Enzymatic Detergents

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Enzymatic detergents are widely used to clean gastrointestinal endoscopes before high-level disinfection, although proper use of enzymatic detergents may appear straightforward. Common misuses include failure to dilute the enzymatic detergent, over-dilution of the enzymatic detergent, use of expired enzymatic detergent, inadequate exposure time, and failure to rinse the enzymatic detergent off the instrument (Society of Gastroenterology Nurses and Associates [SGNA], 2000, 2004). To make appropriate decisions to facilitate the removal of visible and non-visible soil, staff members must have a sound knowledge of the items they are cleaning and the tools available to accomplish the cleaning (Lind, 2003).

The goal of cleaning endoscopic devices before sterilization or high-level disinfection is to reduce the amount of bioburden on the instrument being cleaned (Society of Gastroenterology Nurses and Associates [SGNA], 2000, 2004). To make appropriate decisions to facilitate the removal of visible and non-visible soil, staff members must have a sound knowledge of the items they are cleaning and the tools available to accomplish the cleaning. Such knowledge leads to an enhanced effectiveness of the high-level disinfection or sterilization protocol being followed (Lind, 2003).

An ideal cleaning solution should be inexpensive, readily available, and not harmful to the device being cleaned or the person cleaning it (Lind, 2003). Tap water is only marginally successful in cleaning instruments because of its multi-million dollar cost, inefficiency, and the potential for instrument corrosion (Perkins, 1998).

Surfactants are another important component of these cleaning solutions. Surfactants lower surface tension, enabling droplets of solution to disperse more easily and more quickly, and completely coat a surface. Surfactants also emulsify oily soils, keeping them dispersed and suspended so they can be more readily rinsed away. Many cleaning solutions contain two or more surfactants, each of which serves a different purpose. Surfactants are amphiphilic molecules that can lose their effectiveness over time, when using enzyme detergent, especially when the washing solution is not changed frequently enough to prevent cross-contamination (Nelson et al., 2003).

The Truth and Consequences of Enzymatic Detergents

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Enzymatic detergents are widely used to clean gastrointestinal endoscopes before high-level disinfection. Although proper use of enzymatic detergents may appear straightforward, common misuses include failure to dilute the enzymatic detergent, over-dilution of the enzymatic detergent, use of expired enzymatic detergent, inadequate exposure time, and failure to rinse the enzymatic detergent off the instrument. Each type of misuse has its own rationale. In these studies, the authors show by high-performance liquid chromatography that the type of enzymatic detergent and the dilution and rinsing of enzymatic detergents affect the amount of residual high-level disinfectant (ortho-phthalaldehyde) left on test segments of flexible endoscope insertion tubes. The authors also qualitatively demonstrate that proteinaceous material, which is stained a dark color by ortho-phthalaldehyde (OPA), remains on colonoscopes that have been cleaned with improperly diluted or rinsed enzymatic detergents. These findings emphasize the importance of diluting and using enzymatic detergents exactly as directed by their manufacturers to reduce bioburden and residual amounts of high-level disinfectant on flexible endoscopes.
Molecules of surfactant can be electrically charged or neutral. Anionic surfactants are negatively charged in solution (Perkins, 1998). They have excellent cleaning properties and create a lot of suds. Laundry, dishwashing, and personal cleansing products are examples of household anionic detergents.

Nonionic detergents do not form ions in solution. They clean most surfaces well and generally are effective even in hard water. Nonionic detergents are low sudsing. Automatic dishwashing detergent and laundry detergent are examples of household nonionic detergents.

For all the components in cleaning solutions to work well, they must be in the correct concentrations (Wasek, 2003); therefore, accurate dilution of cleaning solutions according to manufacturers' instructions is important. Usually, 0.5 or 1.0 ounce of enzymatic detergent is used per gallon of water.

Although proper use of enzymatic detergents is straightforward, detergents also can be used improperly (Chobin & Erickson, 2003; Wasek, 2003). Common misuses include failure to dilute the enzymatic detergent, overdilution of detergent, use of expired enzymatic detergent, inadequate exposure time, and failure to adequately rinse the enzymatic detergent from the instrument being cleaned. Each type of misuse has its own rationale, including:

- **Use of undiluted enzymatic detergent commonly occurs in the precleaning stage, when the undiluted detergent is suctioned into the endoscope and may or may not be followed by water. The false rationale is that the higher concentration of enzymatic detergent is more effective in reducing bioburden before cleaning.**

- **Overdilution commonly occurs during cleaning in settings in which a “recipe card” of volumes of water and enzymatic detergent established for proper dilution of the detergent is not posted as a visual reminder. The false rationale is that individual technicians have different preferences of volumes to be used and that volume is of no consequence because “a little goes a long way.”**

- **Use of expired enzymatic detergent occurs commonly where large inventories of detergent are in storage. The incorrect belief that the enzymatic detergent is only soap, so the expiration date is inconsequential, is behind this particular misuse.**

