Cost-Effectiveness of 90-day Single-use Flexible Cystoscope Trial: Single Center Micro-Costing Analysis and User Satisfaction

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OBJECTIVE To evaluate cost-effectiveness and user satisfaction of a single-use flexible cystoscope at a tertiary care center we conducted a 90-day trial. Single-use flexible cystoscope advancements have introduced alternative options to reusable scopes. However, there is a paucity of cost-effectiveness and provider satisfaction studies examining the implementation of a hospital-based transition to single-use cystoscopes.

METHODS Following institutional device-approval we initiated a 90-day trial period (November 1, 2020-January 29, 2021) where all flexible, transurethral, and percutaneous, urologic care was provided with a disposable AMBU aScope. We performed a micro-costing analysis examining payor per case cost of the reusable flexible cystoscope (including servicing and processing) to the disposable units. Provider surveys assessed visual quality, deflection, ease of working channel and overall satisfaction on a 10-point Likert scale.

RESULTS Over the 90-day period, we encountered 84 cases (78 operative, 5 inpatient, 1 emergency department) where flexible cystoscopy was required. One disposable flexible cystoscope was successfully used in 78 of 84 (93%) cases. Of the 6 failures, 2 were due to an inability to access a disposable scope/monitor. Per use cost of the reusable flexible cystoscope at our center was $272.41 versus $185.00 for the single use. Extrapolating our average case volume and conservative failure rate (3 single use failures/month, requiring reusable), transitioning to predominately single use scopes results in $39,142.84 annual cost savings.

CONCLUSIONS This single center 90-day trial of disposable flexible cystoscopy identified per-use costs to be less when a single-use flexible cystoscope was utilized at a high-volume tertiary care center. UROLOGY 167: 61–66, 2022. © 2022 Elsevier Inc.

Flexible cystoscopes are fundamental diagnostic and therapeutic instruments used to provide urologic care in the outpatient and inpatient settings. Historically, most centers utilize reusable scopes, which are known to have associated upfront purchasing costs along with annual processing and service fees. Novel changes in scope technologies have introduced many alternatives to both the reusable flexible cystoscopes and ureteroscopes; which have been recently evaluated in a variety of settings with regards to both a provider satisfaction and cost perspective.[1-3] Prior studies evaluating the cost effectiveness of disposable cystoscopy have focused on outpatient procedures.[4-7] Our publication uniquely focuses on the cost-effectiveness of a complete adoption of disposable units in a high-volume academic setting with both advanced endourology, reconstruction and emergency department or ward bedside procedures.

When specifically considering high volume endourologic centers, where flexible cystoscopes are also used for flexible nephroscopy, having a reliable and well-maintained scope repository is critical for success. Scope wear and breakage often occurs with regular use, sterilization, and reprocessing – leading to increased cost and an unpredictable number of available scopes. One study supports that an extensive reprocessing protocol not only reduces the infectious risks for reusable scopes, but also can help minimize the mechanical scope failures, further

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highlighting the importance of developing a thorough reusable scope sterilization process.[8] Unfortunately, not all sterilization protocols are able to entirely eradicate microorganisms from cystoscopes and failure to sterilize properly can lead to additional use related delays or morbidity to patients.[9] Contrastingly, the adoption of disposable cystoscopes for both transurethral and percutaneous surgery provides consistent and brand-new scope mechanics, such as vision quality and deflection capacity for every case. Additionally, there is a decreased potential risk of microorganism contamination and no need for an extensive sterilization protocol.

Recent bench side and early clinical studies have demonstrated comparable visibility, maneuverability, and utilization of graspers between disposable and reusable cystoscopes.[6,7,10,11] However, there are few studies looking at the cost differences between disposable and reusable scopes in a busy clinical setting. Critics state that cost-analysis research is hard to complete in such a way that the findings are generalizable in different practice settings. This is exemplified by the current early contrasting publications within the recent disposable vs. reusable cystoscope and ureteroscope literature.[3,5,7,12] Never-the-less the need for cost and quality evaluations of disposable platforms is still beneficial to health systems and urologic practices attempting to mitigate rising healthcare costs while maintaining quality care for their patients.

