patient was hypoxic for some minutes but recovered after placement of bilateral chest drains and performance of a surgical tracheostomy.

Case 2
A patient developed extensive surgical emphysema after two high-pressure inflations through a cricothyroidotomy; the patient required an emergency surgical tracheostomy due to complete airway obstruction from surgical emphysema combined with thyroid cancer, which had already led to critical airway narrowing.

Tracheostomy on the intensive care unit is a routine procedure and may on occasion be required urgently and out of hours. The necessary equipment should be available and the personnel with appropriate skills should be able to attend in a short period of time. Suitable monitoring including capnography and bronchoscopic observation of the procedure from within the airway should be regarded as standards of care as they will reduce the risk of tube misplacement. Good communication and team working is vital to the successful performance of a tracheostomy and this is particularly so when it forms part of management of a difficult airway. Case 3 is an example of this good teamwork.

Case 3
A child had inhaled a foreign body and was transferred to another hospital for further management. The foreign body could not be retrieved until, after two hours, a decision to form a tracheostomy was made. There was an acute fall in oxygen saturation as the surgeons were scrubbing to perform the procedure so an emergency tracheotomy was performed, which was then converted to a formal tracheostomy. The foreign body was removed through a rigid bronchoscope. The child was decannulated two days later.

Less frequently patients will be admitted to the emergency department and require an emergency surgical airway. An emergency tracheostomy may be one of the options but again, outside the operating theatre requires good teamwork, communication and surgical skill: case 4 is an example.

Case 4
A patient with a history of carcinoma of the larynx presented to the emergency department in a peri-arrest state with post-radiation stridor. A senior ENT specialist registrar attended promptly and performed fibreoptic nasendoscopy, which showed no glottic gap so intubation was not attempted. Insertion of a minitracheostomy was not successful and the patient went on to have an emergency percutaneous tracheostomy by the ENT SpR. The patient was admitted to the ICU and the tracheostomy was found subsequently to be in the cricothyroid space. He was referred to a tertiary centre for ongoing care.

The high rate of failure of cannula cricothyroidotomy identified elsewhere in this report (see Chapters 6, 9, 10 and 13) should remind clinicians of the greater importance of both surgical cricothyroidotomy and emergency tracheostomy as airway rescue techniques.

Problems during care of the patient with a tracheostomy

The most common, and most commonly lethal, problem was displacement of the tracheostomy, especially on movement or in the obese patient, or both. None of these patients appeared to have capnography and this frequently led to delays in recognition of the displacement, sometimes to the point of cardiac arrest.

Several cases indicated problems with the length of standard tracheostomies in obese patients. Case 5 describes how in one obese patient, changing an adjustable-flange tracheostomy tube to a more conventional tracheostomy with an inner lumen led to its displacement and near death. In another patient, a size 6.0mm ID tracheostomy tube was placed during an emergency tracheostomy procedure; the tube subsequently dislodged on attempted placement of a nasogastric tube. These cases illustrate how a tracheostomy may not be long enough for a patient's anatomy, either because the patient is large or the tube small. The Table shows the length of commonly used tracheostomy tubes, showing that tubes with an inner lumen and smaller diameter tubes are significantly shorter than adjustable-flange tubes.

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Case 5

An obese patient on ICU after major surgery had a surgical tracheostomy with an adjustable flange tracheostomy tube inserted. Ten days later, the tracheostomy was changed for a conventional tracheostomy with an inner tube. In the early hours of the morning, after suctioning the patient and reconnecting to the ventilator, the ventilator alarm indicated high airway pressures. Nurses caring for the patient attempted to manually ventilate, but it was very difficult and oxygen saturations fell. The doctor attended and observed that the patient was breathing around the tracheostomy and that the reservoir bag was moving but determined that the patient needed a definitive airway. The doctor administered propofol and suxamethonium but could not visualise or intubate the larynx. Attempted bag-mask ventilation was unsuccessful. The patient desaturated further, became bradycardic and suffered a cardiac arrest. Fortunately, ventilation then became possible through the tracheostomy tube and the consultant arrived. The tracheostomy tube was changed over a bougie, and holding the tube in place, enabled a return to theatre where the tracheostomy was refashioned.

Table 1 Lengths and angles of commonly used tracheostomy tubes. Angle refers to the angle between the stomal and tracheal parts of the tube.

Make	Size (internal diameter, ID) (mm)	External diameter (OD) (mm)	Length (mm)	Angle (degrees)
Portex Blue Line	6	8.3	55	90
	8	11	82	90
	9	12.4	87	90
Portex adjustable-flange	9	12.4	135	
Shiley dual lumen	6 (6.4)	10.8	74	135
	8 (7.6)	12.2	79	135
	10 (8.9)	13.8	79	135
Shiley Extended Length	6	8.3	95	135
	8	13.3	105	135
Tracoe twist	8	11.4	74	140
Rusch tracoe flex	8	11.4	88	90
Rusch extra length	8	11.4	128-138	90

Tracheostomy displacement occurred most commonly either on moving the patient or performing airway manoeuvres such as suctioning: cases 6–11 are illustrative.

Case 6

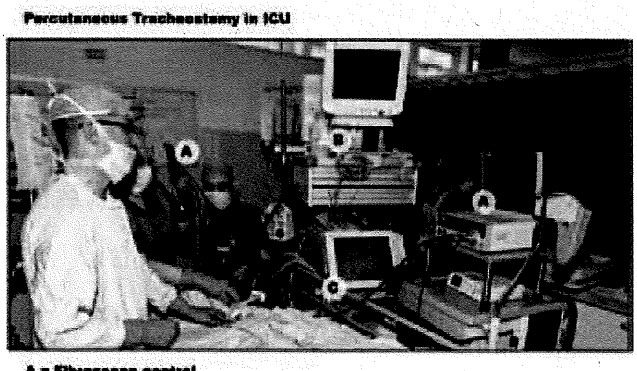
An ICU patient whose tracheostomy was secured with Velcro ties was being turned when the ventilator alarmed and the patient developed surgical emphysema. A difficult oral intubation resulted in high airway pressures, but capnography was not available to confirm correct placement of the tracheal tube and it was removed. A laryngeal mask airway did not enable ventilation, attempted tracheostomy replacement was unsuccessful and the patient, although ultimately intubated, died. In this case, airway equipment considered desirable by the reporter including ProSeal LMA and intubating LMA were not available.

