Checklist for draw-over anaesthetic equipment 2019

Members of the Working Party

D. Connor¹, R. Collis², E. Coley³, B. Greatorex⁴, S. Hodges⁵, J. James⁶, N. McGuire⁷, S. Mercer⁸, R. Neighbour⁹, T. Sheraton¹⁰ and I. Walker¹¹

1. Consultant Anaesthetist, Queen Alexandra Hospital, Portsmouth, UK; Defence Medical Services (co-chair)

2. Consultant Anaesthetist, University Hospital of Wales, Cardiff, UK; Past Vice President, Association of Anaesthetists (co-chair)

3. Speciality Registrar, Lothian NHS Foundation Trust, Edinburgh, UK; Defence Medical Services

4. Consultant Anaesthetist, Raigmore Hospital, Inverness, UK; previously elected member of the Association of Anaesthetists Trainee Committee

5. Consultant Anaesthetist, CoRSU Rehabilitation Hospital, Kampala, Uganda

6. Consultant Anaesthetist, Birmingham Heartlands Hospital, Birmingham, UK; Royal College of Anaesthetists

7. Clinical Director of Devices, Medicines and Healthcare products Regulatory Agency, UK

8. Consultant Anaesthetist, Aintree University Hospital, Liverpool, UK; Defence Medical Services

9. Managing Director, Diamedica UK Ltd, Devon, UK

10. Consultant Anaesthetist, Royal Gwent Hospital, Newport, Wales, UK; Council Member, Association of Anaesthetists

11. Consultant Paediatric Anaesthetist, Great Ormond Street Hospital, London, UK; Trustee, Association of Anaesthetists

Association of Anaesthetists
21 Portland Place, London, W1B 1PY
Tel: +44 (0)20 7631 1650
Email: info@anaesthetists.org
www.anaesthetists.org

Association of Anaesthetists is the brand name used to refer to both the Association of Anaesthetists of Great Britain & Ireland and its related charity, AAGBI Foundation (England & Wales no. 293575 and in Scotland no. SC040697).

This work is licensed under a Creative Commons Attribution-Non Commercial-No Derivs 4.0 International License CC BY-NC-ND
Summary

This checklist with accompanying guidance is written to ensure the correct functioning of draw-over anaesthetic equipment and is important to patient safety. The anaesthetist has a primary responsibility to understand the function of the anaesthetic equipment and check it before use. Anaesthetists should not use equipment unless they have been trained in its use and are competent to do so. A self-inflating bag should be immediately available in any location where anaesthesia is given. A two-bag test should be performed after the breathing system, vaporisers and ventilator have been individually checked. A record should be kept with the anaesthetic machine that these checks have been carried out. The ‘first user’ check, after servicing, is especially important and should be recorded.

Recommendations

1. The checklist is intended to be used by an anaesthetic practitioner trained in the use of draw-over anaesthetic equipment;

2. A full check should be undertaken at the start of every operating session;

3. Verification that the checklist has been completed and local constraints (such as electricity or oxygen supply) should be documented as part of the WHO safety briefing;

4. The short checklist is intended to be used between cases and its use documented as part of WHO safety briefing;

5. The breathing system leak tests with the two-bag test and a vaporiser leak test are an essential part of the checklist and will require training to perform the tasks correctly;

6. Children should be only anaesthetised if appropriate equipment based on the child’s size is available and training in the use of paediatric circuits undertaken by the anaesthetic practitioner.

Scope and aim

The aim of the Working Party was to develop a short practical checklist that can readily be used at the beginning and during an operating list, where draw-over anaesthetic equipment is used. In addition, a longer reference guide accompanies the checklist and provides more complete information on all aspects of the checklist.

Why was this guideline developed?

This is the first checklist to have been developed to be applicable to all settings where draw-over anaesthetic equipment may be used. The standards for checking draw-over anaesthetic equipment and other important auxiliary equipment, such as oxygen supply and suction equipment, should be the same in all settings. Three main settings where the checklist and guidance may be used are:

- Military/defence/disaster relief anaesthesia
- Anaesthesia in low and middle-income countries
- In the future it is hoped the equipment can be used in the NHS or other modern anaesthetic settings to enable training to take place prior to anaesthesia secondment*

*departments of anaesthesia wishing to approve the use of draw-over apparatus on NHS patients should give careful consideration to the governance issues related to their use in place of the standard equipment in current use
How and why does this statement differ from existing guidelines?
The checklist specifies outcomes rather than processes and covers all the equipment necessary to conduct safe anaesthesia, not just draw-over apparatus. It has been jointly written by members of the Association of Anaesthetists and UK Defence Anaesthesia in conjunction with representatives of the Royal College of Anaesthetists (RCoA), the Medicines and Healthcare products Regulatory Agency (MHRA), end-users in low resource settings, and manufacturers. It has been trialled and modified in simulator and in low resource settings.

