

Oxidative Chemistries



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Oxidative Chemistries

Study Guide #17

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Description of the study guide topic

Many of today's surgical instruments and devices are heat-sensitive and therefore require some type of low-temperature processing method. Historically, there have been few available reprocessing methods for these delicate devices.

Compounds called oxidative chemistries have been gaining popularity for low-temperature processing because they give us highly effective options for delivering optimal patient care while providing safety on many levels. It is important for healthcare professionals to compare all options for low-temperature reprocessing and to understand the chemistry, mode of action, efficacy, indications for use, process monitoring and environmental safety of oxidative chemistries in order to make the best use of them in healthcare environments.

Overall purpose of the study guide

This study guide will present a comparison among available reprocessing methods for heat-sensitive equipment with a focus on oxidative chemistries.

Objective:

Upon completion of this study guide program, the participant should be able to:

1. Describe the available low-temperature processing methods for endoscopic and minimally invasive surgical devices.
2. Review the advantages for processing endoscopes using oxidative chemistries.
3. List the process of biofilm formation in endoscopes and automated processors.

Intended Audience

This study guide is a self-study program intended for use by perioperative nurses, surgical technologists, endoscopy suite nurses, central service and sterile processing staff members, infection prevention practitioners and other healthcare professionals

Introduction

Flexible endoscopes were first developed and brought to market back in the late 1950s and early 1960s. At that time, they were strictly a diagnostic tool. Today, in addition to diagnostic testing, many therapeutic procedures are performed using flexible endoscopes.

Because the scopes are fragile and made with some heat-sensitive materials, they often cannot withstand steam sterilization and require low-temperature processing. Low-temperature sterilization involves temperatures of 60 degrees Celsius or less.

Historically, reprocessing methods have been very limited for these types of instruments. To achieve sterilization prior to 1988, there was essentially only one method - sterilizing with ethylene oxide gas (EO). This method required a long cycle time and as a result, each EO-processed scope could only be used one time per day. The only other low-temperature processing alternative in common use was high-level disinfection (HLD) with glutaraldehyde, a dialdehyde compound. Most facilities had a limited number of scopes in inventory, so the scopes needed to be processed quickly to meet the doctors' procedure schedules. Since the scopes were used at that time as a diagnostic tool, they were classified as semi-critical devices. HLD was recognized as an accepted practice by the FDA and soon gained popularity as a quick way to process endoscopic devices.

In addition, as endoscopy departments grew and case loads increased. To speed up turnaround time, instruments that had

previously been processed in the Central Services (CS) Department were now being processed right in the endoscopy suite. This development increased demands on the endoscopy staff and required them to be more highly trained. It also exposed them to chemicals that they weren't previously exposed to. For patients, it sometimes resulted in a dual standard of care since the scopes provided by the CS Department were sterilized and the scopes provided by the Endoscopy Department were put through a HLD process.

The Nature of Disinfectants

All disinfectants are very powerful killing agents. When they are used properly, these chemistries are essential to optimal patient care. However, when used too frequently or improperly, they can be hazardous and toxic to humans, and in some cases, can even be carcinogenic. Not all disinfectants present the same risk. For example, oxidative chemistries can be readily neutralized and don't present the same toxic risks as the more stable dialdehydes.

According to Dr. William Rutala, Professor, University of North Carolina School of Medicine, the ideal disinfectant would:

- > Provide high efficacy: high-level disinfection plus sporicidal activity
- > Exhibit rapid activity
- > Assure material compatibility
- > Be non-toxic
- > Be non-staining
- > Provide monitoring capability
- > Be easy to use
- > Allow prolonged reuse
- > Provide long shelf life without loss of activity
- > Assure unrestricted disposal
- > Be cost-effective

Dialdehydes

The dialdehyde classification includes glutaraldehyde and orthophthalaldehyde, which have similar traits and safety requirements. Historically, glutaraldehyde was used for a process nicknamed "cold sterilization," which was a low-temperature liquid sterilization process requiring a long exposure time. However, glutaraldehyde has also been used as a HLD method within shorter exposure times.

