



Can we make airway management (even) safer? – lessons from national audit

N. Woodall,¹ C. Frerk² and T. M. Cook³

1 Consultant Anaesthetist, Norfolk & Norwich University NHS Foundation Trust, Norwich, UK

2 Consultant Anaesthetist, Northampton General Hospital, Northampton, UK

3 Consultant in Anaesthesia and Intensive Care Medicine, Royal United Hospital, Bath, UK

Summary

The Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society (NAP4) has published an extensive report examining both current practices in the United Kingdom regarding airway management during anaesthesia and the complications of airway management during anaesthesia and in intensive care units and emergency departments. The report makes more than 160 recommendations designed to improve care of patients. These recommendations have implications for individuals, departments, organisations and potentially for national policy in terms of training, standards of practice and the need for guidelines. The report also indicates several specific areas where future research might be directed. This article focuses on the implementation phase of NAP4, emphasising the importance of taking the lessons derived from NAP4 and turning them into actions to improve the safety of airway care delivered to patients, wherever in hospital this takes place.

Correspondence to: Dr N. Woodall

Email: woodall@neat-course.org.uk

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Deaths and significant morbidity result from airway complications during anaesthesia. Most factors which contribute to these complications are well described and many are avoidable. The findings of studies in the UK, USA and elsewhere have led to the introduction of recommendations and guidelines, and to changes in clinical practice with documented improvement in patient safety [1–3]. The Fourth National Audit Project (NAP4) of the Royal College of Anaesthetists and the Difficult Airway Society (DAS) investigated airway complications over a 1-year period. Airway problems occurring during anaesthesia and in intensive care units (ICUs) and emergency departments (EDs) were studied. An airway problem resulting in death, brain damage, the need for an emergency surgical airway, ICU admission or prolongation of ICU stay were the inclusion criteria [4–6]. The analysis of cases submitted to NAP4 provides quantitative and qualitative information on current UK airway management practices. Throughout the UK in one year (2008–2009) 16

airway-related deaths were reported during approximately 2.9 million general anaesthetics, giving a point estimate of 5.6 deaths per million, or one per 180 000 general anaesthetics [4,7]. Most airway events, although being life-threatening, produced morbidity rather than mortality. In total, 133 qualifying events were reported, giving a point estimate for major complications of 46.3 per million or one in 22 000 general anaesthetics. It is highly unlikely that all qualifying events were reported and for reasons described in the report the real figure may be up to four times higher [4, 5]. These figures suggest that currently, most anaesthetists can expect to be involved in a number of these events within their working life. Airway management and intervention outside the operating room are more hazardous than during anaesthesia: overall there were 46 reports of death or brain damage amongst 184 reports, of which 19 were associated with anaesthesia care, 22 with ICU care and five with ED care. Using numerators from NAP4 and denominators from a variety of sources [7–9]

it can be estimated that, compared to anaesthesia, airway events leading to death or brain damage are approximately 30-fold and 60-fold more frequent in the ED and ICU, respectively.

We should be proud that airway management during anaesthesia in the UK is very safe but there is still important work to do in this respect. During the NAP4 case review process, qualitative analysis identified elements of poor airway management in over 75% of reports; this figure rose to 80% in reports of patients who died, suggesting that there is potential for improvement with opportunities to prevent some adverse events, leading to reductions in morbidity and mortality. The output of the NAP4 project [4–6] teaches us some new lessons but perhaps more importantly, shows us that we have not yet learned how to translate findings from previous reports into improved safety for patients. This article attempts to address both these issues.

Major findings and recommendations of NAP4

The NAP4 report runs to 216 pages, containing 24 chapters, with over 160 recommendations [5]. It is possible some anaesthetists will feel overwhelmed by such a document particularly as airway management is only one component of the provision of anaesthesia or care delivery in ICU or ED. For this reason it is important first to review the major findings of the report before suggesting the means by which the recommendations should be implemented.

