Awareness that some diseases are transmissible has existed for centuries. Hippocrates in 450 BC used wine or boiled water to irrigate wounds and, in the second century, Galen was reported to have boiled his instruments before use. In the middle ages, people suffering with leprosy and the severely ill were isolated from the local population. However, modern infection control was only started in the 19th century as a consequence of the work of Pasteur, Lister and other pioneers.

In 1932, Waters was the first to recognize anaesthetic equipment as a vector for nosocomial pathogens. Numerous reports since then have highlighted the potential infection risk from anaesthetic and respiratory equipment. Laryngoscopes have been implicated in the nosocomial spread of *Pseudomonas aeruginosa* and methicillin-resistant *Staphylococcus aureus*. In 1996, the Association of Anaesthetists of Great Britain and Ireland reported on the risk of blood-borne virus transmission and anaesthesia. Evidence that hepatitis C may be transmitted via anaesthetic breathing circuits, as well as the emergence of multiple resistant tuberculosis, resulted in advice to use a new bacterial/viral filter between each patient and the breathing system.

More recently, the role of anaesthetic airway devices in the transmission of variant Creutzfeldt–Jakob disease (vCJD) has been considered by both the Department of Health and the Royal College of Anaesthetists.

Precautions against transmission of infection between patient and anaesthetist or between patients should be a routine part of anaesthetic practice. Compliance with local theatre infection control policies and awareness of decontamination practices with respect to re-usable anaesthetic equipment are important in minimizing the risk of cross-infection. This article provides an overview of current decontamination methods and the service cycle for decontamination of equipment is shown in Figure 1.

A glossary of terms in common use is shown in Table 1. The precise use of terms is crucial to an informed discussion on decontamination procedures.

A rational approach to decontamination

In 1968, Spaulding devised a classification scheme for the decontamination of patient care items; it was so clear and logical that it

---

**Key points**

- Anaesthetic equipment is a potential vector for transmission of disease.
- Single-use equipment should be utilized where appropriate.
- Re-usable items must be processed by a Central Sterile Supplies Department.
- The choice of decontamination method depends on the infection risk associated with the item.
- Cleaning is an essential prerequisite to equipment decontamination.

---

**Figure 1** Service cycle of medical devices.
Decontamination of anaesthetic equipment

Table 1 Glossary of terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioburden</td>
<td>The population of viable infectious agents contaminating a medical device</td>
</tr>
<tr>
<td>Cleaning</td>
<td>The physical removal of foreign material including infectious agents and organic matter. This does not necessarily destroy infectious agents</td>
</tr>
<tr>
<td>Decontamination</td>
<td>A process that removes or destroys contamination so that contaminants cannot reach a susceptible site in sufficient quantities to initiate an infection or any other harmful response. It always involves cleaning followed by disinfection and/or sterilization</td>
</tr>
<tr>
<td>Disinfection</td>
<td>A process that eliminates many or all pathogenic organisms except bacterial spores. Chemicals used to disinfect inanimate objects are called disinfectants. Chemicals used to disinfect body surfaces are termed antiseptics</td>
</tr>
<tr>
<td>High-level disinfectant</td>
<td>A chemical agent that can kill bacteria, viruses and spores. It is only sporicidal under certain conditions</td>
</tr>
<tr>
<td>Sterilization</td>
<td>A process that renders an object completely free of all viable infectious agents by eliminating all forms of microbial life</td>
</tr>
<tr>
<td>Sterile Services</td>
<td>A centralized department specifically designed to reprocess reusable medical devices and equipment</td>
</tr>
</tbody>
</table>

is still used today. The Spaulding classification divides all reusable medical devices and equipment into three categories based upon the degree of risk of infection involved with their use.

Critical items

These are items that enter sterile tissue or the vascular system and therefore pose a high risk of infection if contaminated. This category includes surgical instruments, cardiac and urinary catheters, implants and needles. It is critical that they are sterile at the time of use.

Semi-critical items

Semi-critical items are those that contact mucous membranes and non-intact skin but do not ordinarily break the blood barrier. They present an intermediate risk of infection and examples include breathing circuits, laryngoscopes, fibre-optic endoscopes and thermometers. Intact mucous membranes are generally resistant to infection by bacterial spores but susceptible to bacteria, bacilli and viruses. It follows that semi-critical items require at least high-level disinfection.

Non-critical items

Items that come into contact with healthy skin but not mucous membranes are deemed non-critical. Examples include blood pressure cuffs and pulse oximeters. Skin is an effective barrier to most microorganisms and non-critical items can be cleaned at the point of use. There is a low risk of transmitting infectious agents to patients with these items.

Cleaning

This is the most important part of the decontamination process; its primary purpose is to lower the bioburden before disinfection or sterilization. In addition, it is the method of decontamination of non-critical items.