In our current study, we evaluated the Ambu A/S (Copenhagen, Denmark) disposable flexible cystoscope for a variety of urologic urgent ward and emergency department bedside cases, urethral reconstructive procedures, and complex percutaneous nephrolithotomy (PCNL) requiring extensive flexible renoscopy. Additionally, we had a spectrum of providers from URO 1 residents to fellowship trained endourologic staff using the equipment. All users provided feedback on the disposable scope quality and functionality. Our primary objective was to complete a 90-day trial with micro-costing analysis, utilizing single use flexible cystoscopes at a tertiary care center with complex endourologic care. Secondary outcomes included examining the urology provider teams' assessment and patient safety of the single use cystoscopes during the trial.

MATERIALS AND METHODS

Following institutional device approval, we initiated a 90-day trial period between November 1, 2020 and January 29, 2021 where flexible cystoscopy was first performed with a disposable Ambu aScope 4 cystoscope. At our center we utilized 2 portable cystoscope monitors. Reusable cystoscopes were only utilized in situations where a single use cystoscope failed (eg, surgeon felt intended treatment could not be achieved with the disposable scope) or there was an access issue (eg, monitor or disposable scope). We recorded all events where the first attempt to utilize a disposable cystoscope failed and we switched to the reusable scope. For the purposes of our trial, we did not open a second disposable cystoscope on the same patient/case. Similar to previously published literature on cystoscope micro-costing from the payor perspective, we included elements of repair fees (based on annual contract values averaged over the prior 3 years), sterilization materials and equipment along with accessory sterilization costs, reprocessing costs of the cystoscopes and labor costs.[4] Costs were tabulated from our administrative resources within our urology department and from the companies providing servicing and equipment fees. The identity of the reusable cystoscope platform is purposefully excluded as repair and replacement pricing is variable and negotiated within each institution and vendor.

At our tertiary teaching center, cystourethroscopy is performed by urologists (AK, TL, MR, and MM), endourology fellows, urology resident physicians, and physician assistants. Peruse 3-minute provider surveys and interval trial assessment surveys examining utilization of the disposable cystoscopes were completed anonymously throughout the 90-day period. A 10-point Likert scale (1 worse, 5 equivalent, 10 better) was used to assess the disposable cystoscope compared to the baseline reusable cystoscope in 4 categories: visual quality (VQ), deflection quality (DQ), ease of working channel (EWC), and overall satisfaction (OS).

IBM SPSS software, Version 26 was utilized.[13] Mann-Whitney U-test and 2-tailed T-tests were utilized when comparing continuous variables between groups. Quantitative data were expressed as medians with interquartile ranges. Binary outcomes were compared using Chi-squared or Fishers exact. Significance was set to $P < .05$.

RESULTS

90-Day Experience

Over our 90-day trial period we encountered 84 total cases where a flexible cystoscope was required to provide urologic care within our academic center (78 operative, 5 inpatient, 1 emergency department) (Table 1). Operative utilization of flexible cystoscopy is outlined in Table 1 with the 3 most common procedures performed were PCNL, urethroplasties, and artificial urinary sphincter placement/revision/explants.

Overall, 78 of 84 (93%) cases were successfully completed with one single-use disposable cystoscope. Of the 6 failures, there were 2 occurrences of inability to access a disposable scope/monitor occurred because both disposable cystoscope monitors were already in use when a third flexible cystoscopy was required. Additionally, there were 4 intraoperative events where the scope failed to complete the required surgery and a reusable flexible cystoscope was required. The first 2 instances occurred when the disposable scope visual/monitor malfunctioned after utilizing a laser fiber. Of note, there were 20 cases where a laser lithotripsy was employed without issue in concert with the disposable flexible cystoscope. The remaining 2 intraoperative disposable scope failures were due to mechanical scope issues: broken thumb piece from excess user force and lack of deflection control after >30 minutes of cumulative usage.

