

AAGA during induction of anaesthesia and transfer into theatre



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HEADLINE

8.1 This chapter discusses reports of AAGA between the start of induction of anaesthesia and the start of the surgical intervention. This includes induction of anaesthesia and transfer of the anaesthetised patient into theatre. We refer to this entire period as 'induction' except where aspects of the transfer are discussed. We do not discuss reports of 'syringe swaps' or drug errors, which are discussed in Chapter 13. Half of Certain/probable reports to NAP5 were in this phase of anaesthesia, and half the reports involved patients categorised as NCEPOD urgent or emergency. Over half were obese, a third of reports involved RSI, and in 92% of these, induction was with thiopental. In over a third of reports no opioid was used at induction, notably in cases conducted by trainees working alone. In about a third of cases there was difficult airway management, and failing to continue anaesthesia was judged contributory to AAGA. Despite the brevity of patient experience in this phase, distress was common.

BACKGROUND

Induction

8.2 Induction of anaesthesia in a dedicated anaesthesia room and transfer to the operating theatre (perhaps a UK-specific phenomenon, as discussed below) is a complex process that is readily understood by anaesthetists but, for reasons that are self-evident, less well by patients. Gas induction (used frequently for children and rarely in adults) takes several minutes, so that patients who have undergone this process sometimes recall 'being given a gas to breathe to fall asleep'. For most modern anaesthetics, intravenous drugs are used to produce unconsciousness in the short time it takes for the drug injected into the vein to reach the brain (the 'arm-brain circulation time').

8.3 Despite its rapid nature, induction of anaesthesia is a *process* rather than an *event* and, even for those carefully observing the patient, it is difficult

or impossible to know the exact moment when consciousness is 'lost'.

8.4 Clinical assessment of induction uses end points that rely on absence of some form of *response*, e.g. to calling the patient's name (a relatively weak stimulus so the patient may not respond to sound, but may move or awaken with painful stimulation); the eyelash reflex (a reliable sign of loss of consciousness with thiopental but less so with propofol), and releasing an object held in the hand. All of these have variously been used in trials (Wilder-Smith et al., 1999). Lack of movement in response to airway manoeuvres (a reasonably strong stimulus) can be used to signify adequate depth of anaesthesia, at least for instrumenting the airway (Figure 8.1).

- 8.5 However, concomitant use of neuromuscular blocking drugs during induction blunts or eliminates motor response, thus making all these tests invalid.
- 8.6 AAGA at induction is not widely described in the literature, if at all. Use of depth of anaesthesia (DOA) monitors during induction appears uncommon but there is a paucity of data confirming this. Although 62% of hospitals in the UK have access to DOA monitors only ~1.8% of anaesthetists report routinely using DOA monitors at any point during general anaesthesia (Pandit et al., 2013 a and b).
- 8.7 Studies using DOA monitors at induction focus on dose-sparing effects rather than utility in preventing AAGA at induction (Gürses et al., 2004), and in large trials such as the BAG-RECALL trial, although the DOA monitor was applied before induction and data collected to ensure stable recordings, it is not clear if AAGA at induction was included in the reports

(Avidan et al., 2009; Avidan et al., 2011). Processing time is acceptable for routine use, but is too slow for rapid induction and monitor output is displayed only up to 30 sec later (Nishiyama et al., 2004).

- 8.8 After induction using intravenous agents, the maintenance of anaesthesia relies on either introduction of a volatile agent or continued, uninterrupted administration of intravenous anaesthetic. As the brain concentration of the intravenous induction agent declines, the brain concentration of the maintenance agent gradually increases. Thus there may be a period where the overall concentration of anaesthetic agents is lower than desirable. Patient stimulation during this 'gap' may lead to AAGA. Any delay in starting administration of the maintenance agent, or an interruption, will compound this gap. The Panel called this type of AAGA report 'Mind the Gap', and found that it could occur for a variety of reasons which are discussed below (Figure 8.2).

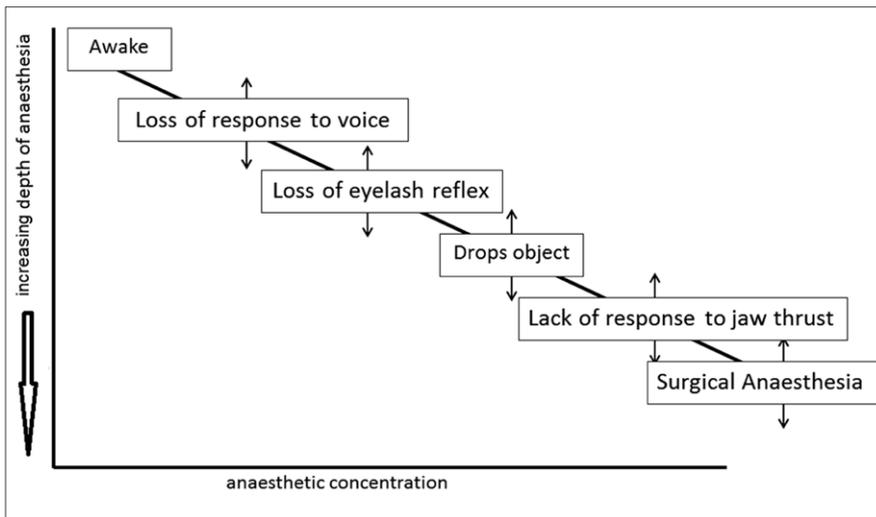


Figure 8.1. Diagrammatic representation of how tests of patient response might vary with anaesthetic depth. Arrow lengths are illustrative only and vary with drugs used