What other guidelines and statements are available on this topic?
This is the first comprehensive checklist on draw-over anaesthetic equipment. Other guidance, information and learning resources are summarised in the references.
Introduction

A draw-over system is designed to provide anaesthesia without requiring a supply of compressed gas. Atmospheric air is used as the main carrier gas and is drawn by the patient’s inspiratory effort through the vaporiser or from the self-inflating bag or bellows in the circuit operated by the anaesthetist. The mixture is then inhaled by the patient via a non-rebreathing valve. In a draw-over system the gases move on a ‘demand-flow’ basis; this means the work of moving the gas in the patient breathing system comes from the patient’s own inspiratory effort during spontaneous breathing, or by operation of a self-inflating bag or bellows during intermittent positive pressure ventilation. Oxygen from a cylinder or concentrator can be added into a reservoir so that an air/oxygen mixture is drawn through a low resistance vaporiser, then to the patient.

The non-rebreathing patient inflating valve (e.g. Laerdal™ or Ambu™ valve) is unique to draw-over anaesthesia. It automatically allows inspiration during spontaneous breathing or lung inflation during intermittent positive pressure ventilation, preventing rebreathing and preventing air from being drawn in via the exit port during spontaneous breathing. It is essential to assemble the components of the draw-over apparatus in the correct order.

The draw-over system is different to continuous flow anaesthesia apparatus, which includes most modern workstations. In these systems, compressed gas is passed continuously through the vaporiser (usually a plenum vaporiser) and then delivered to the patient via a circle or a Mapleson breathing system.

Draw-over vaporisers are small, light, robust and easy to maintain. They are also relatively inexpensive and have a low logistic support burden. These qualities make draw-over anaesthesia ideal for use in low and middle-income countries as well as in disaster relief and military settings.

Checklist

• The content of this accompanying guidance should be used in conjunction with the two-page checklist. The headings in the text follow the headings in the checklist.
• Following the checklist will ensure all aspects of the equipment required for anaesthesia are checked and considered - including the constraints that may be present at any particular time. It is essential that these checks are part of the daily routine so that safe practice is embedded, just like the WHO Surgical Safety Checklist.
• This checklist has been designed to prompt items to be raised at the team brief at the beginning of each operating session. This highlights to the whole team any constraints that the anaesthesia practitioner may be facing.
• This guideline is not a standard of medical care. The ultimate judgement with regard to a particular clinical procedure or treatment plan should be made by the clinician in the light of the clinical data presented, the diagnostic and treatment options available, and the environmental limitations posed.
• Do full checks at the start of every operating session and further checks between cases, as described in the checklist.
• Do not use draw-over anaesthetic equipment unless you have been trained in its use.
• QR codes have been added to the checklist to allow it to be accessed along with additional material.

1. Check self-inflating bag is available
A self-inflating bag is always required as an emergency (or primary) method of ventilation.

2. Assemble equipment in accordance with instruction/diagram
There are a number of draw-over apparatuses available, with specific configurations according to their design. It is important that the manufacturer’s instructions are followed. Either the manufacturer’s instructions or a diagram specific to local configuration based upon manufacturer’s instructions should be locally produced.
**Required equipment**

- Reservoir open or closed (a closed reservoir mandates a pressure relief valve in the system)
- Supplementary oxygen
- Vaporiser (draw-over type)
- Means of ventilation
- Unidirectional valve between vaporiser and means of ventilation
- Non-rebreathing patient valve
- Minimised dead-space between patient valve and airway device

3. **Check all connections are secure**

As with any anaesthetic circuit, there can be a large number of connections in a draw-over apparatus. Each of these connections is at risk of disconnection and should be checked carefully using a ‘push and twist’ technique.

4. **Power supply**

Power supply sources may range from reliable, backed up with generator-fed uninterruptable power supply, to battery only. Power supply may be limited by a wide variety of factors (sunlight for solar, fuel for generator, predicted power outage). These should be communicated in the team brief.

5. **Oxygen supply**

All oxygen supply methods should be checked, including pipeline connections. Supplementary oxygen is required for most patients, but specifically at induction and emergence of anaesthesia. Limitations in oxygen supply should be communicated in the team brief.