Glutaraldehyde gained popularity for HLD because of its cost-effectiveness, but it was not without drawbacks. Healthcare workers started to develop reactions to it because of its toxicity. The fumes were not always properly vented and caused headaches and asthma. When handled improperly or with inappropriate gloves, the glutaraldehyde caused dermatitis and skin problems (dialdehydes do not impact nitrile or butyl rubber gloves, but they do break down latex exam gloves and are then absorbed into the skin). Additionally, some patients developed glutaraldehyde-induced colitis as a result of improper rinsing of glutaraldehyde-processed scopes (Fukunaga et al., 2000; Stein et al., 2001; Schuster, 2003).

Another concern was that the glutaraldehyde process was being used for high-level disinfection rather than sterilization. It is important to note at this point that processed items are either **sterile** or **not sterile**; there is no in-between. Furthermore, when an instrument

*In 1988, STERIS introduced the first low-temperature sterilization system:

processed by HLD is placed on a sterile back table, that back table is no longer considered sterile, but now has HLD status. Healthcare professionals began to have valid concerns about whether these instruments should be used on patients who require sterile instruments. According to Dr. Earl Spaulding, instruments that are used on normally sterile areas of the body (the vascular system and non-intact mucous membranes) are deemed to be “critical items” and should be sterilized (Spaulding, 1972). An instrument that has undergone HLD only meets the criteria for “semi-critical” status and really shouldn’t be used in a sterile field.

The next step in the reprocessing cycle is to determine what is appropriate - disinfection or sterilization. Dr. Spaulding developed a classification system for patient care items based on the risk that is present when the instrument is used. Spaulding’s classifications are as follows:

- > Critical items - Devices that enter sterile tissue or the vascular system. Examples of critical devices are hemostats, scissors, snares, sphincterotomes, injectors, or biopsy forceps. These items need to be sterilized.
- > Semi-critical items - Devices and equipment that come in contact with intact mucous membranes. An example of a semi-critical device is an endoscope that is used for diagnosing a condition. The preferable choice of reprocessing is sterilization but high-level disinfection is acceptable.
- > Non-critical items - Devices and equipment that come in contact with intact skin but not with mucous membranes. Examples of non-critical items are bed pans, blood pressure cuffs, and stethoscopes. The choice of reprocessing is decontamination.

As the patient and staff safety risks and environmental hazards were being identified, people began looking for alternatives to glutaraldehyde. In 2000, a new dialdehyde compound, orthophthalaldehyde, was introduced to the market. This product was promoted as being glutaraldehyde-free and many people felt that this was the answer they were looking for. Shortly after it was introduced, Great Britain banned the use of glutaraldehyde due to safety and efficacy concerns as people switched to orthophthalaldehyde. After orthophthalaldehyde was on the market for a few years, it also started to develop a problematic health and safety history.

In 2004, orthophthalaldehyde was linked to anaphylactic reactions in bladder tumor patients and was not recommended for patients suspected to have bladder tumors. After undergoing cystoscopy procedures, some patients with allergic reactions also had foreskin edema. There was a risk of allergic reactions when the orthophthalaldehyde-processed cystoscope came into contact with the urethral mucosa. As a result of these findings, some facilities have discontinued the use of orthophthalaldehyde for their urology patients.

Many disinfectants, including dialdehydes, are chemistries that have a reuse period. Because the same solution is used over and over, the potency of the solution decreases as it becomes diluted with water and debris. The manufacturers of these products recommend that the minimal effective concentration (MEC) be checked prior to each use by using a chemical dipstick to check the potency. However, many facilities only check it at the beginning of the day. If the MEC reaches substandard levels at some point during that day, it wouldn’t be identified until the next day when it is checked again. There is no way at that point to know which patients had scopes that were properly disinfected and which patients did not receive adequate disinfection for their scopes. This raises concerns regarding patient notification.

