Recommendations for standards of monitoring during anaesthesia and recovery
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This is a consensus document produced by expert members of a working party established by the Association of Anaesthetists of Great Britain & Ireland (AAGBI). It updates and replaces previous guidance published in 2007. It has been seen and approved by the Board of the AAGBI.
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1. Summary

This guideline updates and replaces the 4th edition of the AAGBI Standards of Monitoring published in 2007. The aim of this document is to provide guidance on the minimum standards for physiological monitoring of any patient undergoing anaesthesia or sedation under the care of an anaesthetist. The recommendations are primarily aimed at anaesthetists practicing in the United Kingdom and Ireland.

Minimal standards for monitoring patients during anaesthesia and in the recovery phase are included. There is also guidance on monitoring patients undergoing sedation and also during transfer of anaesthetised or sedated patients.

There are new sections discussing the role of monitoring depth of anaesthesia, neuromuscular blockade and cardiac output. The indications for end tidal carbon dioxide monitoring have been updated.

There are other published guidelines on standards of monitoring from the European Board of Anaesthesiology (2012), the American Society of Anesthesiology (2011) and the Australian and New Zealand College of Anaesthetists (2013). This 2015 5th edition of the AAGBI standards for monitoring guidelines focus on contemporary anaesthetic practice in the United Kingdom and Ireland and also discuss the current and future role and of neuromuscular, depth of anaesthesia and cardiac output monitoring. Lessons learned from the 2014 Joint Royal College of Anaesthetists and Association of Anaesthetists of Great Britain and Ireland 5th National Anaesthetic Project on accidental awareness under general anaesthesia were considered by the working party when updating this guideline.
Recommendations

The Association of Anaesthetists of Great Britain & Ireland regards it as essential that minimum standards of monitoring are adhered to whenever a patient is anaesthetised. These minimum standards should be uniform irrespective of duration, location or mode of anaesthesia.

1. The anaesthetist must be present and care for the patient throughout the conduct of an anaesthetic.*

2. Minimum monitoring devices (see 5.3) must be attached before induction of anaesthesia and their use continued until the patient has recovered from the effects of anaesthesia.

3. The same standards of monitoring apply when the anaesthetist is responsible for local/regional anaesthesia or sedative techniques.

4. A summary of information provided by all monitoring devices should be recorded on the anaesthetic record.

5. The anaesthetist must ensure that all equipment, including monitoring equipment, has been checked before use. Alarm limits for all equipment must be set appropriately before use. Audible alarms should be enabled during anaesthesia.

6. These recommendations state the monitoring devices that are essential (‘minimal’ monitoring) and those that must be immediately available during anaesthesia. If it is absolutely necessary to continue anaesthesia without an essential monitor, the anaesthetist should record the reasons in the anaesthetic record.

7. Additional monitoring may be necessary as judged appropriate by the anaesthetist.

8. Minimal monitoring should be used during the transfer of anaesthetised patients.

9. Provision, maintenance, calibration and renewal of equipment are the responsibilities of the institution in which anaesthesia is delivered.

10. All patient monitoring equipment should be checked before use in accordance with the AAGBI guideline Checking Anaesthetic Equipment 2012[1].

*In hospitals employing Physician Assistants (Anaesthesia) [PA(A)s], this responsibility may be delegated to a PA(A), supervised by a consultant anaesthetist in accordance with guidelines published by the Royal College of Anaesthetists [2].
2. Introduction

2.1 The presence of an appropriately trained and experienced anaesthetist is the main determinant of patient safety during anaesthesia. However, human error is inevitable, and many studies have shown that adverse incidents and accidents are frequently attributable, at least in part, to error by anaesthetists [3,4].

2.2 Monitoring will not prevent all adverse incidents or accidents in the peri-operative period. However, there is substantial evidence that it reduces the risks of incidents and accidents both by detecting the consequences of errors, and by giving early warning that the condition of a patient is deteriorating [5-11].

