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ORIGINAL ARTICLE

A micro-costing analysis of outpatient flexible cystoscopy: implications for adoption of single-use flexible cystoscopes

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Abstract

Purpose To evaluate the total cost of outpatient flexible cystoscopy associated with reusable device purchase, maintenance, and reprocessing, and to assess potential cost benefits of single-use flexible cystoscopes.

Methods Cost data regarding the purchasing, maintaining, and reprocessing of reusable flexible cystoscopes were collected using a micro-costing approach at a high-volume outpatient urology clinic. We estimated the costs to facilities with a range of annual procedure volumes (1000–3000) performed with a fleet of cystoscopes ranging from 10 to 25. We also compared the total cost per double-J ureteral stent removal procedure performed using single-use flexible cystoscopes versus reusable devices.

Results The cost associated with reusable flexible cystoscopes ranged from $105 to $224 per procedure depending on the annual procedure volume and cystoscopes available. As a practice became more efficient by increasing the ratio of procedures performed to cystoscopes in the fleet, the proportion of the total cost due to cystoscope reprocessing increased from 22 to 46%. For ureteral stent removal procedures, the total cost per procedure using reusable cystoscopes (range $165–$1469) was higher than that using single-use devices ($244–$420), unless the annual procedure volume was sufficiently high relative to the number of reusable cystoscopes in the fleet (≥ 350 for a practice with ten reusable cystoscopes, ≥ 700 for one with 20 devices).

Conclusion The cost of reprocessing reusable cystoscopes represents a large fraction of the total cost per procedure, especially for high-volume facilities. It may be economical to adopt single-use cystoscopes specifically for stent removal procedures, especially for lower-volume facilities.

Keywords Reusable flexible cystoscopes · Cost · Cystoscope reprocessing · Single-use flexible cystoscopes · Micro-costing

Introduction

Flexible cystoscopy is one of the most common urologic procedures performed in the office setting to diagnose and treat conditions in the lower urinary tract. Reprocessing reusable flexible cystoscopes after each procedure is essential for assessing instrument integrity [1] and reducing contamination-related infections [2–6]. The reprocessing of reusable cystoscopes is a multistep process that requires time and expense: (1) pre-cleaning, (2) leak-testing, manual cleaning, and visual inspection, (3) high-level disinfection, (4) rinsing, and (5) drying and storage. Reprocessing can therefore be a limiting factor in a urology practice where multiple providers need to perform a high number of procedures concurrently.

To overcome this limitation, new technologies have been introduced, including disposable sheaths to shorten

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the reprocessing time [7, 8] and more recently, single-use digital flexible cystoscopes which have been approved for double-J ureteral stent removal [9, 10]. Potential benefits of these technologies in clinical practice include ease of clinical integration and cost savings in comparison to reusable flexible cystoscopes. However, there are currently limited data on the cost associated with reprocessing reusable cystoscopes to inform practice-level decisions regarding adoption of single-use flexible cystoscopes.

Micro-costing is an effective method that allows precise estimation of the likely costs of health care interventions [11]. This method has been utilized in a recent analysis to assess the cost of purchasing, reprocessing, and maintaining reusable colonoscopes, in a similar context of evaluating the economic benefit of adopting disposable colonoscopes [12]. To investigate potential cost benefits of single-use flexible cystoscopes, we employed micro-costing to evaluate the total potential costs and cost-savings associated with the purchase, maintenance, and reprocessing of reusable flexible cystoscopes in urology practices.

Methods

All cost data regarding the purchasing, maintaining, and reprocessing of reusable flexible cystoscopes were obtained at a high-volume outpatient urology clinic (Johns Hopkins Outpatient Center, Baltimore, Maryland, United States). Where cost estimates for specific items were not available, we utilized values reported from the existing academic and commercial literature. All cost data were collected in United States dollars using a micro-costing approach.

Capital costs

Purchase costs of reusable flexible cystoscopes and accessories, camera platforms and associated hardware, and equipment used for reprocessing cystoscopes are detailed in Supplemental Tables 1 and 2. We assumed three sets of camera platforms at a urology practice. Capital costs of reusable cystoscopes and accessory devices were amortized over 5 years, and capital costs of camera platforms and associated hardware were amortized over 8 years. For cystoscope reprocessing, we assumed two automated endoscopic reprocessors (AERs), typically used for high-level disinfection of cystoscopes during reprocessing, available at a urology practice regardless of annual procedure volume. The AERs and drying cabinets were amortized over 8 years. Capital costs were discounted at 3.5% per year to calculate the present value of capital expenditures.

