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Major Article

Endoscope reprocessing: Comparison of drying effectiveness and microbial levels with an automated drying and storage cabinet with forced filtered air and a standard storage cabinet

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Key Words:
Duodenoscope
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High-level disinfection
Waterborne infection

Background: Automated drying may help prevent endoscopically transmitted infections. We aimed to assess the efficacy of an automated drying and storage cabinet compared to a standard storage cabinet in achieving endoscope dryness postreprocessing and in reducing the risk of microbial growth.

Methods: Drying times of bronchoscopes, colonoscopes, and duodenoscopes using 2 drying platforms (an automated drying and storage cabinet vs a standard storage cabinet) were measured using cobalt chloride paper. Drying assessments occurred at: 30 minutes, 1 hour, 2 hours, 3 hours, and 24 hours. A simple linear regression analysis compared rates of microbial growth after inoculation with *Pseudomonas aeruginosa* following high-level disinfection at: 0, 3 hours, 12 hours, 24 hours, and 48 hours.

Results: Using the automated drying and storage cabinet, internal channels were dry at 1 hour and external surfaces at 3 hours in all endoscopes. With the standard storage cabinet, there was residual internal fluid at 24 hours, whereas external surfaces were dry at 24 hours. For bronchoscopes, colonoscopes, and duodenoscopes, the standard cabinet allowed for an average rate of colony forming unit growth of 8.1×10^6 per hour, 8.3×10^6 per hour, and 7.0×10^7 per hour, respectively; the automated cabinet resulted in colony forming unit growth at an average rate of −28.4 per hour ($P = .02$), −38.5 per hour ($P = .01$), and −200.2 per hour ($P = .02$), respectively.

Conclusions: An automated cabinet is advantageous for rapid drying of endoscope surfaces and in reducing the risk of microbial growth postreprocessing.

Approximately 54 million Americans visited health care providers in 2015 for management of gastrointestinal diseases.[1] Flexible endoscopy is often performed to diagnose and manage patients presenting with various gastrointestinal issues. With an increasing burden of digestive diseases in the United States, there has been a rise in the use of endoscopy with over 20 million procedures being performed annually.[2]

The overall risk of patient-to-patient transmission of infection via endoscopy is exceedingly low. However, in the last decade, numerous centers around the world have reported endoscopically transmitted outbreaks of waterborne and multidrug resistant organisms.[3-8] A particular concern is that many of these outbreaks appear to have occurred despite strict adherence to endoscope reprocessing guidelines.[9] To address these concerns, in 2016, a multisociety statement provided recommendations on how to standardize endoscope reprocessing and decrease transmission of endoscope-mediated infections between patients. Recommended steps included point-of-use precleaning, pressure and leak testing, meticulous manual cleaning, visual inspection, manual and automated high-level disinfection (HLD), adequate drying, and appropriate hanging and storage.[10]

Although several studies have focused on improving the performance of HLD, few have focused on assessing and enhancing the drying process.[11-16] The importance of this critical step in endoscope

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reprocessing should not be understated. Thaker et al[17] demonstrated that the instrument channels of endoscopes stored vertically overnight contained moisture 28% of the time compared to 0% of endoscopes that underwent vertical storage along with forced air drying. All endoscopes in this study had undergone extensive precleaning and automated HLD.[17] Barakat et al[18] reported similar findings with residual moisture noted in 43% of endoscopes after reprocessing and drying. Likewise, Ofstead et al[19] demonstrated residual fluid and debris in 95% of endoscope channels after HLD and drying with automated endoscopic reprocessors (AERs). Remnant fluid within endoscope channels poses a significant risk to successful endoscope reprocessing as moisture within these channels provides an ideal milieu for bacteria to organize and form biofilms. These biofilms have been identified within the channels of endoscopes despite intense decontamination.[20] However, although adequate drying is recognized as an essential step in endoscope reprocessing, there is no consensus on the most efficient method to achieve this aim.[21-24]

An automated drying and storage cabinet that allows for the constant flow of compressed air (additionally filtered through a 0.01 micron filter) through each individual endoscope channel may effectively automate the drying step in endoscope reprocessing. By directly connecting to each channel of the endoscope, constant airflow may remove remnant fluid and potentially reduce the risk of subsequent bacterial growth and biofilm formation. In this study, we compared the performance of a standard reprocessing drying cabinet to a new drying and storage cabinet that provides automated drying with forced filtered air in eradicating moisture, which may reduce the risk of microbial growth.

