Airway management is fundamental to safe anaesthetic practice and anaesthetists need to be skilled in airway management techniques. However, complications of airway management have been reported to be both common and serious. A recent analysis of the National Health Service Litigation Authority data for the period 1995–2007 showed claims related to airway management to be the fifth most common reason for anaesthesia-related litigation, but this group of claims was ranked equal highest in terms of the proportion of claims related to damage or fatalities and these claims accounted for 20% of the 50 most costly claims.

The American Society of Anesthesiologists (ASA) has a long-standing interest in closed malpractice claims arising in the USA. Claims relating to airway management are reviewed on a regular basis; these reviews guide clinical practice and allow the role and effectiveness of recommendations and guidelines to be evaluated. No similar systematic detailed appraisal exists in the UK, although the National Patient Safety Agency (NPSA) collects reports of, and responds to, critical incidents. The Fourth National Audit Project of the Royal College of Anaesthetists (NAP4) is an attempt to investigate these areas. It will determine current trends in airway management practice and provide an indication of the incidence of major airway complications. This paper describes a census, taken over a 2 week period, of current UK airway management practice used for general anaesthesia. The census provides an estimate of the annual number of general anaesthetics performed and the airway management techniques in use.

Editor’s key points

- The preliminary stage of Fourth National Audit Project of the Royal College of Anaesthetists (NAP4) reports on all anaesthetics given in a 2 week period.
- Three hundred and nine hospitals reported on airway management of nearly 115,000 cases.
- Supraglottic devices were used in 56% and tracheal intubation in 38%.
- This demonstrates current trends in airway management techniques and provides the denominator for the NAP4 objective to determine the incidence of major airway complications.

Background. The first stage of the Royal College of Anaesthetists Fourth National Audit Project (NAP4) (to determine the incidence of major complications of airway management in the UK) required a national census of airway management techniques currently in use.

Methods. A network of local reporters (LRs) was established, with a link to each of the 309 National Health Service hospitals believed to undertake surgery. LRs were requested to report the primary airway management technique used for all general anaesthetics performed in their hospital during a specified 2 week period. Individual unit’s data for the survey period were extrapolated using a multiplier of 25 to provide an estimated annual usage.

Results. Data were received from all 309 hospitals. The number of general anaesthetics reported in the 2 weeks was 114,904 giving an estimate of 2.9 million annually. Eighty-nine per cent of returns were reported by the LR to be ‘accurate’ or ‘a close estimate’ (an error of <10%). The primary airway management device for general anaesthesia was a supraglottic airway in 64,623 (56.2%), a tracheal tube in 44,114 (38.4%), and a facemask in 6,167 (5.3%).

Conclusions. The second stage of NAP4 is designed to register and collect details of each major airway complication from the same hospitals over a 12 month period. The individual case reports will produce the numerator to calculate the incidence of airway complications associated with general anaesthesia in the UK. The results of the census presented here will provide the denominator.

Keywords: airway; airway, complications; anaesthetic technique, supraglottic airway; anaesthetic technique, tracheal intubation; laryngeal mask

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Methods

Using surface mail, e-mail, and telephone, the anaesthetic department in every National Health Service (NHS) hospital in the UK was contacted and invited to participate in NAP4 and to nominate a local reporter (LR) who would act as the point of contact for the project, co-ordinate a census of current activity and assist with the second phase where reports of individual serious complications were to be submitted. Data were not sought from private hospitals or Independent Sector Treatment Centres (ISTCs); however, data were collected from treatment centres attached to NHS hospitals.

Each LR was asked to return a Hospital Data Submission Form (Supplementary Appendix 1) by electronic or surface mail for the 2 week period from September 15 to 28, 2008. Information was requested under two categories, essential and desirable.

Essential data

Essential data were requested on the number of anaesthetics performed anywhere in the hospital with the exception of those performed in the intensive care unit (ICU) and emergency department (ED): anaesthetics performed in these areas were explicitly excluded. Required data were broken down into two categories: the number of local or regional anaesthetics performed by an anaesthetist without general anaesthesia and the number of general anaesthetics performed. For procedures undertaken under general anaesthesia, detailed information on the primary airway management technique used was requested. Specifically, the total number of times during the 2 week period an anaesthetic facemask, supralglottic airway device (SAD), or tracheal tube was used as the primary airway management technique was requested. The primary airway was defined as that 'used for maintenance of anaesthesia'. Tracheal intubation included all forms of intubation of the trachea: for example, single-and double-lumen tubes, tracheostomy, surgical bronchoscopy, trans-glottic, and trans-tracheal techniques.