Capnography

Capnography is used to confirm ventilation of the lungs; in the presence of pulmonary blood flow the absence of exhaled carbon dioxide indicates absence of pulmonary ventilation which may be due to airway obstruction, tracheal tube misplacement or displacement, or ventilation failure due to central respiratory depression or equipment failure. In some reports from ICU and the ED, oesophageal intubation was not recognised because capnography had not been used. In several cases of cardiac arrest with ongoing cardiopulmonary resuscitation (which will create pulmonary blood flow) the absence of detectable carbon dioxide during ventilation was misinterpreted as being due to the cardiac arrest, rather than due to oesophageal intubation or tracheal tube obstruction. These reports included some from the operating theatres. This led to ineffective attempts at resuscitation in the presence of persistent hypoxia, resulting in permanent morbidity or

death. In the ICU setting, failure to use capnography was implicated in 17 (82%) of events leading to death or brain damage. The use of capnography should be extended to include its routine use in the ICU and ED, and its ready availability in the recovery room to facilitate the early detection of non-ventilation of the lungs. In combination with training in interpretation of capnography for all users, this would be likely to produce the greatest improvement in patient safety to derive from NAP4.

Aspiration of gastric contents

Aspiration was the most common cause of death associated with airway management during anaesthesia. It accounted for 17% of primary anaesthetic airway problems and 50% of anaesthesia deaths. Poor planning was a major factor in many cases, including both failure to assess aspiration risk and failure to use accepted precautions such as tracheal intubation or rapid sequence induction in patients with intestinal obstruction.

Upper airway disease

Upper airway malignancy or disease processes of the head and neck were a feature of 40% of all anaesthesia cases reported to NAP4. Upper airway obstruction was common, some patients presenting in extremis to non-specialist anaesthetists on-call, others being managed by anaesthetists as part of regular head and neck surgery teams. Opportunities for pre-operative airway assessment with scans were not taken in some planned cases, meaning the severity of pathology was underestimated. In urgent cases the only assessment option (nasendoscopy) was also underutilised. In both groups, planning for the possibility of failure of airway management was rarely considered and the option of securing the airway under local anaesthesia by tracheostomy (or fiberoptic intubation) was often not used. Emergency surgical airway failed commonly in this group.

Obesity

Patients with a body mass index (BMI) $> 30 \text{ kg.m}^{-2}$ were at least twice as likely to suffer serious complications of airway management as those with a BMI $\leq 30 \text{ kg.m}^{-2}$. A BMI $> 40 \text{ kg.m}^{-2}$ increased the risk fourfold. Airway assessment was often poor and awake fiberoptic intubation was rarely considered as an option, even in some extreme cases; this tendency was also well documented elsewhere in the report. Inappropriate selection of anaesthetic technique was common, including use of (first generation) supraglottic airway devices where a tracheal tube would have been more

appropriate and selection of a spontaneously breathing anaesthetic technique unsuited to the patient's body habitus, particularly in compromising positions for surgery. Loco-regional anaesthesia was not used in some cases for which it would have been entirely suitable.

Failure to plan or 'strategise'

An airway strategy is a predetermined set of sequential plans designed to manage failure of previous attempts at airway management and ultimately achieve oxygenation, ventilation and protection against aspiration. A common feature of reports was an apparent failure to anticipate and plan for problems. In a quarter of all reports, no airway assessment was recorded and when problems occurred, there was no rescue plan or the plan failed, either because essential equipment was unavailable or on occasion because the anaesthetist did not have the requisite skills or training to use rescue equipment provided. Reports from the ICU and ED similarly demonstrated failure to identify and plan for high-risk patients, late detection of problems, poor provision of equipment, complex problems managed by trainees lacking the appropriate airway skills, poorly structured crisis management and a lack of assistance for the anaesthetist or other clinicians performing airway management. As an example, NAP4 received reports of unavailability of cricothyroidotomy equipment during failed airway management. Poor preparation extended to the process of extubation, where despite its being an elective process, planning and anticipation of problems were also found to be poor and essential equipment was missing when needed in some cases.

New report, same old findings?

Perhaps the most significant finding of NAP4 relates to the lack of use of capnography, notably in the settings of the ICU, ED and recovery room. Anaesthetists are well aware of the significance of capnography and have used this monitor to drive down the peri-operative mortality from the many clinical problems that lead to failure to ventilate the lungs [10]. Routine use of capnography for all patients dependent on an artificial airway *in any location* is now an imperative. This has been previously recommended by the Association of Anaesthetists of Great Britain and Ireland [11] but appears to have been poorly implemented.