Micro-Costing Analysis

To obtain our per-use cost of the reusable cystoscopes at our center we first assessed our reusable cystoscope inventory (n = 10), annual cases completed (range 449-675), and annual service costs for each of 2018, 2019, and 2020. Table 2 outlines the per-use reprocessing and sterilization cost ($70.87) broken down by component for the reusable cystoscopes which was constant from 2018 to 2020. We did not apply an amortized value of the

Table 1. Flexible cystoscope usage characteristics over 90-day trial Emergency Department (ED). Artificial Urinary Sphincter (AUS)

Location of Use	Procedure	Number of Events
ED	Cystoscopy foreign body removal	1
	Cystoscopy complex urethral catheterization	3
Inpatient	Cystoscopy placement of 5f open ended ureteric catheter and urethral catheter	1
	Cystoscopy stent removal	1
Intraoperative	Percutaneous nephrolithotomy	41
	Urethroplasty	9
	AUS placement/revision/explant	7
	Cystorrhaphy	6
	Complex urethral catheterization	6
	Diagnostic cystoscopy/retrograde pyelogram	5
	Ureteric stent placement	1
	Traumatic urethral repair	1
N/A	Failed to obtain disposable cystoscope/monitor	2
	Total	**84**

Emergency Department (ED). Artificial Urinary Sphincter (AUS).

initial purchase price of our reusable cystoscopes and necessary tower equipment to simplify the cost evaluation. The average per-use cost for the reusable cystoscope was $272.41 (USD) when averaging the annual per-use cost from the 3 years (2018-2020). The cost per use of the disposable cystoscope was $185.00 (USD). The cost of the upfront purchase of the mobile disposable cystoscope monitors were not evaluated within this study.

We subsequently performed cost-analysis comparisons with varying levels of case volumes based on 3-month period cystoscope use ranges (100-170 per quarter) obtained from 2015-2020. Our mean average cystoscope use per quarter during those 5 years was 133 encounters. We encountered 6 total events within the 90-day period where the first attempt to utilize a disposable cystoscope failed (average 2/month). Within our cost comparison (Fig. 1 and Supplemental Fig. 1) we assessed varying levels of monthly failure rates (2-10/month) both factoring for using a disposable cystoscope every time prior to utilizing the reusable cystoscope and using a disposable cystoscope prior to reusable cystoscopes 75% of the time (remaining 25% inability to access disposable cystoscope or monitor).

An analysis was performed to determine the break-even point for the use of the Ambu disposable cystoscope for urology accounting for a range of monthly failure rates and varying proportions of cases requiring both a disposable and reusable cystoscope. At our center, if our quarterly case volume is >37 cases and disposable cystoscope failure rate remains <5/month, then even with all failures utilizing both a single-use cystoscope first followed by a reusable, there is a cost savings by transitioning to a predominately disposable cystoscope model. As outlined further in Figure 1 and Supplemental Figure 1, accounting for backup reusable scopes for disposable failures at a rate of 3 uses/-month, extrapolating our data over an average 3-month period (140 cases) results in $9,785.71 cost savings or $39,142.84 annually.

Table 2. Reusable cystoscope reprocessing/sterilization costs per-use (USD)

Costing Component	Cost Per-use (USD)
PPE for decontamination	$2.00
Cleaning brush	$13.58
Salary for 30 min	$12.25
Sterrad indicator	$0.07
Underguard	$0.57
Sterilization wrapper	$1.39
Sterrad tape	$0.09
Salary for 30 min	$12.25
Cyclesure biological	$11.08
Cassette of hydrogen peroxide	$11.47
Salary for 15 min	$6.12
Total	**$70.87**

Provider Surveys

There were 82 single use cystoscopes used that were eligible for a provider survey (2/84 excluded due to inability to access the monitor or disposable cystoscope itself). Completed provider surveys accompanied 73 of 82 (89%) procedures (Table 3). Average (range) scores for visual quality (VQ), defection quality (DQ), ease of working channel (EWC) and overall satisfaction (OS) were reported by provider role (Table 3).