METHODS

Drying times and microbial levels of endoscopes stored in an automated drying and storage cabinet with forced filtered air (ENDODRY Drying and Storage Cabinet, Medivators, Minneapolis, MN) were compared to a standard storage cabinet (Olympus Corporation, Tokyo, Japan) without forced filtered air.

Drying and storage cabinets

Automated drying and storage cabinet

An automated drying and storage cabinet allows constant flow of compressed air to a specified purity class with respect to particles, humidity, and oil. This compressed air then passes through a 0.01 micron filter for additional filtration before it progresses through each endoscope channel with direct connections to endoscope channels. In addition to the constant flow of compressed high-efficiency particulate air (HEPA), the endoscopes are placed in a cassette system, using the AER hookups that allows endoscopes to dry and store horizontally. The cabinet also has circulating air within the cabinet that intends to enhance the drying of the external surfaces of the endoscopes. The automated drying and storage cabinet will henceforth be referred to as the automated cabinet.

Standard storage cabinet

A standard storage cabinet without compressed or HEPA was used as the comparator because this is the current standard used in the United States. This cabinet provides no direct airflow through the endoscope channels or any airflow over the external surfaces. The endoscopes hang in the vertical position, which is believed to facilitate drying via gravity-aided drainage of fluid. To store the endoscope in this cabinet, all detachable components are removed. This cabinet will henceforth be referred to as standard cabinet.

Endoscopes

For this study, a total of 3 bronchoscopes (Olympus BF-3C20), 3 colonoscopes (Olympus CF-Q160AL), and 3 duodenoscopes (Olympus TJF-160F) were used. All endoscopes that are part of this study are the property of Cantel Medical (Minneapolis, MN). These instruments are representative of devices used in the clinical environment. All endoscopes were inspected on a regular basis and were repaired as necessary to maintain equivalence to original equipment manufacturer specifications. Rigorous inspection including leak testing was conducted prior to each experiment to ensure consistency of results.

In between experiments, each endoscope was connected to the appropriate hookup and underwent a full cycle in the automated endoscope reprocessor (Advantage Plus, Medivators, Minneapolis, MN). The cycle in this AER begins with a leak test of the endoscope. Once the leak test has passed, water fills the basin and circulates through the spray head and hookup until the correct temperature has been reached. Next, detergent (Intercept; Medivators), is introduced into the basin and circulates for 3 minutes. Water is then rinsed through the endoscope to remove any residual detergent. The basin is filled with water again and the disinfectant solution (Rapicide PA; Medivators) is then introduced and circulates through the endoscope. The safety control unit makes sure that the contact time of 5 minutes is always met. The disinfectant is then rinsed out of the endoscope. Finally, the channels are purged with air and the cycle is complete. The parameter sets selected for this study did not include alcohol at the end of the cycle. The alcohol flush was not performed to simulate worst case scenarios for the drying study taking into consideration that the alcohol flush is not used across Europe. For the microbial part, the alcohol flush was eliminated to prevent microbial suppression of the inoculum due to alcohol residue in the endoscopes. The manual cleaning was not performed because the Advantage Plus has a cleaning claim in the United States, which provides the option to eliminate the manual cleaning of endoscopes prior to the AER cycle.

