Anaesthesia
Journal of the Association of Anaesthetists of Great Britain and Ireland

Anaesthesia, 2011, **66**, pages 331–340

Editorial

A rude awakening after our fourth 'NAP': lessons for airway management

The latest National Audit Project, NAP4, is the fourth in a series overseen by the Royal College of Anaesthetists (RCoA) since 2005 [1, 2]. NAP4 was initiated jointly by the Difficult Airway Society (DAS) and the RCoA, and it constitutes a key event in the evolution of our understanding of airway management. The data generated represent the best estimates we are likely to get, using current methodologies, of the incidence and impact of airway-related mortality and morbidity. While much has been learned regarding the impact of airway misadventures from analyses of closed medicolegal cases [3, 4] and from critical incident reports [5, 6] these retrospective studies by their nature give a picture that is less than complete. NAP4 provides prospective details of the factors that contributed to major adverse events whilst also offering – perhaps for the first time – the all-important 'denominator' statistic, the number of general anaesthetics that yield the complications. The findings make compelling reading and should constitute a clarion call to our discipline.

Background and summary of NAP4 data

Some background detail is required to understand the importance of NAP4's findings. It represents an almost Herculean task of data collection and analysis, with a number of endpoints of interest: death; permanent disability such as brain damage; an unplanned surgical airway; or an unanticipated admission to the intensive care unit (ICU) (all defined as 'severe complications'), arising from difficulties in airway management across all 309 NHS hospitals in the UK over the one-year period from 1 September 2008 to 31 August 2009. Local reporters at each hospital recorded the relevant data and in a smaller subset of hospitals, also provided details of complications arising in the emergency department or ICU (where prolongation of ICU stay was also termed a 'severe complication'). A census of all clinical activity over one 'snapshot' month was carried out to estimate the number of patients who underwent anaesthesia during the audit period to yield the 'denominator' and permit calculation of incidence figures.

Overall, there were 194 reports that qualified as serious, of which 133 related to general anaesthesia. This equated to 46 events per million general anaesthetics or 1: 22 000. There were 16 deaths and three episodes of persistent brain damage, resulting in an airway-related mortality rate of 1:180 000. Perhaps surprisingly, aspiration of gastric contents (rather than cerebral hypoxia per se) was the major cause of airway-related mortality and morbidity in these patients.

Summary of adverse events in theatre

Somewhat reassuringly, only a minority of events in theatre occurred outside daylight hours, there was evidence that a senior clinician (i.e. a consultant) was present in the majority of cases, and many cases were managed by several senior anaesthetists working together. Help was generally sought early and nearly always arrived promptly (although there were unexplained delays in a small minority of cases).

In relation to airway-related events occurring during anaesthesia, it is striking that in the majority of cases, airway difficulty was not anticipated. However, in order to 'anticipate' something, one needs first to be aware of its possibility, so it is striking (and disappointing) that a formal airway assessment was recorded in only 35 of the 133 cases (26%). But when performed, difficulty was anticipated, quite correctly, in the majority (i.e, in 25 of these 35 cases). This suggests that airway examination is worthwhile. Doubts about the utility of routine airway assessment assessments such as Mallampati score and thyromental distance [7] may have led to some practitioners erroneously abandoning pre-operative clinical examination of the airway. Or perhaps anaesthetists generally only record the results of adverse, as opposed to routine, findings. We return to this point later in this editorial.

Thirty-eight (29%) of the 133 events occurred at the end of anaesthesia or during the recovery period, with airway obstruction the major problem. Nearly 50% of these events followed surgery within the airway, with evidence of poor anticipation and planning for management of extubation. Other subgroups highlighted included children and pregnant women but reassuringly, outcome was generally better in these groups.

Summary of adverse events in the ICU and emergency department

The data for patients who suffered serious adverse events in the ICU or emergency department (> 25% of the total) also give significant cause for concern [1, 2]. The doctors performing airway management were more junior with more limited experience, whether they were anaesthetists or not. In contrast to the operating theatres, most of these events

occurred out of hours, and there was a much poorer outcome: for example, ICU accounted for just 20% of all notified events but almost 50% of deaths, and > 60% of ICU events led to death or brain damage compared with just 14% in reports from operating theatres. Hypoxia was the predominant cause of death.