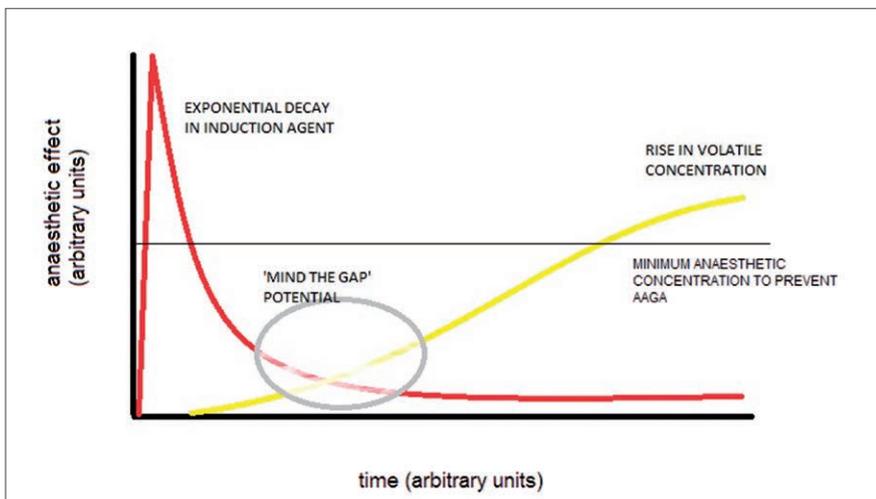


Figure 8.2. Diagrammatic representation of a 'gap' in delivery of anaesthetic when the volatile agent is turned on a little too late, at too low a rate or is interrupted, as the effect of the initial intravenous bolus is in decline. The thin line represents the minimum agent concentration required to prevent AAGA

Anaesthetic rooms and transfer into theatre

- 8.9 In the UK induction is usually in a dedicated anaesthetic room (Bromhead & Jones, 2002). Anaesthetic rooms are rare in Australasia, the United States or Europe. (Masters & Harper, 1990). Perceived advantages of anaesthetic rooms are privacy for the patient, teaching, line insertion or regional blocks, but patients do not seem to mind where they are anaesthetised (Soni & Thomas, 1989). There may be benefits, but the practice involves interruption in the delivery of anaesthetic during transfer from anaesthetic room to operating theatre and is therefore a systemic risk.
- 8.10 Transfer from the anaesthetic room to theatre takes on average ~51 sec (Riley et al., 1988), but can take > 3 min (Broom et al., 2006). Once re-connected to a breathing circuit there will be further delay in delivering anaesthetic to the patient, as this circuit needs to first fill with vapour.
- 8.11 The transfer process can create distractions that increase the possibility of AAGA from task fixation errors (see Chapter 23; Human Factors). Airway and intravenous access events during transfer are, unsurprisingly, common and demand immediate attention. Even minor problems such as lead tangles, sticking brakes, table/trolley height differences or lack of available staff can add delays of up to 30 sec in reconnection to the breathing system or monitoring (Broom et al., 2006). Such distractions may lead to errors of omission so that the maintenance volatile is not turned on. These risks and advantages of anaesthetic rooms must be balanced.
- 8.12 Ghoneim & Block (1992) summarised the then known methods for avoiding AAGA in this phase of anaesthesia:
- Premedication with 'amnesic' agents.
 - Use more than the minimum dose of intravenous agent to induce unconsciousness (especially when the plan is to immediately follow this with neuromuscular blockade) and administer even more induction agent if intubation is prolonged.
 - Avoid neuromuscular blockade wherever possible and if used, avoid complete paralysis.
 - Use volatile agents at >0.6 MAC (end-tidal) with nitrous oxide, or >0.8 MAC if used alone.
- 8.13 In summary, existing literature includes not only evidence that anaesthetic induction and transfer are situations in which events can conspire to produce a relatively high risk of AAGA, but also sensible advice for reducing these risks.

NAP5 CASE REVIEW AND NUMERICAL ANALYSIS

- 8.14 The Activity Survey reported that 71% of all general anaesthetic inductions took place in anaesthetic rooms; 92% of inductions were intravenous and 8% gaseous. In adults the figures are 98% and 1% respectively. After induction a volatile agent was used in 92% of UK general anaesthetics and TIVA (in a variety of forms) in 8% (Activity Survey, 2014).
- 8.15 A specific DOA monitor was used, 2.8% of GAs in the Activity Survey, two thirds being processed EEG. However, the Activity Survey did not establish how many anaesthetists use DOA monitoring during induction.
- 8.16 Of the 141 'Certain/probable' or 'Possible' (Class A and B) reports, half (72) involved the induction phase (five of these involved both induction and maintenance; two both induction and emergence, and in six cases there was some uncertainty about the exact phase, but induction was likely involved). Of these, 58 occurred at induction and 12 on transfer into theatre (in two not specified). There was a preponderance of women, 47 (65%) in line with the overall data. A bolus induction agent and volatile maintenance were used in the majority 62 (86%) of cases, with 10 (14%) using TIVA throughout (these proportions being broadly in line with data in the Activity Survey). Nitrous oxide featured in 21% of reports consistent with the Activity Survey (27%).
- 8.17 Half (37, 51%) of cases at induction, were in elective patients and half were in NCEPOD urgent or emergency cases. Fifty seven (79%) patients were ASA 1 and 2. A consultant or non-consultant career grade anaesthetist cared for 46 (64%) of patients, a senior trainee for eight (11%), and a CT1 or CT2 (i.e. a junior trainee) for 5 (7%) of patients. Grade was unknown in seven (10%).
- 8.18 Body habitus was known in 62 of the 72 patients: 25 (35%) were overweight, obese, or morbidly obese. In the Activity Survey, 22% of all surgical patients were overweight, obese or morbidly obese.
- 8.19 In 67 (93%) of cases, neuromuscular blockade was used at induction (vs 45% of cases in the Activity Survey).

Underdosing and patient weight

- 8.20 In 23 (32%) of cases reported during induction, the Panel judged the induction agent dose inappropriately low and identified it as a contributory factor to AAGA.

A very obese adult underwent orthopaedic surgery and reported AAGA after induction. There was recall of being transferred onto the operating table and people talking. The patient could not move. The patient remembered trying to cry in an attempt to alert the anaesthetist. The period lasted an estimated three minutes before consciousness was lost. The patient is scared of future anaesthesia. A consultant anaesthetist undertook RSI with thiopental 250mg, suxamethonium 150mg and maintenance with remifentanyl by infusion, sevoflurane, nitrous oxide and atracurium. The anaesthetic chart first recorded sevoflurane ten minutes after induction.

