

Assessment of the economic relevance of the use of single-use digital flexible ureteroscopes: A systematic review

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ABSTRACT

Introduction: Breakages and repairs related to flexible digital reusable ureteroscopes (flURS) are expensive. Thus, we aimed to assess the cost-effectiveness of single-use flexible digital ureteroscopes (SUDFU).

Methods: We conducted a literature review on MEDLINE and EMBASE until September 19, 2018. Systematic reviews and guidelines were assessed for methodologic quality by using standardized grids (R-AMSTAR and AGREE-II). Original studies were analyzed according to local customized grids. The CAPS (Critical Appraisal Skills Program) tool enabled the assessment of the economic aspects in the literature.

KEY MESSAGES

- Breakages of flURS, which are fragile devices, are associated with expensive repair costs.
- According to results from economic studies, the mean cost per intervention is generally higher with SUDFU than with flURS
- In our current context, it may be possible that selective SUDFU usage in targeted high-risk interventions reduces breakages and repair-related costs, but with a high degree of uncertainty.

We also collected local data over a year in 2017–2018 and conducted an economic evaluation by cost minimization, comparing SUDFU and flURS in our center. By generating different flURS breakage reduction scenarios, we aimed to demonstrate the budgetary impact that would have SUDFU introduction in our center.

Results: Five economic studies were included. Data on flURS showed breakage rates between 6.4% and 13.2%, and mean numbers of interventions before breakage between 7.5 and 14.4. Four of the five economic analyses suggested a higher cost per intervention with SUDFU. Our local data demonstrated similar results (6.4% and 11.8 cases) and enabled us to estimate the annual number of ureteroscopies for which SUDFU would become profitable: 11–26 (depending on the chosen device). Furthermore, we illustrated how selective use of SUDFU can reduce annual costs by avoiding breakages in different scenarios.

Conclusions: The mean cost per intervention with SUDFU is usually higher than with flURS in high-volume centers and exclusive use becomes unprofitable from a small number of cases.

INTRODUCTION

Ureteroscopy is a common minimally invasive procedure that enables diagnosis and treatment of upper urinary tract conditions like urolithiasis and upper tract urothelial carcinoma [1, 2]. However, flexible ureteroscopes, especially digital models, are fragile devices associated with high breakage rates which can occur during the surgical procedure itself but also during the reprocessing, transport, and storage phases [3-6]. Recently, single-use digital flexible ureteroscopes (SUDFU) have been commercialized and could represent an interesting alternative to reusable digital flexible ureteroscopes (flURS), particularly in terms of material resource management. Several models are currently available in Canada, for instance LithoVue™ (Boston Scientific), Uscope (Pusen Medical, Clarion®) and Neoflex (Neoscope®). In our tertiary medical center *Centre Hospitalier Universitaire de Québec-Université Laval (CHU de Québec)*, digital flexible ureteroscopes are used since 2015 and are mostly performed in one affiliated hospital, *Hôpital St-François d'Assise (HSFA)*. Considering the high costs related to their use and the risk of service breakdown, SUDFU have been introduced and tested by local urologists.

Despite a few articles in the literature, SUDFU appears to be as effective as flURS in treating urolithiasis [5, 7-10]. Nevertheless, this review aims to assess the economic relevance of SUDFU. Another purpose of this study is to evaluate if SUDFU could be a cost-effective alternative in a high-volume center to reduce flURS breakages in selected high-risk cases. To carry out this review, we collaborated with a local multidisciplinary team of research professionals called *Unité d'évaluation des technologies et des modes d'intervention en santé (UETMIS)*.

METHODS

Literature review

The research strategy was based on the methodological guide of the UETMIS [12]. An interdisciplinary group of individuals concerned with the decisional question was conceived. Globally, UETMIS participated in the economic evaluation plan, data collection and results analysis, and in understanding our local clinical, practical, and economic context.

A review of the scientific publications was conducted on two indexed databases, EMBASE and MEDLINE, from their beginning until September 19th, 2018. Research strategies are presented in Appendix 1. The documentary research was performed in accordance with the study designs hierarchy and was restricted to French and English. Table 1 summarizes the selection criteria. In order to identify economic analyses of interest, we also consulted Internet websites including the Toronto Health Economics and Technology Assessment Collaborative (<http://theta.utoronto.ca/home>), the Program for Assessment of Technology in Health of the McMaster University (<http://www.path-hta.ca/Home.aspx>), the Institute for Clinical and Economic Review (www.icer-review.org), the Institute for Health Economics (www.ihe.ca), and the economic studies database of the Centre for Reviews and Dissemination (<http://www.crd.york.ac.uk/CRDWeb/>) (see Annex 2).

