Recommendations for Pre-Anesthesia Checkout Procedures (2008)
Sub-Committee of ASA Committee on Equipment and Facilities

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Guidelines for Pre-Anesthesia Checkout Procedures

Background

Improperly checking anesthesia equipment prior to use can lead to patient injury and has also been associated with an increased risk of severe postoperative morbidity and mortality.(1,2) In 1993 a pre-anesthesia checkout (PAC) was developed and widely accepted to be an important step in the process of preparing to deliver anesthesia care.(3) Despite the accepted importance of the PAC, available evidence suggests that the current version is neither well understood nor reliably utilized by anesthesia providers.(4,5,6) Furthermore, anesthesia delivery systems have evolved to the point that one checkout procedure is not applicable to all anesthesia delivery systems currently on the market. For these reasons, a new approach to the PAC has been developed. The goal was to provide guidelines applicable to all anesthesia delivery systems so that individual departments can develop a PAC that can be performed consistently and expeditiously.

General Considerations

The following document is intended to serve not as a PAC itself, but rather as a template for developing checkout procedures that are appropriate for each individual anesthesia machine design and practice setting. When using this template to develop a checkout procedure for systems that incorporate automated checkout features, items that are not evaluated by the automated checkout need to be identified, and supplemental manual checkout procedures included as needed.

Simply because an automated checkout procedure exists does not mean it can completely replace a manual checkout procedure or that it can be performed safely without adequate training and a thorough understanding of what the automated checkout accomplishes. An automated checkout procedure can be incomplete and/or misleading. For example, the leak test performed by some current automated checkouts does not test for leaks at the vaporizers. As a result, a loose vaporizer filler cap, or a leak at the vaporizer mount, could easily be missed.

Ideally automated checkout procedure should clearly reveal to the user the functions that are being checked, any deficient function that is found and recommendations to correct the problem. Documentation of the automated checkout process should preferably be in a manner that can be recorded on the anesthesia record.

Operator's manuals, which accompany anesthesia delivery systems, include extensive recommendations for equipment checkout. While these recommendations are quite extensive and typically not utilized by anesthesia providers, they are nevertheless important references for developing machine-specific and institution-specific checkout procedures.

Personnel performing the PAC

The previously accepted Anesthesia Apparatus Checkout Recommendation placed all of the responsibility for pre-use checkout on the anesthesia provider. This guideline identifies those aspects of the PAC that could be completed by a qualified anesthesia and/or biomedical technician. Utilizing technicians to perform some aspects of the PAC may improve compliance with the PAC. Steps completed by a technician may be part of the morning pre-use check or part of a procedure performed at the end of each day. Critical checkout steps (e.g. availability of backup ventilation equipment) will benefit from intentional redundancy (i.e., having more than one individual responsible for checking the equipment). **Regardless of the level of training and support by technicians, the anesthesia care provider is ultimately responsible for proper function of all equipment used to provide anesthesia care.**

Adaptation of the PAC to local needs, assignment of responsibility for the checkout procedures, and training are the responsibilities of the individual anesthesia department. Training procedures should be documented. Proper documentation should include records of completed coursework (e.g. a manufacturer course) or for in-house training, a listing of the competency items taught and records of successful completion by trainees.

Objectives for a new PAC

- Outline the essential items that need to be available and functioning properly prior to delivering every anesthetic.
- Identify the frequency with which each of the items needs to be checked.
- Suggest which items may be checked by a qualified anesthesia technician, biomedical technician or a manufacturer-certified service technician.

Basic Principles

- The anesthesia care provider is ultimately responsible for ensuring that the anesthesia equipment is safe and ready for use. This responsibility includes adequate familiarity with the equipment, following relevant local policies for performing and documenting the PAC and being knowledgeable about those procedures.
- Depending upon the staffing resources in a particular institution, anesthesia technicians and/or biomedical technicians can participate in the PAC. Biomedical technicians are often trained and certified by manufacturers to perform on-site maintenance of anesthesia delivery systems and therefore can be a useful resource for completing regular checkout procedures. Anesthesia technicians are not commonly trained to perform checkout procedures. Involving the anesthesia technicians is intended to enhance compliance with the PAC. Each department should decide whether or not the available technicians can or should be trained to assist with checkout procedures. Formal certification of anesthesia technicians by the American Society of Anesthesia Technicians and Technologists (ASATT) is

encouraged but does not necessarily guarantee familiarity with checkout procedures.