All providers average VQ was 7.19 (range 2-10), DQ 7.32 (3-10), EWC 7.27 (3-10), and OS 7.32 (3-10). Average scores by provider cohort (physician assistants and residents, fellows, urologists) favored the single-use flexible cystoscope in all 4 domains. Overall satisfaction persistently favored the single-use flexible cystoscope when comparing survey responses by month (Table 3). No provider deemed the single use clinically unacceptable.

Over the first 60-day, 42.1% of respondents required more information (eg, Costing) or additional use evaluations prior to making their final decision on whether to purchase/use the product after the trial concluded, while 57.9% recommended purchase at that point. Over the remaining 30-day of the trial all respondents recommended transitioning to a predominately disposable cystoscopy model at our institution with backup reusable cystoscopes as needed.

DISCUSSION

The transition toward disposable endoscopy is a relatively new and highly contested topic. Initial concerns surrounding the environmental impact of disposable endoscopes have been resolved on a small scale at the institutional level by prior publications.[4,14] Additionally, there have

	Cost for 140 Cases Over a 3-month Period		
	Predicted Cost (USD)	100% of reusable scope use preceded by disposable	75% of reusable scope use preceded by a disposable
Reusable cystoscopes only (272.41*140)	38137.40	n/a	n/a
Single-use cystoscopes only (185.00*140)	25900.00	n/a	n/a
Single-use + backup 2/mon reusable	26424.46	27534.46	27256.96
Single-use + backup 3/mon reusable	26686.69	28351.69	27935.44
Single-use + backup 4/mon reusable	26948.92	29168.92	28613.92
Single-use + backup 10/mon reusable	28522.30	34072.30	32684.80

Figure 1. Example cost comparison for 3-month period with 140 cystoscope encounters with varying failure rates and utilization of both disposable and reusable cystoscopes. Green = favor disposable predominate cystoscope model. (Color version available online.)

been multiple publications, including this study, that support the safety and quality of disposable units within the clinical setting.[1,4,14] Therefore, the adoption of disposable endoscopy rests largely on the cost-effectiveness of a disposable platform relative to a reusable system. When specifically considering cystoscopy, our study demonstrates that the clinical environment and application of the scope itself plays a major role in determining cost-effectiveness. This study was completed in a high-volume inpatient tertiary care center with a wide skill range of endoscopy. We found that over a 90-day period 93% of cases were completed successfully with the disposable. Our survey data showed a provider satisfaction across 4 quality domains and increasing preference amongst providers with increasing exposure time to the disposable cystoscopes. Lastly, the unit price of the Ambu cystoscope makes disposable endoscopy in this setting more cost effective over our reusable platform with average annual savings of $39,142.84 dollars per year.

Our findings are in direct contrast to a prior study evaluating the cost effectiveness of disposable cystoscopes. One group demonstrated that more than 704 cystoscopy and stent removal cases with the Coloplast *Isiris* single use cystoscope with integrated stent grasper would be needed before the disposable unit would become more cost-effective.[4] Another study exploring the micro-cost analysis between the Ambu aScope 4 cystoscope and the Olympus CYF-VHR and V2 cystoscope for outpatient cystoscopy showed reusable equipment was cost effective in a high volume multi-provider practice when performing >294 cystoscopies, although the scope use duration and subsequent service costs was very low (eg, 4 minor repairs within 1 year).[7] These findings emphasize the need for multiple studies evaluating disposable endoscopes in different clinical settings. Instead of simple transurethral stent removals, our study evaluated the durability and cost-effectiveness in a major hospital setting where complex transurethral and percutaneous procedures were performed. For example, there were 41 PCNLs completed where the Ambu cystoscope served to place the retrograde 5Fr opacifying catheter and to perform flexible nephroscopy (Table 1). In addition to the general wear and breakages from cleaning and reprocessing endoscopes frequently, these PCNL procedures are very taxing on the