Two independent reviewers (S.L. and R.D.) participated in the study selection, methodological quality assessment and data extraction. Systematic reviews and practical guidelines were evaluated by following the R-AMSTAR [13] and AGREE-II [14] standardized grids. However, original studies were evaluated according to a customized grid from the UETMIS [12]. In case of disagreement, a third evaluator was required (A.N.). To achieve an economic evaluation of the studies, we used the CASP tool (Critical Appraisal Skills Programme) from the *Institut national d'excellence en santé et en services sociaux* (INESSS) [11].

Investigation about the local practical use of fIURS

Between February 13th to May 9th 2018, we conducted semi-directive interviews with key stakeholders who had specific roles in the fIURS lifecycle. We aimed to get information from the contributors who were either involved in the clinical utilization, reprocessing, purchasing, or maintenance of the fIURS in our center. The interview guide used is presented in Appendix 3. Subsequently, we consulted the register of the medical devices reprocessing unit (MDRU) between May 28th 2017 and May 27th 2018 to estimate the number of fIURS used and the frequency of breakage over a year. In cases of breakage, with the agreement of the Director of Professional Services, we accessed patient electronic records to collect information about the clinical and technical context of the incidents. Moreover, with the collaboration of the Assistant Head Nurse of the operating facility, we collected data between September 1st 2017 and May 31st 2018 concerning the purchasing of SUFDU and the context of their clinical uses (indications).

Economic evaluation in CHU de Québec

To compare costs between SUFDU and fIURS in our center, we performed an economic evaluation by cost minimization. Indeed, we estimated the mean cost per intervention and the total annual cost for each device. According to a one-year period of local data collection (between May 28th 2017 and May 27th 2018), we took into account the costs related to the purchase, repair, reprocessing and sterilization. Initial purchase costs were provided by the Supply Operations Service. We applied a 6-year amortization to our calculations. This period corresponds to the useful life of a fIURS. To estimate the mean cost per intervention of a fIURS specifically, we used the purchase costs of the Karl-Storz and Olympus devices. Our formula is presented in Appendix 4. Concerning the SUFDU, we considered the purchase costs of the LithoVueTM and Uscope devices.

Our calculations represent our practical context, corresponding to a collection of five fIURS in a high-volume center. To reflect other centers' reality better, we proceeded to calculations considering a collection of one or two fIURS.

More interestingly, we also aimed to demonstrate the budgetary impact of the selective use of SUFDU, by reducing annual repair costs. According to our collection of five fIURS, we calculated several total annual costs depending on the proportion of SUFDU usage and the proportion of prevented breakages (25, 50, 75 and 100%).

RESULTS

Our research strategy enabled us to list a total of 357 publications. After revision of the selection criteria, five articles were retained [15-19]. Figure 1 represents the schematization of our document selection. The main characteristics of the five economic studies are demonstrated in Table 2. These studies were published between 2017 and 2018 in tertiary medical centers or academic centers, in either the United States [16, 18], Germany [15, 19] or Australia [17]. Mostly, ureteroscopies were performed in the context of urolithiasis treatment [16-19]. All of them evaluated the LithoVueTM model. The comparator was either an optic reusable ureteroscope [18, 19], a digital reusable ureteroscope [16, 17], or both [15]. The follow-up period varied from 2 weeks to 4 years. Data concerning flexible reusable ureteroscopes were extracted between January 2013 and December 2016 on a prospective basis [15-18] or retrospectively [19]. Concerning SUFDU, the number of cases realized was only reported in two studies [15, 18]. For flexible reusable ureteroscopes, between 14 and 423 interventions were reported. The frequency of breakage for reusable ureteroscopes varied between 6.4% and 13.2% and the mean number of cases before breakage was between 7.5 and 14.4.

Cost estimation method

Purchase costs, repair costs and costs related to reprocessing-sterilization were considered. Taguchi *et al.* also added the costs related to the device recycling and the use of the operating room, where the mean duration of time was inferior to 20 minutes in cases using SUFDU [18]. The studies divided the purchase cost of all reusable ureteroscopes by the number of cases

realized during the observation period [15, 19] or during their useful life, which was estimated at three years [18]. In two studies, the purchase cost per intervention of reusable ureteroscopes was instead considered as an initial investment in profitability scenarios, in accordance with the number of cases realized in their center [16, 17]. Calculation methods of the mean repair cost per intervention varied from one study to another (see Table 3). SUFDU unit cost was either determined by the manufacturer [18], the market price [16, 19] or both [15, 17].