- Critical items will benefit from redundant checks to avoid errors and omissions.
- When more than one person is responsible for checking an item, all parties should perform the check if intentional redundancy is deemed important, or either party may be acceptable, depending upon the available resources.
- Whoever conducts the PAC should provide documentation of successful performance. The anesthesia provider should include this documentation on the patient chart.
- Whenever an anesthesia machine is moved to a new location, a complete beginning-of-the-day checkout should be performed.
- Automated checks should clearly distinguish the components of the delivery system that are checked automatically from those which require manual checkout.
- Ideally, the date, time, and outcome of the most recent check(s) should be recorded and the information made accessible to the user.
- Specific procedures for pre-use checkout cannot be prescribed in this document since they vary with the delivery systems. Clinicians must learn how to effectively perform the necessary pre-use check for each piece of equipment they use.
- Each department or healthcare facility should work with the manufacturer(s) of their equipment to develop pre-use checkout procedures that satisfy both the following guidelines and the needs of the local department.
- Default settings for ventilators, monitors and alarms should be checked to determine if they are appropriate
- These checkout recommendations are intended to replace the pre-existing FDA-approved Anesthesia Apparatus Checkout Recommendations. They are not intended to be a replacement for required preventive maintenance.
- The PAC is essential to safe care but should not delay initiating care if the patient needs are so urgent that time taken to complete the PAC could worsen the patient's outcome.

GUIDELINES FOR DEVELOPING INSTITUTION-SPECIFIC CHECKOUT PROCEDURES PRIOR TO ANESTHESIA DELIVERY

These guidelines describe a basic approach to checkout procedures and rationale which will ensure that these priorities are satisfied. They should be used to develop institution-specific checkout procedures designed for the equipment and resources available. (Example of institution-specific procedures for current anesthesia delivery systems are published on the same website as this document.)

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Requirements for Safe Delivery of Anesthesia Care:

- Reliable delivery of oxygen at any appropriate concentration up to 100%.
- Reliable means of positive pressure ventilation.
- Backup ventilation equipment available and functioning.
- Controlled release of positive pressure from the breathing circuit.
- Anesthesia vapor delivery (if intended as part of the anesthetic plan).
- Adequate suction.
- Means to conform to standards for patient monitoring.(7,8)

Specific Items

The following items need to be checked as part of a complete PAC. The intent is to identify what to check, the recommended frequency of checking and the individual(s) who could be responsible for the item. For these guidelines, the responsible party would fall into 1 of 4 categories: Provider, Technician, Technician or Provider, or Technician and Provider. The designation "Technician and Provider" means that the provider must perform the check whether or not it has been completed by a technician. It is not intended to make the use of technician checks mandatory. The intent is not to specify how an item needs to be checked, as the specific checkout procedure will depend upon the equipment being used.

Item #1: Verify Auxiliary Oxygen Cylinder and Self-inflating Manual Ventilation Device are Available & Functioning

Frequency: Daily.
Responsible Parties: Provider and technician.

Rationale: Failure to be able to ventilate is a major cause of morbidity and mortality related to anesthesia care. Because equipment failure with resulting inability to ventilate the patient can occur at any time, a self-inflating manual

ventilation device (eg. AMBU bag) should be present at every anesthetizing location for every case and should be checked for proper function. In addition, a source of oxygen separate from the anesthesia machine and pipeline supply, specifically an oxygen cylinder with regulator and a means to open the cylinder valve, should be immediately available and checked. After checking the cylinder pressure, it is recommended that the main cylinder valve be closed to avoid inadvertent emptying of the cylinder through a leaky or open regulator.

Item #2: Verify patient suction is adequate to clear the airway

Frequency: Prior to each use.
Responsible Parties: Provider and technician.

Rationale: Safe anesthetic care requires the immediate availability of suction to clear the airway if needed.

Item #3: Turn on anesthesia delivery system and confirm that AC power is available.