Costs of disposable supplies and equipment repairs

We itemized the costs of common disposable supplies used during an outpatient flexible cystoscopy procedure for diagnosing urinary tract pathology (Supplemental Table 3). The average cost of repairs per AER was $7831.25 per year based on manufacturer estimates [13]. We assumed that each reusable cystoscope was repaired once every 495.4 procedures for an average repair cost of $5.41 per procedure, according to estimates from a prospective study of cystoscope durability [1].

Costs of reprocessing reusable flexible cystoscopes

The cost of supplies used for reprocessing reusable cystoscopes (Supplemental Table 4) was estimated in two steps. First, in a recent study performed at our institution, the supplies used for reprocessing 25 reusable colonoscopes over a 3-day period were tracked using the micro-costing approach [12]. Then, we verified item by item that reprocessing of reusable flexible cystoscopes requires use of the same supplies and equipment at our institution. Average personnel time spent on each step of manual reprocessing of one cystoscope was derived based on estimates from a recent clinical trial [8]. These estimates were also verified to be consistent with the average amount of time spent on manual reprocessing of cystoscopes at our institution.

Infection-related treatment costs

Regarding the costs of treating possible infections after outpatient flexible cystoscopy (Supplemental Table 5), we assumed that that 6.6% of patients present for a follow-up office visit [14], 1.9% have a febrile urinary tract infection requiring oral antibiotics [4], and none develop bacterial sepsis requiring hospitalization [4] based on incidence rates observed in cohort studies.

Primary analyses

We used the cost estimates mentioned above to project the total cost per use of reusable flexible cystoscopes to a urology practice with a range of annual procedure volumes (1000–3000) performed with a fleet of cystoscopes ranging from 10 to 25 cystoscopes. The tested range for annual procedure volumes was based on typical annual volumes of outpatient diagnostic flexible cystoscopy procedures performed at our center.

Secondary analysis

We performed a secondary analysis to compare the costs of performing double-J ureteral stent removal procedures in the

office setting using reusable flexible cystoscopes versus single-use flexible cystoscopes. For this analysis, we assumed a purchase cost of $200 per single-use flexible cystoscope, and a unit purchase cost of $788.49 for reusable flexible grasping forceps, based on cost estimates at our institution. We assumed three sets of grasping forceps available at a practice. The costs of grasping forceps were amortized over 1 year. In calculating the total cost per procedure associated with single-use flexible cystoscopes, we included the same purchase costs of camera platforms and associated hardware (i.e., display monitor, camera platform, equipment cart, printer and documentation system) and disposable supplies used per procedure, and we excluded the costs of reusable cystoscope repairs and reprocessing. In the base-case analysis, we excluded the cost of infection-related treatment for single-use devices. In a sensitivity analysis, we included the infection-related treatment cost for single-use devices by assuming the same rates of infection after reusable devices. We compared the per-procedure cost to a urology practice performing a range of stent removal procedures annually (100–900) using a fleet of 10–25 flexible reusable cystoscopes versus single-use flexible cystoscopes exclusively.

Results

Primary analysis for outpatient diagnostic cystoscopy procedures

The per-procedure cost associated with reusable flexible cystoscopes was highly dependent on the annual procedure volume and the number of cystoscopes available at a urology practice (Supplemental Fig. 1). As the annual procedure volume varied between 1000 and 3000 and the available cystoscopes varied from 10 to 25, the cost per procedure ranged from $105.47 to $224.36. Divided into individual cost categories, the capital cost per procedure ranged widely from $21.94 to $135.61 depending on the annual procedure volume and the number of cystoscopes in the fleet (Table 1). The average cost of equipment repairs per procedure performed varied from $8.02 to $13.24 depending on the annual procedure volume. The estimated per-procedure cost for the other cost categories was independent of the annual procedure volume and number of cystoscopes available. The cost of disposable supplies used per procedure was $21.78. For the cost of reprocessing reusable flexible cystoscopes, the cost of supplies used in reprocessing of one cystoscope was $25.23 and the personnel cost for time spent on manual cleaning and disinfecting one cystoscope was $23.64, adding up to an overall reprocessing cost of $48.87 per procedure. Personnel cost accounted for 48% of the reprocessing cost. In addition, the infection-related treatment cost was on average $4.85 per procedure.