While it is likely that these findings reflect, in part, the fact that patients in the emergency department and ICU are inherently more sick than those undergoing anaesthesia, there are important lessons to be learned. The rescue techniques used in the ICU and emergency department all had high failure rates. Problems with equipment, including unavailability and unfamiliarity, were recurring features. A specific issue was the role of displacement of tracheostomies, which caused 50% of all events in ICU. The majority of events in emergency departments concerned difficult or failed tracheal intubation. Unrecognised failed tracheal (i.e. oesophageal) intubation was a significant factor. Capnography was often not used or was misinterpreted, and was a contributory factor in 73% of deaths or neurological injury.

Waking up after NAP: the lessons

What can be learned from these data? Superficially, it would seem an adverse airway event is uncommon (1: 22 000 general anaesthetics). However, NAP4's authors suggest that only ~25% of the adverse cases were captured, indicating a 'truer' incidence of perhaps 1: 5500. Furthermore, they commented that the data followed a Poisson distribution, so an incidence of up to ~1:1375 could arise 5% of the time [8]. These 'adjusted' incidences are much less reassuring than the original point-estimates since they place the reasonable expectation of a serious adverse event well within the career experience of many anaesthetists. Indeed, 'near-misses', such as failed intubation or severe hypoxic episodes due to difficult airway management that do not lead to actual harm, are likely to be considerably more common than 1:5500 and therefore experienced on a possibly 'regular' basis. Thus NAP4's data underline the fact that vigilance in airway management remains essential.

Another reason why the point-estimate for occurrence of adverse events of 1:22 000 is far from reassuring is that it includes cases that were realistically never likely to come to any harm at all, even with the poorest form of airway management. By analogy, if we crossed several roads with our eyes shut, it would be misleading in our assessment of the overall risk to include data from the many small country tracks that never see a car. It is data from busy roads that should be the most relevant. We learn little from the cars that do not crash into pedestrians; we need to focus on the factors common to the accidents.

In this regard, a number of common themes were identified within the patient group that suffered harm: the real insights that should drive improvements in clinical practice and stimulate research are to be found in these more detailed analyses of the adverse events. First, patients requiring tracheal intubation were disproportionately represented in the adverse incidents. This does not mean that intubation is itself harmful, but more likely that clinical situations in which intubation is deemed necessary (whether for surgical or anaesthetic reasons) all warrant a greater degree of concern. Second (and perhaps consistent with the first), obese patients were twice as frequently represented in the population that suffered incidents than in the group that did not. If it has hitherto not been the case, obesity must now be regarded as a significant material risk in airway management [9, 10]. Third, surgery involving the head and neck appeared more prevalent in the group suffering complications; again, greater care is needed when faced with a patient presenting for this type of surgery. In summary, an obese patient requiring tracheal intubation for head and neck surgery, with signs that might predict potential difficult airway management and perhaps additional co-morbidities, presents significant risk (akin to a 'very busy road' that should require greater care to cross).

Common themes were also identified in relation to clinical practice. Central to NAP4's conclusions was the finding by its review group that aspects of airway management were frequently suboptimal or poor in 75% of anaesthesia events and in > 80% of deaths. In the emergency department and ICU, only 11% and 13% of cases, respectively, were completely well managed. Reviewers noted a failure of healthcare providers to anticipate and plan for airway management difficulties, and failure to follow recommended practice for airway rescue in case of difficulty. The human factors most frequently identified as aggravating were poor communication or teamwork, poor leadership and task fixation. Clearly, better planning, better knowledge and/or judgement and better communication may have mitigated or even prevented some adverse events. The reviewers did not specify what was 'good' management but we presume it involves the following components: recognising potential difficulties and recording these on the anaesthetic chart [11, 12]; specifying a management plan that includes sequential Plans A, B, C, D [13]; ensuring that the correct equipment is available, and in good working order to execute these plans; ensuring that where possible, there is appropriate assistance and back-up; and finally, communicating to all in the surgical-anaesthetic team that these potential difficulties are expected [14–16].

Although there are relatively few comments in NAP4 on specific equipment, it is notable that while capnography was universally used in the operating room, poor interpretation of the capnogram was identified as a contributing factor in three anaesthesia-related cases. The use of capnography in recovery might have led to earlier identification of complete airway obstruction in several cases [17].

The use of capnography in the ICU and emergency department was infrequent, and again compounded by errors of misinterpretation [18]. Use of needle cricothyroidotomy as a rescue technique suffered a 75% failure rate and although more successful, the better performance of emergency surgical airway may be confounded by the fact that most surgical airways were undertaken by surgeons. However, there is evidence from animal models that surgical access techniques performed by anaesthetists work well [19] and clearly more research is needed to define the respective roles of needle cricothyroidotomy and the surgical airway.