Frequency: Daily
Responsible Parties: Provider or Technician

Rationale: Anesthesia delivery systems typically function with backup battery power if AC power fails. Unless the presence of AC power is confirmed, the first obvious sign of power failure can be a complete system shutdown when the batteries can no longer power the system. Many anesthesia delivery systems have visual indicators of the power source showing the presence of both AC and battery power. These indicators should be checked and connection of the power cord to a functional AC power source should be confirmed.
Desflurane vaporizers require electrical power and recommendations for checking power to these vaporizers should also be followed.

Item #4: Verify availability of required monitors and check alarms.

Frequency: Prior to each use.
Responsible Parties: Provider or technician.

Rationale: Standards for patient monitoring during anesthesia are clearly defined. (7,8) The ability to conform to these standards should be confirmed for every anesthetic. The first step is to visually verify that the appropriate monitoring supplies (BP cuffs, oximetry probes, etc.) are available. All monitors should be turned on and proper completion of power-up self tests confirmed. Given the importance of pulse oximetry and capnography to patient safety, verifying proper function of these devices before anesthetizing the patient is essential. Capnometer function can be verified by exhaling through the breathing

circuit or gas sensor to generate a capnogram, or verifying that the patient's breathing efforts generate a capnogram before the patient is anesthetized. Visual and audible alarm signals should be generated when this is discontinued. Pulse oximeter function, including an audible alarm, can be verified by placing the sensor on a finger and observing for a proper recording. The pulse oximeter alarm can be tested by introducing motion artifact or removing the sensor. Audible alarms have also been reconfirmed as essential to patient safety by ASA, AANA, APSF and JCAHO.[i] Proper monitor functioning includes visual and audible alarm signals that function as designed.

Item #5: Verify that pressure is adequate on the spare oxygen cylinder mounted on the anesthesia machine.

Frequency: Daily
Responsible Parties: Provider and technician

Rationale: Anesthesia delivery systems rely on a supply of oxygen for various machine functions. At a minimum, the oxygen supply is used to provide oxygen to the patient. Pneumatically-powered ventilators also rely on a gas supply. Oxygen cylinder(s) should be mounted on the anesthesia delivery system and determined to have an acceptable minimum pressure. The acceptable pressure depends on the intended use, the design of the anesthesia delivery system and the availability of piped oxygen.

- Typically, an oxygen cylinder will be used if the central oxygen supply fails.
- If the cylinder is intended to be the primary source of oxygen (e.g. remote site anesthesia), then a cylinder supply sufficient to last for the entire anesthetic is required. If a pneumatically-powered ventilator that uses oxygen as its driving gas will be used, a full "E" oxygen cylinder may provide only 30 minutes of oxygen. In that case, the maximum duration of oxygen supply can be obtained from an oxygen cylinder if it is used only to provide fresh gas to the patient in conjunction with manual or spontaneous ventilation. Mechanical ventilators will consume the oxygen supply if pneumatically powered ventilators that require oxygen to power the ventilator are used Electrically-powered ventilators do not consume oxygen so that the duration of a cylinder supply will depend only on total fresh gas flow.
- The oxygen cylinder valve should be closed after it has been verified that adequate pressure is present, unless the cylinder is to be the primary source of oxygen (i.e. piped oxygen is not available). If the valve remains open and the pipeline supply should fail, the oxygen cylinder can become

[i] ASA- American Society of Anesthesiologists; AANA- American Association of Nurse Anesthetists; APSF-Anesthesia Patient Safety Foundation;JCAHO-Joint Commission on the Accreditation of Healthcare Organizations

depleted while the anesthesia provider is unaware of the oxygen supply problem.

Other gas supply cylinders (e.g. Heliox, CO_2, Air, N_2O) need to be checked only if that gas is required to provide anesthetic care.

Item #6: Verify that piped gas pressures are ≥ 50 psig.

Frequency: Daily
Responsible Parties: Provider and technician

Rationale: A minimum gas supply pressure is required for proper function of the anesthesia delivery system. Gas supplied from a central source can fail for a variety of reasons. Therefore the pressure in the piped gas supply should be checked at least once daily.

Item #7: Verify that vaporizers are adequately filled and, if applicable, that the filler ports are tightly closed.

Frequency: Prior to each use.
Responsible Parties: Provider. Technician if redundancy desired.

