GREEN ENDOSCOPY: RELATION BETWEEN STORAGE TIME AND MICROBIOLOGICAL SAFETY LEVEL

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ABSTRACT

The importance of applying sustainability concepts to endoscopes has recently been raised particularly in low to moderate-income countries. This concept aims to provide high-quality care, reducing negative impacts on the environment, healthcare workers, and the endoscopes themselves, without impairing patient safety. A total of 14 endoscopes (6 gastroscopes, 4 bronchoscopes and 4 duodenoscopes) were stored for 10-20 days after being high level disinfected using a standard technique according to recommended guidelines and sampled by flush-brush-flush sampling method (FBFSM) to screen for bacterial recontamination after storage. According to the study, no bacterial count difference between days (1-8) for gastroscopes, (1-11) for duodenoscopes and days (1-15) for bronchoscopes which means that the shelf life of the endoscope could be extended from 24 hours to 8 days for gastroscopes, 11 days for duodenoscopes and for bronchoscopes the duration could be extended to 15 days without reprocessing.
Keywords: Endoscope Surveillance; Flush Brush Flush Method; Endoscope Sustainability; Green Endoscopy.

INTRODUCTION

Flexible endoscopes are essential diagnostic and therapeutic tools for different healthcare conditions. As they are reusable devices, there have been significant worries concerning transmission of infectious agents in between patients (Beilenhoff 2023; Deb *et al*., 2022; Shin and Kim 2015).

Diagnostic endoscopes require at least high-level disinfection (HLD) during reprocessing since they fall under the category of semi-critical devices in the Spaulding classification system. The goal of high-level disinfection is to eliminate or inactivate microorganisms, including lipid and non-lipid viruses, vegetative bacteria, mycobacteria and fungi, but not necessarily large numbers of bacterial spores (Centers for Disease Control and Prevention 2023).

The processing of endoscopes by HLD consist of multiple steps, including pre-cleaning, leak testing, cleaning, soaking in a suitable high-level disinfectant to the recommended contact time water rinsing, followed by drying and storage. All these steps are performed after each use and again at the beginning of the day, after storage. (Luiet al. 2017; Shimpi and Spaete 2022).

HLD involves the use of potentially environmentally hazardous substances like glutaraldehyde, throughout each decontamination cycle, which if not treated correctly, can have negative health consequences on health care workers involved in the disinfection process, and its harmful impact on the environment (Pohl 2023).

Endoscopic procedures and processing techniques generate waste and increases greenhouse gas emissions, waste production, and water and energy consumption. Climate change and other environmental issues gave rise to the green endoscopy movement (Siddhi *et al*. 2021).

Green endoscopy is the term used to describe eco-friendly endoscopic procedures and processing techniques. By considering measures to minimize waste production and greenhouse gas emissions, it attempts to overcome the negative effects of endoscopic treatments on the environment. Green endoscopy is one of the sustainable healthcare methods that support global health goals (Maurice et al., 2021; de Santiago *et al*., 2022).

Realistic practical measures to reduce waste, use less energy, and implement environmentally friendly practices to reduce the environmental impact becomes essential especially in low-to middle income countries (LMICs), where the healthcare infrastructure is already under pressure (Mol *et al.* 2022).

Applying the principles of circular economy the 5R sustainability principles (Reduce, Reuse, Recycle, Rethink, and Research) to endoscopy can encourage appropriate waste management; it is advisable to avoid routine reprocessing of multiple-use endoscopes. Instead, procedures should be prioritized based on clinical necessity. Not every endoscope requires thorough cleaning before each use. Although this strategy is fascinating, it is

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essential to ensure that there is no harmful impact on patient's health as well to (Gayam 2020; Maurice *et al.* 2020; MacNeillet al. 2020; Sonaiya *et al*. 2024).

It's critical to strike a balance between environmental responsibility and patient safety by encouraging effective resource utilisation with effective disinfection techniques (Setoguchi *et al*., 2022; WHO 2020).

Thus, defining the appropriate window of time to utilise endoscopes following processing without any further unnecessary high level disinfection practice has been an important challenge in clinical practise, particularly regarding patient safety and reducing the possibility of outbreaks and cross-infections. The study will test the hypothesis that storage time of different types of endoscopes can be extended safely while maintaining them microbiologically free.

In this regard, we aimed to determine the maximum storage time of each endoscope type while maintaining it microbiologically safe.

MATERIALS AND METHODS

Experimental Material

Endoscopes

A total 14 endoscopes were randomly selected from February to December 2023 from the endoscopy centre of a hospital in Cairo, Egypt.