Table 1 Estimation of the per-procedure costs of reusable flexible cystoscopes by varying annual number of procedures and number of cystoscopes available at a urology practice

Summary of costs	1000 procedures	2000 procedures	3000 procedures	Costs that will remain with single-use flexible cystoscope
Capital cost				Yes: purchase of single-use flexible cystoscope per procedure, camera platform, and associated hardware
10 cystoscopes	$65.83	$32.92	$21.94	
15 cystoscopes	$89.09	$44.55	$29.70	
20 cystoscopes	$112.35	$56.18	$37.45	
25 cystoscopes	$135.61	$67.81	$45.20	
Disposable supply cost	$21.78			Yes
Repair cost	$13.24	$9.33	$8.02	No
Reprocessing cost: supplies	$25.23			No
Reprocessing cost: personnel	$23.64			No
Infection-related treatment cost	$4.85			Not for infections caused by cystoscope cross-contamination
Total cost				
10 cystoscopes	$154.58	$117.74	$105.47	
15 cystoscopes	$177.84	$129.37	$113.22	
20 cystoscopes	$201.10	$141.01	$120.97	
25 cystoscopes	$224.36	$152.64	$128.73	

As a practice became more efficient by increasing the ratio of annual procedure volume to cystoscopes in the fleet (i.e., moving from the left lower corner to the right upper corner of Supplemental Fig. 1), the proportion of the total per-procedure cost due to cystoscope reprocessing increased from 22 to 46% (Supplemental Fig. 2a), while that due to capital purchase decreased from 60 to 21% (Supplemental Fig. 2b).

Secondary analysis for double-J ureteral stent removal procedures

As the number of stent removal procedures performed annually at a practice increased from 100 to 900, the total cost per procedure associated with using single-use reusable cystoscopes decreased from $420.13 to $243.82. Supplemental Fig. 3 compares the per-procedure costs for single-use versus reusable cystoscopes. Unless the annual procedure volume was sufficiently high, the per-procedure cost associated with single-use cystoscopes would be lower than that with reusable cystoscopes. For example, if a practice performed fewer than 350 procedures per year using a fleet of ten reusable cystoscopes, the practice would incur a lower total cost per procedure if the practice performed the same number of procedures annually using entirely single-use cystoscopes. The more reusable cystoscopes already available at a urology practice, the higher the break-even annual procedure volume in terms of per-procedure cost for switching to exclusively single-use cystoscopes (Fig. 1). The break-even procedure volume increased linearly with the number of reusable devices owned by a practice. In the sensitivity analysis where we applied the infection-related treatment costs associated with reusable devices to single-use devices, the break-even procedure volumes did not change considerably from the base-case analysis where such costs were excluded for single-use devices (Supplemental Fig. 4).

Discussion

Our study illustrates that the total per-procedure cost of outpatient flexible cystoscopy, including purchase, maintenance, reprocessing, and infection-related treatment, varies considerably depending on the annual procedure volume and number of reusable cystoscopes available at a urology practice. Over the range of annual procedure volumes and available cystoscopes tested in our analysis, the total cost per procedure ranges between $105 and $225. Most of the variation is due to capital purchase cost. As a urology practice gains efficiency by performing a greater volume of procedures using the same number of reusable cystoscopes, the average capital purchase cost per procedure performed decreases. The demonstration of cost variation allows our findings to be interpreted in and adapted to the context of individual urology practices with varying patient volumes and device quantities in their fleet.