Table 3. Breakdown of provider survey responses by month for visual quality (VQ), deflection quality (DQ), ease of working channel (EWC), and overall satisfaction (OS)

Cystoscope Characteristic		Month 1	Month 2	Month 3
Visual quality (VQ)	Average	7.54	7.68	6.81
	Median	8	8	7
	IQR	6.25-9	7-8.25	5-8
Deflection quality (DQ)	Average	7.84	7.82	6.27
	Median	8	8	6
	IQR	7-9	7.75-9	5-7.25
Ease of working channel (EWC)	Average	7.32	7.68	7
	Median	8	8	7
	IQR	5-9	6.75-9	5-8.5
Overall satisfaction (OS)	Average	7.64	7.5	6.5
	Median	8	8	7
	IQR	7-9	7-8.25	5-8

10-point Likert scale (1 — Worse, 5 — Equivalent, 10 — Better) comparison to baseline reusable cystoscope.

endoscopes because of complex prolonged flexion/deflection maneuvers with concomitant laser lithotripsy and stone basketing. We demonstrated that even when accounting for 10 Ambu endoscope failures per 110-140 cases, an annual cost savings between $11,321.20 and $21,810.40 dollars can be achieved (Fig. 1, Supplemental Fig. 1).

Our urology team providers identified improvements compared to baseline reusable scope in all 4 domains (visual quality, deflection quality, ease of working channel, and overall satisfaction) with all providers recommending transition to a predominate disposable cystoscope model at the conclusion of the trial. This aligns with recent publications that identify good visual acuity and reusable cystoscope equivalence of provider assessed visualization of key urologic anatomy, image color, illumination, presence of bright spots and overall visual quality to complete the desired task.[6,15] Of note, for the purposes of our analysis, we only utilized one disposable cystoscope per case which would be followed by a backup reusable cystoscope in the case of a failure event. However, none of our disposable cystoscope failures were due to an inherently perceived technology disadvantage compared to the reusable cystoscopes and consideration of an entirely disposable cystoscope model may be feasible. Additionally, the use of the Ambu scope itself did not cause any Clavien-dindo complications throughout the trial.

One limitation of our study is that we sought to only compare the per-use micro-costing analysis between reusable and disposable cystoscopes without evaluating the start-up costs or impact of inflation. Up front purchasing of the required disposable cystoscope monitors depending on how many your center may require, or the initial purchasing costs of the reusable cystoscopes were not compared within our analysis. It is well described that one of the limitations to any cost analysis is the variability in the purchasing price for endoscopes and monitors.[4] Additionally, there are inherently regional or institutional differences in the cost reprocessing and sterilizing endoscopes that challenge the external validity of our study. Despite any potential concerns surrounding the generalizability of our data, micro-cost analyses are still valuable tools to aid in the reduction of healthcare costs without compromising on quality outcomes. The ability to replicate our study findings at other centers is impacted by similar baseline reusable cystoscopy use, clinical case volumes, complexity of cases requiring flexible cystoscopy, and the presence of trainees. Although some studies suggest equivalent environmental impact of transitioning a center from reusable to disposable cystoscopes or ureteroscopes, the true impact of a large-scale transition is not known. If adoption of disposable products increases, it will be invaluable to advocate for increasing use of recyclable materials and company initiatives to reduce their carbon footprint in the manufacturing of these disposable products. Another limitation of our study is that provider survey categories for reusable and disposable cystoscopes vary within the literature (eg, visual quality, optical quality, ease of manipulation, ease of working channel, ease of insertion, illumination, deflection quality, overall ease of use, overall satisfaction) and there is no validated objective provider satisfaction survey by which to compare cystoscopes.[7,8] We selected 4 cystoscope characteristics that were determined to encompass previously reported characteristics within the literature as well as what were important to the 4 urologists within our study (VQ, DQ, EWC and OS) which we evaluated using a nonvalidated survey incorporating a 10-point Likert scoring system. One strength of our study is the inclusion of these per-use provider surveys throughout the duration of the 90-day trial period.