Drying study protocol

The test was performed according to BS EN 16442:2015 (controlled environment storage cabinet for processed thermolabile endoscopes).[25,26] A total of 6 endoscopes: 2 bronchoscopes, 2 colonoscopes, and 2 duodenoscopes, were reprocessed and dried using the 2 different drying platforms. Each endoscope was connected to the appropriate hookup and underwent a full cycle in the AER. For the automated cabinet, the endoscopes were connected to a dry hookup and placed in a dry cassette before they underwent the determined drying cycle. For the standard cabinet, all the detachable components of the endoscopes were removed prior to being placed in the cabinet. The drying times were: 30 minutes, 1 hour, 2 hours, 3 hours, 24 hours $\pm$ 5 minutes. After the appropriate drying period, the endoscopes were removed from the cabinets, disconnected from hookups, if applicable, and were subjected to a cobalt chloride test paper (Indigo Instruments, Waterloo, Ontario, Canada) analysis. Cobalt chloride test paper analysis is a qualitative analysis in which the cobalt paper changes color from blue to pink in the presence of liquids. A piece of cobalt chloride test paper was used to wipe down the external surfaces of each endoscope, including all levers, controls, and other crevices. To investigate if any residual water was present in the internal channels, the endoscopes were connected to an appropriate hook up (Medivators DSD AER hookup). A piece of cobalt paper was placed in front of the distal tip at a distance of 50-100 mm, and each individual channel was subjected to an air purge at 15 psi. If water was discharged from the endoscope, the cobalt paper changed color from blue to pink. Two observers were present during the air purge and the color change was immediately recorded. Pictures were taken to record the results (Appendix Figure A1-3). Therefore, the endoscopes

were considered dry if the color remained blue and considered wet if any pink marks were detected on the paper.

Repetition

Each time point was tested only 1 time for each 1 of the 2 different drying platforms, resulting in a total of 30 drying cycles.

Controls

To assess the limit of detection for cobalt chloride paper, the endoscopes were dried for at least 48 hours in the automated cabinet, then specific volumes of water were placed inside each of the channel systems of the endoscopes using a micropipette. For each channel, the volumes used were 5, 10, 50, 100, 150, 200, and 250 μL. For the colonoscope and duodenoscope, the water was inserted in the light guide channel outlets, which mark the furthest lengths of the channel to the distal tip. For the bronchoscope, it was placed in the suction valve opening at the control head. The endoscopes were connected to appropriate Medivators DSD AER hookups, a piece of cobalt paper was placed in front of the distal tip at a distance of 50-100 mm, and each individual channel was submitted to an air purge at 15 psi. The lowest volume in which the water discharge was observed in the cobalt paper was considered to be the limit of detection for that channel. Two observers were present during the air purge and the color change in the cobalt paper was recorded.

Microbial study protocol

Growth of Pseudomonas aeruginosa *culture and inoculum preparation*

The bacterial culture was obtained from ATCC, (*P aeruginosa* ATCC 15442; ATCC, Rockville, MD). A working culture was prepared by subculturing directly from defrosted cryovials, 0.1 mL of *P aeruginosa* was inoculated into 150 mL tryptic soy broth (Becton, Dickinson and Company, Franklin Lakes, NJ) and incubated at 37 ± 2°C for 2 days. Optical density at 550 nm was used to estimate the population of the test organism. The inoculum concentration for duodenoscopes and colonoscopes was approximately 4×10^4 colony forming units (CFU)/15 mL and the inoculum concentration for bronchoscopes, due its smaller channel, was approximately 7×10^3 CFU/2 mL to reproduce the scenario in which an endoscope would be re-contaminated by microorganisms present in the water used in the final rinsing stage. The *P aeruginosa* culture was diluted per EN 16442 diluent to prepare the inoculums.[25] The inoculums were serially diluted and enumerated through membrane filtration method to confirm the inoculum population. The filters were plated on tryptic soy agar (Becton, Dickinson and Company) and incubated for 2 days at 37 ± 2 °C.

Inoculation of the endoscopes

Before the first inoculation and between trials, the endoscopes underwent HLD cycle in the AER with the appropriate hookup attached. Wearing sterile personal protective equipment, each endoscope was aseptically placed in a covered sterile plastic tub and transferred to a laminar flow hood. Sterile deionized water was flushed through the channels before the inoculation to establish baseline conditions. The total inoculum for duodenoscopes and colonoscopes was 15 mL, distributed into the endoscope channels via the hookup, based on overall volume of the channels: 10 mL for suction/biopsy channel, 4 mL for the air/water, and 1 mL for elevator or auxiliary channel. The bronchoscopes were inoculated with 2 mL of inoculum in the suction/biopsy. Each channel was inoculated separately, in which the distal end of the endoscope was immersed in the tube with the inoculum, and the bacterial suspension was drawn up each channel through the distal end by pulling up through the appropriate hookup port using a sterile catheter syringe. After BS EN 16442:2015,[26] the inoculum remained in the endoscope channels for 30 ± 5 minutes at the ambient temperature before it was manually purged with air using a sterile catheter syringe to remove the excess inoculum. The endoscopes sat at ambient temperatures in the laminar flow hood for 1-1.25 hours before being placed in the cabinets to simulate the time between reprocessing and storage that might occur in a clinical scenario. For the standard cabinet, the hookups were removed before the endoscopes were placed in this cabinet. For the automated cabinet, the endoscopes were connected to other appropriate hookups and cassettes that had been previously HLD before it was dried and stored in this cabinet. The cabinets were cleaned between each trial with disinfectant wipes to maintain baseline conditions.