Case 7

An obese patient had a difficult emergency tracheostomy placed by an ENT surgeon to manage supraglottic airway obstruction. While on ICU, during turning in the middle of the night the tracheostomy became displaced. Capnography was not in use. Surgical emphysema developed, and the patient could not be intubated or ventilated by the attending registrar. The ENT and ICU consultants arrived promptly and managed to replace the tracheostomy over a bougie at second attempt. The patient suffered hypoxic brain injury.

Case 8

An awake morbidly obese patient (BMI 45 $kg.m^{-2}$) with a tracheostomy, secured with sutures and ties, developed respiratory distress after moving off a bedpan in the middle of the night while on ICU. Capnography was not in use. Recognition of tracheostomy displacement was delayed and the patient became agitated and hypoxaemic. Surgical emphysema developed when attempting to ventilate through the tracheostomy. The patient had complex facial fractures, which made bag-mask ventilation and intubation difficult. The tracheostomy could not be replaced using either a bougie or fibreoptic bronchoscope. It was removed, with difficulty because of the sutures, a bougie passed into the stoma and a tracheal tube placed. During the event, the patient aspirated and ICU stay was prolonged.



A = Fibrescope control
B = Continuous vital signs monitoring
C = Continuous capnography

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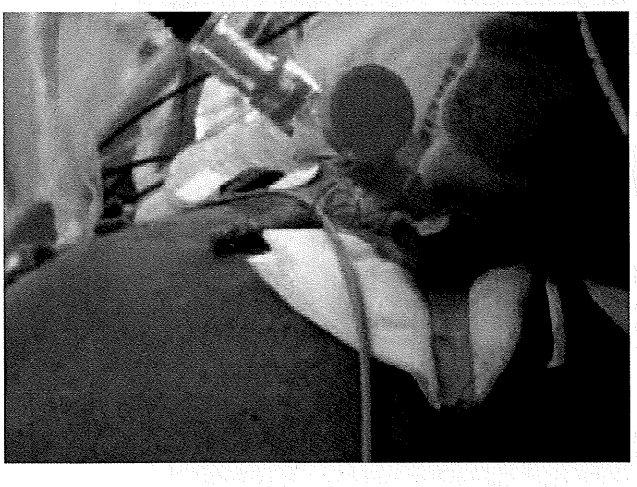
Complex airway management in the middle of the night can be fraught. The airway knowledge and experience of medical staff attending in these circumstances is now very variable due to changes in medical staffing of ICUs. To some degree problems may have been avoided by identification of patients likely to be problematic and the pre-formulation of a strategy to manage such an event. In some cases, in addition to poor knowledge or use of protocols, poor team behaviour was judged to have contributed to a poor outcome.

Case 9

In the early hours on ICU, an obese patient with a tracheostomy was turned and became 'impossible to ventilate'. The patient rapidly developed surgical emphysema, and bag-mask ventilation was unsuccessful. The tracheostomy had been performed less than four days previously; a fibreoptic bronchoscope was not available to attempt reinsertion. Attempted oral intubation resulted in oesophageal intubation; there was no capnography in place. Airway rescue with a supraglottic airway device or cricothyroidotomy was not attempted.

Case 10

An obese patient with airway obstruction due to an oropharyngeal abscess had an emergency tracheostomy. The tracheostomy was sutured in place. Forty-eight hours later, early in the working day, two junior trainees were on ICU when the tracheostomy became obstructed. Bag-mask ventilation through the tracheostomy was initially partially successful, but then became impossible. The doctors attempted to re-insert the tracheostomy by passing a suction catheter down the tracheostomy and when that failed, attempted to bypass the tracheostomy with a wide bore cannula. They did not attempt oral intubation. The consultant intubated the patient with difficulty after 30 minutes, however the patient had two cardiac arrests and a pneumothorax, did not recover neurologically and died five days later.



Case 11

A patient on ICU with a cervical spine injury who was ventilator-dependent requested that sutures securing a tracheostomy in place be removed. The tracheostomy subsequently became dislodged but this was initially unrecognised. Capnography was not in place and the patient suffered a cardiac arrest and died.

Tracheostomy displacement occurred with all types of devices used to secure the tube in place. It is likely that displacement on ICU is unavoidable. It was not possible to identify whether the absence of stay sutures (sutures inserted into the lower part of the tracheal stoma that when pulled aid in re-identifying the stoma) played any role in causing the reported events but few had them. On ICU failure to use rescue techniques that would be used in anaesthesia (orotracheal intubation, supraglottic airway device insertion) was regularly identified. While effort should be made to minimise the risk of displacement the greatest benefit will likely come from early detection (nursing awareness, use of capnography) and prompt management of displacement (SOPs and protocols that trainees are familiar with and for which the necessary equipment and skills are available).

The need for protocols to manage predictable events, for identification of patients with particular difficulty and for immediate access to appropriate equipment and skilled staff are discussed in more detail in Chapter 9.

Late complications

Patients who have had a tracheostomy in the past may develop late complications. These include infection, haemorrhage, and tracheal stenosis or tracheomalacia.

There were no reports to the project of airway complications related to infection. There were two reports of haemorrhage. One occurred when a percutaneous tracheostomy inserted for the purposes of weaning from mechanical ventilation was removed 24 hours after insertion. The patient immediately lost more than a litre of blood and sustained hypoxia secondary to aspiration. The tracheostomy was reformed and the patient recovered without the source of bleeding being discovered.