Developing strategy from these lessons: the role of DAS

Comprehensive as it is, NAP4 contains an important (albeit understandable) omission. While deficiencies in management of cases suffering an adverse event are well documented, poor management in cases with successful outcomes are not.

In a recent case reported by a Scottish procurator fiscal's court, there was a failure to identify a patient as having a difficult airway. This initial 'error' of judgement led to train of events culminating in a fatal outcome. Much can be learned from this analysis. Yet, this same 'error' had presumably been made six weeks previously when the patient had elsewhere undergone successful general anaesthesia and surgery but since no harm resulted, there was no review of the (possibly identical) initial judgement or subsequent interventions [20]. To refer to an analogy we have used earlier: if we cross a motorway once or even several times successfully with our eyes shut, it does not mean it is the proper way to cross a road.

It follows that the manner in which we – collectively as a specialty – manage *all* our cases is highly relevant, since it helps determine what happens in the few difficult cases. Yentis correctly argued that because of the inherent rarity of the condition, we are poor at predicting patients whose tracheas are difficult to intubate [7]. Logically therefore, a vigilant approach to all patients is necessary to manage well those few who turn out to be difficult. But we can be a little more precise: the aggregate positive predictive value from several trials is just ~0.25, meaning that for every four patients we judge to be potentially at risk based on clinical examination, only one is actually difficult [7]. However, anyone who concluded that this should be interpreted to mean that airway assessment is 'pointless' misunderstood his argument. In fact, the statistic highlighted by Yentis means we might regard the group identified as potentially difficult to intubate as having a 'disease'. Then, if some form of specialised rather than routine 'treatment' (i.e, airway management such as awake or sedated fibreoptic intubation, or videolaryngoscopy) were more successful than conventional 'treatment' (i.e, direct laryngoscopy), then our number needed to treat (NNT) for preventing 'harm' from failed intubation would be ~4. This is far better than published NNTs for many commonplace interventions (e.g. compression stockings for deep vein thrombosis have NNT of ~64 [21]; thrombolysis for acute myocardial infarction has an NNT of ~34 [22]). Because Yentis's analysis also indicated that we are extremely good at predicting when an airway is 'easy', it follows that (vigilance apart) we can restrict any specific specialist interventions to a reasonably manageable number of patients identified as 'difficult' without exposing unduly large numbers of 'easy' patients to unnecessary techniques.

In summary, NAP4 has given DAS a very clear sense of direction in coordinating the research efforts of the airway management community in the UK. Amongst the key questions now to be answered are: can we improve the predictive ability of tests for a difficult airway or difficult intubation? Can we develop evidence-based algorithms for airway management in those *predicted* to be difficult, in addition to those guidelines that exist for *unanticipated* difficult intubation? Which specific devices (e.g. videolaryngoscopes to replace standard Macintosh laryngoscopes) are most appropriate in these difficult settings? Should we adopt surgical approaches instead of needle cricothyroidotomy to manage failed intubation? Persuasive answers to these questions will require large, multicentre trials and in turn this will require a robust infrastructure within our subspecialty. This logic has led DAS formally to adopt a strategy of evolving into a dedicated national research network, bringing together the individual, small, research-active units across the country to work together as part of a more co-ordinated mission (Pandit JJ, Popat MT, Cook TM, et al. The Difficult Airway Society, 'ADEPT' strategy for airway-related equipment evaluation. Work in progress). In many ways NAP4, co-sponsored by DAS, represents the first fruits of that strategy. Our NAP is over; it is now time to wake up and act.

Competing interests

EO'S is President and JJP Scientific Officer of DAS. No other conflicts of interest or funding declared.

E. O'Sullivan
Consultant Anaesthetist,
St James's Hospital,
Dublin, Ireland
J. Laffey
Consultant Anaesthetist,
Galway University Hospitals,
Galway, Ireland
Professor of Anaesthesia,
National University of Ireland,
Galway, Ireland
J. J. Pandit
Consultant Anaesthetist,
Nuffield Department of Anaesthetics,
John Radcliffe Hospital,
Oxford, UK
Senior Lecturer,
Nuffield Division of Clinical Neuroscience
University of Oxford, Oxford, UK
Email: eosullivan2000@eircom.net