Microbial recovery from the endoscopes

At the appropriate storage times of 0 hours, 3 hours, 12 hours, 24 hours, and 48 hours ± 15 minutes, the endoscopes were taken out of the cabinets using sterile personal protective equipment and transferred to a laminar flow hood to be sampled. The endoscopes were connected to the appropriate reusable HLD hookups and valves; the distal end of the endoscope was placed in a sterile wide-mouth bottle. Using a sterile syringe, the air and water channel was flushed with 18-22 mL of sampling solution (EN 16442), followed by 20 mL of air, then 8-12 mL sampling solution with another 20 mL of air. The suction/biopsy channel was flushed with 95-105 mL of sampling solution and 100 mL of air. The biopsy channel was brushed from the control head to the distal tip 6 times using a sterile channel brush. As the brush emerges from the distal tip, the brush tip was submerged in the sampling solution to remove any additional adherent organisms. The suction channel was thereafter flushed with 45-55 mL of sampling solution and 100 mL of air. The bottle contents were serially diluted and filtered through 0.22 μm membrane filters and rinsed with two 25-30 mL portions of 0.85% saline solution. The filters were plated on tryptic soy agar (Becton, Dickinson and Company) and incubated for 2 days at 37 ± 2°C. The time point zero was used to enumerate the microbial population in the scope after the prestorage procedure. In addition, to evaluate long-term storage conditions for the automated cabinet, a 31-day storage time point was completed following the same procedure only for this cabinet. To assess microbial levels, recovered bacteria at different time points were quantified as CFUs. The total CFU recovered from the endoscopes at different time points after drying (0 hours, 3 hours, 12 hours, 24 hours, 48 hours, and 31 days) was compared using a logarithmic scale.

Repetition

Each time point was tested in duplicates for each 1 of the endoscopes tested. The time points 3 hours, 12 hours, and 24 hours ± 15 minutes were tested in the 2 different drying platforms, whereas the time point 31-days was tested only in the automated cabinet. The time point 0 hour was tested before the insertion of the scopes in the drying platforms. For all time points mentioned earlier, there was a positive control kept in the counter for each type of endoscope. Therefore, there were a total of 90 tests performed. Three endoscopes of each type were used per time point, 2 for the duplicates and 1 as the positive control.

Controls

The suitability of the sampling solution, rinsing solution, and diluent with test organism was tested by performing toxicity tests. The growth medium was tested for sterility through negative controls. Saline and sampling solution also had negative control plates that were filtered and incubated with the sample plates. The microbial air quality of the cabinet was monitored with tryptic soy agar settle plates inside the cabinet for 3 hours with doors closed and incubated for 5 days at 37 ± 2°C. For each time point, 1 endoscope of each type was kept on the counter at room temperature for the same time period to demonstrate that the bacteria do not die over time inside of the endoscope.

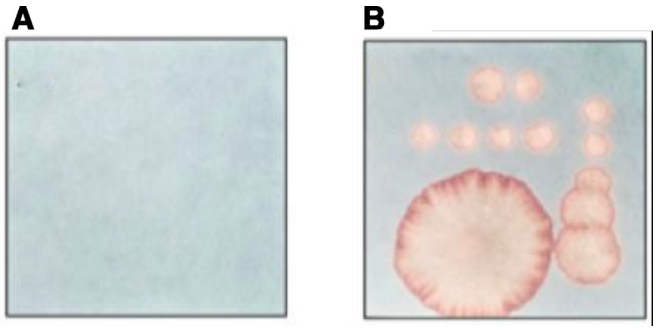

Fig 1. Cobalt chloride paper (A) negative result (B) positive result—small and large water droplets.