A very obese patient underwent emergency abdominal surgery and later reported AAGA to another anaesthetist saying they felt something inserted into their mouth. "It was as if there was no anaesthetic at all. I saw a man at my head, he kept pushing the thing in my mouth and I heard him say: "This has been a really busy day and there's still more to come'. I tried to lift my hand up but someone at my side held my arm down. I felt everyone was rushing". The patient felt paralysed and was fearful of dying. Two trainee anaesthetists induced anaesthesia with 500mg of thiopental and 100mg of suxamethonium. There was minor difficulty with laryngoscopy and intubation. No opioids were used at induction.

Opioids and thiopental

- 8.21 It was striking that RSI was over-represented in the cases occurring at induction. Whereas RSI was used in only 7.4% of general anaesthetics in the Activity Survey, it was the induction technique in 26 (36%) of all Certain/probable AAGA cases.
- 8.22 In the Activity Survey, more than two-thirds of patients received opioids during RSI, but of AAGA cases involving RSI, only one-third received opioids.
- 8.23 Thiopental was disproportionately the induction agent in cases of RSI-related AAGA. In the Activity Survey 33% of RSIs used thiopental, while 92% of cases of AAGA during RSI involved thiopental. The Activity survey indicates that thiopental is predominantly used for RSI: it is used for <3% of all inductions of which 87% of uses are for RSI.
- 8.24 In 28 (39%) reports no opioids were used at induction and their omission, including during RSI, was either highlighted by the Local Co-ordinator or judged by the Panel as contributory to AAGA on several occasions. Although traditional teaching suggests they should be omitted from an RSI, in fact RSI without opioids is a rare technique (Morris & Cook, 2001), and in the Activity Survey opioids were used in over two-thirds of RSIs.

Opioids were used at induction in 96% of cases when career grade anaesthetists were involved, but in only 31% of cases when trainees were managing the patient, either solo or accompanied by another trainee.

A middle-aged, slim, healthy patient underwent urgent abdominal surgery. There was unexpected difficulty with intubation during an RSI undertaken by a trainee anaesthetist, and the patient reported AAGA to an anaesthetist at a later procedure saying: "Next time you try to put the tube down could you please make sure that I'm asleep. I could feel some pressure on my neck, some poking around in my throat and then something larger coming down". Only thiopental and suxamethonium were used at induction.

- 8.25 It is uncertain if RSI was required in all cases where it was used, or if better pre-operative preparation would have avoided it. In obese patients there is often justification for tracheal intubation (Cook et al., 2011), but the reasons for choosing formal RSI were unclear from the reports.

Difficult airway management

- 8.26 Twenty-one (30%) reports at induction occurred during protracted or 'difficult' airway management; 12 during RSI. The overall incidence of difficult airway management is unclear, in part due to issues of definition: difficult bag mask ventilation occurs in approximately 1–5%, difficult or failed supraglottic airway insertion in 1–2%, a grade 3 view at laryngoscopy in approximately 6% (Cook & MacDougall-Davis, 2012), and difficult intubation (three or more attempts) in up to ~4% (Crosby et al., 1998). Based on these figures, NAP5 confirms that the risk from difficult airway management is to some extent coupled with a risk of AAGA.

Difficult airway management is a risk factor for AAGA



- 8.27 In several cases of AAGA during airway difficulty, it was unclear whether the anaesthetic team intended to persist with attempts at intubation or to cease anaesthesia and awaken the patient.

A middle-aged very obese patient underwent urgent surgery at night. Induction was with fentanyl 100µg, thiopental 500mg and suxamethonium 100mg. There was unexpected difficulty with intubation and after repeated intubation attempts, during which no further drugs were administered, the case was abandoned and the patient awoken. The patient heard discussion about intubation difficulty, felt instruments in his mouth and was unable to move.

An elderly overweight patient underwent general anaesthesia for major orthopaedic surgery. There was unexpected airway difficulty and the vaporiser was turned off to avoid 'pollution' during intubation. Induction was with propofol, midazolam, fentanyl and atracurium then sevoflurane for maintenance. Bag and mask ventilation was easy but laryngoscopy was difficult and help was summoned. The lack of volatile was recognised when the blood pressure was noticed to be elevated during ILMA insertion. Airway management lasted 45 minutes. It was unclear whether the plan was to wake the patient up, or to continue with attempts to secure the airway. The patient told recovery staff of recall of voices, the sensation of being ventilated with a mask and a description consistent with insertion of a supraglottic airway.

- 8.28 In numerous cases where AAGA occurred during airway difficulty, no additional intravenous anaesthetic agent was administered. Anaesthesia relied on volatile administration during either difficult/failed mask ventilation or repeated attempts at instrumenting the airway. The Panel judged that this contributed or caused AAGA which was preventable.

A very obese unfit middle-aged patient reported hearing the consultant tell the trainee to "...get out of the way!" during her operation. There was a high quality record showing the trainee had difficulty with tracheal intubation and handed over to the consultant. Induction was with fentanyl 100µg, propofol 200mg and rocuronium 45mg. The anaesthetic record showed elevated blood pressure and heart rate during airway management.

- 8.29 In some reports the Panel judged that the dose of neuromuscular blocking drug was low by weight and may have itself contributed to difficult or prolonged intubation.

Vaporisers: prolonged 'gap' in administration of anaesthetic on transfer ('mind the gap')

- 8.30 Six cases (8%) occurred as a consequence of failing to turn on the vaporiser either after induction (n= 3) or on arrival in theatre.
- 8.31 In other cases the Panel judged that actions including starting volatile agents at too low a level, at too low fresh gas flow or using an unchecked (and faulty) vaporiser were causal in cases of AAGA. The rapid and appropriate action of the anaesthetists when AAGA was recognised and subsequent management of cases demonstrate an appropriate 'rescue' mechanism if AAGA is suspected.

