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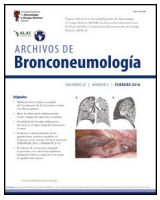

Scientific Letter

Disposable Versus Reusable Bronchoscopes: A Narrative Review of Cost-effectiveness, Risk of Cross-contamination and Environmental Impact

To the Director,

A flexible bronchoscope is an essential tool for diagnosing and treating various airway and lung diseases.[1] Driven by cross-contamination risks and evolving technologies over the past decade, various disposable bronchoscopes have been developed (see Table 1). The use and number of commercially available disposable bronchoscopes has skyrocketed since the 2019 coronavirus (COVID-19) pandemic, especially after the American Association for Bronchology and Interventional Pulmonology (AABIP) endorsed the statement that "disposable bronchoscopes should be used first line when available" in patients with suspected or confirmed COVID-19 infection.[2] This statement, along with other expert statements and the advantages of disposability during the pandemic, provided a strong incentive to use disposable bronchoscopes.[3] Given that disposable bronchoscopes have acquired a permanent position in nowadays pulmonology practice, it is important to evaluate the differences between disposable and reusable bronchoscopes in terms of utility, cost-effectiveness, risk of cross-contamination and environmental impact. Reusable bronchoscopes have been used for several decades, serving routine indications and advanced diagnostic and therapeutic procedures, including airway stent or valve placement and cryotherapy. In recent years, the quality of disposable bronchoscopes has significantly improved, aiming to match the visualization, image quality, rotation function, crutch handling, manoeuvrability, adequate channel size for instruments and scope deflection of reusable bronchoscopes.[4] Compared to reusable bronchoscopes, disposable bronchoscopes offer the advantage of complete sterility and eliminate the need for reprocessing. Deciding on whether to use reusable or disposable bronchoscopes can be challenging due to the lack of reviews and guidelines. Therefore, we undertook a comparative narrative review to assess the difference in cost-effectiveness, risk of cross-contamination and environmental impact between reusable versus disposable bronchoscopes.

In general, the price per use of the disposable bronchoscope ranges between 186 and 269 euros (see Table 1). The price of the reusable bronchoscope is highly dependent on the number of bronchoscopies performed on an annual basis, with the lowest cost per use measured in the hospitals that perform more than 1000 bronchoscopies per year.[5–7] In a micro-costing analysis, Mouritsen et al.[8] determined the total cost per use of a reusable flexible bronchoscope to be 281 euros, whereas the cost per use of a disposable flexible bronchoscope was 248 euros. They also conducted a systematic review, revealing a post-bronchoscopy patient infection risk of 2.8%.[8] The authors concluded that the actual cost per use of a reusable bronchoscope, including the expenses for treating post-bronchoscopy infections, was 621 euros. However, this finding is an overestimation, given that the infection rate was derived from outbreak reports rather than prospective registries. This study has notable limitations, including the aggregation of patient numbers from various studies to calculate an overall risk of 2.8% based on reported outbreaks only. Additionally, the authors utilized infection treatment costs applicable to the USA, which are considerably higher, compared to European prices.

Despite significant efforts put into cleaning and disinfecting reusable bronchoscopes, and although rare considering the high number of bronchoscopies performed world-wide, multiple reports of contaminated reusable bronchoscopes and outbreaks have been published. Infection control guidelines have been established to mitigate the risk of infection transmission following bronchoscopy.[9,10] Cross-contamination causes include inappropriate cleaning, disinfection, or rinsing of bronchoscopes, as well as inappropriate leak testing or drying. The relatively small size of the multiple channels in a flexible bronchoscope contributes to the risk of residual contamination and the formation of a biofilm.[11] A bronchoscope is particularly more difficult to clean when damaged. Cracks and pits in bronchoscopes facilitate the formation of biofilm and bacterial colonization.

The risk of bronchoscopy related infections both endogenous and exogenous are unknown and the problem could potentially be underreported. Ofstead et al.[12] conducted a prospective study examining 24 clinically used bronchoscopes. They concluded that 100% of these bronchoscopes had residual contamination after manual cleaning, and 58% of fully reprocessed bronchoscopes harboured microbial growth. The micro-organisms that were predominantly found included *Escherichia coli*, *Shigella* species, *Stenotrophomonas maltophilia* and mould.

Only one comparative study on the environmental impact of reusable and disposable bronchoscopes has been published. Sørensen et al.[13] aimed to evaluate the CO_2-equivalent emissions and resource consumption from using a disposable bronchoscope compared to the materials used to clean flexible bronchoscopes. The comparison was made using a simplified life-cycle-assessment methodology. The study showed that if reusable bronchoscopes are cleaned using one set of personalized protective equipment (PPE) per operation per bronchoscope, the consumption of material is significant. The authors concluded that using one set of PPE per operation and the materials for cleaning and disinfection determine whether reusable scopes have comparable or higher material and energy consumption, as well as higher emissions of CO_2-equivalents and resource consumption. Cleaning two or more

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Table 1
List of Commercially Available Disposable Bronchoscopes and Specifications.