Data analysis

To assess microbial levels, recovered bacteria at different time points were quantified as CFUs. The total CFU recovered from the endoscopes at different time points after drying (0 hours, 3 hours, 12 hours, 24 hours, 48 hours) was compared using a logarithmic scale. A simple linear regression analysis compared rates of microbial growth over time. A P value of <.05 was considered to be significant.

RESULTS

Drying effectiveness

Drying effectiveness was tested by measuring the drying time necessary to remove all residual water from the external and internal surfaces of the endoscopes. Qualitative assessments of internal and external scope dryness were made using cobalt chloride paper (Fig 1).

For all 3 types of endoscopes, residual water was not observed on the cobalt chloride paper used to wipe the external surfaces of the endoscopes at 24 hours of drying in the standard cabinet, and at 3 hours of drying in the automated cabinet. Residual water continued to be observed on the cobalt chloride paper used to assess any discharge of water of the internal channels at 24 hours of drying in the standard cabinet and was not observed on the cobalt chloride paper at 1 hour of drying in the automated cabinet (Fig 2).

The controls showed that the limit of the detection of the cobalt paper for the bronchoscope is 5 μL of water. For the duodenoscope, the limit of detection is 250, 100, and 50 μL of water for the air water channel, suction biopsy channel, and elevator channel, respectively. For the colonoscope, it is 100, 150, and 10 μL of water for the air water channel, suction biopsy channel, and elevator channel, respectively. Therefore, all endoscopes considered dry could have retained values equal to or less than levels of water established as limits of detection for each channel.

Microbial assessment

The differences between microbial levels after drying in the standard cabinet compared to the automated cabinet are demonstrated in Figure 3. After 48 hours of drying, compared to the standard cabinet, the automated cabinet resulted in 8 log, 7 log, and 9 log fewer recovered organisms for bronchoscopes, colonoscopes, and duodenoscopes, respectively.

For bronchoscopes, colonoscopes, and duodenoscopes, the standard cabinet allowed for an average rate of CFU growth of 8.1×10^6 per hour, 8.3×10^6 per hour, and 7.0×10^7 per hour, respectively; the automated cabinet resulted in CFU growth at an average rate of −28.4 per hour ($P = .02$), −38.5 per hour ($P = .01$), −200.2 per hour ($P = .02$), respectively.

Long-term storage and microbial assessment

The automated cabinet resulted in low microbial levels after long-term storage of 31 days in all 3 endoscopes types. There were no microorganisms recovered from the colonoscope and from the bronchoscope after 31 days of storage; these scopes had been inoculated with approximately 4.77×10^4 and 7.88×10^3 CFU of *P aeruginosa,* respectively. The duodenoscope was inoculated with approximately 4.11×10^4 CFU, and only 1 CFU was recovered after 31 days of storage in the automated cabinet.

DISCUSSION

In this study, an automated cabinet was found to be superior to a standard cabinet in its ability to dry the internal channels and external surfaces of 3 types of commonly used endoscopes. Based on cobalt chloride test paper analysis, the automated cabinet facilitated drying