- **Inadequate exposure time commonly occurs when the technician cleaning endoscopes is quick and efficient but does not allow for adequate contact time as stated on the label, particularly in the channels of endoscopes. The incorrect belief behind such inadequate exposure is that for proper processing, mere exposure of an endoscope to enzymatic detergent would suffice.**

- **Lack of rinsing is common when using an automatic endoscope reprocessor (AER). The rationale is that because the AER rinses the instrument before high-level disinfection, manual rinse to remove enzymatic detergent is unnecessary.**

Cleaning of endoscopes goes in tandem with high-level disinfection. An aqueous solution of ortho-phthalaldehyde (OPA) is used widely as a high-level disinfectant during endoscope reprocessing because of its excellent materials compatibility, safety, and ease of use. Because OPA stains proteinaceous material, residual bioburden appears black after exposure to OPA. This characteristic of OPA, but not of other high-level disinfectants, can be used to qualitatively assess the presence of residual proteinaceous material in endoscopes after reprocessing. Ortho-phthalaldehyde itself can be quantitatively assessed by analytical chemistry techniques. We report the results of two experiments designed to look at the types of enzymatic detergents and the effect of cleaning conditions on the amount of OPA and the presence of stainable proteinaceous material recovered after high level disinfection of colonoscopes.

**Methods**

**Quantitative Assessment of Residual OPA**

Twelve 10- to 12-cm segments of flexible endoscope insertion tube (Pentax Medical Company, Montvale, NJ) were exposed to bioburden similar to that which would be present in a clinical setting and were then allowed to air dry. After drying, the segments were divided into three groups of four, labeled “Nonionic 1 (expired),” “Anionic,” and “Nonionic 2” based on the detergent type to be used. Each group was then manually cleaned with the designated test detergent under one of four use conditions:

1. One ounce of detergent per 4 gallons of water, followed by water rinses
2. One ounce of detergent per 1 gallon of water, followed by water rinses
3. One ounce of detergent per 1 gallon of water, with no water rinse
4. Undiluted detergent, followed by water rinses

The manufacturers’ instructions for both test detergents specified that 1 ounce of detergent should be used per gallon of water.

After being cleaned, the segments were again air dried and then exposed to 0.55% OPA solution (Advanced Sterilization Products, Irvine, CA) at room temperature (20°C) for 12 minutes. After being exposed to the OPA, the test samples were rinsed with sterile water according to the manufacturer’s directions for use. The rinsed segments were then placed individually in glass test tubes containing 100 mL of 0.87% physiological saline. These test tubes were then placed in a 37°C incubator. After 24 hours, an aliquot from each test tube was analyzed for OPA residual by high performance liquid chromatography (HILC Waters 2690 with UV Detector, Waters Corporation, Milford, MA).

**Qualitative Assessment of Residuals**

Five Pentax colonoscopes received bioburden during colonoscopies performed at Presbyterian Hospital of Dallas (Dallas, TX). The colonoscopes were precleaned in the procedure room by wiping the exterior of the insertion tube with properly diluted enzymatic detergent and suctioning the detergent solution through the endoscope channels. The colonoscopes were then manually cleaned with the designated test detergents as follows:

- **Endoscope 1:** 1 ounce of Nonionic Enzymatic Detergent 1 per 1 gallon of water, followed by water rinses
- **Endoscope 2:** 1 ounce of Nonionic Enzymatic Detergent 2 per 1 gallon of water, followed by water rinses
- **Endoscope 3:** 4 ounces of Nonionic Enzymatic Detergent 2 per 1 gallon of water, followed by water rinses
- **Endoscope 4:** 1 ounce of Nonionic Enzymatic Detergent 1 per 1 gallon of water, with no rinse
- **Endoscope 5:** Undiluted Nonionic Enzymatic Detergent 1, followed by water rinses
For both detergents, the manufacturers’ instructions directed that 1 ounce of detergent be used per 1 gallon of water. The colonoscopes were then processed in Presbyterian Hospital of Dallas’ AER using OPA solution as the high-level disinfectant. The scopes did not receive a final air purge or alcohol flush at the end of the reprocessing cycle. They were hung vertically to dry. An absorbent, white cloth was placed on the floor of the endoscope cabinet to catch effluent dripping from the distal tips of the endoscopes.

**Results**

**Residual OPA**

Figure 1 shows the amounts of OPA remaining on disinfected endoscope segments previously cleaned with enzyme-containing detergents under various conditions. Under all conditions, cleaning with anionic detergents was associated with at least twice as much residual OPA as cleaning with nonionic detergent.

**Residual Proteinaceous Material**

Ortho-phthalaldehyde reacts with residual bioburden and other proteinaceous material to form dark stains. The photographs in Figure 2(A–E) show stains on absorbent cloth that caught fluid dripping from hanging colonoscopes as they air dried. The colonoscopes were cleaned as indicated and then underwent high-level disinfection with OPA solution. The amount of staining varied, depending on the cleaning conditions.