Desirable data

Supplementary detailed information was requested on the specific type of airway device used. Additional questions were also included on the anaesthetic induction methods for patients in whom airway problems were anticipated.

The decision on how to collect these data was left at the discretion of the LR. The data collection exercise could be performed using a paper-based method or, if facilities existed locally, information could be collected electronically. To assist, electronic copies of the NAP4 Anaesthetist’s Data Collection Form (Supplementary Appendix 2) were distributed to LRs for use, if they elected to use a paper-based method, although they were free to create their own if they deemed this appropriate. A detailed written explanation of the NAP4 project and the purpose of the census were placed on both the Difficult Airway Society (DAS) and Royal College of Anaesthetists (RCoA) websites and the Anaesthetist’s Data Collection Form was also available for downloading from both websites. An Anaesthetist’s Data Collection Advice Sheet explaining the data to be collected was provided for distribution by the LRs to individual anaesthetists. The project was very widely advertised to promote awareness and encourage participation. LRs collected data on the activities of individual anaesthetists and submitted a return based on the activities of the whole hospital.

For each figure submitted, LRs were asked to indicate its accuracy as: accurate (0–2% error), close estimate (2–10% error), estimate (>10% error), or guess (no data to support the figure).

LRs were contacted at regular intervals by surface mail, e-mail, or telephone and encouraged to return data. If they found they were unable to fulfil their role, alternative volunteers were identified in their hospitals. When this occurred after September 15, 2008, or if local circumstances had prevented data collection during the planned census period, LRs were invited to submit data for an alternative 2 week period. Where no data had been received before the end of August 2009, data for the 2 week period from September 14 to 27, 2009, were requested instead.

Submitted electronic data were checked to identify rogue data such as data entry errors, mathematical errors, or illogical data, and these were corrected where possible after consultation with the LR responsible. If submitted data were conflicting and correction by the LR was not possible, those data deemed by the LR on the submission form to be the most accurate were used. If an assessment was not possible, data were accepted as presented.

Data for each category from all hospitals were added to provide a cumulative national total for the 2 week period. These totals were then multiplied by 25 to provide an estimate of annual activity. The multiplier of 25 was based on calculation made in the authors’ base hospitals. The surgical activity during year August 31, 2008, to September 1, 2009, was divided by the surgical activity recorded during the study period. These were found to be 24.5 at the Norfolk and Norwich University Hospital and 24.9 at the Royal United Hospital Bath. These were rounded to 25 to create the multiplier for calculating annual activity.

In an attempt to validate the data returned by LRs for the total number of general anaesthetics, Hospital Episode Statistics (HES) data collected from hospitals in England for the 2008–9 period were analysed. This database records the primary procedure performed on NHS patients over each financial year. The HES data provide numbers for procedures performed on all NHS patients in England including those treated within the private sector or in ISTCs. The database provides no information on the type of anaesthesia. A group of clinicians including anaesthetists with experience in all clinical specialities (including general, orthopaedic, obstetric, gynaecological, urological, paediatric, vascular, thoracic, cardiac, head and neck, plastic, otorhinolaryngological, oro-maxillary-facial, and neuro-surgery) reviewed the list of primary procedures and estimated the percentage of
cases performed under general anaesthesia as 100%, 95%, 75%, 50%, 25%, 5%, or 0%. These multipliers were used to estimate the total performed under general anaesthesia, for each procedure listed in the HES database. This figure for England was then multiplied by 1.2 (based on population census figures for England, Wales, Scotland, and Northern Ireland) to provide an estimate for the population of the UK.

**Results**

By September 2008, all 309 NHS hospitals had agreed to participate and had appointed an LR. All 309 hospitals (100%) returned data: ‘essential data’ were returned by 100% and ‘desirable data’ by 98%.