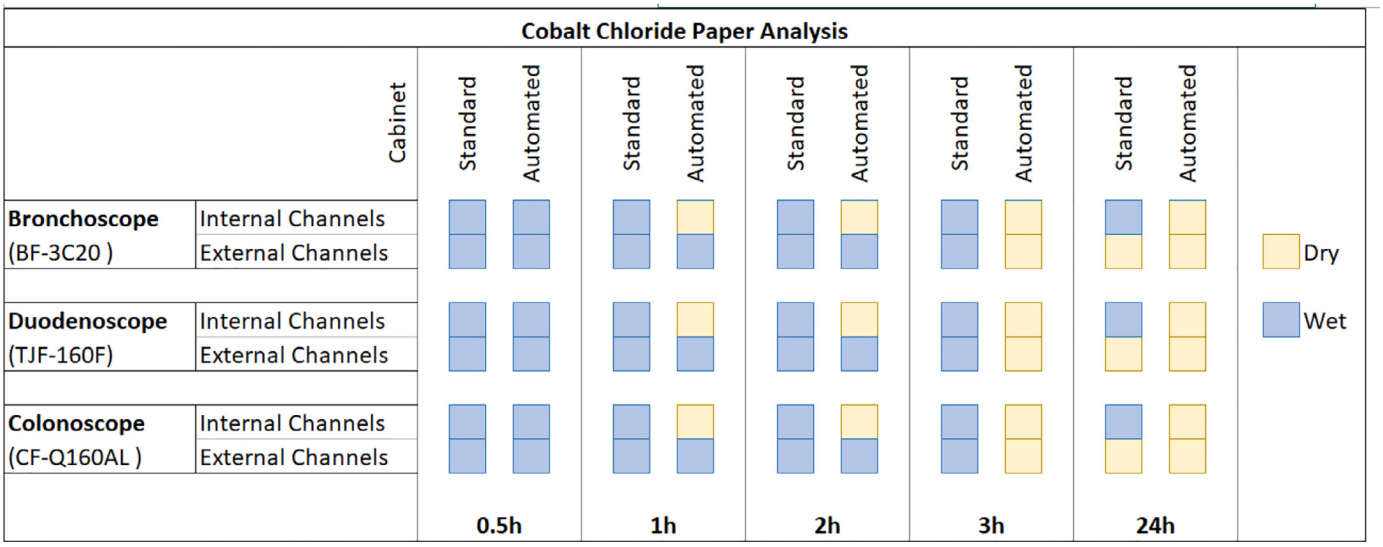

Fig 2. Graphic representation of cobalt chloride paper analysis to assess internal and external channel dryness for bronchoscopes, duodenoscopes, and colonoscopes.