Dialdehydes are also known to be protein binders. This means that if a scope is not meticulously cleaned and any protein residue from a patient remains in the scope, this protein could become “fixed” or attached to the scope when it is reprocessed with a dialdehyde solution. When this scope is used for the next patient, he or she could be inoculated with

protein from the previous patient and therefore be at risk for infection. This fixed protein will also act an attachment site for bacteria and fungi during subsequent use.

Dialdehydes, which have fixative properties, can also facilitate the build-up of residue inside the scope. Figure 1 shows an actual biopsy channel from a scope that was reprocessed with glutaraldehyde. This coating can mask problems with the scope, so a scope that should be turned in for repairs is still in use. This can eventually lead to a more expensive scope repair or potentially result in negative patient outcomes.

Figure 1

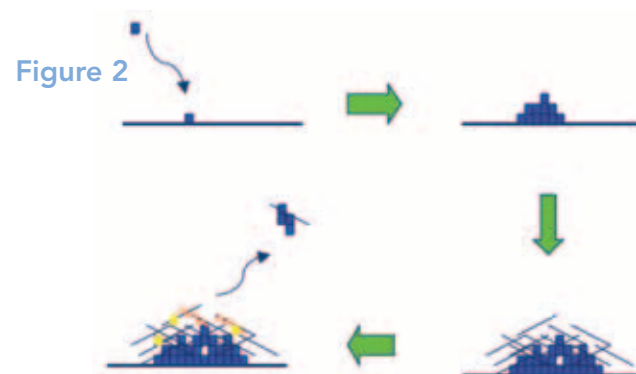


The fixative property of dialdehydes has also been linked to issues with biofilms in processors and scopes.

What is a biofilm and how does it form?

The term “biofilm” is used to describe a structured community of cells in an aquatic environment enclosed in a self-produced polymeric matrix that attaches to an object such as a pipe, sediment deposit, or any surface (either inert or living). Another name for biofilm growth on a surface is “slime.”

The existence of biofilms has been recognized for years. Their development is typically a progression through four functional states, as seen in Figure 2.



- > Attachment: freely mobile, known as “planktonic” bacteria, recognize and attach to a surface
- > Aggregation: once attached, the bacteria aggregate and form into micro-colonies
- > Formation: chemical signals are then released within and between micro-colonies and biofilm formation, including what is known as exopolysaccharide encasement, begins
- > Detachment: once biofilm is formed, a natural pattern of programmed detachment of planktonic bacteria occurs and the process starts over in a new location

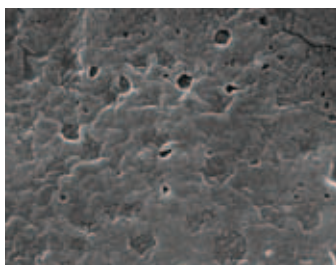
The first step in the process of microbial colonization on a surface is attachment. Under suitable conditions, organic matter attaches and begins to accumulate on a surface, forming a biofilm that is then colonized by bacteria. The bacteria develop and begin to produce and

excrete substances that form the polysaccharide matrix, which gives the slimy nature to the biofilm. The polysaccharide matrix consists of organic polymers that are referred to as extracellular polymeric substances. This matrix can protect the bacteria from the environment (including the effects of disinfectants).

The different species of bacteria associated with the formation of biofilm include certain streptococci, staphylococci, enterococci *Pseudomonas* species and enteric bacteria. Some biofilms involve a single bacterial species, while others involve multiple bacterial species and sometimes fungi.

Biofilms are sometimes formed as continuous, evenly distributed layers, but are often quite patchy in appearance. As the slime layer thickens, micro-environmental changes take place within the biofilm as a result of the activities of the bacteria. Biofilms in water distribution systems are thin, reaching maximum thicknesses of perhaps a few hundred micrometers. In addition, the film often contains organic and inorganic debris from external sources. Figure 3 shows an actual microscopic photo of a biofilm.