A young healthy patient underwent urgent abdominal surgery. While the senior trainee anaesthetist was waiting for the patient the theatre co-ordinator changed the vaporiser for a new 'trial vaporiser' without informing the anaesthetist. Meanwhile the anaesthetist was called to an emergency. On returning, anaesthesia was induced without a further machine check. Following uneventful induction a regional block was performed and the heart rate and blood pressure were observed to be elevated so more opioid was administered. At incision heart rate increased further and at this point the vaporiser was checked and found to be empty. Midazolam and propofol were immediately given to deepen anaesthesia and the vaporiser filled. The patient reported hearing voices, being unable to move and feeling someone "...cleaning their tummy and then a tube going in..." The patient received an offer of counselling.

The movement of a patient from anaesthetic room to theatre is a period of risk for AAGA



Human factors: distractions and organisational issues on transfer

8.32 The Panel noted several cases where AAGA had arisen at induction, apparently because of distraction, fatigue and organisational issues; i.e., a desire to increase rapid turnover of cases, or last minute changes in list order or operating theatre, etc. This topic is discussed further in the Human Factors chapter (Chapter 23).

Failure to turn on a vaporiser was an important cause of AAGA at induction (and early in maintenance)



A middle aged patient experienced AAGA in the early part of the operation. The patient could not move, felt their buttocks being positioned, placement of sheets under their sacrum and heard a detailed conversation. The patient knew something was wrong and panicked because they could not move. The patient tried to scream out but could not. The patient "...felt violated, and then everything went blank..." The patient told the recovery nurse immediately on waking and post-operative discussion with the on-call anaesthetist suggested the patient was very distressed and psychologically affected. After intravenous induction and administration of a muscle relaxant the machine record of volatile concentrations showed no agent detected for a period of 15 minutes after arrival in theatre. On transferring the patient into theatre the anaesthetist was distracted by failure of the pulse oximeter and accidentally omitted to turn on the volatile anaesthetic agent. During this period both heart rate and blood pressure were elevated.

Problems with intravenous induction of anaesthesia, including neuromuscular blockade

8.33 Five cases (7%) occurred when the induction agent went back up the intravenous line or when the cannula 'tissued'.

An anaesthetist attempted an RSI but experienced unexpected difficulty. The patient subsequently reported attempts at intubation and a feeling of suffocation when bag/mask ventilation was performed. Although the incident was very brief the patient was distressed, feared death and developed a new anxiety state related to a 'near death experience'. The report suggests that the thiopental had backtracked up the intravenous giving set because a one-way valve failed. No more thiopental was prepared or available and no-one was available to help prepare any more.

8.34 In two cases (where the recorded dose of thiopental is very adequate on a dose per kilogram basis) it was suggested by the reporter that underdosing may have occurred because the thiopental was not fully dissolved. This is similar to cases reported in Chapter 16 (Obstetrics) and Chapter 13 (Drug Errors).

8.35 In two cases the report suggested that the neuromuscular blocking drug had been given too early in the induction process. In neither case was the drug suxamethonium.

NMBs should not be administered until loss of consciousness has been confirmed



Patient experience and assessment of care

8.36 Superficially it might seem that in terms of duration or sensation, patient reports during induction and transfer were mild and generally self-limiting: Nine (13%) of reports were of auditory sensation only although three included distress; 24 (34%) were confined to tactile sensation without pain of which a third caused distress. Paralysis was specifically mentioned in 36 (51%) of reports (and was more

commonly associated with distress), and pain was reported in 7 (10%). The feeling of movement or positioning was uncommon, (5, 7%, patients) as were visual experiences or bright lights (2, 3%, patients). Distress was present in 30 (43%) reports using the Michigan score. The longer-term impact as judged by modified NPSA score was no different in range from that occurring at other phases (see Patient Experiences, Chapter 7).

- 8.37 The common experience of auditory sensation in several reports, suggests that professional conduct and communication with the patient might mitigate adverse impact when AAGA occurs.

A young patient due to undergo urgent surgery was assessed by a very junior trainee. The trainee predicted a normal airway, but during RSI with thiopental and suxamethonium, laryngoscopy was Grade 3 and intubation failed. Help was called and a senior trainee attended and secured the airway.

No additional induction agents were given, and the patient awoke at end of surgery reporting AAGA. However, the patient's experience was a positive and reassuring one as they appreciated the efforts the doctors were making to keep things safe. The patient thanked the doctors for their care.

- 8.38 Quality of care was assessable in 65 cases: it was deemed 'good' in 19 (26%) of cases, mixed in 22 (31%), and poor in 24 (33%).
- 8.39 Poor care referred to poor pre-operative assessment, poor standards of charting, poor decision making, and poor management. Distraction was described as contributory in some cases, and this reflects poorly on theatre systems which require anaesthetists to leave the patient to assist in other matters. Poor charts were often referred to by the Local Co-ordinator as making identification of causes and timings very difficult, and the Panel was sensitive to the risk of negative hindsight bias in such cases in classing the report as poor vs. good. Examples of good care include prompt cessation of surgery, reassuring patients during the event if AAGA is suspected, the rigorous checking of potential causes, an early apology and offers of counselling.
- 8.40 In 69 cases there was sufficient information to assess preventability: AAGA was judged preventable in 42 (58%) of reports, possibly preventable in 13 (18%) and not preventable in 14 (19%). Preventable factors included: underdosing of induction agent by weight (often by apparently limiting drug dose to one vial rather than using a weight-based dose); underdosing of neuromuscular

blockade, making intubation more difficult; RSI used when apparently not strictly necessary, which made intubation predictably more difficult; failing to prepare additional intravenous induction drugs; and actions which increased the risk of error (such as turning vaporisers off during intubation, and/or failure to turn it on immediately after intubation). The most striking example was a patient with a previous airway problem and a past history of AAGA, where lack of adequate history-taking and airway assessment led to problems at induction which contributed to another episode of AAGA.