**Discussion**

This study demonstrates the importance of using nonionic surfactant enzymatic detergents only as specified by their manufacturers. The cleaning conditions used in the study were selected because anecdotes of similarly improper use—and the false rationale behind such use—are well known (Chobin & Erickson, 2003; Wasek, 2003). Our study illustrates the rationale behind the use of improperly diluted enzymatic detergents is erroneous, and such improper use results in serious, negative consequences.

**Residual OPA**

The low-sudsing character of the nonionic detergent made it easy to rinse. In contrast, the anionic surfactant detergent was high-sudsing, making it difficult to rinse at all dilutions. This difference in ability to rinse provided the most plausible explanation for the lower OPA residual seen with nonionic detergent compared with anionic detergent for all dilutions examined. Overall, OPA residuals were at least twice as high after washing with anionic detergent as after nonionic detergent washing. For dilutions of fresh (not expired) anionic enzymatic detergent, higher concentrations of detergent and detergent not rinsed according to the manufacturer’s directions generally led to higher OPA residuals. Residual levels of OPA should be of concern to instrument-processing technicians and supervisors because they indicate improper processing of scopes and the potential for the negative consequences of trapped bioburden.

**Proteinaceous Residue**

No staining of proteinaceous material by OPA was observed after high level disinfection of endoscopes that had been cleaned with properly diluted nonionic detergent and then rinsed with water. In contrast, staining was observed with the endoscope that had been cleaned with properly diluted detergent, but not rinsed. Significant staining also was observed with endoscopes cleaned with underdiluted and undiluted nonionic detergent and then rinsed as usual. These results provided a visual illustration of the importance of using detergent as directed by the manufacturer. The residual material that stained the white cloth was a result of liquid that dripped from the endoscope because no final air or alcohol flush was performed at the end of the reprocessing cycle. This demonstrates that in improperly cleaned endoscopes, small amounts of such residual material might be left on interior and exterior surfaces of endoscopes as they dry. This visual illustration of residual material stained by OPA is a message to technicians and supervisors that they should evaluate current cleaning procedures to ensure successful high-level disinfection and complete removal of any bioburden on instruments, ensuring patient safety. In addition, the possibility of build-up over time could raise concerns about the effectiveness of future cleaning processes after repeated improper cleaning, as well as the negative effect on the optimal functioning and lifetime of the endoscope itself.

**Improving the Process to Enable Better Use of Enzymatic Detergent**

Our study underscores the importance of using nonionic enzymatic detergents precisely as directed by their manufacturers. Implementation of two simple, practical changes could
help with precleaning and cleaning in many endoscopy suites. For precleaning, every morning an appropriately diluted gallon of nonexpired enzymatic solution could be placed in each procedure room. The properly diluted enzymatic solution is then poured from the gallon container into a smaller container for immediate suctioning of solution through the channels of the endoscope directly after use, before bioburden has a chance to dry in the channels.

In the cleaning room, a permanent marker or piece of tape could be used to mark in the sink the amount of water necessary to submerge an endoscope. Then a “recipe card” could be posted specifying how many pumps of nonexpired enzymatic detergent should be added to that amount of water (Figure 3). Fresh water should be used for every endoscope. To achieve a reliable reduction of bioburden, the endoscope should remain submerged in the detergent, and the channels should be in contact with the solution for the amount of time specified on the detergent’s label. The endoscope should then be rinsed with fresh water to remove the enzymatic detergent.

**FIGURE 2.** Photos show the white cloth positioned below endoscopes manually cleaned with nonionic enzymatic detergents and water rinsed (unless indicated otherwise) as follows: (A) detergent 1 properly diluted (1 oz/gallon water), (B) detergent 2 properly diluted (1 oz/gallon), (C) detergent 2 underdiluted (4 oz/gallon water), (D) detergent 1 properly diluted (1 oz/gallon) but not rinsed before high level disinfection, and (E) detergent 1 undiluted.
Conclusions

Although it is true that when used correctly, enzymatic cleaners are very effective in removing soil and organic matter, it also is true there are serious negative consequences associated with enzymatic misuse. In these studies, nonionic detergents are associated with much less residual OPA after high-level disinfection than are anionic detergents. We believe this difference is attributable to the low-sudsing and easy-to-rinse characteristics of the nonionic detergents compared with the high-foaming nature of the anionic detergents. Furthermore, if nonionic detergent is not rinsed after cleaning, or if it is underdiluted or undiluted for cleaning, OPA-stained liquid will drip from the distal tip of the cleaned, high-level disinfected endoscopes. This will be evidenced by staining of the absorbent cloth, indicating bioburden remains on the endoscope after cleaning, and this residual material may interfere with successful high-level disinfection. These findings are evidence that to achieve the best possible outcomes, nonionic enzymatic detergents used for cleaning gastrointestinal endoscopes should be fresh and properly diluted and used as specified by the manufacturer.

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References