In the 2 week study period a total of 114,904 general anaesthetics were recorded as having been performed (Table 1). The primary airway management device for general anaesthesia was a supraglottic airway in 64,623 (56.2%). The majority of these were reported to be standard laryngeal masks. Approximately 10% of anaesthetics were delivered via one of the newer SADs, the i-gel (Intersurgical, Wokingham, UK) and ProSeal LMA (Intavent Direct), with the former being used more than twice as often as the latter. A tracheal tube was the primary airway in 44,114 (38.4%) general anaesthetics. The majority of tracheal intubations were performed with a single lumen tube. Anaesthesia via a double lumen tracheal tube or tracheostomy represent, between them, fewer than 1 in 100 general anaesthetics and general anaesthesia using a surgical laryngo-bronchoscope, trans-tracheal techniques and bronchial blockers are very infrequent each being used in less than 1 in 1000 general anaesthetics and fewer than 1 in 500 tracheal intubations. Anaesthesia by facemask alone was used for 6,167 procedures (5.3%). The percentage of data returns reported as ‘accurate’ or close estimate’ were: number of general anaesthetics 89% and by airway device 82–84%.

Extrapolating to annual activity suggests that in the UK, 2.9 million general anaesthetics were performed during the year of the NAP4 study in the units surveyed. This represents an annual activity of 1.6 million general anaesthetics in which the airway was maintained with an SAD, 1.1 million with a tracheal tube, and 0.15 million with an anaesthetic facemask.

In 2554 (2.2%) patients, airway management was expected to be difficult as judged by the anaesthetist. Of these reported predicted difficult airways, 91% were in adults and 9% in children. Management of patients with predicted difficult airways in adults was predominantly (81%)

### Table 1: Main results and airway management techniques. *To the nearest 100*

<table>
<thead>
<tr>
<th>Device (accurate or close estimate)</th>
<th>Uses during Census</th>
<th>Number per annum*</th>
<th>Percentage of general anaesthetics</th>
<th>Indicated as ‘accurate’ or close estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>General anaesthetics</td>
<td>114 904</td>
<td>2 872 600</td>
<td>100</td>
<td>89%</td>
</tr>
<tr>
<td>Supraglottic airway device</td>
<td>64 623</td>
<td>1 616 100</td>
<td>56.2</td>
<td>83%</td>
</tr>
<tr>
<td>Tracheal tube</td>
<td>44 114</td>
<td>1 102 900</td>
<td>38.4</td>
<td>84%</td>
</tr>
<tr>
<td>Facemask</td>
<td>6167</td>
<td>154 200</td>
<td>5.3</td>
<td>82%</td>
</tr>
</tbody>
</table>

### Table 2: Detailed breakdown of airway devices used. *To the nearest 100*

<table>
<thead>
<tr>
<th>Device (accurate or close estimate)</th>
<th>2 week total</th>
<th>Annual estimate*</th>
<th>% of all airways</th>
<th>% of subgroup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facemask (80)</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Anaesthetic facemask</td>
<td>4784</td>
<td>119 600</td>
<td>4.2</td>
<td>77.6</td>
</tr>
<tr>
<td>Hudson type of mask</td>
<td>1383</td>
<td>34 600</td>
<td>1.2</td>
<td>22.4</td>
</tr>
<tr>
<td>Supraglottic airway (80)</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Laryngeal mask</td>
<td>56 388</td>
<td>1 409 700</td>
<td>49.2</td>
<td>87.3</td>
</tr>
<tr>
<td>i-Gel</td>
<td>4574</td>
<td>114 400</td>
<td>4.0</td>
<td>7.1</td>
</tr>
<tr>
<td>ProSeal LMA</td>
<td>1920</td>
<td>48 000</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Other</td>
<td>1741</td>
<td>43 500</td>
<td>1.5</td>
<td>2.7</td>
</tr>
<tr>
<td>Tracheal tube (81)</td>
<td></td>
<td></td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Single lumen</td>
<td>42 752</td>
<td>1 068 800</td>
<td>37.3</td>
<td>96.9</td>
</tr>
<tr>
<td>Double lumen</td>
<td>634</td>
<td>15 900</td>
<td>0.55</td>
<td>1.4</td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>399</td>
<td>10 000</td>
<td>0.35</td>
<td>0.9</td>
</tr>
<tr>
<td>Surgical laryngo-bronchoscope</td>
<td>133</td>
<td>3300</td>
<td>0.12</td>
<td>0.3</td>
</tr>
<tr>
<td>TTJV</td>
<td>83</td>
<td>2100</td>
<td>0.07</td>
<td>0.19</td>
</tr>
<tr>
<td>Bronchial blocker</td>
<td>60</td>
<td>1500</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Other</td>
<td>53</td>
<td>1300</td>
<td>0.05</td>
<td>0.12</td>
</tr>
</tbody>
</table>
with i.v. induction of anaesthesia, with a minority being managed by inhalation induction (9%) or awake fibreoptic intubation (10%). In children with predicted difficult airways, inhalation induction (63%) was much more common than i.v. induction (37%) and awake fibreoptic intubation was not reported at all.