Figure 3



Biofilms essentially become a reservoir for bacterial growth and have been implicated in healthcare associated infections (HAI) due to contaminated washer-disinfectors and medical devices. It is important to understand that freely floating planktonic bacteria, unshielded by protective excretions, are generally susceptible to antibodies and antibiotics and can be treated in humans. However, once encased in a biofilm, the bacteria are generally not susceptible to either antibodies or antibiotics, making them difficult or impossible to treat with antimicrobial agents.

Mycobacterium chelonae is also being isolated with increasing frequency from washer-disinfectors and the endoscopes processed in them. This has, on occasion, led to misdiagnosis and iatrogenic infections. Recent reports suggest that using 2% glutaraldehyde on a regular basis to disinfect machines may have resulted in the selection and growth of strains of *Mycobacterium chelonae*, possibly in biofilm, that have significantly decreasing susceptibility to glutaraldehyde (Griffiths et al., 1997).

It is preferable to use washer-disinfectant systems in which all fluid pathways, including those for delivering rinse water, are disinfected with an appropriate agent during each cycle. If this is not possible, then daily cleaning and disinfection of the system and regular system maintenance should prevent biofilm formation and contamination with disinfectant-resistant strains of mycobacteria. In addition to the automated disinfection process, the use of sterile or bacteria-free (filtered <0.45 micron) water is essential for bronchoscopes and all invasive endoscopes.

There are several strategies that can be employed to combat biofilms. In theory, prevention can be achieved by interfering with any of the four phases (attachment, aggregation/micro-colonization, biofilm formation, and detachment/dispersal). In reality, the key clinical approaches now in place center on the prevention of bacterial attachment and on the limitation of detachment/dispersal.

It is interesting to note in Figure 4, in an experiment that investigated the effects of various disinfectants on biofilm disinfection and removal, that both glutaraldehyde and orthophthalaldehyde are initially effective in reducing biofilms. Over time, dialdehydes

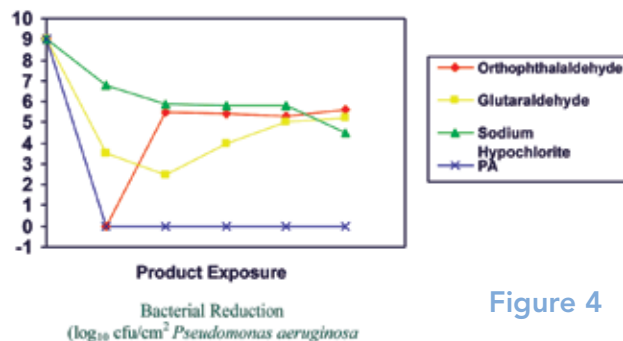


Figure 4

actually support biofilm growth. The only chemistry that actually inhibited biofilm development was peracetic acid (PA), a particularly powerful oxidative agent

Ethylene Oxide Sterilization

Ethylene oxide (EO) has been used for a very long time in agriculture and industry. Its healthcare applications account for only a small portion of its use. Prior to 1988, when the first low-temperature liquid chemical sterile processing system was introduced, EO was really the only option for low temperature sterilization, and because of its availability, many of the heat-sensitive instruments we use today were able to be developed.

Because tanks of 100% EO can be somewhat unstable and combustible, chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) were added to it to make it more stable. However, the use of CFC and HCFC had to be discontinued because these compounds were depleting the earth's ozone layer. Fortunately, EO can now be safely used in its pure form due to the development of disposable canisters that are much more stable and are safer to use.

The greatest limiting factor for EO processes is the length of their cycles, which require long aeration times. Typically, a total cycle will last 14 hours or more. This puts pressure on the staff as well as on the budget, since more instruments must be purchased to meet the demands of the procedure schedule.

Oxidation and Oxidative Chemistries

Oxidation is the loss of an electron by a molecule, atom, or ion. So, oxidizing agents will do one of three things in a reaction: contribute oxygen, extract hydrogen, or extract electrons.

Oxidizing agents are agents that remove electrons from the other substance and are thus reduced themselves. A molecule that is reduced gains electrons; a molecule that is oxidized loses electrons.