DISCUSSION

Dosing

- 8.41 For AAGA to occur at induction of anaesthesia means that some stimulus such as airway manipulation occurs before the patient has attained a sufficient degree of unconsciousness. The anaesthetist's dilemma is that on one hand the airway needs to be secured promptly (an example being RSI, where there is concern about aspiration; or a difficult airway where there is concern about hypoxia); but on the other hand, that the duration of unconsciousness may not endure for protracted airway management.
- 8.42 At the very least, avoidance of AAGA at induction requires some reference to minimum published doses of induction agent, and these are given below (Table 8.1). Where there is a concern about co-morbidities such as cardiovascular instability then anaesthetists may reasonably plan to administer lower than published doses, and this can be readily justified. It is, however, notable that in the cases of AAGA due to induction agent underdosing this was rarely, if ever, due to concerns over co-morbidities, nor was there clear explanation as to why such low doses had been used.

Table 8.1 Standard dose ranges for (non-obstetric) induction agents. Doses are quoted as milligram per kilogram bodyweight. The reference is in a condensed form and full references are at the end of the chapter

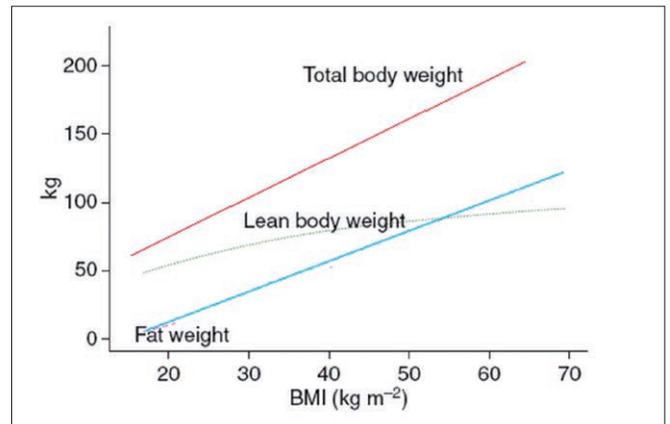
Agent	Adult dose range	Reference
Propofol	1.5-3mg/kg	Caro (2013)
Thiopental	4-6mg/kg	AnaesthesiaUK
Etomidate	0.2-0.35mg/kg	Holdcroft A et al., 1976
Ketamine	1-2mg/kg (i.v.)	Caro (2013)

- 8.43 There were a small number of instances where intentional underdosing of induction agent was used to reduce cardiovascular side effects. Provision of anaesthesia in a critically ill or unstable patient is challenging, but in principle the Panel felt that greater attention could have been paid to cardiovascular optimisation (e.g. by better use of inotropes or fluid resuscitation) rather than simple reduction in anaesthetic dosing (see also ICU Chapter 17). Where reduced dosing is deemed unavoidable, then (if possible) the higher risk of AAGA should be communicated as part of the consent process. Furthermore, the use of reduced volatile anaesthetic concentrations in the face of cardiovascular instability is one that warrants consideration of specific DOA monitoring
- 8.44 The use of low induction doses (<2mg/kg of propofol or <4mg/kg of thiopental), and the increased volume of distribution in obese patients were commented on by the Panel, who were unanimous in their view that a thiopental dose of barely 2mg/kg is inadequate in healthy patients. The duration of anaesthesia would have been prolonged by thiopental doses closer to 5 or 6mg/kg or propofol doses larger than 2mg/kg. There were numerous examples of apparent 'dosing by ampoule'; i.e. thiopental 500 mg, propofol 200mg and suxamethonium 100mg appeared commonly stated induction doses.

Obesity

- 8.45 As compared with the Activity Survey, there was an excess of obese and morbidly obese patients in Certain/probable or Possible AAGA cases at induction. Whereas obesity or morbid obesity represents ~22% of the general anaesthetic population overall, it represents 35% of AAGA cases at induction.
- 8.46 The relationship between total and lean body weight in obese patients is well known (Figure 8.3). In obese patients fat weight and lean weight do not increase in proportion as body weight increases; the former increases disproportionately.

Figure 8.3. Increase in total, lean and fat body weight with increasing body mass index; fat weight increases out of proportion to lean weight, and constitutes an ever increasing proportion of total body weight in the obese (re-drawn from Ingrande & Lemmens, 2010)



- 8.47 It is recognised that anaesthetic drugs, which are very fat soluble, distribute in the fat and therefore have reduced availability for action on target organs (i.e. the effective volumes of distribution are greater in the obese): consequently, larger doses are needed. For example, thiopental shows a ~60% lower peak plasma concentration after a single dose in obese vs. normal weight subjects (Wada et al., 1997).
- 8.48 Cardiac output is also relevant as it determines the speed of redistribution of an administered drug, and cardiac output is proportionately higher in the obese. Thus for both propofol and thiopental, volumes of distribution and clearances increase with total body weight (Ingrande & Lemmens., 2011).
- 8.49 Current recommendations are that induction drug doses should be based on lean body weight (Ingrande et al., 2011). This would result in induction doses indeed being limited to about one ampoule of propofol or thiopental even in the very obese (Figure 8.3). However, this advice also recommends that propofol infusions (in contrast to induction dosing) should better be titrated to total body weight. The recommendation of limited induction dosing appears to be based on the observation that obese subjects administered propofol based on *lean* body weight required similar doses as lean subjects given propofol based on *total* body weight using the endpoint of unresponsiveness at induction (Ingrade et al., 2011). However, it is apparent from NAP5 and other data that even when this endpoint is attained, AAGA can result with stronger stimuli (e.g. airway manipulation or instrumentation).

- 8.50 One concern about using dosing to total body weight is that it results in very high doses of induction agents that might result in extreme cardiovascular instability. In other words, the drug effects on the cardiovascular system do not parallel the effects on relevant brain systems involved in consciousness. The administered dose required to achieve suitable unconsciousness comes at the price of exaggerated haemodynamic response. However, data on whether this is actually the case are sparse and Lam et al. (2013) have found no haemodynamic instability when obese patients are administered induction doses titrated to total body weight.
- 8.51 The results of NAP5, indicate that induction is a high risk phase of anaesthesia for AAGA, and that AAGA may be more common in the obese. This raises the possibility that dosing of induction drugs based on total body weight might be a better strategy to reduce the risk of AAGA. Further research is required.