2.3 It is appropriate that the AAGBI should define the standards of monitoring for use by anaesthetists in the United Kingdom and Ireland. Newer monitoring modalities such as derived EEG depth of anaesthesia (DOA) and cardiac output monitors are not established as routine and the working party considered their place in contemporary anaesthesia practice in Appendices 1 and 2.
3. The anaesthetist's presence during anaesthesia

3.1 An anaesthetist of appropriate experience, or fully trained PA(A) under the supervision of a consultant anaesthetist, must be present throughout general anaesthesia, including any period of cardiopulmonary bypass. Using both clinical skills and monitoring equipment, the anaesthetist must care for the patient continuously. The same standards must apply when an anaesthetist is responsible for a local/regional anaesthetic or sedative technique for an operative procedure. When there is a known potential hazard to the anaesthetist, for example during x-ray imaging, facilities for remotely observing and monitoring the patient must be available.

3.2 Accurate records of the values determined by monitors must be kept. Minimal monitoring data (heart rate, BP, peripheral oxygen saturation, end-tidal carbon dioxide and anaesthetic vapour concentration [if volatile anaesthetic agents or nitrous oxide are used]) must be recorded at least every 5 minutes, and more frequently if the patient is clinically unstable. It is recognised that contemporaneous records may be difficult to keep in emergency circumstances but modern patient monitoring devices allow accurate records to be completed or downloaded later from stored data.

3.3 Local circumstances may dictate that handing over of responsibility for patient care under anaesthesia to another anaesthetist may be necessary. If so, a detailed handover must be delivered to the incoming anaesthetist and this should be recorded in the anaesthetic record. A handover checklist is useful, and one example of this is the ‘ABCDE’ checklist suggested in the NAP5 report [12].

3.4 Very occasionally, an anaesthetist working single-handedly may be called on to assist with or perform a brief life-saving procedure nearby. Leaving an anaesthetised patient in these circumstances is a matter for individual judgement, but another anaesthetist or trained PA(A) should be sought to continue close observation of the patient. If this is not possible in an emergency situation, a trained anaesthetic assistant must continue observation of the patient and monitoring devices. Any problems should be reported to other available medical staff in the area. Anaesthesia departments should work towards having an additional experienced anaesthetist available (e.g. a ‘Duty Consultant’) to provide cover in such situations.

3.5 Anaesthesia departments should make arrangements to allow anaesthetists working solo during long surgical procedures to be relieved by a colleague or PA(A) for meal and comfort breaks [13]. The 1998 European Working Time Regulation Legislation states that an individual should have an uninterrupted break of not less than 20 minutes if the working day exceeds 6 hours [14].
4. Anaesthetic equipment

4.1 It is the responsibility of the anaesthetist to check all equipment before use, as recommended in the AAGBI guideline *Checking Anaesthetic Equipment 2012*[1]. Anaesthetists must ensure that they are familiar with all the equipment they intend to use and that they have followed any specific checking procedures recommended by individual manufacturers.

Oxygen supply

4.2 The use of an oxygen analyser with an audible alarm is essential during anaesthesia. The anaesthetist should check and set appropriate oxygen level alarm limits. The analyser must be placed in such a position that the composition of the gas mixture delivered to the patient is monitored continuously. Most modern anaesthetic machines have built-in oxygen analysers that monitor both inspired and expired oxygen concentrations.

Breathing systems

4.3 During spontaneous ventilation, observation of the reservoir bag may reveal a leak, disconnection, high pressure or abnormalities of ventilation. Continuous end-tidal carbon dioxide concentration monitoring will detect most of these problems, so this is an essential part of routine monitoring during anaesthesia. The 2011 AAGBI position statement on capnography outside the operating theatre recommended that it should be used for all unconscious anaesthetised patients regardless of the airway device used or the location of the patient [15].

Vapour analyser

4.4 The use of a vapour analyser is essential during anaesthesia whenever a volatile anaesthetic agent or nitrous oxide is in use. The end-tidal concentration should be documented on the anaesthetic record.