Patients with previous tracheostomy may be difficult to intubate due to either stenosis, tethering of the airway to the tracheostomy scar or, very rarely, tracheomalacia. Such problems should be anticipated and planned for in patients with previous tracheostomy.

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Case 12

A patient who had a previous surgical tracheostomy while recovering from severe ARDS developed progressive stridor, several weeks after it had been removed. A CT scan of the neck led to a diagnosis of tracheomalacia and airway collapse. The patient's symptoms were relieved with heliox. The patient was transferred to the ICU and then deteriorated because of copious secretions and coughing so that re-intubation was required urgently. This was expected to be straightforward but staff and equipment were assembled in case of difficulty. A rapid sequence induction was performed but despite a grade 1 laryngeal view a fixed, 'solid' stenosis prevented intubation. Bag and mask ventilation was impossible. The tracheostomy scar was opened to pass a wire but a cricothyroidotomy device did not pass though the stricture. Eventually a mini-tracheostomy wire was manipulated past the stricture and a mini-tracheostomy railroaded successfully. The patient was ventilated for some hours through the device before being taken to theatre for surgical tracheostomy.

Numerical analysis

There were 75 cases of unplanned emergency surgical airway access reported to NAP4. Most are dealt with in the 'can't intubate, can't ventilate' chapter (Chapter 13).

Two ICU patients had adverse outcomes because of failure to place a tracheostomy successfully. Capnography was not used in one of these cases. A further patient had an emergency tracheostomy that was placed in the cricothyroid space.

There were two cases of significant haemorrhage, one on tracheostomy insertion, one on removal of a tracheostomy placed 24 hours previously.

There were 14 cases of accidental dislodgement of tracheostomies reported, all in the intensive care unit, with seven patient deaths (50%) and four patients left with hypoxic brain injury. In two-thirds of these cases, dislodgement occurred on turning or moving the patient. Half of the patients were obese (BMI >30 kg m^{-2}). The use of capnography was not recorded in any of these cases. A plan for the management of tracheostomy displacement was clearly lacking in at least six of these cases. Most of these cases occurred outside normal working hours.

In at least two obese patients, tracheostomy dislodgement occurred because tracheostomy tubes may have been too short or ill-designed for the patient's anatomy. The method of fixation of tracheostomy tubes was not specified in a sufficient number of cases to comment specifically, but tracheostomy tubes become displaced even when both sutures and ties are used to secure them.

Of the 25 cases directly examining tracheostomy-specific problems, there were ultimately 12 deaths. Education and training contributed to the airway event in 13 of the 25 cases, and was a positive feature in one. Judgement was questioned in 19 cases and in four was felt to be good. Lack of equipment was assessed to be contributory in 18 cases, and made a positive contribution in two. Organisation and strategic factors figured negatively in nine cases and were positive in a further five. Difficult patients make difficult cases, and it was felt that 19 of these patients presented identifiable management difficulties, most frequently obesity.

Comment

Many of the cases discussed here are cross-referenced in the Chapter 9.

The themes emerging in this chapter have considerable overlap with those in the ICU chapter and highlight many common themes in the management of adverse airway incidents:

1. **Staff**: Problems with tracheostomy tubes present whatever the hour or the doctor available to deal with them. However, because of the potential complexity of the airway problem, the patient needs an individual with advanced airways skills to deal with the issue. This is not always immediately available and may contribute to patient harm.
2. **Patient**: Obese patients appear to suffer disproportionately more airway misadventures related to tracheostomy than the non-obese patients, and the outcomes of these events in obese patients are more adverse. In addition, patients with airway pathology (e.g. oropharyngeal tumours or obstruction) are also over-represented in this group of patients. Again, it is important that personnel with appropriate skills are available to deal with their airway problems.
3. **Procedures and protocols**: Tracheostomy displacement occurs, especially in obese patients, and especially on patient movement or with interventions in the patient's airway, e.g. nasogastric tube insertion. Standardised operating procedures must be available and understood when airway difficulty arises.

Capnography

Of the cases of inadvertent tracheostomy tube displacement, capnography was not reported in any case. It is almost inevitable that this led to delays in recognition of tracheostomy blockage and of tracheostomy displacement. Use of capnography is the standard of care for ventilated patients in the operating theatre and it is difficult to justify a lesser standard for patients who are intubated and ventilated in ICU.

Transfers/movement

Patients who suffered displacement of tracheostomies in the ICU most frequently suffered these events on movement or on manipulation of the airway.

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Obesity
Patient factors, most frequently obesity, were felt to be a significant factor in the adverse tracheostomy-related incident in the majority of patients. This suggests that the design of tracheostomies has not kept pace with the change in the body habitus of the UK population, in that tracheostomies were too short for some of the patients who suffered adverse outcomes reported to this project.

Equipment
Lack of equipment was highlighted in several cases both in the context of planned tracheostomies or for management of tracheostomy displacement. It is clear that ICUs managing potentially difficult airways must have appropriate equipment for such events.

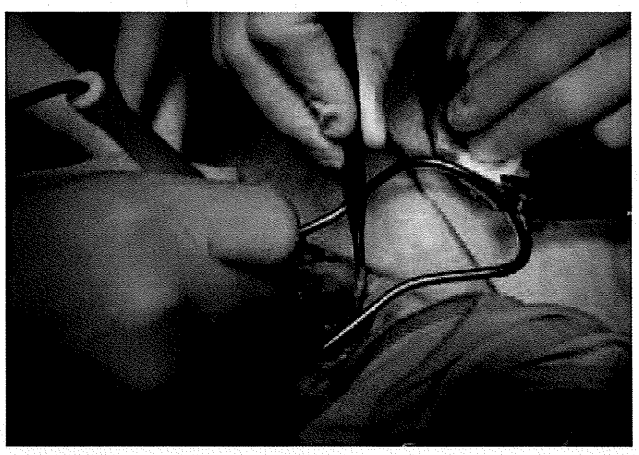
Planning
One of the major learning points from reviewing cases in the NAP4 project is that lack of anticipation of potential airway misadventures contributes to the lack of a systematic and logical plan for resolving the issue. Although 'standardised operating procedures' are common in other high-risk areas such as aviation, they have not been widely adopted in medicine. It may be the time to revisit our approach.