We often associate the term "oxidation" with rusting. While rust can be a result of oxidation with some materials (with iron to form iron oxide), not all materials that interact with oxygen result in rust; it depends on the material and the particular oxidative chemistry. For example, carbon steel, like the type used to build cars, can rust over time. However, stainless steel surgical instruments are manufactured to be rust-resistant.

Oxidative chemistries include a class of compounds referred to as peroxygen compounds. These compounds contain an additional atom of oxygen bound to oxygen.

Oxidative chemistries are simply products that use oxidation to interrupt cellular functions. The reaction occurs with macromolecules (proteins, carbohydrates, lipids and nucleic acids) within the microorganism. The chemical formulation and the physical state of the process can determine what type of access the chemistry has to these molecules. Once these reactions occur, the microorganism can't sustain life and is killed. The mechanism of action is non-specific, which means that macromolecule structure is no longer intact and the cell ceases to function.

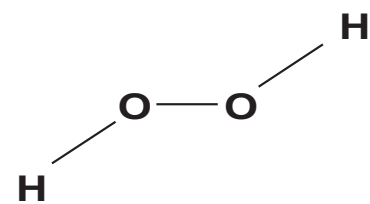
Oxidative chemistries exhibit excellent cleaning, disinfecting and sterilizing properties and are generally non-toxic. We can probably think of products we use in our home that tout the cleaning properties of oxidation (Oxyclean®, for example). Oxygen is one of the by-products of these household cleaners.

However, not all oxidative chemistries can be used to process flexible scopes. This is because of the way scopes are constructed and the physical formulation (or physical state) of the oxidative agent. Liquids seem to work better than gas or plasma.

A simple example of an oxidative chemistry is hydrogen peroxide. We are all familiar with what happens when you put hydrogen peroxide on a wound. Oxidation occurs as it cleanses the wound and bubbling or foam develops as oxygen is released.

Hydrogen peroxide is a very good oxidative agent and can achieve either high-level disinfection or sterilization. However, hydrogen peroxide-based chemistries in the past typically have been hard on many flexible endoscope materials. Historically, bronchoscopes, cystoscopes, rigid telescopes, fiber optic light cables, batteries and cameras were difficult to sterilize because they cannot withstand the heat and moisture

Figure 5



Hydrogen Peroxide

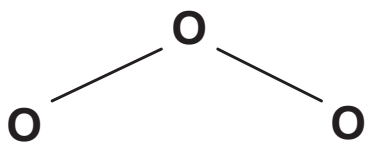
of steam.

There is an automated processor that uses hydrogen peroxide in a condensed gas form in combination with a plasma process that achieves sterilization. However, because of the physics of the process and the structure of the scopes, it is not possible to sterilize long, complex lumens, but can sterilize simple, single-lumen scopes, specifically bronchoscopes and cystoscopes.

In addition to being a high-level disinfectant and sterilant, hydrogen peroxide can be an excellent antiseptic agent and can also be used for cleaning and surface decontamination. A dry vapor form of hydrogen peroxide called Vaporized Hydrogen Peroxide (VHP®) has been used for decades for sterilization during pharmaceutical medical device production, and in recent years to disinfect enclosed spaces such as buildings and laboratories. VHP technology is currently being offered by STERIS Corporation for its application in a variety of spaces such as ambulances, aircraft and hospital rooms.

Ozone has also been used as a disinfection and sterilization chemistry. It is a broad-spectrum antimicrobial agent that uses oxygen, water and electricity to generate ozone. Ozone is a very reactive oxidative gas that quickly and effectively deactivates microorganisms by denaturing cell membranes. It is also environmentally friendly since oxygen and low humidity water vapor are the by-products of this process. Because it is a

Figure 6

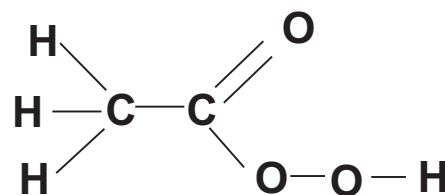


Ozone

rapidly oxidizing agent, it can be harsh on some materials used in flexible endoscopes.