Cleaning usually involves washing with cool water and a detergent. The water temperature should not exceed 45°C as higher temperatures may lead to coagulation of proteinacious material forming a protective layer for microorganisms. It is performed by manual or automated mechanical methods. During manual cleaning instruments should be dismantled to ensure unrestricted contact of all parts of the instrument with solution. Washing of devices should not be done in the anaesthetic room as it places theatre staff at increased infection risk and does not ensure standardized cleaning. Re-useable equipment should be sent back to the sterile supplies department (SSD) after use.

Automated methods have largely replaced manual cleaning; they are controlled processes that provide more consistent results and greater productivity. Staff are also protected from exposure to chemicals and microorganisms. Various mechanical methods exist including washer disinfectors, low temperature steam and ultrasonic baths. Ultrasonic cleaning removes material from crevices in instruments and is used once gross debris has been removed. The chamber is filled with water and detergent and transducers generate ultrasonic waves producing tiny bubbles that collapse and implode. These create a negative pressure that pulls debris away from the surface of the instrument. This process is called cavitation. Not all items tolerate ultrasonic cleaning.

Disinfection

Disinfection is accomplished with liquid chemicals or pasteurization. The degree of disinfection is dependent on the type and level of contamination, concentration and exposure time to the disinfectant, nature of the item, pH and temperature. Chemical disinfectants are capable of destroying Gram-positive and Gram-negative vegetative bacteria and enveloped viruses (also called lipophilic viruses). A few disinfectants have sporicidal activity with prolonged exposure and are called high-level disinfectants. It is this level of disinfection that is commonly used for semi-critical anaesthetic and respiratory therapy equipment. High-level disinfectants include gluteraldehyde, stabilized hydrogen peroxide, peracetic acid, chlorine and chlorine-releasing compounds. Low-level disinfectants will kill most vegetative bacteria and some viruses and fungi. Examples include alcohols, sodium hypochlorite and iodophore solutions.

Chemical disinfection

Chemical disinfection is convenient, rapid and cheap but can be toxic, flammable and corrosive or chemically incompatible with certain devices (Table 2). For example, chlorine-releasing compounds have corrosive effects and are not used on some semi-critical items. Chemical disinfection can also be affected by inappropriate storage (especially high temperatures) of the disinfectant resulting in loss of efficacy. Following disinfection,
items are rinsed with water, dried and stored in a manner that prevents recontamination.

**Pasteurization**

Pasteurization is a process that uses hot water at temperatures of 77°C for a period of 30 min to achieve intermediate-level disinfection. Bacterial spores are not killed by this method. However, there is no risk of toxic chemical residues and no need for post-processing rinsing.

**Decontamination of endoscopes**

Organisms such as *Pseudomonas*, *Klebsiella* and *Mycobacter* can be commonly transmitted by endoscopes; therefore it is important that they are thoroughly disinfected. Rigorous mechanical cleaning is essential to remove debris from all accessible channels immediately after use. The external surface should be washed and rinsed. Internal channels are brushed to loosen and remove organic debris and then flushed with detergent solution. Detachable parts of the endoscope should be removed, brushed and soaked in detergent.

Gluteraldehyde 2% is the agent of choice for high-level disinfection of endoscopes. It may be used in an automated or manual system. When using the latter, the pre-cleaned endoscope must be immersed for a minimum period of 20 min followed by thorough rinsing. Endoscopes are pressure (leak) tested to determine integrity of seals before immersion in any liquid in order to reduce the risk of damage to the head of the endoscope.

**Steam sterilization**

Steam sterilization is the recommended method for devices that can withstand the heat and moisture of the process. It is the most efficient and safest method. It is also non-toxic, non-corrosive and a rapid and fully automated process. Organisms are destroyed by denaturation and coagulation of enzymes and structural proteins within the bacterial cell. Micro-organisms are killed at a lower temperature if moist (rather than dry) heat is used. Before sterilization, items should be cleaned to reduce bioburden to the lowest possible level. After cleaning, the instruments are packaged before being loaded into the autoclave. The purpose of packaging is to permit effective sterilization and ensure sterility until the pack is opened.

The basic principle of steam sterilization is to expose the item to direct steam contact at the required temperature for the specified time. In the steam autoclave, items are heated much more rapidly than in dry heat because latent energy is released when water vapour condenses on the instrument. Temperatures >100°C are required to kill some microorganisms and increasing the pressure in the autoclave allows these temperatures to be obtained. Steam is the sterilizing agent and air in the autoclave needs to be evacuated to allow efficient steam penetration. Ideal steam for sterilization is 100% dry and saturated. Efficacy is also dependent on the time–temperature cycle. The most common combinations are sterilization temperatures of 121°C or 134°C and minimum holding times of 15 min or 3 min, respectively. The higher temperature is preferred if the device is able to tolerate it. It is important to remember that these are holding times and that the full cycle (heating up, cooling down) is much longer.