Teamwork
It is clear that communication and mutual co-operation between intensivists, anaesthetists and ENT surgeons is vital to the successful management of difficult airways. There were many examples of good teamwork during events that prevented progression to worse morbidity or mortality. In a minority of cases teamwork and communication was poor and contributed to events.

Ward based events
It is acknowledged that airway events occur during ward care of patients with tracheostomies. NAP4 did not seek or review events arising on the ward. More than 5,000 tracheostomies are performed each year in the UK and only a minority of these patients are nursed only on ICU. It is worth remembering that in addition to those cases reviewed here there is no doubt, that during the period of NAP4 data collection, numerous cases of tracheostomy-related harm will also have occurred to patients on the wards.

Learning points and recommendations

Cricothyroidotomy failure
As needle cricothyroidotomy fails frequently, tracheostomy (both surgical and percutaneous) is an important rescue technique for severe airway emergencies.



Recommendation: Training in tracheostomy, including as an emergency, should be prominent in both ENT and intensivist training.

Capnography
In cases of tracheostomy displacement recognition was delayed by a lack of capnography. Diagnosis of misplacement during formation of tracheostomy was also delayed for the same reason.

Recommendation: Capnography must be available at each bed space in the ICU and should be used continuously while patients are being mechanically ventilated.

Recommendation: Multidisciplinary staff training should focus on the recognition and interpretation of capnography.

Recommendation: Continuous capnography should be used during the performance of percutaneous tracheostomy.

Protocols and strategies
There was sometimes a failure of a logical and step-wise approach to managing airway events that occurred after accidental tracheostomy displacement or elective decannulation, especially out of hours.

Recommendation: Algorithms must be available for all staff for management of accidental decannulation of the trachea and a step-wise approach to management of the compromised airway. An example of such is included in Appendix 2.

Recommendation: There must be clear lines of communication for escalation of airway events to individuals with advanced airway skills. If individuals covering ICUs do not have advanced airway skills, they must know who to contact for help.

Movement and transfers
Transfers of patients with unstable airways are fraught with hazard. Equally, moving patients as part of routine care can lead to airway displacement.

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Recommendation: All staff involved in the care of patients with tracheostomies should be alert to and receive training in maintaining the airway and in safe movement of the patient.

Obesity

Obese patients present additional problems. Tracheostomy tubes that are suitable for patients with normal body habitus may be too short or poorly designed for these patients.

Recommendation: Extra long or adjustable-flange tracheostomy tubes should be available for obese patients who have tracheostomies.

Recommendation: Appropriate bodies such as the Intensive Care Society should engage with manufacturers to redesign tracheostomies, recognising especially the general increase in body mass index in the patient population.

Equipment

Lack of necessary airway equipment repeatedly contributed to a poor outcome in patients whose tracheostomies displaced. Previous studies have shown that ICUs frequently do not have a similar standard of difficult airway trolley to the anaesthetic department in the same hospital.

Recommendation: Difficult airway trolleys must be available to ICUs and their contents familiar to staff.

Recommendation: The difficult airway trolley should have the same contents and organisation as the difficult airway trolley used in the theatre suite of the same hospital.

Recommendation: A flexible fibrescope should be immediately available on the ICU to check position of tracheal/ tracheostomy tubes and assist with fibreoptic intubation or percutaneous tracheostomy placement.

Staffing and teamwork

Team-working and involvement of senior staff are important in successful airway management in patients who may have complex compromised airways. This may include patients with tracheostomy or complications of a previous tracheostomy.

Recommendation: Clear lines of communication are required between the various teams that manage airway problems related to tracheostomy (ICU, anaesthetic and ENT clinicians) in order to best manage such patients with potentially difficult airways. Mechanisms are also required within teams so senior staff are appropriately available and involved when adverse airway incidents occur.

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CHAPTER 21
Children


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Headline

Using a definition of age <16 years for children there were 13 paediatric cases referred to NAP4: 11 anaesthesia cases, one in ICU and one in the emergency department. Ten of the children were aged under ten and nine aged under four. These 13 cases represent 7% of all cases reported to NAP4 and 8.3% of anaesthesia cases. There was one death in each of the clinical areas.

Airway events occurred in a number of children with congenital developmental abnormalities that made airway management predictably difficult. Difficulties in airway management also occurred in a small number of healthy children, unexpectedly.

Areas of particular interest are unpredictable difficult intubation, often managed simply by multiple attempts, cardiovascular complications of airway management (bradycardia and cardiac arrest were frequent), problems occurring before, during or after patient transfer.

What we already know

Airway management in children is generally straightforward but can occasionally be an extraordinary challenge. The total number of children anaesthetised per year is unknown but anaesthesia and airway management are required for the vast majority of operations and many non-operative procedures as children and babies are less likely to be managed with sedation or regional techniques than adults. Sick children requiring airway management also present to emergency departments and to the approximately 300 UK Paediatric ICU beds. During the study year 2008–2009 children admitted to any of these areas, who had major airway complications, may have been reported to NAP4.

Many hospitals apply a lower age limit for elective admission of paediatric patients. The Royal College of Anaesthetists has recommended that anaesthetists managing children should have a regular commitment to routine paediatric work and that all departments should have agreed guidelines in place to manage elective and emergency paediatric workloads.[1] NCEPOD in 1999 advised that practitioners should not be involved in 'occasional paediatric practice'.[2] In a recent report on anaesthesia and ICU services, it was recommended that all departments should be aware of the limits of their expertise and have agreed guidelines in place to manage elective and emergency paediatric workloads.[3] In addition there should be local arrangements to ensure there are services in place to resuscitate, stabilise and if necessary transfer children to specialist centres.