Peracetic acid (PA) is an oxidizing agent that is an effective biocide at low temperatures. Its chemical formula is acetic acid (vinegar) plus

Figure 7



Peracetic Acid

an extra oxygen atom. This extra oxygen atom is highly reactive and interacts with most cellular components to cause cell death.

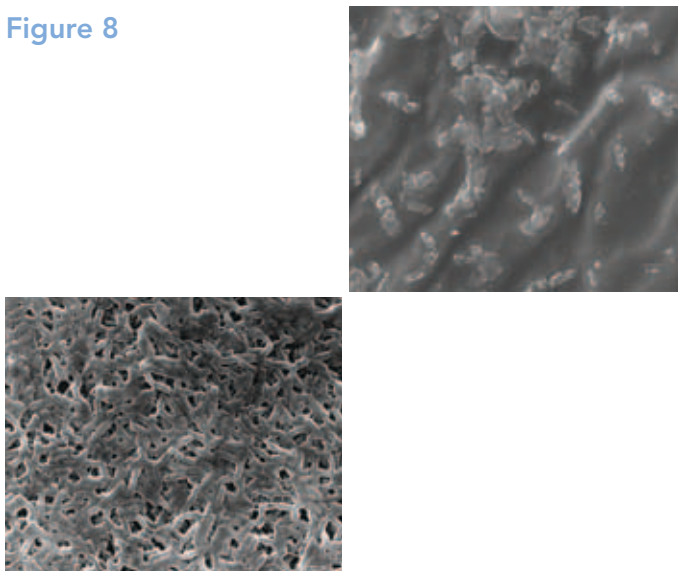
PA at relatively low concentrations (less than 1%) is an effective germicidal agent and more potent than hydrogen peroxide. Combined with proper buffers and anti-corrosives it can safely disinfect or sterilize flexible scopes and other medical devices. It is tuberculocidal, fungicidal, virucidal, bactericidal and sporicidal. It can be used for sterilization or HLD, depending on the exposure time, formulation or labeled use.

In addition to its broad spectrum of antimicrobial activity, PA is highly water-soluble and free-rinsing. As with the other oxidizing agents, it is environmentally friendly and has no harmful by-products (acetic acid, water, and oxygen). Unlike other oxidative chemistries, it is also very effective in the presence of organic matter at low temperatures. In fact, studies indicate that peracetic acid is superior to glutaraldehyde in the presence of organic matter. This is an important point to consider when contemplating the difficulty of ensuring “meticulous” cleaning of every endoscope, by every person processing scopes, after every procedure. Because of its safety, efficacy and ease of use, there has been a sharp increase in the use of peracetic acid-based chemistries in recent years.

Peracetic-acid-based low-temperature liquid chemical sterile processing systems have been in use since 1988. They provide a rapid, safe low-temperature sterile process for immersible devices and are intended for just-in-time processing of scopes, instruments and devices so they can be turned around quickly at the site of use as needed. One of the advantages of these types of systems is that their sterile processing cycle is complete in about 30 minutes.

Peracetic acid is also an effective agent against biofilms. Figure 8 below

Figure 8



shows biofilm build-up (left) and biofilm being broken down after exposure to a peracetic acid-based chemistry (right). These photos illustrate how PA not only stops the growth of biofilm, but actually can physically remove it, which is supported in the graph in Figure 4.