Main results

Mean costs per intervention of SUFDU and flURS were estimated according to data reported in the studies (see Table 4). The number of available reusable ureteroscopes was between 1 and 12, and the number of ureteroscopies considered for calculations varied between 28 and 1000. For the reusable ureteroscopes, the average acquisition cost per intervention ranged from 154 to 1370 \$ CA. The mean repair cost per intervention was between 373 and 1268 \$ CA, and the mean costs per intervention related to reprocessing and sterilization ranged from 25 to 221 \$ CA.

Globally, four studies suggest that the mean costs per intervention related to the use of the LithoVue™ device are higher than for reusable ureteroscopes. By considering costs related to operating time, Taguchi *et al.* concluded that the mean costs per intervention were equivalent.

Contextualization and local investigation results

According to available data in our center, between 900 and 1000 ureteroscopies are performed yearly (Table 5). We observe a growth in activity over the years. Currently, a total of 21 flexible reusable ureteroscopes are available in our tertiary medical center, where five are digital models from the Karl-Storz (n = 3) and Olympus (n = 2) companies. Most of the flexible reusable ureteroscopes are in one of our affiliated establishments (HSFA) (n = 11).

Between May 28th 2017 and May 27th 2018, 938 flexible reusable ureteroscopes were reprocessed in HSFA and 35% of those were digital models (n = 328). Of the digital models reprocessed, two-thirds were from the Karl-Storz company (n = 224). During the follow-up period, 21 breakages (6.4%) were observed by the MDRU or the operating room staff. The mean number of cases before breakage was estimated at 11.8 (see Table 6). The breakage rate was higher with Olympus models (8.7%) than with Karl-Storz models (5.4%).

Between September 2017 and May 2018, nine interventions with a SUFDU were reported, two of those being in an antegrade fashion. In seven cases they were used in the context of the treatment of urolithiasis and the two others for ureteric strictures management. A laser was used in almost half of the cases (n = 4).

Considering a total of 328 ureteroscopies with flURS, we estimated many components of the costs. Regarding purchasing costs and by considering a 6-year amortization, the total annual costs of ureteroscopes were calculated at 12 948 \$ and the mean cost per intervention was 39 \$ (see Table 7). The estimation of costs related to repair is presented in Table 8. On 21 breakages, we calculated 95 635 \$ in total repair costs, 4 554 \$ in mean cost per breakage and 292 \$ in mean repair cost by intervention. Concerning reprocessing and sterilization, several components of the

costs are shown in Table 9. The estimated unit cost was around 22 \$, which represents a total of 7 216 \$ per year for 328 ureteroscopies. By combining purchasing, repair, reprocessing and sterilization-related costs of our five flURS, we estimated total annual costs at 115 799 \$ and a total mean cost per intervention of 353 \$ (see Table 10).

The unit purchase cost of SUFDU is 1 500 \$ for a LithoVue™ device and 800 \$ for a Uscope device. Respectively, total annual costs for 328 ureteroscopies are estimated at 492 000\$ and 262 400\$.

Scenarios comparing mean costs per intervention in accordance with the number of available ureteroscopes and the number of ureteroscopies performed per year

Considering the hypothesis where all interventions were solely and entirely performed with either our actual collection of five flURS, LithoVue™ or Uscope SUFDU models, we managed to illustrate mean costs per intervention according to the annual number of ureteroscopies (see Figure 2). It should be noted that the mean cost per intervention is a variable cost that was estimated by dividing the annual costs of five flURS with a 6-year amortization (12 948 \$) by the annual number of cases. Costs per intervention related to repair and reprocessing were fixed at 292 \$ and 22 \$. Our results indicate that the mean costs per intervention are equivalent between flURS and SUFDU, when 11 interventions per year are realized with a LithoVue™ model, or when 26 interventions per year are realized with a Uscope model. Beyond these thresholds, the flURS becomes more cost-effective than the SUFDU.

To best represent the context in low-volume centers, we repeated the same exercise by considering the purchase of one or two flURS (see Table 11). The mean cost per intervention was higher when 2 to 4 interventions per year were realized with the LithoVue™ device when compared to the use of one or two flURS from Karl-Storz. Regarding the Uscope device compared to the same flURS, the thresholds were estimated at 6 or 13 interventions per year.

Scenarios comparing annual costs depending on the proportion of SUFDU usage

We aimed to assess if a targeted usage of SUFDU in high-risk cases could prevent breakage and reduce annual repair costs. We tested multiple scenarios by taking into account a collection of five flURS, a fixed number of 328 ureteroscopies and the same annual costs related to repair and reprocessing. The annual costs depending on the proportion of SUFDU usage and the percentage of avoided breakage are illustrated in Tables 12 and 13. For instance, using a LithoVue™ device in 5% of all interventions could reduce annual costs from 115 799 \$ to 112 543 \$, if 25% of flURS breakages are prevented. For the Uscope model and the same scenario considering 25% of breakages avoided, it could be possible to realize 10% of all interventions (33 ureteroscopes) and get a reduction of annual costs from 115 799 \$ to 110 236 \$.