Children and their families should receive expert paediatric care which is child and family focused.[4] Resources should be made available to achieve this. Anaesthetists with a paediatric interest should have had a minimum of six months higher specialist paediatric anaesthesia training and should continue to have at least one regular paediatric theatre list. Anaesthetists with a predominately paediatric practice are expected to have had at least a year of specialist paediatric anaesthesia training.[5]

However, all anaesthetists are expected to be familiar with anaesthetising children and management of paediatric patients is part of the core competencies for anaesthetic training as stipulated in the curriculum of the Royal College of Anaesthetists at intermediary, higher and advanced level.[6] Basic and advanced airway management forms part of this training. All post-CCT anaesthetists would be expected to be competent to manage children older than three years.

Several factors have made it inevitable that anaesthetic (and other) trainees now have less practical exposure to paediatric practice than in the past. As training has been streamlined and the European Working Time directive implemented, this has resulted in a reduction in practical experience gained by trainees.[7] With the expansion of a consultant delivered service, and a reduction in trainee hours, the opportunities for experience with paediatric patients is limited and this is likely to affect skills and confidence in sub-specialty areas of practice. 'Hands-on' workshops and simulator-based training are increasingly used to address this training gap.

Nationally paediatric services have been centralised in recent years. There is a conflict between the desire to deliver services near to the child's home, which assumes paediatric services in all hospitals, and the desire to deliver the highest quality services concentrated in hospitals with the full range of specialist paediatric services. In anaesthetic-surgical practice there has been a particular decrease in the management of children below four years of age in district general hospitals (DGHs), due to planned reorganisations of both anaesthetic and surgical services. This trend applies particularly to emergencies. The shift in work patterns has been facilitated by new 'managed

clinical networks', where there are formal links between DGHs and regional centres.[4] This reorganisation means that transfers of paediatric patients to centres which provide specialist services are now more common. Regarding airway management this is particularly relevant to adult and paediatric intensive care units (ICUs/PICUs). The majority of children under the age of 12 are now cared for in regional centres with paediatric specialists. If young children needing ICU care present to a DGH they will require transfer to a centre providing paediatric services. To support this there has been an expansion in dedicated paediatric retrieval services which have been a valuable addition to care.

Although the impact of these changes on paediatric anaesthetic and intensivist skills in a DGH, is unknown, a child presenting to a DGH Emergency Department with an airway problem will enter an environment with fewer paediatric anaesthetists, and trainees with lesser paediatric experience, than previously. The same will apply to surgical services. Many DGHs will now have no resident ENT staff and the service support may be provided from a remote location requiring transfer of either the doctor or the patient in an emergency. Similar arguments apply of course to nursing and anaesthetic support services. Should the child need immediate airway management or admission to ICU for ventilation it is likely that the anaesthetists and or intensivists, including many consultants, will have less experience in management of sick children and their airways than a decade ago. Dedicated paediatric rotas to cover such emergencies may or may not be in place.

Transfer of a sick child may be necessary for further definitive care, or simply to take the child to where the services are. Retrieval is generally reliable but the sickest children may require airway management before tertiary expertise is available and in these circumstances transfer without securing the airway is unwise. Retrieval teams are not always trained in difficult paediatric airway management and may rely on staff in the DGH to manage the child's airway before transferring them. Decisions about when to intervene and whether to transfer a sick child with a normal airway or a child with a potentially difficult/ compromised airway require communication and careful decision-making of the highest quality. This may involve a paediatrician, an emergency physician and intensivists or anaesthetists at the DGH communicating with these and other specialist services at the tertiary centre.

We do not know the incidence of either difficult airway management or difficult intubation in the general paediatric population, but it is widely accepted as being considerably lower than in adult practice. Certain groups have been studied and the incidence of difficult intubation of 4.7% has been reported in children with cleft palate (with 7% in those younger than six months)[8] and 1.25% in children with cardiac anomalies.[9]

Equipment also differs in paediatric practice. Innovations are often initially targeted at the adult market and development of smaller paediatric versions has perhaps lagged behind adult equipment developments. However in recent years there has been considerable activity with the introduction of several new paediatric supraglottic airway device (SADs) and laryngoscopes/intubating aids. Evaluation of paediatric airway equipment is often slow and much of the literature on the use of various innovative techniques or airway equipment is individual case reports or short series. There is a marked lack of evidence-based information on the management of even the routine paediatric airway.

Finally, there are some areas of practice which remain notably different between adult and paediatric practice. In adults it is routine to perform and document a formal airway assessment at the preoperative visit, while this is not so in paediatric practice. Most airway tests have not been validated for paediatric patients and are difficult to interpret with the varying ages and sizes of patients.[10] The NAP4 census noted a marked divergence between the management of the predicted difficult airway in adult and paediatric practice: in adult practice (which accounted for 91% of all such cases) management was 81% intravenous induction of anaesthesia, 9% inhalation induction and 10% awake fibreoptic intubation, while in children (9% of such cases) inhalational induction was used for 63% and intravenous for 37%, with awake techniques not reported at all.

Case review

Most paediatric cases reported to NAP4 (11 of 13) were anaesthesia-related and involved young children (three infants and four under the age of four years). Several issues were raised though the cases are quite heterogeneous.

Difficult intubation

Two deaths were related to difficult intubation and four other cases involved difficult or impossible intubation. Two cases are described as Case 1 and 2, these occurred in the emergency department and ICU respectively.

Predicted difficult intubation occurred in several children with dysmorphic features. In one case difficulty at intubation identified during routine surgery, was due to an unexpectedly narrow trachea, in an otherwise normal child, a congenital abnormality which is extremely rare.