**Chemical sterilization**

Chemical sterilization is an effective alternative for items that cannot withstand steam sterilization.

**Ethylene oxide**

In the US, ethylene oxide is used commonly for the sterilization of heat- and moisture-sensitive devices. It is a colourless gas and very flammable; risks of fire are reduced by dilution with inert gases such as carbon dioxide or hydrofluorocarbons. Microbiocidal
activity is thought to be the result of alkylation of protein, DNA and RNA. Temperatures of 29–65°C are employed and cycles are 5–12 h. After sterilization, items are aerated to make them safe for personnel handling and patient use. Ethylene oxide is highly penetrative, effective and non-corrosive; it does not require high temperatures or pressures. However, the lengthy, expensive and potentially toxic nature of the process limits its use to items that cannot be steam sterilized. This process is not recommended for respiratory equipment and not used widely in the UK.

**Glutaraldehyde 2%**

Immersion in gluteraldehyde 2% is a form of sterilization and is used for optical instruments such as cytoscopes or bronchoscopes as it is non-corrosive and has no deleterious effects on lens cement. Immersion must be >10 h; less time will result in disinfection, not sterilization.

**Gas plasma sterilization**

Gas plasma sterilization is a relatively new technique which has the potential to displace ethylene oxide sterilization. Gas plasma is a highly ionized gas containing ions and free radicals capable of inactivating microorganisms. These particles can diffuse through packaging materials in the chamber and sterilize their contents. Gas plasma provides non-toxic, dry, low-temperature sterilization with a cycle time of only 75 min.

**Quality control**

Mechanical, chemical and biological indicators are used to ensure specific conditions of the sterilization process are met. They do not verify that an item is actually sterile. Mechanical controls include thermometers recording the temperature of the sterilizing cycle. Chemical controls or indicators include indicator tape, colour change cards and sealed glass tubes with pellets that melt once favourable time and temperature conditions are attained. Indicator tape should be on all packages sterilized. The stripes that appear only serve to distinguish processed from unprocessed packages. Indicators are also placed inside test packages to check performance, for example the effectiveness of steam penetration into a pack during autoclaving.

Biological indicators are the most accurate method of checking sterilization effectiveness; they contain a population of non-pathogenic spore-forming organisms that are highly heat resistant. Commercially prepared test packs are available.

**Conclusion**

There are several considerations to be made when choosing a method of decontamination. These include effectiveness and availability of the method, compatibility of the method with the device, cost and safety. Hospitals are required to have monitored decontamination procedures and tracking systems in place. Infection control guidelines for specific items of anaesthetic equipment are shown in Table 3.

### Table 3  Infection control guidelines for anaesthetic equipment

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Action</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Face masks</td>
<td>Sterilized or single patient use</td>
<td></td>
</tr>
<tr>
<td>Airways</td>
<td>Single patient use</td>
<td></td>
</tr>
<tr>
<td>Tracheal tubes</td>
<td>Single patient use</td>
<td></td>
</tr>
<tr>
<td>Laryngeal masks</td>
<td>Sterilized or single patient use</td>
<td>40 uses maximum’</td>
</tr>
<tr>
<td>Catheter mounts/angle pieces</td>
<td>Single patient use</td>
<td></td>
</tr>
<tr>
<td>Breathing systems</td>
<td>Disposable</td>
<td>Change weekly provided new bacterial/viral filter used with every patient; change sooner if visibly contaminated or after highly infectious case</td>
</tr>
<tr>
<td>Bougies</td>
<td>High-level disinfected or single use</td>
<td>5 uses maximum’</td>
</tr>
<tr>
<td>Laryngoscope blades</td>
<td>Sterilized or single patient use</td>
<td>Laryngoscope handles should also be regularly disinfected</td>
</tr>
<tr>
<td>Oxygen mask and tubing</td>
<td>Single patient use</td>
<td></td>
</tr>
<tr>
<td>Temperature probes</td>
<td>Single patient use</td>
<td></td>
</tr>
<tr>
<td>BP cuffs/pulse oximeters</td>
<td>Cleaned</td>
<td>These items should be cleaned at the end of the day or whenever visibly contaminated</td>
</tr>
<tr>
<td>Stethoscopes</td>
<td>Cleaned</td>
<td></td>
</tr>
<tr>
<td>Resuscitation equipment</td>
<td>Sterilized or single patient use</td>
<td></td>
</tr>
</tbody>
</table>

‘Manufacturers’ recommendations.

Much is still not understood about the infectivity of the prion protein and, in patients with suspected vCJD, single-use instruments should be used provided they do not compromise clinical outcome.

**Key references**


See multiple choice questions 72–74.