Figure 9

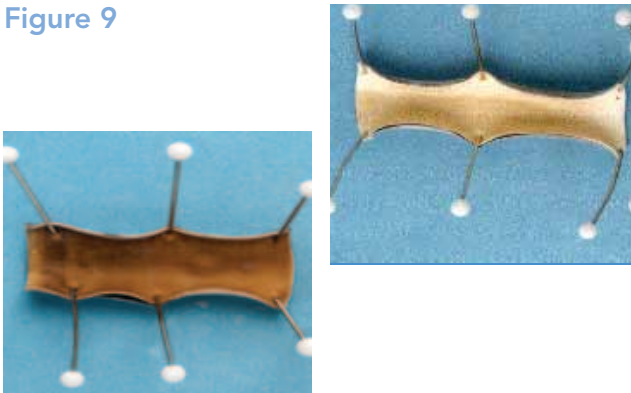


Figure 9 illustrates how peracetic acid can actually clean the inside of a lumen through oxidative action. The picture on the left is the biopsy channel from a scope that had been processed many times in glutaraldehyde. The picture on the right shows the same biopsy channel after being processed five times in a SYSTEM 1® Sterile Processing System. The oxidative nature of the peracetic acid was actually found to break down the old layers of residue and remove them from the channel.

Today's Trends

The demand for less invasive surgical procedures continues to change the nature of surgery. The trend from traditional surgical operations to minimally invasive surgery (MIS) has been dramatic over the past 10-15 years. Today, more than 20 million people a year undergo rigid and flexible endoscopic procedures.

Increased demand for MIS has led to the development of more sophisticated, expensive and delicate devices that are heat-sensitive. The need for rapid turnover, along with the budgetary need to limit device inventory, presents reprocessing challenges for these complex reusable devices.

The two primary chemistries used to reprocess endoscopes today are dialdehydes and oxidative chemistries. Use of oxidative processes has dramatically increased in recent years as the technology gains acceptance and credibility. Also, as people gain a greater understanding of oxidative chemistries, they are becoming the preferred method for reprocessing.

The number of procedures continues to rise, but because of the cost of new scopes, inventory often remains the same. This combination of more patients treated with the same number of scopes increases the use and damage to these scopes, and thus increases scope repair costs.

Tight budgets can also lead to tight staffing. As people work harder to accomplish more with less, shortcuts are often taken and steps skipped during reprocessing to save time. As pressures mount on the staff to keep up with an increasing patient load and to keep costs down, they continue to seek the most efficient ways to reprocess their scopes.

Because people are looking for greater efficiencies, the two main trends in endoscopy today are:

- > **A shift from manual to automated processing.** This takes much of the “human factor” and variability out of the process, ensures a validated process that has predictable outcomes and goes a long way to

reducing scope damage and associated repair costs. It also frees more of the staff to care for patients or to accomplish other tasks. These benefits are critical for facilities that are trying to get by with minimum staffing, but are also appreciated by facilities with adequate staff.

- > **A shift from dialdehydes to oxidative chemistries.** **Safety, efficacy, and efficiency** are the three priorities when choosing a decontamination or sterilization process:
- > Safety of the chemicals and process for the patients, healthcare staff, instruments, and environment
- > Efficacy of the chemistries and the process, including the ability to prevent biofilm formation in scope processors
- > Efficiency of the process (efficiency, although critical in today's fast-paced environment, should be considered only after the other two priorities have been satisfied)

Oxidative chemistries meet all three of these requirements, and are thus being chosen more frequently.

Summary

Oxidative chemistries are becoming more popular because of their many advantages over the other available low-temperature processing options for diagnostic and therapeutic endoscopes. They are versatile, highly effective chemistries that exhibit outstanding antimicrobial activity in a relatively short time and at low temperatures. They can be formulated into different physical states offering a wide-variety of options for the sterilization of many different types of instruments and materials. They discourage the build-up of biofilm. Most importantly, they are safe for patients, safe for healthcare personnel to use, safe for expensive instruments and safe for our environment.

As we look at the future, we can expect more disinfection and sterilization technologies to be developed that use oxidative agents. We can expect to see improved formulations that will make these chemistries even more versatile. We can also expect new and even easier ways to use these exciting compounds.

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Glossary

Biofilm

A layer of microorganisms in an aquatic environment held together in a polymeric matrix attached to a substratum such as a pipe, sediment deposit or any surface.