The cost of reprocessing of reusable cystoscopes between uses accounts for a considerable fraction of the total per-procedure cost of outpatient flexible cystoscopy, and this fraction increases with the procedure volume of a urology

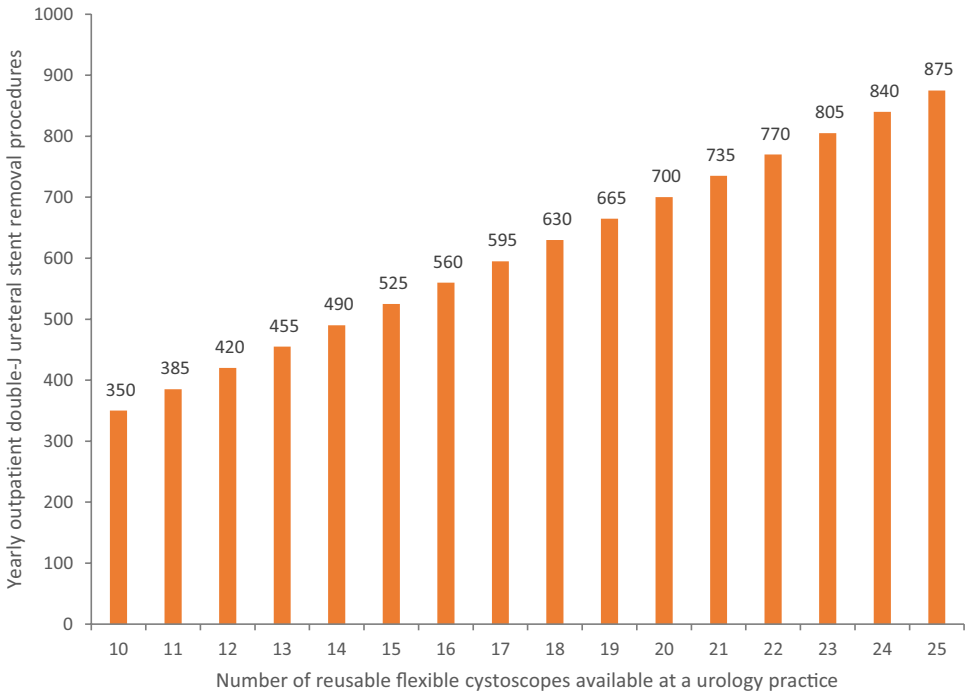

Fig. 1 The number of outpatient double-J ureteral stent removal procedures a urology practice needs to perform annually given the number of reusable flexible cystoscopes already available at the practice in order for the total cost per procedure performed using reusable cystoscopes to be lower than the total cost per procedure performed using single-use devices

practice. In a practice performing 3000 outpatient diagnostic cystoscopy procedures annually, the cost of cystoscope reprocessing may account up to nearly half of the total cost per procedure. This result highlights that in order for a urology practice to achieve a high procedure volume, a considerable amount of time and expense needs to be spent on cleaning and disinfecting of devices after each use.

For double-J ureteral stent removal procedures, on the basis of total cost per procedure performed, our analysis showed that adopting single-use flexible cystoscopes may be economical for a urology practice unless the practice performs a high volume of these procedures. This is because the unit purchase cost is much higher for a reusable cystoscope than a single-use device. The number of procedures performed thus needs to be sufficiently high in relation to the number of reusable cystoscopes already purchased by a practice for the average purchase cost of reusable devices per procedure to be lower than the purchase cost of a single-use cystoscope. Furthermore, reusable cystoscopes would incur additional costs due to device repairing and reprocessing. Therefore, for urology practices that do not perform a very high volume of stent removal procedures (i.e., <350 procedures annually for a practice owning ten reusable cystoscopes, and <700 procedures annually for a practice owning 20 devices), they may achieve cost savings by performing these procedures exclusively using single-use devices.

Our study adds to a currently limited base of literature on the economic comparisons between reusable and single-use flexible cystoscopes. To our knowledge, only two existing studies have compared the costs of performing stent removal procedures using single-use versus reusable flexible cystoscopes. An Italian study compared the average per-procedure cost of 127 stent removal procedures using single-use flexible cystoscopes in the office setting versus 170 stent removal procedures performed using three reusable flexible cystoscopes in the operating room (OR). This study tracked the device purchase, repair, and reprocessing cost as well as OR occupancy cost and found that overall, single-use devices had a lower total cost per procedure [10]. In contrast to the Italian study, our analysis examined the cost of stent removal procedures in the office setting for both single-use and reusable cystoscopes. Additionally, we included the cost of infection-related treatment following procedures performed using reusable cystoscopes. The second study was a recently published analysis of nearly 900 stent removal procedures performed using reusable flexible cystoscopes, in which the estimated cost per procedure, including purchase, maintenance, and reprocessing, was $161.85 [15]. This study further reported that if the procedure volume was low (<704), the cost per stent removal procedure performed using single-use cystoscopes would be lower than that using reusable cystoscopes, a conclusion supported by our calculations. In comparison to this study, our study conducted a more thorough cost comparison by additionally assessing the costs of capital equipment including the camera platforms and associated hardware, disposable supplies used during each procedure, and treatment of infections after procedures. Furthermore, in comparison to both of the existing studies, our study projected the cost comparisons to a wide range of annual procedure volumes and number of reusable devices in the fleet, instead of a fixed procedure volume and a specific number of reusable devices available at the respective study institution.