Endoscopes tested included (6 gastroscopes, 4 bronchoscopes and 4 duodenoscopes). During that period, two scopes were sampled every month on a rotational basis.

All endoscopes underwent HLD and dried for 6 minutes in automated endoscope reprocessor (AERs) and stored in dust free, unfiltered commercial cabinets at temperature 20-25℃. Health care assistant staff cleaned the cabinets once a week as well as when necessary.

To standardize the HLD processing technique to ensure that it will not affect the study results a rapid protein test used after HLD and a microbiological sample obtained at day zero before storage if any bacterial growth observed the endoscope excluded from the study and reprocessed again.

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Microbiological Sampling

Endoscopes were sampled at least 6 hours after the last reprocessing procedure using the flush brush flush sampling method (FBFSM) according to the USA guidelines (FDA 2018).

FBFSM for duodenoscope and gastroscope

25 ml of sterile water flushed through the biopsy port, a sterile disposable brush then inserted, and the channel brushed until the brush completely exited the instrument channel. The upper part of the brush cut off (2 cm) using sterile scissors, and then added to the same bottle for testing. Another 25 ml of sterile water injected into the instrument port, then the total volume of elution mixed and cultured (Figure1). In the case of bronchoscope, the total volume was 20 ml of sterile water divided into two halves before and after brushing.

The collected sample was mixed with an equal amount of neutralizing broth. Then, the final sample was divided into two portions. Each half was filtered through 0.45-µm membrane filters and placed on nutrient agar and MacConkey's agar media. The incubation was carried out at 35–37 °C for 72 hours.

Suspected grown colonies were counted and identified by the automated VITEK® 2 system (bioMérieux. Marcy l'Etoile, France) that is used for species identification. It's a rapid and convenient system where suspended microorganisms are incubated and interpreted automatically according to its procedure manual.

Colonies isolated on both media were counted, and the results were expressed as number of (CFU)/ endoscope sample. These results were calculated after 1 day of hang time and for each other day till the positive result or maximum interval for 1 month. (FDA 2018).

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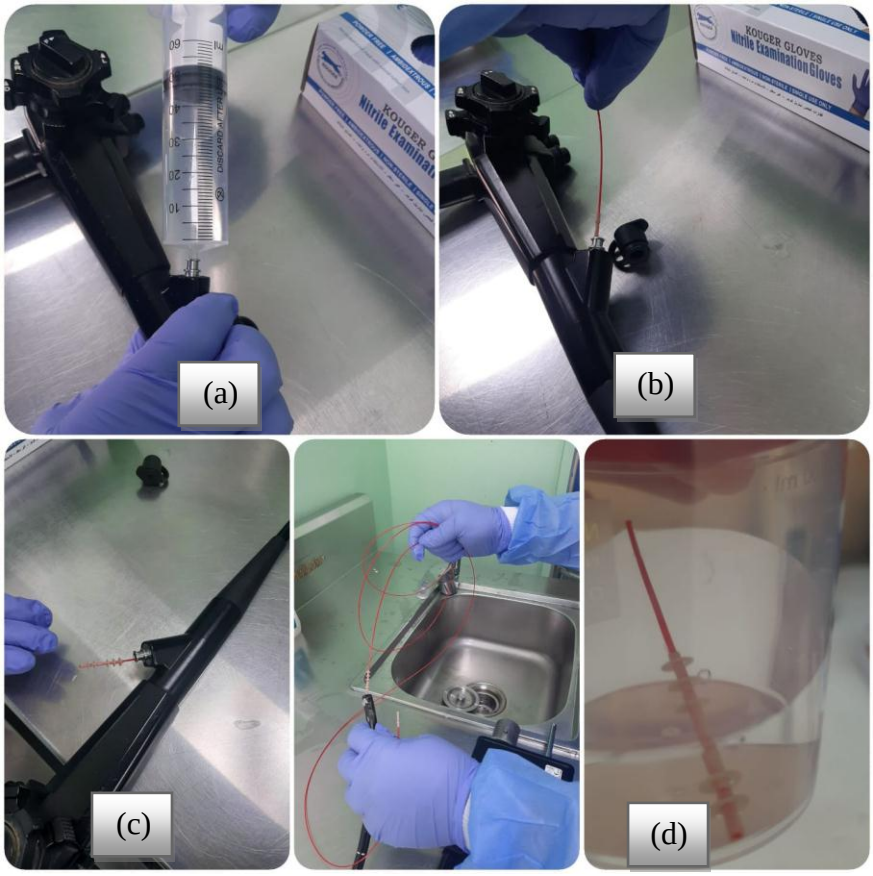

Figure 1: flush-brush-flush sampling method (FBFSM) using pulling thru brush (a) flushing the biopsy channel with sterile water (b) insertion of the pull thru brush (c) pulling the brush through the channel (d) the collected sample.