RSI and thiopental

- 8.52 The observed association of AAGA with RSI is of concern. Conventional RSI involves pre-oxygenation, application of cricoid force and a rapid induction with a pre-judged dose of induction agent and immediate administration of a rapid acting neuromuscular blocking drug. Traditionally, the neuromuscular blockade was with suxamethonium, but with rapid reversal of rocuronium now possible this may be a suitable alternative. The goal of RSI is to achieve prompt unconsciousness and paralysis, to enable immediate tracheal intubation during the limited period of safe apnoea time.
- 8.53 It is clear that elements of RSI can predispose to AAGA. In the 'classic' RSI there is no co-administration of opioid and no scope for assessing that the prejudged dose of induction agent has been adequate. The high numbers of unmodified RSI cases reported to NAP5 suggest that this technique has significant hazards.
- 8.54 The Panel therefore judged that a re-evaluation of what is regarded as a suitable RSI is warranted, and whether all of its conventional elements are necessary to achieve the goal of reducing aspiration risk. Several questions are pertinent
- Would administration of opioids (or other adjuncts) lower the risk of AAGA while still achieving the goals of RSI?
 - Is there time to assess the effect of induction agent, and provide more if needed?

- Can the administration of the rapidly acting neuromuscular blocking drug be delayed slightly to check conscious level (and/or even check the ease of bag-mask ventilation, itself a test of depth of anaesthesia)?
- Does thiopental have a place in modern anaesthetic practice, and what is that place?

- 8.55 RSI with thiopental was notably over-represented in cases reported to NAP5. A dose of thiopental of ~4mg/kg as commonly used for RSI produces a wide spread of bispectral index values (BIS) including a significant number with BIS values >70 (Sie et al., 2004). Thiopental also has a relatively short duration of action (due to rapid redistribution) and the period of unconsciousness it induces is frequently shorter than the duration of paralysis caused by suxamethonium (Heier et al., 2001). These facts, combined with the infrequent use of thiopental outside RSI (as demonstrated in the Activity Survey) raise questions over the utility of thiopental (especially without opioids) for RSI. Propofol, despite a possibly slower onset time, has a slightly longer duration of action and additional dosing is easier to judge, so may be a more rational choice to ensure unconsciousness during intubation (Sie et al., 2004).

Rapid sequence induction with thiopental was a risk factor for AAGA



Difficult airway management

- 8.56 Avoiding AAGA due to unanticipated airway problems starts with identification of patients with difficult airways at pre-operative assessment and the formulation of an appropriate strategy. While it is relatively common that a patient who is predicted to have a difficult airway turns out to be easy (i.e., the positive predictive value of current predictive tests is low) it is rare for a patient predicted to be easy in fact to be difficult (i.e. the negative predictive value

of existing tests is high; Shiga et al., 2005). There were several examples where an airway assessment had not been recorded. Failure to perform or act on airway assessment was an important feature of NAP4 (Cook et al., 2011), and it appears there is an unfortunate overlap in the consequences of this for both airway management and AAGA. It is also surprising that the clear messages of NAP4 do not yet appear to have been learnt.

- 8.57 To avoid AAGA, anaesthesia should continue during prolonged attempts at securing the airway. The alternative, in cases of difficult airway management is to wake the patient (Henderson et al., 2004). Anaesthetists should therefore adhere to prevailing airway management guidelines and make clear the path they are following in their management algorithms. Where the decision is made to wake the patient, it is logical to omit further induction or opioid drugs. On the other hand, if the airway plan

involves continuing efforts, consideration should be given to how AAGA will be avoided.

- 8.58 Relying solely on volatile agents to maintain anaesthesia during prolonged intubation is irrational, as repeated attempts at intubation do not permit time for effective bag mask ventilation. Furthermore, when intubation fails, bag mask ventilation is also much more likely to be difficult (Kheterpal et al., 2013).
- 8.59 Thus either:
- anaesthetists should manage the airway in an anaesthetised patient using a series of different management options and equipment – in which case they need to ensure the patient remains fully anaesthetised. In this scenario, continued administration of intravenous agent would seem more logical than use of volatiles since the uptake of the latter is likely impaired or absent during difficult airway management.