Infusion devices

4.5 When any component of anaesthesia (hypnotic, analgesic, neuromuscular blockade) is administered by infusion, the infusion device must be checked before use. Alarm settings (including infusion pressure alarm levels) and infusion limits must be verified and set to appropriate levels before commencing anaesthesia. It is important to verify that these drugs are delivered to the patient and it is recommended that the intravenous cannula should be visible throughout the procedure. It is recommended that infusion devices are connected to mains power whenever possible. When using a total intravenous anaesthesia technique (TIVA) with neuromuscular blockade, a DOA monitor is recommended (see sections 5.7–5.9).

Alarms

4.6 Anaesthetists must ensure that all alarms are set to appropriate values. The default alarm settings incorporated by the manufacturer are often inappropriate. During the checking procedure, the anaesthetist must review and reset the upper and lower limits as necessary. It is recommended that anaesthetic departments agree consensus based alarm limits for their monitors and ask their medical physics technicians to set these up. Audible alarms must be enabled before anaesthesia commences.

4.7 When intermittent positive pressure ventilation is used during anaesthesia, airway pressure alarms must also be used to detect high pressure within the airway and to give warning of disconnection or leaks.

4.8 Provision, maintenance, calibration and renewal of equipment are the responsibilities of the institution in which anaesthesia is delivered.

Monitor displays

4.9 Care should be taken to configure the display setup, with attention to both the size and arrangement of on-screen data with regular updating of displayed values. An appropriate automatic non-invasive blood pressure (NIBP) recording interval should be set. NIBP monitors should not continue to display readings for longer than 5 minutes to reduce the risk of an older reading being mistaken for a recent one.

4.10 Many devices used in anaesthetic practice need their own checks and monitoring. This includes monitoring the cuff pressure of tracheal tubes and cuffed supraglottic airway devices. Cuff pressure manometers should be available to avoid exceeding manufacturers’ recommended intracuff pressures which can be associated with increased patient morbidity [16].
5. Monitoring the patient

5.1 During anaesthesia the patient's physiological state and adequacy of anaesthesia need continual assessment. Monitoring devices supplement clinical observation in order to achieve this. Appropriate clinical observations may include mucosal colour, pupil size, response to surgical stimuli and movements of the chest wall and/or the reservoir bag. The anaesthetist may undertake palpation of the pulse, auscultation of breath sounds and, where appropriate, measurement of urine output and blood loss. A stethoscope must always be available.

Monitoring devices

5.2 The monitoring devices described in 5.3 are essential to the safe conduct of anaesthesia. If it is necessary to continue anaesthesia without a particular device, the anaesthetist must record the reasons for this in the anaesthetic record and only proceed where the benefits or clinical urgency outweigh the risks.

5.3 Minimal monitoring for anaesthesia

- Pulse oximeter
- NIBP
- ECG
- Inspired and expired oxygen, carbon dioxide, nitrous oxide and volatile anaesthetic agent if used (see section 4.4)
- Airway pressure
- Peripheral nerve stimulator when neuromuscular blocking drugs used (see Appendix 3)
- Temperature

5.4 Monitoring must continue until the patient has recovered from anaesthesia (see below). Anaesthesia departments must work towards providing capnography monitoring throughout the whole period of anaesthesia from induction to full recovery of consciousness as recommended by the AAGBI guideline *Immediate Post-anaesthesia Recovery 2013* [17].

During induction of anaesthesia in children and in uncooperative adults it may not be feasible to attach all monitoring before induction. In these circumstances monitoring must be attached as soon as possible.

Recovery from anaesthesia

5.5 Minimal monitoring should be maintained until the patient has recovered fully from anaesthesia. In this context, ‘recovery’ means that the patient no longer needs any form of airway support, is breathing spontaneously, alert, responding to commands and speaking. Monitoring must be maintained to enable rapid detection of airway, ventilatory and cardiovascular disturbance. The period of transfer from theatre to recovery can be a time of increased risk depending on the local geography of the theatre complex and the status of the patient. Departments should work towards providing full monitoring, including capnography in patients with a tracheal tube or supraglottic airway in situ, for these transfers. Supplemental oxygen should routinely be given to patients during transfer to the recovery room.