Harm arose due to repeated attempts to intubate the trachea without change of technique. In one case intubation was achieved after six attempts and in another multiple attempts led to trauma that required ICU admission (Case 3).

One death occurred from unrecognised oesophageal intubation in the emergency department (Case 1). The capnograph, which was in use, was not interpreted correctly and this is an important training issue.

Case 1

A small infant with a congenital neuromuscular disease presented to the emergency department in respiratory failure. Three attempts were made to intubate by a paediatric registrar from PICU. Clinical signs were used to confirm tube position. Capnography was in use but the flat capnograph trace was either not seen or not correctly interpreted. The infant had a hypoxic cardiac arrest and cardiopulmonary resuscitation was necessary for several minutes. When passing a nasogastic tube the tracheal tube was found in the oesophagus. The infant was transferred to ICU for further care but did not survive.

Case 2

A notably dysmorphic preterm neonate with respiratory problems was intubated, after considerable difficulty, by a DGH neonatologist and then transferred by a neonatal transfer team to a larger hospital. During a non-invasive procedure the tube was displaced when the head was moved and reintubation by a consultant neonatologist failed. Mask ventilation was only possible with a two person technique. Intubation was still not achieved after assistance from an ICU consultant and a consultant anaesthetist experienced in difficult paediatric airway management. A tracheostomy was planned and ventilation was just possible after insertion of a laryngeal mask. During transfer of the patient to theatres, which were not adjacent, the airway became obstructed, hypoxia and death followed.

Case 3

A young child due for routine surgery required unanticipated admission to PICU following iatrogenic airway trauma due to repeated intubation attempts. Mask ventilation was impaired and intubation difficult despite a good view of the larynx. Eventually a small tracheal tube was successfully passed.

Emergency surgical airway

An emergency surgical airway was needed in five paediatric cases reported to NAP4: four were attempted, three succeeded and one patient (Case 2) died during transfer for an emergency tracheostomy. One baby for elective superficial surgery unexpectedly had marked subglottic stenosis. Tracheal intubation was impossible: the airway was managed on a facemask and an ENT surgeon performed an emergency tracheostomy: an example of excellent management all round. A second case involved an infant with croup who was being anaesthetised to secure the airway prior to transfer to a larger hospital. Laryngoscopy was easy but tracheal stenosis prevented intubation: hypoxia and cardiac arrest intervened and emergency tracheostomy was performed during CPR. The child recovered. The only cricothyroidotomy, and the only paediatric emergency surgical airway performed by an anaesthetist, was a case of airway obstruction due to a massive regurgitation in an older child: the tracheal tube was dislodged during vomiting, aspiration of gastric contents occurred despite suction and intubation was impossible. The anaesthetist attempted to rescue the airway with a needle cricothyroidotomy but this failed (see also Chapter 13). A further attempt at re-intubation was successful and the child recovered. The final two Cases are Cases 2 and 4.

Case 4

A child inhaled a plastic pen top and was transferred from one hospital to another. A spontaneously breathing anaesthetic facilitated rigid bronchoscopy by an ENT consultant but removal of the pen top was very difficult and ultimately required an emergency tracheostomy. This required considerable co-operation and co-ordination between the anaesthetist and surgeons.

Events at the end of surgery and in recovery (blood in or around the airway)

There were three cases in which blood in the airway at the end of surgery contributed to an adverse airway event. One was a patient who, after tonsillectomy, was extubated and aspiration of blood caused first laryngospasm and then hypoxia from lobar collapse. The patient was admitted to ICU and recovered. The other two cases are described in Cases 5 and 6.

Case 5

An obese, young, dysmorphic child had minor intra-oral surgery with uneventful anaesthesia. Two senior anaesthetists attended. There was a small amount of bleeding into the pharynx before extubation. Immediately after extubation the child developed airway obstruction. Hypoxia was rapid and re-intubation was delayed by searching for a new tracheal tube (the first having been discarded) and by blood obscuring the laryngeal view. Bradycardia required a brief period of cardiac compression but after transfer to ICU the child made a full recovery.

Case 6

A young healthy child arrived in recovery after intubated tonsillectomy and soon after had a respiratory arrest. Despite re-intubation, ventilation was ineffective and hypoxia led to cardiac arrest. Bronchospasm was considered. Ventilation was only possible when, after a period of some time, the trachea was re-intubated with a cuffed tube and a blood clot was removed from the airway. Hypoxic damage had occurred and the patient died.

As can be seen a significant minority of cases of harm in children in this project were problems at the end of anaesthesia, a common finding throughout NAP4. In these cases blood in the airway led to patient harm and in one case death.

Aspiration of gastro-oesophageal contents

Aspiration was a rare event in this cohort, being seen in only two reported cases. Both cases involved minor orthopaedic trauma surgery (closed fracture manipulations) on slim children performed out of hours, and use of a laryngeal mask. In both cases the aspiration occurred during surgery and both were significant. One case (described above) required attempted cricothyroidotomy to rescue the airway and one led to extensive airway soiling managed with rigid bronchoscopy and lavage. Neither child had additional risk factors for aspiration. Both children were admitted to ICU but made a rapid recovery and were discharged the following day.

Monitoring

Monitoring was generally of a high standard. In only two cases the review panel considered that monitoring might perhaps have been improved. The use of capnography was frequent, but not universal during anaesthesia (eight of 11 cases), except during events in recovery. Most anaesthetists used a combination of monitoring and clinical signs to determine correct placement of the airway device. In six cases some reliance was placed on clinical measures. In one case, outside theatres, a non-anaesthetist intubator apparently failed to appreciate the importance of a flat capnograph trace and missed an oesophageal intubation.