ANAESTHETIC COMPONENTS OF THE WHO CHECKLIST: AC-WHO

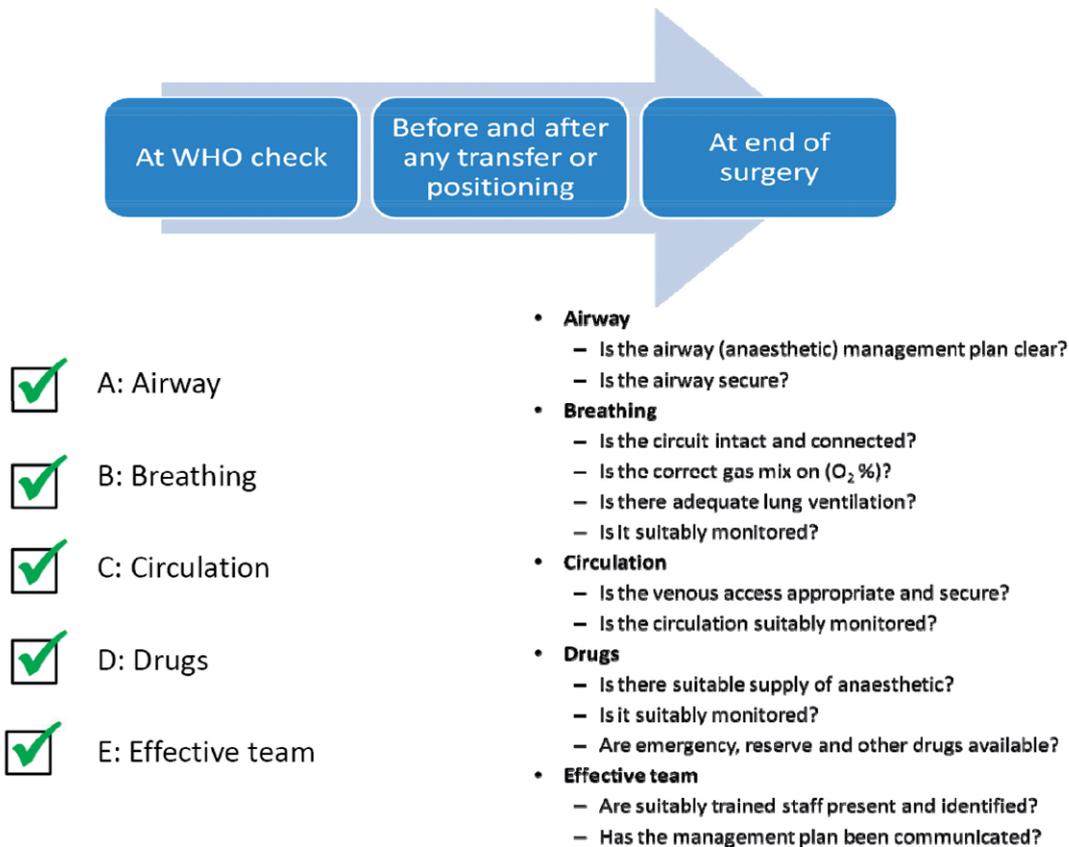


Figure 8.4. A proposed NAP5 Anaesthesia (sub)checklist of the WHO checks. This should be conducted on every movement of the patient

Or:

- (b) anaesthetists should plan a wake up strategy – in which case they need to cease airway manipulation, cease anaesthetic administration, reverse neuromuscular blockade (if possible) and awaken the patient.

8.60 Where the decision was to continue with airway management and therefore with anaesthesia, the review Panel expressed reservations about the use of thiopental. The need for dissolution creates delays in administration unless several doses are drawn up in advance, mixing may not always be perfect, and it is unclear if thiopental has any advantage over other induction drugs in this setting. These limitations should raise questions as to what extent this drug should retain a role in modern anaesthetic practice.

8.61 The Panel noticed reference to turning off vaporisers during laryngoscopy and reduction of anaesthetic room 'pollution', but considered that turning off the fresh gas would achieve the same result without the risk of AAGA because the absence of fresh gas is immediately obvious and when turned on again, the delivery of volatile would automatically be restored. Some newer anaesthetic machines incorporate a time-limited facility to pause anaesthetic agent delivery during circuit disconnections, which might reduce AAGA due to such events.

Transfer into theatre and 'mind the gap'

8.62 Transfer of the patient from anaesthetic room to theatre, where there are further distractions such as positioning is a time of increased risk for AAGA. Volatile anaesthesia needs to be discontinued in the anaesthetic room, and then restarted in theatre. We received several reports of AAGA when this process failed. Even during total intravenous anaesthesia (TIVA) some pumps become disconnected or can fail unexpectedly. Several measures might help prevent these mishaps and include:

- (a) adoption of a suitable 'checklist' to be applied after every transfer of the patient. Such a checklist might include confirmation that there is appropriate fresh gas flow, monitoring, and delivery of anaesthetic (See Figure 8.4).
- (b) using appropriately high fresh gas flows and drug concentrations (or priming the anaesthetic circuit) on re-connection to an 'empty circuit' to avoid volatile 'washout';
- (c) diligent use of low volatile or low MAC alarms
- (d) appropriate use of specific DOA monitors as monitors of anaesthetic delivery. However, over-reliance on such monitors can cause its own problems (see Chapter 20 DOA).

Movement of patients requires discontinuation of anaesthesia and monitoring. This 'gap' in delivery may lead to AAGA. A checklist may be helpful



8.63 A suitable time to conduct the proposed checklist is at the same time as the WHO safer surgery checklist. Figure 8.4 presents a very simple version that could be adopted.

8.64 Eliminating the use of anaesthetic rooms would reduce one step in the transfer of anaesthetised patients and so prevent the cases of AAGA associated with this. Their role in modern anaesthesia could usefully be re-evaluated.

8.65 The use of a 'low end-tidal' alarm for volatile agents (and perhaps also TIVA devices) should alert the anaesthetist to the fact that insufficient agent is being administered. Some newer anaesthetic machines incorporate targeted end-tidal volatile concentrations which have the potential to reduce AAGA. However, such alarms must be carefully designed not to be misleading or intrusive during planned emergence or if TIVA is planned as well as between cases.

Human factors

8.66 Distraction and fatigue were mentioned in several cases. Operating theatres are considered high-pressure environments, but this 'pressure' should be only in the sense that careful attention is needed to the management of each patient. There is no reason for the theatre environment as a whole to be an inevitable risk to patient safety. Now that there are sophisticated planning tools for surgical operating lists based on known times to perform the operations listed (Pandit & Tavare, 2011), over-booking surgical lists and consequent time pressure between cases must be regarded as an avoidable and serious safety risk (Phillips, 2010).

Patient experience

- 8.67 The sensation of paralysis is not usual for patients and hence is a very distressing experience. Even well-prepared volunteers find it unpleasant (Topulos et al., 1993). NAP5 confirms that it leads to considerable long-term problems (see Chapter 7, Patient Experience). It is therefore incumbent upon anaesthetists to avoid paralysing patients who are not unconscious, yet the Panel found several reports of elective cases where non-depolarising neuromuscular blocking drugs were administered, either concurrently with the induction agent, or before establishing sufficient levels of unconsciousness. Past reasons for this technique were to rapidly create optimal conditions for tracheal intubation when available agents (pancuronium, tubocurarine) were very slow in onset (Katz, 1971; Minsaas & Stovner, 1980). However, the more rapidly acting agents available today make this a rationale with minimal benefit and considerable risks for AAGA at induction.
- 8.68 Auditory experiences were common. Remarks of an unprofessional nature do not reassure a patient who is experiencing awareness, fear, and possibly pain. On the other hand, patients were reassured to hear that their carers had recognised the problem and were addressing it; anaesthetists may wish to consider how to communicate with patients both routinely and especially when they think may be aware.