Critical Item

Instruments or other objects that are introduced directly into the human body, either into or in contact with the bloodstream or normally sterile areas of the body.

Disinfection

A process that destroys some forms of microorganisms, excluding bacterial spores.

High-Level Disinfection

A process that destroys all microorganisms, with the exception of high numbers of bacterial spores. High-level disinfectants are capable of inactivating hepatitis B virus, human immunodeficiency virus, and mycobacterium tuberculosis.

Microorganism

An organism that is too small to be seen with the naked eye and requires a microscope; bacteria, viruses, fungi and protozoa are generally called microorganisms.

Oxidation

Term originally used to describe reactions in which an element combines with oxygen molecules and all the different substances they may encounter; oxidation is the loss of an electron by a molecule, atom, or ion.

Oxidative Chemistries

The class of compounds referred to as peroxygen compounds; these compounds contain an additional atom of oxygen bound to oxygen.

Oxidizing Agents

Agents that remove electrons from other substances, and are thus reduced themselves.

Reducing Agents

Agents that add electrons to other substances and thus are oxidized themselves.

Semi-critical Item

Instruments or other objects that come in contact with non-intact skin and mucous membranes, but do not permeate the blood barrier.

Sterilization

The complete elimination of all forms of microbial life.

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Review Questions

1. Dialdehydes are known to be protein binders.
A. True
B. False
2. The minimal effective concentration (MEC) should be checked prior to each use for products that have a reuse period.
A. True
B. False
3. Biofilms have not been implicated in healthcare acquired infections due to contaminated washer-disinfectors and medical devices.
A. True
B. False
4. What agent is the most effective at preventing biofilm formation?
A. Sodium hypochlorite
B. Peracetic acid
C. Glutaraldehyde
D. Orthophthalaldehyde
5. The phases of biofilm formation occur in what order?
A. Formation, detachment, attachment, aggregation
B. Aggregation, formation, detachment, attachment
C. Attachment, aggregation, formation, detachment
D. Attachment, formation, aggregation, detachment
6. Examples of oxidative chemistries are:
A. Hydrogen peroxide, ozone, peracetic acid
B. Hydrogen peroxide, glutaraldehyde, peracetic acid, ozone
C. Glutaraldehyde, peracetic acid, ozone, ethylene oxide
D. Glutaraldehyde, orthophthalaldehyde, ozone, ethylene oxide
7. Oxidizing agents remove electrons from other substances, and are thus reduced themselves.
A. True
B. False
8. Automated processing systems that use hydrogen peroxide plasma gas can sterilize all flexible endoscopes.
A. True
B. False
9. Safety, efficacy and efficiency are the three priorities when choosing a decontamination or sterilization process.
A. True
B. False
10. Oxidative chemistries, when used properly, are safe for which of the following.
A. Patients
B. Staff
C. Instruments
D. Environments
E. All of the above

- Answers:
1. A. True
 2. A. True: Biofilms have been implicated in healthcare-associated infections due to contaminated washer-disinfectors and medical devices.
 3. B. False: Biofilms have been implicated in healthcare-associated infections due to contaminated washer-disinfectors and medical devices.
 4. B. Peracetic acid
 5. C. Attachment, aggregation, formation, detachment
 6. A. Hydrogen peroxide, ozone, peracetic acid
 7. A. True
 8. False: These systems can only be used to sterilize single-lumen scopes, specifically bronchoscopes and cystoscopes.
 9. True
 10. All: patients, staff, instruments, environment

Evaluation Form
Study Guide 17: Oxidative Chemistries

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| 1. Describe the available low-temperature processing methods for endoscopic and minimally invasive surgical devices. | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |
| 2. Review the advantages for processing endoscopes using oxidative chemistries. | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |
| 3. List the process of biofilm formation in endoscopes and automated processors. | <input type="checkbox"/> 1 | <input type="checkbox"/> 2 | <input type="checkbox"/> 3 | <input type="checkbox"/> 4 | <input type="checkbox"/> 5 |
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