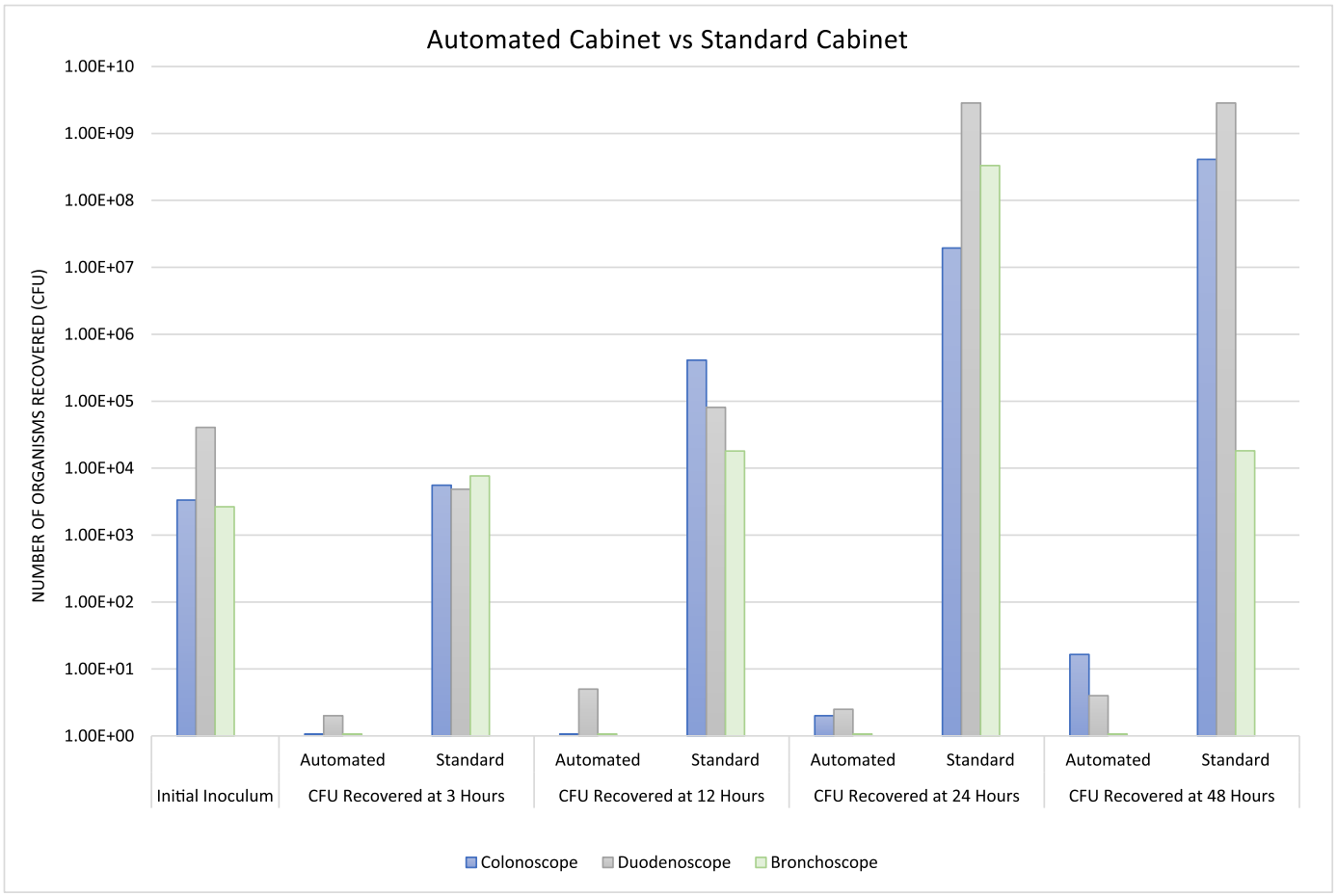

Fig 3. Bar graph demonstrating the number of organisms recovered from bronchoscopes, colonoscopes, and duodenoscopes that were inoculated with *Pseudomonas aeruginosa* prior to drying and storage using the automated and the standard cabinets. *CFU*, colony forming unit.

of internal channels at 1 hour and external surfaces at 3 hours; endoscopes stored in the standard cabinet still had internal fluid at 24 hours of drying. Furthermore, this cabinet was only able to dry the external surfaces of the endoscopes at 24 hours. This difference in the drying time of internal channels is important in clinical practice. Although external surfaces can be dried expediently with manual wiping, internal channels pose a challenge. In addition, comparing the automated cabinet to the standard cabinet in microbial burden of contaminated endoscopes, the automated cabinet demonstrated lower microbial levels at all time points. Finally, our study demonstrates that the automated cabinet resulted in low microbial levels after long-term storage at 31 days.

With the emergence of endoscope-related waterborne and multidrug-resistant infections despite reported adherence to manufacturer guidelines, there has been intense scrutiny of the many steps involved in endoscope reprocessing.[3-8] With this attention in addition to prior research on this topic,[11-16] it has become clear that residual moisture after HLD of endoscopes may result in bacterial proliferation and biofilm formation.[13,20] Lack of adequate drying during endoscope reprocessing and endoscope storage have been identified as key issues with the existing standard for endoscope reprocessing.[21] Our study confirms the role of moisture in facilitating bacterial growth and demonstrates that an automated cabinet may aid in remedying these issues.

Endoscope drying can be performed manually, within AERs,[16] or in automated cabinets. Manual drying is limited by human error. Although AERs may have an optional short drying cycle, they are typically inadequate for attaining complete drying. Ofstead et al[19] demonstrated residual fluid and debris in 95% of endoscopes and microbial growth in 60% of endoscopes within inner channels after HLD and drying with AERs during a 7-month longitudinal study. In contrast, automated cabinets, now recommended by some guidelines,[27,28] force HEPA for a prolonged period of time through endoscope inner channels and store endoscopes in an enclosed environment. Residual fluid is present in nearly half of endoscope working channels after 24-48 hours of standard nonventilated storage,[17] which is a sufficient timeframe for biofilm formation. Nevertheless, a survey of 249 centers revealed that not even half performed drying with forced filtered air, despite its established importance in optimal reprocessing.[17]

For decades, failures in endoscope reprocessing were attributed to human error resulting in breaches of existing reprocessing protocols. It is becoming increasingly apparent that although human error can play a role, existing protocols for endoscope reprocessing may also be insufficient.[29] Scrutiny in the wake of highly publicized endoscope-related infections has revealed the potential for reprocessed endoscopes to remain contaminated, to some extent, on a detailed evaluation.[3-8] If moisture remains after endoscope reprocessing, recolonization with bacteria during endoscope storage can occur.[21] Without the drying step in endoscope reprocessing, fluid may reside within endoscopes for days.[17] As there is a paucity of data regarding the optimal method and duration of drying post-HLD in endoscope reprocessing, validating new drying techniques is essential.