IMPLICATIONS FOR RESEARCH

Research Implication 8.1

There is scope for investigating the utility and practicality of using DOA monitors during induction of anaesthesia, especially to assess if their use reduces the incidence of AAGA.

Research Implication 8.2

The notion of a 'rapid sequence induction' and what it means in modern anaesthetic practice could usefully be re-evaluated. Particular areas of interest include: Which induction drug should be used? Should opioids be used? In which groups of patients is RSI indicated (e.g. whether it should normally be used in, say, the obese, diabetic patients, those with reflux, etc)? Is there time to assess adequate depth of anaesthesia (or even assess mask ventilation) before administering neuromuscular blockade?

Research implication 8.3

Further *in vivo* research is needed to establish the optimum dosing regimen for obese patients, which avoids overdose while reducing the increased risk of AAGA seen in this group in NAP5.

Research Implication 8.4

'Smart' end-tidal anaesthetic concentration alarms, could usefully be further developed that alert the anaesthetist when agent levels fall too low. The technical challenge is that they should be sensibly adaptable for changing levels of agent during a case.

Research Implication 8.5

Airway management research should, amongst other things, focus on whether 'wake up' or 'keep asleep' is the optimum method of managing a failed tracheal intubation, and the implications this has for risk of AAGA.

Research Implication 8.6

Research or debate should establish whether there are benefits to using thiopental that counter the disadvantages identified in this Report.

Research Implication 8.7

Research is needed into developing an appropriate checklist for anaesthesia (perhaps incorporated into, or an extension of, the WHO checklist) to be applied after any patient transfer, to act as an *aide-memoire* to check that the key components of anaesthesia and monitoring are in place. Specifically, the utility of the checklist proposed in this NAP5 report should be assessed.

Research Implication 8.8

Research is needed into anaesthesia-specific timings (including preparation and recovery timings) that can be incorporated into surgical list planning in rational ways, to reduce all risks (including AAGA) associated with the otherwise avoidably high-pressure environment of operating theatres.

Research Implication 8.8

Research or debate should establish the benefits and risks of separate anaesthetic rooms.

RECOMMENDATIONS

RECOMMENDATION 8.1

Standard induction doses for intravenous agents should be used as a reference in dosing. Deviating greatly from these requires justification.

RECOMMENDATION 8.2

During routine induction, loss of consciousness after induction should be verified by loss of response to verbal command and simple airway manipulation (e.g. jaw thrust) before undertaking further anaesthetic interventions, including the administration of neuromuscular blocking drugs.

RECOMMENDATION 8.3

Formal airway assessment is a mandatory component of anaesthesia. If a difficult airway is anticipated, a clear management strategy must be communicated to anaesthesia assistants and to the surgical team. A patient with a difficult airway must also be considered to be at higher risk of AAGA at time of induction, and (unless it is planned to secure the airway awake or sedated) this risk should be communicated to the patient as part of the process of consent.

RECOMMENDATION 8.4

When airway management becomes prolonged, the anaesthetist should decide whether to awaken the patient or to continue to try to secure the airway; if the latter, general anaesthesia must be continued. This is more logically done by continued administration of an intravenous agent.

RECOMMENDATION 8.5

Anaesthetists should exercise caution when using thiopental for RSI. This caution should include appreciation of the need to have additional doses of an appropriate induction agent for possible use during prolonged airway management.

RECOMMENDATION 8.6

Obesity should be considered a risk factor for AAGA at induction, especially if RSI is planned. Careful dosing is required to ensure adequate but not excessive dosing.

RECOMMENDATION 8.7

Intentional underdosing of anaesthetic drugs at induction to avoid cardiovascular instability is appropriate in some circumstances, but the risk of AAGA should be considered and where it is unavoidable:

- (a) The higher risk of AAGA should be communicated to the patient.
- (b) Invasive monitoring should be considered to enable accurate early use of vasopressor drugs and adequate doses of anaesthetic agents to be administered safely.
- (c) Specific depth of anaesthesia monitoring should be considered.

RECOMMENDATION 8.8

Anaesthetists should regard transferring an anaesthetised patient from anaesthetic room to theatre (and by logical extension all patient transfers) as a period of risk for AAGA. There are several interventions that can mitigate this risk; among these is by the use of a suitable checklist as proposed by NAP5.

RECOMMENDATION 8.9

Anaesthetists and organisations should ensure that operating lists are planned in a rational manner that explicitly includes adequate time to ensure safe conduct of anaesthesia, and that will reduce pressures and scope for distractions.

RECOMMENDATION 8.10

At all times, conversation and behaviour in theatres should remain professional, including where there is a situation or concern that AAGA is a risk (e.g. RSI, prolonged intubation, transfer).

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ABCDE checklist

ANAESTHETIC COMPONENTS OF THE WHO CHECKLIST: AC-WHO

At WHO check

Before and after
any transfer or
positioning

At end of
surgery



A: Airway



B: Breathing



C: Circulation



D: Drugs



E: Effective team

- **Airway**
 - Is the airway (anaesthetic) management plan clear?
 - Is the airway secure?
- **Breathing**
 - Is the circuit intact and connected?
 - Is the correct gas mix on (O₂ %)?
 - Is there adequate lung ventilation?
 - Is it suitably monitored?
- **Circulation**
 - Is the venous access appropriate and secure?
 - Is the circulation suitably monitored?
- **Drugs**
 - Is there suitable supply of anaesthetic?
 - Is it suitably monitored?
 - Are emergency, reserve and other drugs available?
- **Effective team**
 - Are suitably trained staff present and identified?
 - Has the management plan been communicated?

A proposed NAP5 Anaesthesia (sub)checklist of the WHO checks. This should be conducted on every movement of the patient