Transfers

Cases 2, 4 and 6 all illustrate issues related to transfer. Transfer may be hazardous because an airway has not been secured, or because an airway device used to secure a difficult airway may become displaced during transfer. Management of airway compromise 'in transit' is fraught with hazard as limitations of monitoring, patient access, equipment, assistance, personnel and environment all interact. NAP4 had cases reported where a child with an 'at-risk' airway developed complications during attempted intubation for transfer, where a child with an 'at-risk' airway was transferred (successfully) without securing the airway, where a secure airway was lost during intra-hospital transfer and where an airway was lost after retrieval had been completed. Transfer issues therefore arose in around one in three of the cases reported to NAP4: these events included one case of cardiac arrest and one death.

Training and staffing

Consultants were involved in the initial care of 11 of the 13 paediatric cases reported to NAP4 and, if not already present, attended all events soon after they started. Frequently when additional help was requested another consultant or consultants were available to help manage the difficulties.

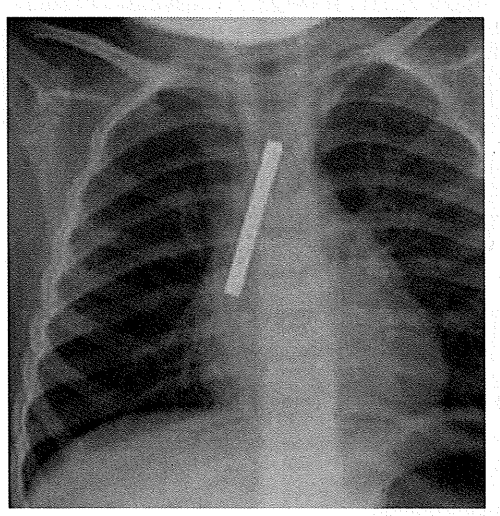
In one case oesophageal intubation occurred in emergency department and there was evidence the intubator, who was a trainee paediatrician, although using clinical signs to determine that intubation had been achieved correctly, did not correctly interpret the capnograph that was in use. There were several instances where multiple attempts at intubation either risked or caused airway trauma.

Numerical analysis

Thirteen paediatric reports met the criteria for submission to NAP4. The two events occurring outside theatres involved infants both of whom had congenital abnormalities.

In three cases the outcome was death. This included the one patient in ICU, one in the emergency department and one in the theatre recovery area. Two of the children who died had severe co-morbidity.

The 11 events that occurred in theatres, involved three infants and four were aged 1–4 years. Males and females were equally represented. Eight of the 11 were ASA 1–2, one was obese. Four had congenital or acquired abnormalities. Four had airway assessment performed and two had a predicted difficult airway. Anaesthesia was administered by a consultant from the start in ten cases. Anaesthetic induction was gaseous in six cases and intravenous in five. Five events occurred at the induction of anaesthesia, two during maintenance, three at emergence and one in the recovery area. The primary airway device used during anaesthesia was a tracheal tube in eight, laryngeal mask in one and rigid bronchoscope in two. Monitoring was used for all cases: with capnography used for eight inductions. Primary airway problems were: failed intubation two, blocked airway three, airway trauma one, aspiration of gastric contents one, tube displacement one, problem at extubation three.



Nine children had a moderate level of harm, one no harm and three death. Overall airway care was rated good in two, mixed in five, poor in four and not commented on in two.

Discussion

It is anticipated that overall there has been an under-reporting of cases to NAP4 and this is likely to apply equally to children. However the varied nature of the cases reported gives us confidence that the main issues related to the care of children with acute difficulties in airway management have been included. The project has identified a small number of cases of poor outcome including permanent morbidity and mortality associated with the airway management of children.

Whilst it is unusual to have unanticipated airway difficulties in children the anxiety created by these cases is extreme. The incidence of difficulties with tracheal intubation in children is very low, and this project confirms that many difficult paediatric airways or difficult intubations are associated with recognised syndromal abnormalities.

Difficult intubation

Management of predicted difficult intubation in small dysmorphic children requires considerable skill and experience. When emergency intubation is required in such children the difficulty may be exacerbated. Options available in adult practice may be impractical or unavailable. Cases require very high levels of teamwork and communication. Case 2 highlights the precarious nature of the airway in babies with severe facial abnormalities, particularly micrognathia. When a difficult airway has been rescued it is vital that the airway is protected and the precarious nature of it might usefully be communicated to all those involved in the patient's care. Two deaths occurred outside the theatre setting: it has been noted in the review of adult cases that equipment in the emergency department and ICU often falls short of that in theatres. There was no evidence that this contributed in the cases described but the issue of availability of difficult airway management equipment is equally pertinent to paediatric practice.

While the techniques available for difficult intubation are more limited in paediatric practice, repeatedly using a technique which has already failed has little logic. Alternative techniques should be considered and with the recent development of more advanced paediatric SADs these may find an increased role in paediatric airway management in the future. Use of a SAD for airway rescue in children was seen only in one case in NAP4.

The importance of maintaining a wide range of small tubes (especially smaller than expected) is illustrated by several of the reported cases. On a related topic, one case was reported during an anaesthetic for a radiological investigation in an infant: after intubation the small tracheal tube obstructed, due to excessive secretions, leading to hypoxia and brief cardiac arrest. Paediatric airways are small and the inserted tubes make them smaller, which can create problems rarely seen in adult practice. While this finding is well known, these cases serve as a reminder.

Emergency surgical airway

It must be acknowledged that paediatric ENT support may not now be available in all hospitals where children are anaesthetised. In the NAP4 cohort four children had an emergency surgical airway and in a further case this was planned. The cases described above reflect the benefit of having access to emergency ENT expertise. The use of direct transtracheal techniques are controversial in young children due mainly to technical difficulties.[12] Formal surgical tracheostomy is used in most cases and cricothyroidotomy, as a rescue technique, is very rarely employed in children. NAP4 has found a high rate of failure for needle cricothyroidotomy in adults (see Chapter 13) and it is likely the procedure in children will be even more demanding.