Historically, aspiration is a common complication of anaesthesia and this remains the commonest cause of death associated with airway problems during anaesthesia [12]. Despite prevention of aspiration being at the

core of anaesthetic practice, reports submitted to NAP4 indicated that assessment of aspiration risk was poor and routine precautions in those at risk were not deployed.

Management of the obstructed airway is a significant clinical challenge and was previously reviewed in detail by the National Confidential Enquiry into Peri-Operative Deaths who published their findings in 1998 [13]. They suggested that there was a need for senior input, local protocols, thorough pre-operative evaluation, and consideration of tracheostomy under local anaesthesia. Many of their recommendations about managing this testing group of patients are repeated in the NAP4 report.

The lungs of obese patients are known to be difficult to ventilate by facemask and their tracheas may be more difficult to intubate [14, 15]. Yet, poor assessment and planning of airway management were noted in this group. Unsuitable techniques (such a first generation SAD in morbidly obese patients undergoing emergency surgery who also had other risk factors for aspiration) were selected and awake fiberoptic intubation was not used where indicated. These findings echo the analysis of the American Society of Anesthesiologists Closed Claims Project and the Australian Incident Monitoring studies [16, 17]. These earlier reports showed that even when faced with predictable problems, anaesthetists failed to alter behaviour, favouring repeated attempts at direct laryngoscopy and tracheal intubation, despite knowledge that this strategy is rarely successful [18]. These findings too are repeated in the NAP4 report.

Thus, in many ways NAP4 reiterates the findings of several other reports. One novel finding is that in the UK, emergency cricothyroidotomy performed by anaesthetists is associated with low (36%) levels of success. The reasons for failure included problems with technique, with training, and with the equipment used. Because this is a core skill for the management of, the 'cannot ventilate, cannot intubate' situation this finding is a serious cause for concern. The Fourth National Audit Project also highlights the failure of correct interpretation of capnography, including the apparent widespread misconception that an absence of detectable exhaled carbon dioxide may be attributed to cardiac arrest [19].

How do we improve the care we provide?

The NAP4 report provides evidence that we have failed to learn or apply lessons from previous reports and past experience. The fact that so many of the lessons of the past do not translate into improvements in care is not a

new finding. In 2000 the Department of Health published a report entitled '*An Organisation with a Memory*' which encouraged that where lessons are identified the necessary changes should be put into practice [20]. In 2001 the National Patient Safety Agency (NPSA) was created and a further report '*Building a Safer NHS for Patients*' [21] highlighted the difficulty in translating lessons learned into the provision of better care. Experience within and outside the National Health Service clearly demonstrates that reports alone are unlikely to bring about sustainable change. Thus, in individual or organisational practice, implementing and sustaining change requires ongoing education, learning and performance assessment at local and national levels. The collection and analysis of data, as performed in NAP4, is perhaps the easy part. Knowledge and understanding of the issues is not enough and to create improvement we need to study the recommendations and introduce changes to the way we work.

Is the NAP4 report sufficiently robust to justify changes to the way we work?

Despite its 'authoritative status', NAP4 is based only on a large series of case reports and as such is lowly rated on a grading system of evidence-based medicine (level 4) [22]. However, it is now acknowledged that sources of evidence like national enquiries and databases are as strong for some clinical questions as are randomised controlled trials [23]. The Fourth National Audit Project probably represents the largest ever UK study of complications of anaesthesia and its findings reflect current practice across the breadth of the UK; both the project design and data collection were meticulous as was the review process, conducted by a broad pool of clinical anaesthetists and others. This minimised issues such as hindsight and outcome bias and 'group-thinking' [5, 24–26]. Similar methods have been applied in other safety-conscious industries as well as in medicine to identify and correct deficiencies of care [13, 27]. The numerical data obtained by NAP4 are the most accurate we are likely to get in the foreseeable future. The project itself also identified areas where future investigation and clinical trials might inform the profession and these aspects of the report should not be overlooked.