- Check oxygen cylinder numbers and pressure. All cylinders should be securely seated and turned off after checking their contents
- Check oxygen concentrator according to manufacturer guidelines (if applicable). Check inlet filter for dust and clean as necessary. Switch on concentrator and check for oxygen indicator light. Set flow to 5 l.min⁻¹ and check concentrator’s oxygen concentration status indicator alarm. This should indicate oxygen concentration of above 85% within 5 min of switching on. If there are concerns about concentration, connect a calibrated oxygen concentration analyser to the oxygen outlet to confirm concentration delivery
- Check the hour clock on the concentrator to see when the machine service is due. Ensure backup oxygen and method of delivery (self-inflating bag) are available in case of power failure
- Where the concentrator is also set up to deliver air (e.g. Glostavent®), check that the air flowmeter works throughout its range

6. **Breathing system**

- System checked, patent, with no foreign objects
- Vaporisers filled with correct agent. Check the bottle where the agent was stored before filling the vaporiser and check the instruction on the vaporiser
- Perform breathing system tests
  - Correct function (two-bag test)
  - Pressure leak test
  - Confirm no volatile leak

Breathing systems should be inspected visually for correct configuration and assembly. Ensure there are no leaks or obstructions in the reservoir bags or breathing system and that they are not obstructed by foreign material [1]. Check presence of the unidirectional valve at the patient end of the circuit. Perform a ‘two-bag test’ before use, as described in ‘Breathing System Tests’ in the checklist.

Various configurations and common mistakes, problems and dangers associated with breathing systems are described in Appendix 1.

**Vaporisers**

Check that the vaporiser(s) for the required volatile agent(s) are fitted correctly within the breathing system. Ensure the vaporisers are adequately filled, but not overfilled, with the correct volatile agent** for that vaporiser and the control knobs rotate fully through the full range. Ensure the
vaporiser is not tilted and the filling port is tightly closed. Vaporisers must always be kept upright as tilting a vaporiser can result in the delivery of dangerously high concentrations of vapour. Turn off the vaporisers when not in use.

If there are limitations to volatile anaesthetic availability, this should be raised at the team brief.

**Correct volatile means the user should ensure that the volatile being used is the same as the vaporiser calibration scale label. Local solutions such as only using one type of volatile agent in any one environment are recommended where the gold standard of volatile agent monitoring is not available.

Correct function test incorporating two-bag test
- Attach the patient end of the breathing system (including mount, angle piece and filter) to a closed breathing bag
- A two-bag test should be performed after the breathing system, vaporisers and ventilator have been checked individually. See ‘Breathing System Tests’ in the checklist.
- If an adjustable pressure limiting valve is part of the apparatus, check the function of this by squeezing both bags
- To prevent intrusion of foreign bodies, breathing systems should be protected with a purpose made obturator, test lung or bag when not in use

7. Ventilator
Check the ventilator is configured correctly for its intended use, using the manufacturer’s guidelines. Ensure the ventilator tubing is securely attached. Set the controls for use and ensure adequate pressure is generated during the inspiratory phase. Confirm battery status including backup and external power supply, if available.

Check that alarms are working and correctly configured. Check that the pressure relief valve functions are correctly at the set pressure.

Configure the breathing system for controlled ventilation and turn on the ventilator to ventilate the test bag. Turn off the fresh gas flow or reduce to a minimum. Ensure ventilation is maintained. Open and close each vaporiser in turn. There should be no loss of volume in the system.

Plans for alternative ventilation can be stated at the team brief.

When using Oxford Inflating Bellows (Fig. 1) as a means of ventilation there should only be a single one-way valve between the bellows and the patient – the magnet must be ‘ON’ to disable the second valve (if the second valve on the Oxford Inflating Bellows is active along with the one-way valve at the patient end an airlock will develop in the system).

Figure 1 Oxford Inflating Bellows
8. Suction
Assemble suction apparatus as per instructions. Check it is functioning and all connections are secure; test for the rapid development of an adequate negative pressure. Confirm battery power and mains connection (if applicable).

Check the availability of backup unit, if possible. State at the team brief what your backup suction option is.

9. Scavenging
Attach passive scavenging tube
OR
Check that the absorber is connected and working

For all scavenging systems, ensure tubing is attached to the appropriate exhaust part of the breathing system or ventilator and that all the tubing is fully patent. If an active system is in use, check that the scavenging system is switched on and functioning.

If using a passive absorption system (e.g. Cardiff Aldasorber), ensure this is connected properly and weighed. Replace according to manufacturer guidelines. Externally vented passive scavenging systems should have the outlet checked.

10. Document check in the patient’s anaesthetic record
Documentation of the machine check is an important part of good record keeping.

