Article published online: 2023-04-28

Endoscope reprocessing: How to perform an adequate air drying?

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Endosc Int Open 2023; 11: E440–E442
DOI 10.1055/a-2066-8191
ISSN 2364-3722

Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

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Due to their transmission route, endoscopy-associated infections can be divided into endogenous and exogenous infections.

Endogenous infections are triggered by the spread of the patient's own local flora and mainly include Escheria coli, Klebsiella species, Enterobacter species and enterococci. Endogenous infections cannot completely be avoided due to the nature of endoscopic procedures and vary according to the invasiveness of the procedure.

Since the 1970 s there have been sporadic reports of exogenous infections associated with endoscopic procedures [1]. Since the 2000 s, increased focus has been given on exogenous infections with multi-resistant organisms [2]. In exogenous infections, the endoscope or the endoscopic instruments can be the vehicles for pathogenic or facultative pathogenic germs that originally come from previously examined patients or from the environment.

The decisive factor in triggering an exogenous infection is the germ load within the endoscope channels or on critical endoscope components (e. g. the albarran elevator).

The quality of endoscope reprocessing is an important factor in the development of exogenous infections:

- If cleaning and disinfection is insufficient, organic residues and germs remain on endoscope surfaces and in endoscope channels. If the endoscope is not dried sufficiently, these germs have enough moisture and good living conditions to multiply and become a danger to the next patient.
- If the last rinsing water contains germs, the freshly disinfected endoscope can be re-contaminated with this water. If the endoscope is not dried sufficiently, these germs can then multiply and pose a danger to the next patient.

Therefore, inadequate drying is not the sole cause of exogenous infections. It is rather a catalyst that amplifies existing errors and irregularities and turns them into a problem [3].

There are various manual and automated options available for drying and storage of flexible endoscopes. Kwakman et al. investigated a new device which provides an automated drying cycle and storage in a closed system.

Manual drying

Manual drying is the simplest method which is supported using medical compressed air, because even hanging endoscopes cannot drip out and endoscope channels cannot dry out with the help of gravity due to their narrow lumina [4].

Medical compressed air used for endoscope drying should be free of oil residues and contamination [5]. During their filtration, particles of ≤ 2 µm should be reduced by 99.99 %. The compressed air guns must be cleaned and disinfected regularly. In hospitals, medical compressed air is monitored on a regular basis.

Thaker showed that endoscope channels can be dried sufficiently with medical compressed air [6]. However, this manual process always depends on the human factor. The US guidelines recommend 10 minutes for drying cycle [7]. This period seems unrealistic for manual processes due to the high level of personnel commitment. Reviews show that manual drying, which is very labour-intensive and time-consuming, is neglected, especially when staff work under time pressure [8, 9].

Automated drying

The following methods are available for automated drying of flexible endoscopes:

- Drying cycles integrated in endoscope washer disinfectors (EWD)
- Automated drying in drying cabinets
- Automated drying with processors

Drying cycles integrated in EWD

Many EWD do not have an intensive drying program. In this case, additional manual or automated drying is necessary after reprocessing and before storage.

Some EWD offer drying programs in different drying qualities [5]. According to the European norms DIN EN ISO 15883–4 and DIN EN 16442, the efficiency of automated and manual drying processes should be tested as part of the validation: Medical compressed air is flushed through the endoscope channels. Anhydrous copper(II)-sulfate indicator paper is placed with a distance of 5–10 cm at the distal end of the endoscope, no discoloration due to liquid residues may occur at an overpressure of up to 120 kPa [5, 10].

In some EWD, rinsing with isopropanol is added to the drying process, with the idea of supporting the drying process. National and European guidelines do not recommend alcohol rinsing anymore because 70 % isopropanol has a protein-fixing effect on residual proteins and would support the formation of deposits in the canals in the long term if not cleaned properly [11, 12].