How can the NAP4 report influence patient care?

Serious adverse events are rarely the consequence of an individual's performance. More often they are the end

result of the interaction of numerous factors including systems, organisation, equipment and workspace design. Opportunities to make patient care safer therefore exist at many levels, from the individual anaesthetist's behaviour through to the policies and support infrastructure offered by departments, trusts and national organisations such as specialist societies, royal colleges and the Department of Health itself. These national organisations ultimately have the greatest ability to influence our behaviour and help ensure that the recommendations are incorporated and integrated into the way we work.

To effect improvement, the necessary changes need to be clearly defined at all levels of the organisation. The outlines below, though not exhaustive, give an indication of how NAP4's recommendations and responsibilities might be presented. There is considerable overlap in the responsibilities and some are relevant at multiple levels throughout the healthcare system.

Individual response

All anaesthetists should familiarise themselves with the learning points and recommendations of the NAP4 report and incorporate its advice into their practice. Many of the recommendations relate directly to clinical presentations and practical skills. College tutors and educational supervisors should use many of NAP4's recommendations as the basis for specific teaching in this field.

Departmental response

A major responsibility for the application of recommendations lies at this level; collectively anaesthetists should exert pressure to resolve departmental and Trust level issue.

Guidelines, standards, checklists and charts

There were a number of recommendations in this category designed to address deficiencies. Specifically, NAP4 recommends departmental guidelines for pre-operative airway assessment including aspiration risk, the management of unexpected difficulty with tracheal intubation, extubation and accidental tracheostomy or tracheal tube displacement in ICU. Where national or specialist society guidelines exist such as those of the DAS [28] or the Intensive Care Society (ICS), these may be adopted or modified for local needs. In some cases care might be positively influenced by changes to the anaesthetic record or by the provision of checklists. For example, a tick-box on the pre-anaesthetic record might indicate plan A, B then C for oxygenation after

induction of anaesthesia. This would require assessment of the airway and generation of a strategy. Inability to produce such a strategy then clearly identifies a problem.

Equipment

The content of local difficult airway trolleys should be agreed and must be compatible with guidelines. The contents of difficult airway trolleys should be the same throughout the hospital including those used in the ICU and ED. The Fourth National Audit Project can act as a driver to obtain equipment where it is needed. For example, NAP4 indicated that fiberoptic laryngoscopes are sometimes not available to anaesthetists and in ICU during management of anticipated and unanticipated problems; this is no longer acceptable. Other regularly used items were also identified as necessary but unavailable in reported cases; these included second generation supraglottic airway devices, Aintree catheters and in ICU, variable-flange and long tracheostomy tubes.

Organisation, training and audit

The Fourth National Audit Project recommends that where awake fiberoptic intubation is needed it should always be available. Thus, there should be regular and appropriate training of new staff of all grades, local guidelines and an infrastructure for audit. A system should be in place to enable anaesthetists lacking this skill to obtain help, whenever needed. Investigation of airway-related critical incidents, complications and deaths is required to evaluate the effectiveness of the local response.

Airway lead

An important recommendation of NAP4 is the appointment of an 'airway lead' anaesthetist in each trust, to show leadership in airway management issues and to coordinate the activities referred to above. This task represents a significant time commitment for the development of guidelines, selection of equipment and the provision of training; this will require funding by the hospital.

Trust level response

Capnography

A key recommendation of the report was to make the use of capnography in ICU mandatory for all ventilator-dependent patients and to ensure its availability in post-anaesthesia recovery areas. Since the NAP4 report, the President of the Royal College of Anaesthetists has written to all UK NHS hospital trusts

reinforcing this message. A recent editorial in *Anaesthesia* further endorses this recommendation [9]. The ICS has added this recommendation to its standards for capnography [29]. The European Board of Anaesthesiology has gone further, by approving a recommendation that all patients with intubated tracheas should be monitored with continuous capnography, be they in operating theatres, ICUs or EDs, or outside hospital [30]. Expansion of the availability of capnography has financial implications for some trusts which will need to invest in additional equipment, pay maintenance costs and fund staff training. A rapid response report on this topic is currently in preparation by the NPSA (personal communication, Joan Russell, NPSA).