Statistical Analysis:

IBM SPSS statistics (V. 27.0, IBM Corp., USA, 2020) was used for data analysis. Data were expressed as both number and percentage for categorized data. Data was analysed using the Mann-Whitney *U* Test for non-parametric data.

RESULTS

In this study, a total of 14 flexible endoscopes were sampled during storage in cabinet outside the endoscopy unit using FBFSM method to determine the maximum period for storage of the endoscope without recontamination to avoid excessive reprocessing.

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For each type of endoscope, we assessed the overall percentage of negative cultures (no growth) and positive cultures. Positive cultures were defined as either ≥1 CFU of any High Concern organism (HCOs) (*Pseudomonas aeruginosa, Staphylococcus aureus*, *Acinetobacter baumannii* and *Klebsiella pneumoniae*) or >100 CFU of any Low or Moderate Concern organisms (LCOs) (*coagulase-negative staphylococci* and *Bacillus spp*.). These assessments were conducted after one day of storage and subsequently on each subsequent day until a positive result or the maximum interval of 1 month. The interpretation followed the Duodenoscope Surveillance Sampling & Culturing Protocols (FDA 2018).

Results showed that among the 14 endoscopes sampled with the FBFSM the large percentage of negative cultures remained consistent for the first 8 days for gastroscopes, 11 days for duodenoscopes and for up to 15 days for bronchoscopes (Fig2).

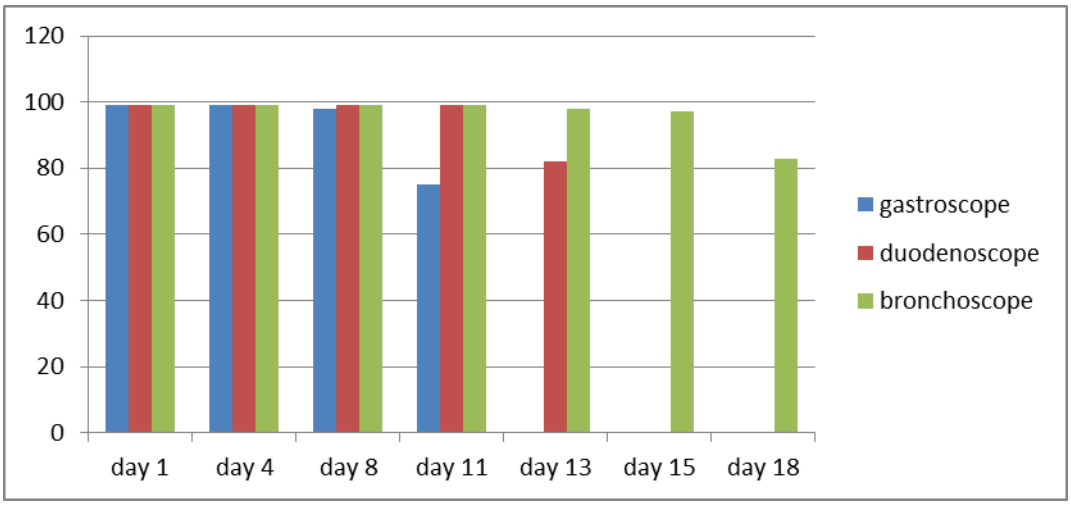

Figure 2: Percentage of negative cultures from each endoscope sample throughout the test period.

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All samples did not reach the maximum CFU for low to moderate concern organisms, but it is considered a positive result due to the presence of high concern organisms (Fig 3).