From the HES data (which includes ISTCs and NHS patients treated in private hospitals) using the method described, we estimated that 3.0 million general anaesthetics per annum were performed in all UK hospitals in 2008.

Although not a prime aim of the census, our returns indicated 27 096 cases performed under local or regional anaesthesia during the census: an annual estimate of activity of 0.68 million cases. Using our estimate of general anaesthetic activity, this gives a split of 81:19% for general to regional/local anaesthetic activity, for cases in which an anaesthetist is involved.

**Discussion**

This census of general anaesthesia and airway management activity was primarily designed to provide a realistic estimate of the total number of general anaesthetics performed annually in the UK within NHS hospitals. Additional information on the airway management techniques used during general anaesthesia was collected. These data will form the denominators in the calculations of the incidence of major complications associated with such techniques. Ideally, such information would be available from a continuous nationwide analysis of practice. Currently, these data are collected and available in some UK hospitals, but no national co-ordinated analysis is available to provide this information for the NHS or the country as a whole.

Consideration was given to asking reporters to collect information over a longer (12 month) period; however, it was thought that a prolonged period of measurement might represent an unreasonable burden, ultimately leading to a lower response rate. The response rate (100%) is excellent and, although self-rated, the reported accuracy of the data (89% described as ‘accurate’ or a ‘close estimate’ for the type of anaesthetic and >82% as ‘accurate’ or a ‘close estimate’ for the primary airway management device) supports the decision to pursue a ‘snapshot’ approach, meaning that robust denominator data are available once a 12 month review of complications has been completed. The 100% compliance rate probably reflects the recognized importance of the overall aim of the project and the persistence with which data were sought.

To provide an estimate of annual activity, the results of the 2 week census were multiplied by 25 on an empiric basis supported by data from the authors’ hospitals. It is postulated that elective surgical activity is reduced during holiday periods, by bank holidays, and perhaps when new trainees are introduced, though urgent/emergency surgery continues. Our multiplier of 25 equates to approximately 49–50 weeks of both elective and emergency works, and 2–3 weeks of emergency only work, this having a differential effect on the several anaesthetic subspecialties. In the Royal United Hospital, Bath, a large district general hospital, the total number of procedures performed annually is available and leads to multiplication factors between 23.5 and 26 for each speciality, and an overall multiplier of 24.9. At the Norfolk and Norwich hospital during the survey period, the multiple was 24.5. Therefore, on the basis of these data, 25 was accepted and applied to all data.

Although not a prime aim of the census, our data suggest approximately 19% of anaesthetists’ NHS surgical activity (about 0.7 million cases per annum) involved cases performed under regional or local anaesthesia alone. The framing of this question in the census means it is possible that this figure excludes regional analgesia for labour, which would add an additional 110 000 cases. Regional anaesthesia, without general anaesthesia, is likely to account for 20–22% of anaesthetic activity.

The Royal College of Anaesthetists has direct links to all NHS hospitals and these links were considered to form a reliable collection network (for both this and the second stage of the project). In order to ensure that incidence calculations are as accurate as possible, numerator data (numbers of complications) will be drawn from the same population as the census. Cases reported from ISTC and private sector hospitals may be submitted during the second phase of NAP4, but these will not be used for the calculations of incidence.