Name	Company	Number of Available Sizes	Working Length (in mm)	Total Diameter (in mm)	Resolution (in Pixels)	Field of View	Insertion Channel (in mm)	Instrument Channel (in mm)	Bending Angle
Ambu® aScope	Ambu	3	600	5.0, 5.6		120°		2.2, 2.8	U195°/D195°
EXALT™ Model B	Boston Scientific	3	600			90°	3.8, 5.0, 5.8	1.2, 2.2, 2.8	U180°/D180°
H-SteriScope™	Olympus	5	600	6.5, 5.7, 4.8, 3.3, 2.3		110° ± 5°	6.2, 5.8, 4.9, 3.2, 2.2	3.2, 2.8, 2.2, 1.2	U210°/D210° L90°/R90°
EN-BRD Portable Disposable Bronchoscope	Besdata	4	600	2.8, 3.8, 5.2, 5.8	1280*720	120°		1.2, 2.2, 2.8	U180°/D130°
C-MAC® FIVE S bronchoscope	Karl Storz	1	650	5.3		100°		2.2	U180°/D180°
BFlexTM	Verathon	4	610			85°	2.8, 3.8, 5.0, 5.8	1.2, 2.2, 3.0	U185°/D185°, U175/D180°, U165°/D160°, U140°/D135°
NeoFlex Bronchoscope	Neoscope	1		6.5	400*400			5.0	U280°/D280°
INNOVEX Single-Use Flexible Bronchoscope	Innovex Medical	3	620		640*480	110° ± 10°	4.1, 5.0, 5.9	1.2, 2.0, 2.8	U210°/D180°
EndoSheath® Bronchoscopy	Vision Sciences	4	600				4.1, 5.2, 5.7, 6.0	1.5, 2.1, 2.8	U215°/D140°
Video bronchoscope BR-F1	Shenzhen Besdata Technology	4	600	3.8	400*400	120°	2.8, 3.8, 5.2, 5.8	1.2, 2.2, 2.8	U180°/D130°
Video bronchoscope GYBR-W01	Zhejiang Geyi Medical Instrument	1	600		400*400	120°	3.1	1.2	U220°/D220°
PENTAX Medical ONE Pulmo™	Pentax Medical		600		1920*1080	120°	3.4, 5.3	1.2, 3.0	U230°/D210°, U210°/D180°
Video bronchoscope MIK-C232LOFB03	Hangzhou Hikimaging Technology	1	600		400*400	120°	3.1	1.2	U220°/D220°
Broncoflex™	The Surgical Company	2			400*800	120°	3.9, 5.6	1.4, 2.8	U220°/D220° U200°/D200°
Video bronchoscope BC series	Endoso Life Technology	2	600	2.9–6.4	1280*800, 1920*1080	110°	2.8,3.2	1.2–3.2	U180°/D180°

reusable scopes per set of PPE already makes the impact fairly comparable. Other aspects, such as differences in disposal of PPE or disposable scopes and energy consumption for washing and drying units, were also assessed in this study. The authors found that the three parameters that impact the environmental impact the most are the use of PPE, disposal of PPE and disposable scopes, and energy consumption for drying and washing units. However, they could not conclusively determine which type of bronchoscope affects the environmental factors the most, because these three parameters are highly dependent on the use of protective equipment and cleaning procedures per hospital.

Disposable bronchoscopes appear to be suitable for the vast majority of routine bronchoscopy indications, with costs comparable to reusable bronchoscopes. This comparative narrative review suggests that the use of reusable bronchoscopes carries a low risk of cross-contamination. In the past five years fewer than five outbreaks were published. Publication bias may exist, as post-bronchoscopy cross-contamination and infection could be underreported and possibly overestimated when calculated solely from retrospective outbreak reports.

While disposable bronchoscopes are suitable for a vast majority of bronchoscopy indications, such as inspection, mucous clearing and bronchoalveolar lavages, many bronchoscopists still prefer using reusable bronchoscopes due to their stability, functionality, image quality, and the ability to perform discrete endobronchial abnormality detection and advanced therapeutic procedures. To gain a better understanding of the difference in quality and functionality between disposable and reusable bronchoscopes, further studies are needed. Published studies thus far have focused on various settings, patient types, indications for bronchoscopy, and study endpoints, making it challenging to draw general conclusions on whether a disposable bronchoscope is comparable in performance to reusable bronchoscopes.

With regard to environmental impact, no definitive conclusions on the differences between reusable and disposable bronchoscopes can be drawn, because the three main determinants of environmental impact (PPE, disposal of PPE and disposable scopes, and energy consumption) are highly dependent on the local workflow. More studies are needed to accurately assess the environmental impact of bronchoscopes.

In summary, reusable bronchoscopes have a low risk of cross-contamination and post-bronchoscopy infection. The cost-effectiveness of a reusable bronchoscope versus disposable bronchoscopes is highly dependent on the number of bronchoscopies performed annually at a hospital. The utility performance per indication and environmental impact of reusable bronchoscopes versus single-use bronchoscopes needs further investigation.

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