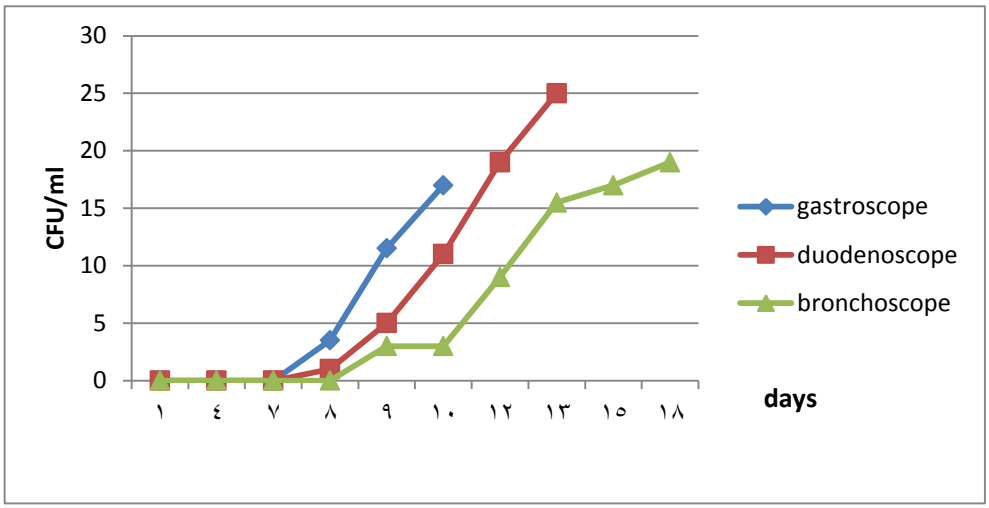

Figure 3: Average count of CFU for low to moderate concern organisms for each endoscope type, where the highest bacterial count from gastroscope was (17 CFU / endoscope) at day 10, from duodenoscopes was (25 CFU/ endoscope) at day 13 and from bronchoscope (19 CFU/ endoscope) at day 18.

Regardless of hang time, all cultures showed complete negative bacterial growth for the first seven days after storage. When all endoscope samples were compared, there was no significant difference, after 8 days of storage for gastroscopes, 11 days for duodenoscopes and 15 days for bronchoscopes (Tables 1, 2 & 3).

Table 1: Comparison of the bacterial growth cultured from gastroscopes among subsequent days:

GASTROSCOPES						
Samples	**N**	**Median**	**25 Perc**	**75 Perc**	**U**	**P**
Day 7	8	0	0	0		
Day 8	10	3.5	0	17.5	-1.64	0.101
					Sig.	NS
Day 7	8	0	0	0		
Day 9	6	11.5	7	14.5	-2.623	0.009
					Sig	HS
Day 7	8	0	0	0		
Day 10	3	17	14	20.5	-2.837	0.005
					Sig	HS

Table 2: Comparison of the bacterial growth cultured from bronchoscopes among subsequent days.

BRONCHOSCOPES						
Samples	**N**	**Median**	**25 Perc**	**75 Perc**	**U**	**P**
Day 8	8	12	4	14.5		
Day 10	8	13.5	6	17.5	-1.205	0.112
					Sig.	NS
Day 8	8	12	4	14.5		
Day 13	7	15.5	7	18.25	-1.235	0.148
					Sig.	NS
Day 8	8	12	4	14.5		
Day 15	10	17	9	20	-1.385	0.166
					Sig.	NS
Day 8	8	12	4	14.5		
Day 17	5	19	13	19	-2.637	0.007
					Sig.	HS

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Table 3: Comparison of the bacterial growth cultured from duodenoscopes among subsequent days.

DUODENOSCOPES						
Samples	**N**	**Median**	**25 Perc**	**75 Perc**	**U**	**P**
Day 8	8	15	5.5	30		
Day 10	10	16.5	9	31.5	-1.004	0.151
					Sig.	NS
Day 8	8	15	5.5	30		
Day 11	10	20.5	15	34.75	-1.006	0.314
					Sig.	NS
Day 8	8	15	5.5	30		
Day 13	6	25	19	37.25	-2.137	0.002
					Sig.	HS

The mostly isolated (HCOs) in this study (*Pseudomonas aeruginosa*) was found in (68.8%), (*Klebsiella pneumoniae*) in (14.84%), (*Acinetobacter baumannii*) in (4.36%), and (*Staphylococcus aureus*) in (3.2%) of total positive cultures. Regarding the (LCOs) (*coagulase-negative staphylococci*) in (13.5%) and (*Bacillus spp*.) in (4.3%) of total collected samples.

DISCUSSION

Providing more sustainable practice would be facilitated by transition to a more circular economy. Circularity might be hindered by Infection control guidelines and manufacturer instructions. A circular health care economy provides an alternative to the unsustainable effects of present practices. It is based on the concepts of resource conservation (water, disinfectants, and electricity), efficiency, and cycles of material recovery and reuse.

Limited research has been done on the storage period of the endoscope 'shelf-life', which can be definite as the storage period after which endoscopes need to be reprocessed again before use. The maximum storage times for flexible endoscopes after reprocessing by HLD have been shown to vary depending on differences in guidelines.

According to the results of our study, endoscopes can be stored for up to 7 days after HLD without bacterial recontamination. The bacterial count, expressed in CFU per screening sample, remained at zero or showed no significant change when compared between day one and day seven of storage. Similar findings were reported by Scanlon and his colleague (2017) they evaluated the need for reprocessing of endoscopes prior to use after storage and found that most endoscopes remained uncontaminated up to 56 days after reprocessing and there were no ones that showed significant contamination for more than 7 days after storage.