Rationale: If anesthetic vapor delivery is planned, an adequate supply is essential to reduce the risk of light anesthesia or recall. This is especially true if an anesthetic agent monitor with a low agent alarm is not being used. Partially open filler ports are a common cause of leaks that may not be detected if the vaporizer control dial is not open when a leak test is performed. This leak source can be minimized by tightly closing filler ports. Newer vaporizer designs have filling systems that automatically close the filler port when filling is completed. High and low anesthetic agent alarms are useful to help prevent over- or under-dosage of anesthetic vapor. Use of these alarms is encouraged and they should be set to the appropriate limits and enabled.

Item #8: Verify that there are no leaks in the gas supply lines between the flowmeters and the common gas outlet.

Frequency: Daily and whenever a vaporizer is changed.
Responsible Parties: Provider or technician.

Rationale: The gas supply in this part of the anesthesia delivery system passes through the anesthetic vaporizer(s) on most anesthesia delivery systems. In order to perform a thorough leak test, each vaporizer must be turned on individually to check for leaks at the vaporizer mount(s) or inside the vaporizer. Furthermore, some machines have a check valve between the flowmeters and the common gas outlet, requiring a negative pressure test to adequately check for leaks. Automated checkout procedures typically include a leak test but may not evaluate

leaks at the vaporizer especially if the vaporizer is not turned on during the leak test. When relying upon automated testing to evaluate the system for leaks, the automated leak test would need to be repeated for each vaporizer in place. This test should also be completed whenever a vaporizer is changed. The risk of a leak at the vaporizer depends upon the vaporizer design. Vaporizer designs where the filler port closes automatically after filling can reduce the risk of leaks.

Technicians can provide useful assistance with this aspect of the machine checkout since it can be time consuming.

Item #9: Test scavenging system function.

Frequency: Daily
Responsible Parties: Provider or Technician

Rationale: A properly functioning scavenging system prevents room contamination by anesthetic gases. Proper function depends upon correct connections between the scavenging system and the anesthesia delivery system. These connections should be checked daily by a provider or technician. Depending upon the scavenging system design, proper function may also require that the vacuum level is adequate which should also be confirmed daily. Some scavenging systems have mechanical positive and negative pressure relief valves. Positive and negative pressure relief is important to protect the patient circuit from pressure fluctuations related to the scavenging system. Proper checkout of the scavenging system should ensure that positive and negative pressure relief is functioning properly. Due to the complexity of checking for effective positive and negative pressure relief, and the variations in scavenging system design, a properly trained technician can facilitate this aspect of the checkout process.

Item #10: Calibrate, or verify calibration of, the oxygen monitor and check the low oxygen alarm.

Frequency: Daily
Responsible Parties: Provider or Technician.

Rationale: Continuous monitoring of the inspired oxygen concentration is the last line of defense against delivering hypoxic gas concentrations to the patient. The oxygen monitor is essential for detecting adulteration of the oxygen supply. Most oxygen monitors require calibration once daily, although some are self-calibrating. For self-calibrating oxygen monitors, they should be verified to read 21% when sampling room air. This is a step that is easily completed by a trained technician. When more than one oxygen monitor is present, the primary sensor which will be relied upon for oxygen monitoring should be checked.

The low oxygen concentration alarm should also be checked at this time by setting the alarm above the measured oxygen concentration and confirming that an audible alarm signal is generated.

Item #11: Verify carbon dioxide absorbent is not exhausted.

Frequency: Prior to each use
Responsible Parties: Provider or technician

Rationale: Proper function of a circle anesthesia system relies on the absorbent to remove carbon dioxide from rebreathed gas. Exhausted absorbent as indicated by the characteristic color change should be replaced. It is possible for absorbent material to lose the ability to absorb CO_2 yet the characteristic color change may be absent or difficult to see. Some newer absorbents do change color when desiccated. Capnography should be utilized for every anesthetic and, when using a circle anesthesia system, rebreathing carbon dioxide as indicated by an inspired CO_2 concentration > 0 can also indicate exhausted absorbent. (See Note 2 in Appendix)

Item #12: Breathing system pressure and leak testing.

Frequency: Prior to each use.
Responsible Parties: Provider and technician.