Minimal monitoring for recovery from anaesthesia

- Pulse oximeter
- NIBP
- ECG
- Capnography if the patient has a tracheal tube, supraglottic airway device in situ or is deeply sedated [15]
- Temperature

Additional monitoring

5.6 Some patients will require additional monitoring, for example intravascular pressures, cardiac output (Appendix 1), or biochemical or haematological variables depending on patient and surgical factors. The use of additional monitoring is at the discretion of the anaesthetist.

5.7 Use of DOA monitors, for example processed EEG monitoring, is recommended when patients are anaesthetised with total intravenous techniques and neuromuscular blocking drugs, to reduce the risk of accidental awareness during general anaesthesia (AAGA) (see Appendix 2). However, there is no compelling evidence that routine use of DOA monitoring for volatile agent-based general anaesthetics reduces the incidence of AAGA when end-tidal agent monitoring is vigilantly monitored [12,18].
Regional techniques and sedation for operative procedures

5.8 Patients must have appropriate monitoring, including [19]:

- Pulse oximeter
- NIBP
- ECG
- End-tidal carbon dioxide monitor if the patient is sedated
6. Monitoring during transfer within the hospital

6.1 It is essential that the standard of care and monitoring during transfer of patients who are anaesthetised or sedated is equivalent to that applied in the operating theatre, and that personnel with adequate knowledge and experience accompany the patient [20].

6.2 The patient should be physiologically as stable as possible for transfer. Prior to transfer, appropriate monitoring must be commenced. Use of a pre-transfer checklist is recommended [12]. Oxygen saturation and NIBP should be monitored in all patients and an ECG must be attached. Intravascular or other monitoring may be necessary in special cases. An oxygen supply sufficient to last the duration of the transfer is essential for all patients. If the patient has a tracheal tube or supraglottic airway in situ, end-tidal carbon dioxide should be monitored continuously. Airway pressure, tidal volume and respiratory rate must also be monitored when the lungs are mechanically ventilated.

6.3 Monitoring DOA is desirable when transferring sedated patients who have received neuromuscular blocking drugs, but will remain difficult until portable, battery powered DOA monitors become available.
7. Anaesthesia in locations outside the operating suite

7.1 The view of the AAGBI is that the standards of monitoring used during general and regional analgesia or sedation administered by an anaesthetist should be the same in all locations.

7.2 Anaesthesia outside the operating suite
When anaesthetists are called to administer general or regional anaesthesia and/or sedation in locations outwith the operating theatre (for example emergency department, cardiac catheter lab, radiology, electroconvulsive therapy suite, endoscopy, pain clinic, community dental sedation, critical care, delivery suite), the same minimum essential standards of monitoring already outlined in this document should apply:

- Pulse oximeter
- NIBP
- ECG
- Inspired and expired oxygen, carbon dioxide, nitrous oxide and volatile anaesthetic agent if used
- Airway pressure
- Peripheral nerve stimulator when neuromuscular blocking drugs used (see Appendix 3)
- Temperature
References


Appendix 1

Cardiac output monitors

There are a range of cardiac output monitors available, such as those estimating cardiac output from pulse pressure, carbon dioxide rebreathing, lithium dilution or oesophageal Doppler measurements; however, their routine use is uncommon. Although the literature base is large, there is little evidence that one type of monitor is superior to another. Training in the use of the technique adopted is essential. Invasive methods, such as those requiring a pulmonary artery catheter, are more accurate but, because of the small risk of serious complications associated with the use of the pulmonary artery catheter, their routine use outside of cardiac surgical centres cannot be recommended.

There are concerns about the accuracy and reliability with many cardiac output monitors. The percentage error of pulse contour analysis, oesophageal Doppler, partial carbon dioxide rebreathing, and transthoracic bio-impedance has been shown to be greater than 30%, the accepted cut-off [21]. The use of cardiac output monitoring for assessment of fluid responsiveness has been shown to be more accurate but inter-patient variability and dynamic changes in stroke volume may be significant [22].