Automated drying in drying cabinets

Drying cabinets, correctly referred as “controlled environment storage cabinets for processed thermolabile endoscopes” (DIN EN 16442) [10], enable standardized and validated drying and storage of flexible endoscopes in a closed system. They completely dry the endoscope surfaces and channel systems by circulating filtered air. The process of drying takes 90 minutes to several hours depending on the Endoscope type and channel configuration.

As described in the standard DIN EN 16442, a drying cabinet is not designed to improve reprocessing, but to maintain the microbiological status [10]. The efficiency of these drying cabinets has been demonstrated in clinical and non-clinical studies [13–15].

Automated drying with processors

Separate processors are available which dry endoscopes completely within up to 10 minutes by using standardized drying cycles. Usually, a constant flow and consistent pressure are used. Studies showed that standardized and automated drying cycles show better drying results than manual drying [4, 13–16]. The Center for Disease Control (CDC) also emphasizes the advantage of automated work processes, with the argument that necessary reprocessing steps cannot be cancelled due to time pressure and workload, which has been observed in surveys [8, 9].

The drying and storage device, Kwakman et al evaluated in their study, dries endoscopes with a combination of initial lamina flow and final turbulent flow within 0.5 to 2.5 minutes, depending on the endoscope channel configuration [17]. The combination of two types of flow supports the efficiency of drying in a shorter period of time.

Kwakman et al used endoscopes which were contaminated artificially with a test soil containing a supraphysiological bacterial load with GUT microorganisms. The significant high number of germs and the concentration of 3 different test germs is a major challenge for the reprocessing cycle. It is therefore not surprising that germs could be detected after cleaning and disinfection as well as after drying, despite the reprocessing steps were carried out correctly. This high germ load allows to demonstrate the effect of drying.

In their study design, Kwakman et al showed that the number of germs could be reduced by increased drying. It should be pointed out that thorough cleaning is the prerequisite for successful disinfection and drying in the clinical setting. According to the DIN EN ISO 15883 standard, reprocessing cycles in EWD should achieve a total log reduction of 9 $\log_{10}$. An additional log reduction of up to 3–5 $\log_{10}$ can be achieved by manual cleaning steps before the automated reprocessing cycle [19, 20].

Who is the bad boy?

It was striking that one of the three endoscopes examined in the study was found to have an increased bacterial load, which did not completely disappear even after 20 repeated reprocessing cycles. This phenomenon was also described by Higa, who examined endoscopes microbiologically in a clinical setting [18]. Apparently, there are always endoscopes that have the smallest, undiscovered defects that can then be responsible for infections. If certain endoscopes repeatedly show conspicuous microbiological checks, it is advisable to take them out of service, send them in for service and, if necessary, completely replace the canal systems or distal ends.

Open questions

If an endoscope is not used immediately on the patient, the endoscope and its components (such as valves) must completely be dried and stored away from contamination [11]. If an endoscope is used directly on the next patient, guidelines allow to use the wet endoscope on the next patient. Usually the majority of fluid is taken off with a short, limited drying to dry electrical contact points and to prevent dripping on floors or surfaces (risk of accidents) [11]. Kwakman et al questioned this procedure because they found remaining GUT germs after reprocessing, but no remaining bacteria after drying. Short and effective drying cycles can be of benefit during short changing intervals.

Simethicone residues have been detected in endoscope channels after reprocessing using boroscopes. Simethicone residues make drying of the endoscope channels more difficult [22], but have not been associated with subsequent infections to date [23]. The use of simethicone should be documented in

endoscopic procedures in order to be able to draw conclusions retrospectively in the event of outbreaks.

Significant biofilm formation has been reported on dismantled endoscope channels during endoscope reprocessing [21]. Biofilm formation depends on various factors. Further studies are needed to investigate the effect of biofilm formation on the different reprocessing steps.

Conclusion

Different methods are available for endoscopes drying. In the presence of impurities and germs, insufficient drying can act as a catalyst and increase deficits. Automated processes show the best results when drying endoscopes and should be used preferably.

Competing interests

The authors declare that they have no conflict of interest.

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