Organisation

Organisational changes are required to identify patients at risk of airway problems: the obese; patients with airway obstruction; and those with known airway problems. These groups featured repeatedly in the report. Safe pathways need to be developed to ensure appropriate pre-operative evaluation and preparation for anaesthesia. These patients require a detailed airway assessment before anaesthesia as several management options may be available. They must be identified early in their treatment if delays, cancellations and increased risk are to be avoided. Pre-operative assessment leads are vital champions for the safety of patients in this regard. Such patients also present to ICU and the ED and require similar institutional preparedness.

Equipment

If not already in place, a medical devices management committee should be established to set, monitor and control policies and procedures for trust-wide medical devices and their purchase. Anaesthesia departments should maintain representation on this committee, ensuring that the selection of airway equipment is made in conjunction with ICUs and EDs to unify the approach to emergency airway management across a trust.

Communications

Links to other specialties such as the ICU, the ED and relevant surgical departments need to be open to apply the lessons of NAP4. Such links must include nursing staff in ICU and recovery units. Of great importance is good communication with the clinical director through to the trust board as all need to be aware of the risks and the organisational changes required to manage them.

Training and learning

Multidisciplinary simulation-based training is recommended, in part to embed the application of guidelines. Human factors training should also be incorporated including the development of briefing before and debriefing after events. Balancing the needs of organisational learning from adverse events against the demands of ongoing service provision is a difficult challenge for trusts. Governance leads could usefully explore this balance with non-clinical managers and risk departments.

National response

The Fourth National Audit Project made several recommendations requiring a national response and these were subsequently endorsed by two editorials [31, 32]. Specialist societies such as DAS and the ICS should continue to provide leadership, support further research and develop additional guidelines. The latter would reduce the requirement for departments to develop individual guidelines covering the situations recommended in the NAP4 report. Several additional guidelines relevant to these areas are already under development.

The selection, procurement and provision of training in the use of equipment for routine and emergency airway management would be greatly enhanced if national bodies representing anaesthetists, intensivists, emergency physicians and ear-nose-and-throat surgeons were able to agree to minimum sets of core skills and equipment that all clinicians should be trained to use. The Airway Devices Evaluation Project Team (ADEPT) programme initiated by DAS and aided by the British Association of Respiratory Manufacturers (BAREMA) will, one hopes, assist that process [33]. Identification of the equipment and training needed would greatly simplify induction programmes and safety as staff move between hospitals. Individual units could adapt such guidelines and provide additional training appropriate to local requirements.

With appropriate engagement, liaison at the highest level between medical and nursing colleges could ensure training of nursing staff (particularly recovery and ICU staff) in aspects of airway management with a defined and accepted skill-set and competencies.

Additional research is needed into provision of training in emergency oxygenation techniques for anaesthetists. Other topics suggested for research include the development of tracheostomy tubes that are more suitable for obese patients and determining optimal airway fixation techniques in ICU.

Conclusions

There were many factors that came together to inspire the development of NAP4 but one of the most potent was the response of the anaesthetic community to the report on Elaine Bromiley's death in 2005, from airway complications during elective anaesthesia [34]. Her husband Martin wrote in the foreword to the NAP4 report "Give us the tools that make it easy to get it right, give us the processes that give safety a better chance, and give us the training so that we can use these and behave in a way to make a quantum leap in safe practice". In response it must be the goal of anaesthetists to reduce airway-related deaths to zero and to do this we should follow this advice and look to make changes that will make it easier for us to get it right and to ensure safety-conscious behaviour. He finishes by saying "NAP4 gives us good data on the scale and nature of the problem, narrative evidence such as Elaine's and Gordon's [deaths] makes it real [but] making this new type of anaesthetist the rule not the exception is up to you" [35].

Competing interests

NW and TMC led the NAP4 project and all three authors edited the final project report. TMC has been paid by Intavent Orthofix and the LMA Company for lecturing. His department has received free or at cost equipment of research. He has no other financial arrangements with any such companies. No external funding or competing interest declared.

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