Events at the end of surgery and in recovery (blood in or around the airway)

Suction clearance of the airway before extubation should be performed routinely. When there is, or has been, blood in the airway during surgery it is essential that the airway is also inspected to ensure it is clear before extubation. Whether this is done by the surgeon, the anaesthetist or both is a matter for discussion, the important lesson is it must be done thoroughly for all such patients.

There are recognised alternative methods for protecting the airway from soiling at extubation and these include delaying extubation until the child is completely awake (on the basis that airway reflexes will have fully recovered), or using a laryngeal mask either after deep extubation or as a alternative to a tracheal tube throughout surgery. These latter techniques are likely used less in children than adults and remain controversial.

The cases also remind us that the anaesthetist's responsibility does not end when the patient is extubated or transferred to recovery.

Airway interventions including re-intubation may be needed after extubation or in recovery, and the relevant equipment, personnel and expert assistance should remain available until the need for them has clearly passed. In this regard keeping the child's tracheal tube (or an equivalent) until they are awake, as well as ensuring immediate availability of facemask and intubation equipment, both in theatre and recovery remain good practices.

CHAPTER 21
Children

Airway obstruction

Case 5 illustrates a case of complete airway obstruction. When, as in this case, ventilation is not possible despite clearing the upper airway the management is difficult. In NAP4 (in adults) diagnoses of bronchospasm and anaphylaxis were more likely to be considered than tracheal tube blockage or displacement. Use of capnography, irrespective of the location of the event, may provide valuable diagnostic information. In such circumstances, particularly where blood or secretions may possibly obstruct the airway device or distal trachea, active efforts to diagnose mechanical problems include passage of a 'bronchial sucker' and suction, fibreoptic inspection, tracheal tube removal and rigid bronchoscopy. These have the potential to be life-saving.

These cases are undoubtedly very difficult to diagnose and manage promptly. Prior anticipation, management aimed at avoidance, use of appropriate monitoring to detect an event and equipment to manage it are perhaps the first steps.

Aspiration of gastro-oesophageal contents

The cases of aspiration, with others in this report (see Chapter 19) remind us that aspiration is a significant cause of airway morbidity, that trauma surgery is likely a risk factor and that a standard laryngeal mask cannot be relied on to protect the airway. Aspiration is not necessarily an unusual event in paediatric patients but previous work suggests children are much less likely than adults to have significant harm from this complication.[11]

Cardiovascular complications of paediatric airway events

It is well recognised that hypoxia in children may lead to bradycardia and cardiac arrest. In NAP4 in addition to the three deaths, four other events were complicated by bradycardia, three of which progressed to brief cardiac arrest requiring CPR. The need for those managing paediatric airways to be fully competent at paediatric advanced life support is re-emphasised.

Monitoring

In the recovery area monitoring should be such of such a level that airway events are detected as promptly as possible: this requires continuous oximetry and the one-to-one presence of a trained recovery nurse. Use of blood pressure monitoring and availability of ECG and capnography in recovery are areas where standards may fall short of those practised in adults. One child arrived in the recovery room 'obviously cyanosed': though other details were limited this suggested the patient was not monitored during transfer to the recovery area and the reality is that few patients are. Some would argue that formal monitoring should take place during transfer from theatre to the recovery area: this is a subject that remains controversial and for which this project has not identified a clear answer for either adults or children.

Transfers

Transfers are necessary and inevitable both within and between hospitals. All pose a risk to the airway and this is exacerbated where there is airway difficulty. Planning, communication and good management of the airway before transfer are essential. Senior involvement is required. The risks of transfers do not cease on arrival at the destination hospital.

Training and staffing

The high consultant involvement in these cases provides encouraging evidence of senior involvement and supportive team working. Whilst this is beneficial for patients it may also explain the difficulties trainees have in gaining experience in managing or observing such rare events. In only three anaesthesia cases was a trainee involved at the start of the case. In two cases an event was managed largely by a trainee, in one sub-optimally.

As a whole these cases reinforce the already known message that high quality paediatric airway management requires knowledge and practical skills but it also requires skills such as preparedness, planning, communication,

situation awareness and knowledge of when to stop or change plans. In many cases the clinicians involved in these cases showed evidence that all these skills were in use: however this was not universal.

Learning points and recommendations

Recommendation: Major airway difficulties in children are rare and many are predictable. However there is still a small incidence of unexpected difficulties with airway management and systems must be in place to deal with this.

Recommendation: Formal assessment of the airway was uncommon in this group of patients. The identification and validation of useful airway assessment tests in children would be beneficial.

Recommendation: Some children with congenital abnormalities are extremely difficult to manage and it was not possible to intubate their trachea despite the expertise of the staff. Alternative solutions may need to be actively sought. In a sub-group of these children the airway can only be adequately managed by tracheostomy.

Recommendation: Full monitoring at intubation is essential in paediatric patients. The observation of satisfactory chest expansion, auscultation and observation of the tracheal tube passing the cords, whilst useful clinical signs, must be supplemented with the correct use and interpretation of capnography whenever an artificial airway device is inserted. This applies outside the operating theatre as well as in it.

Recommendation: All staff managing the paediatric airway, in whatever clinical area, require training in practical airway skills and in the use of relevant equipment including capnography and other monitoring.

Recommendation: Theatres, ICU and emergency department areas where children are cared for should have advanced airway equipment rapidly available to manage airway difficulty in children. There should be a clear chain of responsibility so that anaesthetic input is requested early if any child is anticipated to have an airway that is difficult to manage.

Recommendation: All those performing advanced airway management for children should be competent in managing cardiac arrest in children.

Recommendation: During airway difficulty, especially in young children, there should be consideration of involving ENT specialists early.

Recommendation: Senior help must be asked for early if difficulties with management of a child's airway are identified.

Recommendation: Good practice guidelines should be available for management of children in post-anaesthetic recovery areas.

Recommendation: Transfers both within and between hospitals should be recognised as periods of increased risk for airway dislodgement and complications. Planning, equipment and staffing should be appropriate to manage such complications.

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