11. Don’t forget...
• Team brief limitations of equipment/supplies/environment
• Alternate plans for oxygen/power/anaesthesia
• Self-inflating bag available
• Difficult airway equipment and plan
• Resuscitation equipment/emergency drugs

In addition to checking the system for delivering volatile anaesthesia, checking equipment and drugs for emergencies and communicating any anticipated difficulties to the team is an important part of the whole pre-operative check process.

12. Check before each case

| Monitors | • Working and configured correctly  
|          | • National minimum monitoring standards met (e.g. Association of Anaesthetists)  
|          | • Alarm limits set  
| Airway equipment | • Checked as correct and available for the case, and working  
| Breathing system | • Whole system checked, patent, with no foreign objects  
| | • Vaporisers filled with correct agent  
| Ventilator (if available) | • Working and configured correctly  
| | • Plugged in and/or battery status confirmed  
| Suction | • Confirm clean  
| | • Confirm ability to generate suction  
| Scavenging | • Scavenging tubing connected and patent along length  
| | OR  
| | • Absorber connected and working

• It is important to re-check equipment before each case to ensure the correct configuration has been re-established and that anaesthesia can safely be delivered to the next patient
• Known limitations should have been discussed at the team brief, so the checks before each case should be functional only
• Particular attention should be paid when changing between adult and paediatric patients owing to the potential for different equipment requirements, and ventilator and/or monitor settings to be altered
13. Paediatric equipment
- Equipment correctly configured for weight of child
- Correct size airway equipment available
- Specific limitations exist for draw-over in paediatrics
- Safe paediatric anaesthesia requires a supply of appropriately sized facemasks, tracheal tubes, oropharyngeal airways, laryngoscopes and intravenous cannulae, but this essential equipment may not be available [2]. This should be checked as a specific part of the checklist where paediatric patients are planned on the list. Any limitations should be clearly stated at the team brief
- Children weighing $\geq 10$ kg are able to use the draw-over circuits as described for adults, though weight appropriate smaller sized self-inflating bags are recommended
- Small children breathing spontaneously may have difficulty in generating enough inspiratory flow to produce the necessary pressure gradient across the vaporiser, which therefore fails to deliver enough anaesthetic [3]. For this reason, many anaesthetists may prefer to use the continuous flow mode or controlled ventilation for children weighing $< 10$ kg
- When using the draw-over equipment in these children, the standard breathing circuit is first removed from the vaporiser outlet and replaced by an Ayre's T-piece paediatric system (Mapleson F). However, there should still be a non-return valve between the vaporiser and the circuit. The reservoir bag is used to indicate respiratory movements during spontaneous respiration and, with the expiratory port (open end of Ayre's T-piece bag) partially occluded to facilitate controlled ventilation

Paediatric equipment - diagrams

Figure 2 Ayre’s T-piece - open reservoir

![Ayre's T-piece - open reservoir](image1)

Figure 3 Ayre’s T-piece - closed reservoir

![Ayre's T-piece - closed reservoir](image2)

An open-ended T-piece reservoir bag must not be completely occluded as this is the port for expired gases (Fig. 2). Variants of the T-piece exist with an adjustable pressure limiting valve (Fig. 3) and scavenging outlet.
This paediatric T-piece system is used with fresh gas flows of at least three times the patient’s estimated respiratory minute volume down to a minimum of 3 l.min\(^{-1}\) (though greater flows are recommended, especially in the absence of end-tidal CO\(_2\) monitoring).

If using the system in continuous flow mode, it is preferable to use a ‘high flow’ concentrator or an oxygen cylinder. Using a low fresh gas flow in continuous flow mode (i.e. 3 l.min\(^{-1}\)) in the absence of CO\(_2\) monitoring can cause problems, e.g. occlusion of the bag of the T-piece to allow ventilation of the patient and raised FiCO\(_2\). The Oxford Inflating Bellows can also be used to generate the required fresh gas flow for the T-piece [4, 5].

It is important that the whole team is briefed on specific paediatric equipment requirements and anticipated problems at the start of each list.

Further ‘how to’ information is available and referenced in the Further Resources section.

14. Breathing system tests
These should be performed after the breathing system, vaporisers and ventilator have been checked individually.

**Breathing system leak tests**

i. Correct function test (two-bag) test; with test lung or bag attached, squeeze the self-inflating bag or bellows and ensure action of test lung.

ii. Breathing system pressure test: occlude the connector that joins the breathing valve to the patient. Squeeze the bag or bellows. No air should escape.

Note: Two-bag test alone does not ensure the integrity of the draw-over breathing system and patient valves.