A study conducted by Mallette and his colleagues in 2018 found no relationship between hang time and bacterial load. Their findings indicated that using endoscopes within seven days after HLD does not require reprocessing.

Unlike gastroscopes and duodenoscopes, which can be safely reprocessed and used for up to (8 and 11 days) respectively, bronchoscopes can be used within 15 days after high-level disinfection (HLD). Previous studies by Vergis et al. (2007) suggested that endoscope reprocessing is unnecessary after at least seven days, possibly up to two weeks of non-use. Additionally, Brock et al. (2015) found that gastroscopes could be stored for up to 21 days with minimal risk of microbial colonization after regular reprocessing.

In this study Samples displayed contamination after more than 7 days with (HCOs) mainly with gram negative bacteria. *Pseudomonas aeruginosa* was the highly isolated organism, which is a gram-negative pathogen with positive tropism for humid environments, followed by *Klebsiella pneumoniae*, *Acinetobacter baumannii*, and *Staphylococcus aureus*. A study conducted by Singh and his colleagues in (2018) also showed that, reprocessing of endoscope under suitable storage conditions according to manufacturer's recommendations can effectively prevent contamination by high-concern Gram-negative bacteria and extend the shelf life of the endoscope for 3 days. Endoscopes don't seem to require reprocessing before use if they are properly disinfected and stored. This contradicts earlier recommendations that advised decontamination before each use.

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It should be noted that there were certain limitations to this study. Firstly, this was single centre study. Secondly, the sample size of 14 endoscopes is relatively small. Additionally, further research on colonoscopes is required because we were unable to continue sampling using colonoscopes due to shortages in their availability.

CONCLUSION AND RECOMMENDATION

In summary, a conclusive link between the duration of endoscope storage and bacterial presence remains elusive. This study indicates that there is no need to reprocess endoscopes prior to use if they are properly disinfected and stored. If endoscopes are properly cleaned and stored for up to 8 days for gastroscopes, 11 days for duodenoscopes, and 15 days for bronchoscopes, there is no need to reprocess them again before use.

This adjustment would be advantageous for the environment as well as for the institution from a cost perspective. While careful disinfection is necessary to protect patients from infection, healthcare institutions also need to properly train and educate the personnel about the need to comply with the disinfection steps of endoscopes after use and the proper handling and storage methods of the endoscopes after HLD that would extend the safe storage period of the endoscope and decrease the disinfection frequency, leading to resource conservation and less harmful impacts on the worker and the environment.

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المناظير الخضراء: العلاقة بين وقت التخزين ومستوى السلامة الميكروبيولوجية للمناظير

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المستخلص

أصبحت قيمة تطبيق مفهوم الاستدامة على المناظير مطلبا في الآونة الأخيرة خاصة مع نقص الموارد في البلدان منخفضة ومتوسطة الدخل لتوفير رعاية عالية الجودة مع الحد الأدنى من استخدام الموارد لتقليل التأثير السلبي على البيئة والعاملين في مجال الرعاية الصحية وحتى على المنظار نفسه دون التأثير على سلامة المرضى. في هذا البحث تم تخزين مجموعه مكونة من عدد 14 منظارا (ستة مناظير للمعدة و اربعة مناظير رئوية وأربعة مناظير للاثني عشر) لمدة 10–20 يوما بعد الخضوع لعملية تطهير عالي المستوي (HLD). ومن ثم تم أخذ العينات بصوره دورية طوال فتره التخزين لتحديد الوجود البكتيري بعد التخزين. وفقا للدراسة، لا يوجد فرق في عدد البكتيريا بين الأيام (1 –8) لمنظار المعدة، (1–11) لمنظار الاثني عشر و(1 – 15) يوما للمنظار الرئوي مما يعني أنه يمكن تمديد العمر الافتراضي لعملية إعادة تطهير المنظار بعد تخزينه من 24 ساعة علي أساس روتيني طبقا لما هو متبع حاليا إلى 8 أيام لمنظار المعدة، و11 يوما لمنظار الاثني عشر. وبالنسبة للمنظار الرئوي، يمكن تمديد المدة إلى 15 يوما دون إعادة المعالجة وهو ماله دور هام في تقليل استخدام الموارد المائية و المواد الكيميائية الخطرة والحد من تأثيرها الضار على البيئة.

الكلمات المفتاحية: مراقبة المنظار الداخلي–استدامة المنظار الداخلي–وقت تخزين المنظار–المناظير الخضراء

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