The cardiac output monitors currently available all have advantages and disadvantages associated with their use, and the AAGBI Working Party cannot recommend one type over another.

Summary

- The pulmonary artery catheter is probably the most accurate, but less invasive monitoring has superseded its routine use outside of cardiac surgery [23].
- There is conflicting evidence that the use of cardiac output monitoring improves patient outcomes and this is an area of ongoing research.
- Echocardiography can be used to estimate cardiac output and allows cardiac function and filling status to be directly observed; however, training and experience in its use is required [24,25].
- There remains doubt about the accuracy of all other cardiac output monitoring devices currently available, and data is mostly confined to patients whose lungs are mechanically ventilated.
- The use of cardiac output monitors to assess fluid responsiveness has some evidence base.
Appendix 2

Depth of anaesthesia (DOA) monitors

EEG based DOA monitors have been recommended as an option in patients at greater risk of awareness or the adverse effects of excessively deep anaesthesia, and also in patients receiving TIVA [26]. Data on the efficacy of these devices in correctly predicting accidental awareness during general anaesthesia (AAGA) or correctly predicting an adequate level of anaesthesia, remains inconsistent and debated [27]. However, such data may provide an additional source of information on the patient’s condition.

The NAP5 project published in 2014 made a number of recommendations on risk factors for AAGA and the place of DOA monitoring [12].

- AAGA incidence was 1 in 8,000 when neuromuscular blocking drugs were used (as high as 1:670 in caesarean section) and 1 in 136,000 when they were not.
- Half of all reported cases of AAGA occurred around the time of induction of anaesthesia and transfer from anaesthetic room to the operating theatre.
- Almost 20% of cases of AAGA occurred at the time of emergence from general anaesthesia and were commonly related to inadequate reversal of neuromuscular blockade.

The AAGBI Working Party make the following recommendations

- DOA monitoring is recommended when neuromuscular blockade is used in combination with TIVA
- DOA monitoring should commence before induction and be continued until after full emergence from anaesthesia
- Transfer of patients receiving TIVA and neuromuscular blockade presents difficulties in monitoring DOA, because portable battery powered DOA monitors are not widely available. Such devices may come to the market in the future and their efficacy evaluated.
- End-tidal anaesthetic vapour monitoring is an acceptable alternative to DOA monitoring when volatile anaesthetic drugs are used.
- The isolated forearm technique (IFT), is another technique to monitor DOA [28], although experience is very limited.
Appendix 3

Monitoring of neuromuscular blockade during induction, maintenance and termination of anaesthesia

A measure of neuromuscular blockade, using a peripheral nerve stimulator, is essential for all stages of anaesthesia when neuromuscular blockade drugs are administered. This is best monitored using an objective, quantitative peripheral nerve stimulator.

There is variability in the duration of action of non-depolarising neuromuscular blocking agents. Residual neuromuscular blockade can be detected in up to 40% patients for up to 2 hours after their administration [29,30]. Patient harm may result from postoperative hypoxaemia in the post anaesthesia care unit [31] and a risk of AAGA at extubation [12].

The NAP5 project on AAGA reported on the role of neuromuscular blockade in contributing to AAGA, and how patients interpret unintended paralysis in extremely distressing ways.

- A peripheral nerve stimulator is mandatory for all patients receiving neuromuscular blockade drugs.
- Peripheral nerve stimulator monitors should be applied and used from induction until recovery.
- While a ‘simple’ peripheral nerve stimulator allows a qualitative assessment of the degree of neuromuscular blockade, the only reliable guarantee of return of safe motor function is evidence of a train of four ratio > 0.9.
- A quantitative peripheral nerve stimulator is required to accurately assess the train of four ratio [32]. Anaesthetic departments are encouraged to replace existing qualitative nerve stimulators with quantitative devices.