Rationale: The breathing system pressure and leak test should be performed with the circuit configuration to be used during anesthetic delivery. If any components of the circuit are changed after this test is completed, the test should be performed again. Although the anesthesia provider should perform this test before each use, anesthesia technicians who replace and assemble circuits can also perform this check and add redundancy to this important checkout procedure.

Proper testing will demonstrate that pressure can be developed in the breathing system during both manual and mechanical ventilation and that pressure can be relieved during manual ventilation by opening the APL valve. Automated testing is often implemented in the newer anesthesia delivery systems to evaluate the system for leaks and also to determine the compliance of the breathing system. The compliance value determined during this testing will be used to automatically adjust the volume delivered by the ventilator to maintain a constant volume delivery to the patient. It is important that the circuit configuration that is to be used be in place during the test.

Item #13: Verify that gas flows properly through the breathing circuit during both inspiration and exhalation.

Frequency: Prior to each use.
Responsible Parties: Provider and technician.

Rationale: Pressure and leak testing does not identify all obstructions in the breathing circuit or confirm proper function of the inspiratory and expiratory unidirectional valves. A test lung or second reservoir bag can be used to confirm

that flow through the circuit is unimpeded. Complete testing includes both manual and mechanical ventilation. The presence of the unidirectional valves can be assessed visually during the PAC. Proper function of these valves cannot be visually assessed since subtle valve incompetence may not be detected. Checkout procedures to identify valve incompetence which may not be visually obvious can be implemented but are typically too complex for daily testing. A trained technician can perform regular valve competence tests. (See Note 4 in Appendix) Capnography should be used during every anesthetic and the presence of carbon dioxide in the inspired gases can help to detect an incompetent valve.

Item #14: Document completion of checkout procedures.

Frequency: Prior to each use.
Responsible Parties: Provider and technician.

Rationale: Each individual responsible for checkout procedures should document completion of these procedures. Documentation gives credit for completing the job and can be helpful if an adverse event should occur. Some automated checkout systems maintain an audit trail of completed checkout procedures that are dated and timed.

Item #15: Confirm ventilator settings and evaluate readiness to deliver anesthesia care. (ANESTHESIA TIME OUT)

Frequency: Immediately prior to initiating the anesthetic.
Responsible Parties: Provider

Rationale: This step is intended to avoid errors due to production pressure or other sources of haste. The goal is to confirm that appropriate checks have been completed and that essential equipment is indeed available. The concept is analogous to the "time out" used to confirm patient identity and surgical site prior to incision. Improper ventilator settings can be harmful especially if a small patient is following a much larger patient or vice versa. Pressure limit settings (when available) should be used to prevent excessive volume delivery from improper ventilator settings.

Items to check:

- Monitors functional?
- Capnogram present?
- Oxygen saturation by pulse oximetry measured?
- Flowmeter and ventilator settings proper?
- Manual/ventilator switch set to manual?
- Vaporizer(s) adequately filled?

SUMMARY OF CHECKOUT RECOMMENDATIONS BY FREQUENCY AND RESPONSIBLE PARTY

TO BE COMPLETED DAILY

ITEM TO BE COMPLETED	Responsible Party
Item #1: **Verify Auxiliary Oxygen Cylinder and Self-inflating Manual Ventilation Device are Available & Functioning**	Provider and Tech
Item #2**: Verify patient suction is adequate to clear the airway**	Provider and Tech
Item #3: **Turn on anesthesia delivery system and confirm that ac power is available.**	Provider or Tech
Item #4**: Verify availability of required monitors, including alarms.**	Provider or Tech
Item #5**: Verify that pressure is adequate on the spare oxygen cylinder mounted on the anesthesia machine**	Provider and Tech
Item #6**: Verify that the piped gas pressures are ≥ 50 psig**	Provider and Tech
Item #7**: Verify that vaporizers are adequately filled and, if applicable, that the filler ports are tightly closed.**	Provider or Tech
Item #8: **Verify that there are no leaks in the gas supply lines between the flowmeters and the common gas outlet**	Provider or Tech
Item #9**: Test scavenging system function.**	Provider or Tech
Item #10**: Calibrate, or verify calibration of, the oxygen monitor and check the low oxygen alarm.**	Provider or Tech
Item #11**: Verify carbon dioxide absorbent is not exhausted**	Provider or Tech
Item #12**: Breathing system pressure and leak testing.**	Provider and Tech
Item #13**: Verify that gas flows properly through the breathing circuit during both inspiration and exhalation.**	Provider and Tech
Item #14**: Document completion of checkout procedures.**	Provider and Tech
Item #15**: Confirm ventilator settings and evaluate readiness to deliver anesthesia care. (ANESTHESIA TIME OUT)**	Provider