Taken in the context of the current literature, our findings highlight the unique differences between institutions and how those variances manifest in different micro-costing analyses which can yield opposite results (eg, favoring reusable cystoscopes at one center while favoring single use at another), providing further evidence that urology teams should perform institutional cost-assessments when comparable novel technologies are introduced.

CONCLUSION

This single center 90-day trial of single-use flexible cystoscopes identified that based on our micro-costing analysis, per-use cost favors transitioning to single-use flexible cystoscopes at our academic center. Over the trial period most providers identified scope characteristic improvements compared to reusable cystoscopes with all providers recommending a predominate disposable cystoscope model with backup reusable as needed at the conclusion of the trial period.

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SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at https://doi.org/10.1016/j.urology.2022.05.039.

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EDITORIAL COMMENT

This is an outstanding micro-costing analysis comparing the cost of disposal vs multiuse units which concludes that for this tertiary academic center disposable flexible cystoscopes resulted in a lower cost.[1] Only one of the 7 authors was a consultant for the device being investigated, which helps to minimize investigator bias, and measured user satisfaction with the disposable cystoscope during the 3 months of study was high. The authors are to be commended for providing this information that can be used by other centers in consideration of this decision and the study adds to a growing body of literature on this topic.

Technically, this is not a cost-effectiveness study but a cost minimization study[2] as the utility and satisfaction was equivalent with the 2 options and the cost of the disposable unit was lower at this institution. Another important caveat is that — although the authors say the perspective is that of the payor the analysis was actually conducted from the perspective of the institution rather than the payor. The conclusion that the cost of the reusable cystoscope was lower with annual cost savings are internally consistent with what was measured and tallied at the institution; what the payor pays however is the charge of the procedure including provider charges, facility fees, and other overhead charges as well as the cost of having a cystoscope ready for each procedure. A lower cost for the institution therefore results in more profit (payer reimbursement minus expense) per cystoscopic procedure in the traditional fee-for service model and more net revenue for the institution under a capitated arrangement. We have no evidence from this study that the lower cost of the cystoscope will be passed onto the payer in terms of a lower charge per procedure.

Traditionally a cost effectiveness study is conducted from the perspective of society — both in terms of paying for the cost of care, and in terms of tradeoffs that society wishes to make among different care options for their citizens. All industrialized nations beside the United States have a single payer health care system and these countries may be able to purchase the reusable cystoscopes at bulk price that amortized dominate a strategy of continual purchase of disposable cystoscope.

The authors point out that environmental impact concerns have been resolved at the institutional level and make reference to other studies — and point out that this assumption can vary by what is measured. Society cares greatly about the carbon footprint of decisions we make in healthcare and we trust these assumptions about disposable medical equipment are less toxic to society than the reusable are.

The generalizability of this result also may vary by the individual parameters being measured. For example, the cost of re-processing and sterilization is 43% resultant on salary — therefore reusable cystoscopes may be less costly in other states and cities, and in countries where hourly wages are less than that of Chicago. Other costs measured may vary by institution or health care system.

The authors carefully point out that "there are regional or institutional differences in the cost of reprocessing and sterilizing endoscopes that challenge the external validity of our study" and thus to use this micro-costing study in other institutions ends up being a matter of measurement. Careful measurement at each institution — and in each health care system — will allow for application of these findings on an institutional level — for this to be a true cost-effectiveness analysis we would want to reframe the question with society making the measurements of costs and outcomes. Given the comparable medical quality this issue ends up being a local decision — and a matter of measurements.[3]

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