In this study, we highlight the efficiency and efficacy of automated drying with forced filtered air to achieve endoscope dryness and reduce risk of microbial growth. Our study demonstrates that filtering of air used for drying, along with direct hookups to endoscope inner channels, may be critical in reducing endoscope recolonization with pathogens. Duodenoscopes have the most complex design due to elevator channels and large channel diameter, and there are known challenges associated with duodenoscope reprocessing that have contributed to endoscope-mediated multidrug-resistant infections. In this study, the automated cabinet maintained markedly lower bioburden compared to the standard cabinet even in duodenoscopes. Bronchoscopes dried and stored in the automated cabinet, despite narrow channels that may be challenging to clean and dry, showed no presence of test organism at all time points. Colonoscopes, which present a different challenge with the longest channel length, also showed comparatively low microbial presence at all time points when stored in the automated cabinet.

Our study has multiple strengths. First, our study directly examined bioburden by sampling microbial cultures, rather than using a surrogate marker such as adenosine triphosphate bioluminescence.[16] Positive and negative controls validate the efficiency of our culturing methods and ensure absence of external contamination. Furthermore, 3 types of commonly used endoscopes were studied in our investigation, including duodenoscopes, which have been implicated in the transmission of multidrug-resistant infections between patients. The 3 endoscopes were selected for worst case scenarios: owing to their small caliber (bronchoscope), long channel configuration (colonoscope), or large channel diameter with elevator mechanism (duodenoscope). These characteristics make these devices the most challenging endoscopes to reprocess in terms of drying. In addition, the choice of *P aeruginosa,* a waterborne organism, as this agent is among the most common organisms to contaminate stored endoscopes.[6-8] Finally, the demonstration of low bioburden using the automated cabinet at 31 days after inoculation suggests that unused endoscopes may be stored with reduced risk of microbial growth for extended periods of time. Because it is currently routine practice at many institutions to repeat reprocessing of unused endoscopes even after 1 week of storage, the automated cabinet may transform clinical practice by reducing unnecessary reprocessing cycles and associated costs.

There are several important limitations to this study. First, the small sample size of endoscopes studied limits our capacity to stratify the efficacy of our drying method by degree of endoscope wear-and-tear, which may impact the quality of drying and microbial condition. Secondly, the dryness evaluation and culture acquisition were not blinded. However, we posit that cobalt chloride testing is an objective method to ascertain endoscope dryness. Moreover, although our test organism, *P aeruginosa*, is a commonly encountered nosocomial waterborne bacteria, its growth characteristics may not be entirely generalizable to the numerous bacterial agents that could potentially contaminate endoscopes. In addition, the efficacy of the drying process may not overcome endoscopes that have preexisting biofilm formation. Furthermore, to allow for precise inoculation of bacteria, our experiments were not conducted on endoscopes that are actively being used in humans and therefore do not simulate a clinical scenario. Finally, direct visualization of moisture within endoscope working channels via a borescope was not performed.

Additional investigation is warranted to examine the impact of automated cabinets on reducing microbial burden in the setting of existing biofilms.[25] Future studies should examine a wider range of endoscope types and microbial pathogens. Nonetheless, we believe that our data represents a significant step forward in delineating the efficacy and adequacy of automated cabinets in accomplishing endoscope drying that may reduce the risk of microbial growth.

CONCLUSIONS

To our knowledge, our study is the first in the United States to demonstrate that an automated cabinet with forced filtered air efficiently and efficaciously eliminates residual endoscope moisture that can lead to microbial growth. This process advances us beyond the current standard of care in endoscope reprocessing, which involves either manual drying or limited drying with AERs followed by vertical hanging.[10] Moreover, vertical hanging, which is a current multisociety recommended reprocessing step,[10] may become obsolete because of the compact horizontal storage provided by automated cabinets that also can more adequately reduce the risk of recolonization with waterborne pathogens, as demonstrated in this study. Finally, automated cabinets may allow for extended storage that may reduce unnecessary reprocessing cycles and associated costs.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.ajic.2019.02.016.

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