References

1 Royal College of Anaesthetists. *National Audit Projects*. http://www.rcoa.ac.uk/index.asp?PageID=1379 (accessed 19/03//2011).
2 Royal College of Anaesthetists. *4th National Audit Project: Major Complications of Airway Management in the UK*. London: RCoA, 2011.
3 Cook TM, Scott S, Mihai R. Litigation related to airway and respiratory complications of anaesthesia: an analysis of claims against the NHS in England 1995-2007. *Anaesthesia* 2010; **65**: 556–63.
4 Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005; **103**: 33–9.
5 Maclennan AI, Smith AF. An analysis of critical incidents relevant to pediatric anesthesia reported to the UK National Reporting and Learning System, 2006-2008. *Pediatric Anesthesia* 2010 Nov 3; doi: 10.1111/j.1460-9592.2010.03421.x.
6 Thomas AN, McGrath BA. Patient safety incidents associated with airway devices in critical care: a review of reports to the UK National Patient Safety Agency. *Anaesthesia* 2009; **64**: 358–65.
7 Yentis SM. Predicting difficult intubation – worthwhile exercise or pointless ritual? *Anaesthesia* 2002; **57**: 105–9.
8 Pandit JJ. Gambling with ethics? A statistical note on the Poisson (binomial) distribution. *Anaesthesia* 2008; **63**: 1163–6.
9 Kristensen MS. Airway management and morbid obesity. *European Journal of Anaesthesiology* 2010; **27**: 923–7.
10 Juvin P, Lavaut E, Dupont H, et al. Difficult tracheal intubation is more common in obese than in lean patients. *Anesthesia and Analgesia* 2003; **97**: 595–600.
11 Heidegger T, Gerig HJ, Ulrich B, Kreienbühl G. Validation of a simple algorithm for tracheal intubation: daily practice is the key to success in emergencies—an analysis of 13,248 intubations. *Anesthesia and Analgesia* 2001; **92**: 517–22.
12 Snyders SP, Walsh EM. A new airway assessment tool: the anaesthetic chart. *British Journal of Anaesthesia Letters* 2006; http://bja.oxfordjournals.org/forum/topic/brjana_el%3B1123 (accessed 09/03/2011).
13 Henderson JJ, Popat MT, Latto IP, Pearce AC. Difficult Airway Society guidelines for management of the unanticipated difficult intubation. *Anaesthesia* 2004; **59**: 675–94.
14 Barron FA, Ball DR, Jefferson P, Norrie J. 'Airway Alerts'. How UK anaesthetists organise, document and communicate difficult airway management. *Anaesthesia* 2003; **58**: 73–7.
15 Kinsella SM. Anaesthetic deaths in the CMACE (Centre for Maternal and Child Enquiries) Saving Mothers' Lives report 2006-08. *Anaesthesia* 2011; **66**: 243–6.
16 Yentis SM. Of humans, factors, failings and fixations. *Anaesthesia* 2010; **65**: 1–3.
17 Bongard F, Wu Y, Lee TS, Klein S. Capnographic monitoring of extubated postoperative patients. *Journal of Investigative Surgery* 1994; **7**: 259–64.
18 Georgiou AP, Gouldson S, Amphlett AM. The use of capnography and the availability of airway equipment on Intensive Care Units in the UK and the Republic of Ireland. *Anaesthesia* 2010; **65**: 462–7.
19 Murphy C, Rooney SJ, Maharaj CH, et al. Comparison of three cuffed emergency percutaneous cricothyroidotomy devices to conventional surgical cricothyroidotomy in a porcine model. *British Journal of Anaesthesia* 2011; **106**: 57–64.
20 Sheriffdom of Glasgow and Strathkelvin. *Determination of Sheriff Linda Margaret Ruxton in Fatal Accident Inquiry in the Death of Gordon Ewing*. 2010 FAI 15. http://www.scotcourts.gov.uk/opinions/2010FAI15.html (accessed 09/03/2011).
21 Muir KW, Watt A, Baxter G, Grosset DG, Lees KR Randomized trial of graded compression stockings for prevention of deep vein thrombosis after acute stroke. *Quarterly Journal of Medicine* 2000; **93**: 359–64.
22 Heller RF, Dobson AJ. Disease impact number and population impact number: population perspectives to measures of risk and benefit. *British Medical Journal* 2000; **321**: 950–2.

doi:10.1111/j.1365-2044.2011.06755.x

Editorial

Mechanisms of anaesthetics: lessons learned from creatures great and small

Early one Monday morning in the 1980s, I was chased around the car park of a Dundee slaughterhouse by an angry bullock. In those days I would regularly set up shop in the gentlemen's toilet of the abattoir waiting to be handed a steaming mass of bovine fatty tissue, within which was buried an adrenal gland. The gland first had to be isolated, cannulated and flushed with saline before transportation on ice to the lab at Ninewells Hospital where I worked as a PhD student. Chromaffin cells within the adrenal medulla are derived from the neural crest and express neurotransmitter receptors