TO BE COMPLETED PRIOR TO EACH PROCEDURE

ITEM TO BE COMPLETED	Responsible Party
Item #2**: Verify patient suction is adequate to clear the airway**	Provider and Tech
Item #4**: Verify availability of required monitors, including alarms.**	Provider or Tech
Item #7**: Verify that vaporizers are adequately filled and if applicable that the filler ports are tightly closed.**	Provider
Item #11**: Verify carbon dioxide absorbent is not exhausted**	Provider or Tech
Item #12**: Breathing system pressure and leak testing.**	Provider and Tech
Item #13**: Verify that gas flows properly through the breathing circuit during both inspiration and exhalation.**	Provider and Tech
Item #14**: Document completion of checkout procedures.**	Provider and Tech
Item #15**: Confirm ventilator settings and evaluate readiness to deliver anesthesia care. (ANESTHESIA TIME OUT)**	Provider

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APPENDIX
ADDITIONAL NOTES ON PRE-ANESTHESIA CHECKOUT

NOTES

1. Testing the flowmeters: This step is present in the 1993 Checkout Recommendation and is intended to check the oxygen/nitrous oxide proportioning system. It has been eliminated from the Pre-Anesthesia Checkout in these guidelines because proper function is verified during the preventive maintenance and failures of this system in a properly maintained delivery system are rare.

2. Desiccated carbon dioxide absorbent: It has been well established that carbon dioxide absorbents which contain sodium, potassium or barium hydroxide may become dangerous when desiccated, producing carbon monoxide and/or excessive heat leading to fires. Unfortunately, it is not possible to reliably identify when the absorbent material has been desiccated. Some departments elect to change all absorbent material on Monday morning to eliminate the possibility of using absorbent exposed to continuous fresh gas flow throughout the weekend. Other departments elect to use absorbent materials that do not pose a risk when desiccated. It is important to have a strategy to prevent the hazards related to using absorbents containing the problematic hydroxides that have desiccated. There are no steps that could be included in the checkout recommendation that can reliably identify desiccated absorbent. If a department uses absorbent that may be hazardous when desiccated, it may be prudent to change the absorbent material whenever the duration of time exposure to high fresh gas flow cannot be determined and is likely to have been prolonged.
A protocol for preventing absorbent hazards should be part of every department's risk management strategy.

3. Anesthesia information systems and automated recordkeepers: These systems are being adopted by an increasing number of anesthesia departments and are the mainstay of the recordkeeping process in those departments. Reliably functioning systems is therefore important to the conduct of an anesthetic, although not essential to patient safety in the same fashion as the anesthesia delivery system and patient monitors. For departments that rely upon these systems, it would be prudent to have a protocol for checking connections and the proper functioning of the associated computers, displays and network function.

4. Testing circle system valve competence: As part of the test Item #13, (Verify that gas flows properly through the breathing circuit during both inspiration and exhalation), the inspiratory and expiratory valves are visually observed for proper cycling (opening and closing fully). Visual inspection will also detect a missing valve leaflet. Ascertaining full closure of the valve is subjective. Incompetence of the valve may also be detected during test #13 through spirometry at the expiratory limb. For expiratory valve malfunction, a spirometer with reverse flow detection will alarm when gas flows retrograde in the expiratory limb. For inspiratory valve malfunction, the measured exhaled tidal volume

will be less than the expected value. Capnography may also help to detect incompetence of the unidirectional valves. Intra-operatively, an inspiratory valve malfunction may not be indicated by an elevation of the inspired CO2 baseline. If the delivered tidal volume exceeds the volume of gas in the inspiratory limb containing CO2, rebreathing will appear on the capnogram as a gradual, instead of sharp, downstroke. An expiratory valve malfunction is indicated by an elevated CO2 baseline as there is typically a large volume of exhaled gas containing CO2 that can return to the patient.