We believe that this census is the first robust attempt to determine the number of general anaesthetics delivered in the UK, which is something of a surprise. The RCoA census of anaesthetic activity in 2007 estimated that there were 12 600 anaesthetists in the UK. Our data could therefore mean each anaesthetist delivers an average of 230 general anaesthetics per year in the NHS. On initial examination, this figure may appear to be low and this justifies further examination. We have collected data on the number of general anaesthetics, not the number of anaesthetists delivering them. If we assume that one-third of anaesthetics are delivered by two anaesthetists (consistent with figures from the authors’ hospitals), our figures would equate to an average of approximately 340 per annum. If 10% of all anaesthetists (RCoA census) work half-time, the mean full-time equivalent figure increases to 360 general anaesthetics per annum. This figure does not include cases managed under local or regional anaesthesia alone, perhaps an additional 25%. The mean figure is also lowered by the inclusion of anaesthetists on long-term sickness, or maternity leave. Finally, anaesthetists are heavily engaged in other activities including provision of intensive care, obstetric analgesia, acute and chronic pain management, preoperative assessment clinics, research, teaching, and hospital management: each of these activities will reduce the number of general anaesthetics delivered by those involved and the mean figure overall. Pooled data from each of the authors’ hospitals gave a mean figure which ranged from 324 to 333 general anaesthesia cases per annum for consultants with local or regional anaesthesia accounting for 20–30% of overall workload.
The vast majority of tracheal intubations were performed with a single-lumen tube. Our estimate of the frequency of the use of other tracheal intubation techniques is based on small numbers and is therefore the least reliable. Anaesthesia with a double-lumen tracheal tube or tracheostomy represent, between them, fewer than one in 100 general anaesthetics and general anaesthesia using a surgical laryngo-bronchoscope, trans-tracheal techniques, and bronchial blockers are very infrequent each being used in less than one in 1000 general anaesthetics and fewer than one in 500 tracheal intubations. Accepting any reservations about the accuracy of these figures, it is likely that these techniques are performed in a relatively small number of centres and by a relatively small number of anaesthetists, and there is corroborative evidence for this for the usage of surgical laryngo-bronchoscope and trans-tracheal techniques. These findings have potential implications for the use of such techniques in emergencies and by non-experts, which will perhaps be better considered once the second phase of NAP4 is complete.

The study has intrinsic weaknesses. First, whatever method was used to collect data, it is likely any final figure will be an underestimate of actual activity as cases are far more likely to be missed or omitted than fabricated. Secondly, repeated approaches to some units were required to obtain data. The delayed recording of data is likely to lead to a further underestimation of the denominator since forms completed retrospectively may lead to omissions. Thirdly, the increasing subdivision of data make the smaller numbers more prone to variance both because sampling infrequently used devices over a short time period is prone to error and because these figures were reported by the LRs as being less accurate. Fourthly, the range of accuracies of reported data makes it difficult to present confidence intervals for the data we report and we simply offer point estimates. Finally, the data we used for validation is itself not externally validated and the method we used to estimate the number of general anaesthetics from that database has considerable weaknesses, although we are not aware of any better methods of validation. We acknowledge all these limitations but complete compliance with the census and the self-assessed accuracy of the data both support the view that these data are of as high a quality as it is feasible to collect. For the number of general anaesthetics, the LRs reported 89% of submissions to be accurate to within 10%. If we accept this figure and assume 50% error, of the remaining 11% we estimate an error of no more than 15%. For reasons outlined previously, most figures returned will be underestimates but some will be in excess of the number of cases actually performed and these will tend to reduce the degree of inaccuracy. We would welcome information from others that might enable us to refine our estimates.

The overall estimate of 2.9 million general anaesthetics performed in the UK within the 309 units surveyed is very similar to the estimate of 3.0 million derived from HES data which also include NHS patients treated in private hospitals and ISTCs. Independent sector treatment centres were estimated to account for 1.8% of elective NHS activity in 2007–8 and private practice accounts for ~10% of surgical activity in the UK. Using these broad estimates, it is likely that the overall number of general anaesthetics in the UK is between 3.1 and 3.3 million: although the assumptions used make this figure rather less accurate than the figure reported here for activity in NHS hospitals.

In conclusion, a national survey in the UK was undertaken to provide an estimate of the number of general anaesthetics performed in 1 yr in NHS hospitals and to identify the pattern of airway management techniques used for these cases. We estimate that 2.9 million general anaesthetics were performed in this population in 2008–9: 56% utilizing a supraglottic airway, 38% a tracheal tube, and 5% using an anaesthetic facemask. On completion of the second phase of NAP4, these figures will enable calculation of an estimated incidence of the major complications of airway management techniques.

Supplementary material

Supplementary material is available at British Journal of Anaesthesia online.

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Conflict of interest

None declared.

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