**Vaporiser leak tests**

iii. Pressure test: With vaporiser off, and filler cap removed, occlude the connector that joins the breathing valve to the patient. Run oxygen supplementation at 5 l.min\(^{-1}\). No gas should exit the vaporiser. Leaks are audible and a smell of volatile may be detectable.

iv. Back flow test: With vaporiser off, and filler cap removed, occlude the connector that joins the breathing valve to the patient. Squeeze the self-inflating bag or bellows. No gas should exit the vaporiser. Leaks are audible and a smell of volatile may be detectable.

Note: On completion of the vaporiser leak test it is essential that the filler cap is correctly seated and firmly closed.

**References**


Further Resources

- e-SAFE (Safer Anaesthesia From Education) has been developed and funded by the RCoA and Association as an educational tool to support anaesthetists working in resource-limited areas.
  - Theron A, Clyburn P, Fenton P. *Draw-over Anaesthesia Systems*
  - Simpson S, Wilson I. *Drawover anaesthesia review*
  - Dobson MB. *Draw-over anaesthesia Part 2 – Practical application*
- [Gradian Health Systems](#)
- [Diamedica](#)
Appendix 1 Draw-over circuits: diagrams and troubleshooting

**Figure 4** Open reservoir draw-over circuit

- The essential elements of checking this circuit are ensuring the correct directional flow of gases and the elimination of leaks.
- The oxygen supplementation tube is positioned proximal, upstream to the vaporiser, to avoid dilution of agent levels set on the vaporiser.
- The length of the reservoir tube directly affects the ability to pre-oxygenate the patient.
- There should always be a unidirectional valve between the vaporiser and the means of ventilation to ensure that gases are directed to the patient and do not return to the vaporiser.
- The patient valve should ensure that gases are directed to the patient from the vaporiser and expired gases are directed away from the patient.

**Figure 5** Closed reservoir draw-over circuit

- Adding an oxygen reservoir bag to the draw-over circuit has a number of advantages. It allows pre-oxygenation with a higher oxygen concentration and eliminates oxygen wastage through the open-ended reservoir. In addition, it allows automatic conversion to continuous flow operation - if the oxygen flow is increased beyond the patient's minute volume, the reservoir bag fills and directs a gas flow to the patient, allowing the use of the Ayre's T-piece. There must still be a unidirectional valve downstream of the vaporiser with T-piece use.
- The reservoir bag also provides an indication of breathing in a spontaneously breathing patient whose minute ventilation is less than the inflow of oxygen.

Note: if you squeeze the reservoir bag, you will simply vent its contents through the spill valve, and none will reach the patient.

**Figure 6** Modified draw-over patient valve system
• More recent developments of the draw-over circuit have removed the valve from near the patient's airway and located a modified valve system closer to the vaporiser. The main operating principle of these circuits is a means of closing the expiratory valve during the ventilation phase. This is achieved by transmitting pressure from the self-inflating bag or bellows to close the expiratory valve and allow the lungs to be ventilated. In addition to removing weight and bulk at the airway, this modification provides a number of further advantages.
• More conventional circuits such as dual limb and coaxial patient circuits can now be used, and both PEEP and scavenging are more easily applied.

**Figure 7 Tri-Service Anaesthetic Apparatus (2017 Defence Medical Services configuration)**

This vaporiser and circuit arrangement was developed by Brigadier Ivan Houghton L/RAMC (ret’d). It is designed around two Oxford Miniature Vaporisers which, though light and provide initially accurate vaporiser levels, have a number of pitfalls which create potential hazards or difficulties for all users.

**Common pitfalls**

• Awareness of anaesthetic agent levels in vaporiser due to rapid use
• Multiple connections within the breathing system means there is a high risk of disconnection
• Heavy valve/filter arrangement at patient end of circuit
• Putting supplementary oxygen connection distal to the vaporiser in the circuit can lead to dilution of the volatile
• Ensure vaporiser cap is fitted properly
• Failed removal of expired gases - especially when using PEEP
• Lack of temperature compensation can vary output during use
Safer, for everyone

Every anaesthetist aims to keep their patients safe. We aim to safeguard every anaesthetist - by educating, supporting and inspiring them throughout their career.

We represent the life-changing, life-saving profession of anaesthesia - by supporting, informing and inspiring a worldwide community of over 11,000 members.

Our work and members span the globe, yet our voice is local and personal. We stay in close contact with our members, look after their day-to-day wellbeing, and act as their champion.

Our world-class conferences, journal and online resources educate and inform, and our respected guidelines continually improve standards of patient safety.

We preserve and learn from the history of anaesthesia. We use that to inform the present, and facilitate vital research and innovation into its future.

As an independent organisation, we speak up freely and openly for the interests of anaesthetists and their patients. We influence policy, raise public awareness and are at the forefront of safer anaesthesia across the world.