Our study highlights that the economic decision to integrate single-use flexible cystoscopes needs to be individualized for any given urology practice based on the procedure volume of the practice and the amount of capital equipment already purchased by the practice. Currently, single-use flexible cystoscopes have only been approved for ureteral stent removal procedures and do not yet provide sufficient image quality to be used for diagnostic cystoscopy procedures. Therefore, reusable cystoscopes remain indispensable for any urology practice. For stent removal procedures specifically, our analysis results favor switching to single-use devices for a practice with a low volume of these procedures. This may be the case, for example, for a newly established practice, or a practice that does not yet own reprocessing equipment to allow for a large procedure volume. For an established practice regularly performing outpatient stent removals, the economic consideration needs to assess both the procedure volume and the number of reusable cystoscopes already purchased by the facility. If a practice in question has the equipment and efficiency to perform sufficiently many procedures using relatively few reusable cystoscopes in the fleet, it would likely be economical for the practice to continue with reusable devices. But if the practice had to purchase, utilize, and maintain a large fleet of reusable devices to sustain the procedure volume, switching to single-use devices may lead to cost savings by reducing the cost of cystoscope maintenance and reprocessing. Lastly, even for a highly efficient practice maintaining a large procedure volume, there may still be a role of single-use flexible cystoscopes, such as reserving these devices in stent removal procedures for patients at a higher risk of infections, including those with recurrent infections and those who are immunocompromised (e.g., kidney transplant). Further research is thus needed to evaluate the potential clinical benefit of single-use devices in these specific settings.

Our study has several limitations. Our cost estimates are minimum estimates. We did not include costs related to initial personnel training, time spent on documentation of cystoscope repairs, and recurring training for compliance with reprocessing guidelines. The true cost is likely higher if overhead costs, additional reprocessing and equipment purchase costs are included, such as repeat reprocessing after a prolonged period of storage, cost of disposing single-use

flexible cystoscopes and single-use accessories, conducting internal audits, and utility bills. Additionally, our study did not account for the environmental impact of disposable single-use flexible cystoscopes, which was beyond the scope of the study but a relevant consideration in the widespread adoption of single-use devices [16]. The environmental impact per use of device is likely much higher for single-use cystoscopes than reusable cystoscopes, given the carbon footprint that goes into manufacturing each single-use device which gets disposed after one use. This difference in carbon footprint may be partially offset by energy cost associated with reprocessing reusable devices. Further, our results, derived mostly using cost estimates at a single institution, may not be generalizable to other practices and geographies due to regional variation in practice patterns. In particular, our assumptions derived from our institution, such as those regarding equipment lifespan, may not be applicable to centers and health care systems around the world. Nonetheless, the pattern of cost variation identified in our study, and in particular, the study implications suggesting the potential economic benefit of adopting single-use cystoscopes for many urology practices, is likely valid regardless of location. By incorporating variation in the size of cystoscope fleets and reprocessing equipment, our findings should be relevant to urology practices of diverse sizes and procedural patterns.

Conclusion

While the cost of reusable flexible cystoscopes is highly dependent on the number of cystoscopes available and annual procedural volume at individual urology practices, the cost of reprocessing reusable cystoscopes after each use represents a large proportion of the total per-procedure cost for high-volume practices. For ureteral stent removal procedures for which single-use flexible cystoscopes have been developed and approved, integrating single-use devices may yield cost savings for many urology practices, particularly those with lower procedural volume and those with sufficiently high procedural volume to require maintenance of a large fleet of reusable cystoscopes.

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Data availability Full data provided in the data tables.

Code availability Available upon request.

Declarations

Conflict of interest Dr. Brian R. Matlaga is a consultant for Boston Scientific. No other competing financial interests exist.

Ethics approval N/A (no human subjects involved in this study).

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