DISCUSSION

Several studies evaluated the cost-effectiveness of a LithoVue™ device and reported a higher mean cost per intervention when compared to reusable ureteroscopes [15-17, 19], except for one

study where costs were estimated equivalent [18]. However, this last study was financed by the Boston Scientific company.

Despite methodological and contextual limitations, results from the literature may potentially be of interest for the external validation of our local economic analysis. Actually, the breakage rate and the mean number of cases before breakage observed in our center (6.4% and 11.8 cases, respectively) are similar to those from the selected studies (6.4 to 13.2% and 7.5 to 14.4 cases). The mean cost per intervention with the flURS is also generally lower than with SUFDU in our analysis, whether it is a LithoVue™ or a Uscope device. The estimation of the mean cost per intervention related to flURS is influenced by numerous factors, including the number of available flURS, the number of years considered for the purchase cost amortization, the consideration of negotiated unit costs, the number of breakages, the costs related to repair and reprocessing, and the healthcare organization of each country. This may explain why the difference between the two groups is substantially greater in our analysis than in the studies [15-19]. No scenario in the literature seems representative of our local context, where a total of 1000 ureteroscopies are realized yearly, of which around 30% are done with flURS. Several scenarios with low-volume centers were also considered in this project and we found that, compared to flURS, the mean cost per intervention with SUFDU remains higher even though a small number of interventions are done yearly.

More interestingly, our analysis combining multiple scenarios demonstrates that if a selective use of SUFDU in high-volume centers managed to avoid breakage and related repair costs, we could reduce annual total costs related to flURS usage. However, these estimations are based on hypotheses and breakages depend on many factors, which are not always foreseeable. If no breakage is prevented, total annual costs may increase depending on the number of SUFDU used. Since no study demonstrated that targeted use of SUFDU could reduce breakage rates, our observations should be interpreted with caution. To date, no guideline exists to identify risk factors for breakage or clear indications guiding the use of a single-use ureteroscope. However, it is recognized in the literature that extreme and repeated deflection poses a high risk of breakage. In fact, Ozimek et al. [20] determined retrospectively that a steep angle of the infundibulopelvic junction (60 degrees or less) was associated with significantly higher rates of breakage and post-operative complications. In our opinion, it is also reasonable to consider SUFDU usage in harder and larger stones and expected longer cases, due to intensive instrumentation and risk of breakage associated with the working channel.

Also, we did not estimate the impact of adding another flURS in our actual collection, because this would have required more advanced techniques of economic analysis. Furthermore, we did not consider many components of the costs related to SUFDU usage, including video monitor acquirement, transport, storage, and breakage during interventions. Indirect costs related to SUFDU and flURS were also not taken into account, although they may have a significant impact. These include service breakdowns and management fees related to purchasing and repair of ureteroscopes.

Results based on our collection of five fIURS suggest that the total annual cost would increase with a relatively low number of SUF DU usage per year, which is between 10 and 30 depending on the type of ureteroscope. This number could be even lower (less than 8 interventions per year) in low-volume centers with only one or two available fIURS.

Other study limitations

Due to our retrospective design, information bias and bias related to classification errors may be possible. Also, data were manually collected in registers from the MDRU, so it may be possible that some interventions with fIURS or breakages were not documented. Moreover, during the study period, nine SUF DU were used which may have influenced the breakage rate and total annual costs. Thus, we cannot state with certainty that our data collection is representative of the past years.

CONCLUSIONS

This study aimed to assess the economic relevance of implementing SUF DU in our high-volume center. With similar breakage rates as observed in the literature, our mean cost per intervention is generally higher with SUF DU than with fIURS. Also, our economic analysis suggests that the targeted use of SUF DU in selected high-risk cases may have a beneficial budgetary impact, by potentially reducing the breakage rate of fIURS and repair-related costs. However, this hypothesis must be interpreted with a high degree of uncertainty, considering that breakage can also occur during phases of reprocessing and maintenance. Thus, in the absence of sufficiently precise data, we cannot assure that SUF DU usage in order to ensure continuity of service would be the best option in financial and organizational terms. Other alternatives could be explored, including the possibility of expanding the number of available fIURS in each establishment of our center according to their reality of practice. Pending the results of emerging studies, it appears reasonable to limit the use of SUF DU by conducting a pilot study aiming to evaluate the financial and organizational impacts on the institution.

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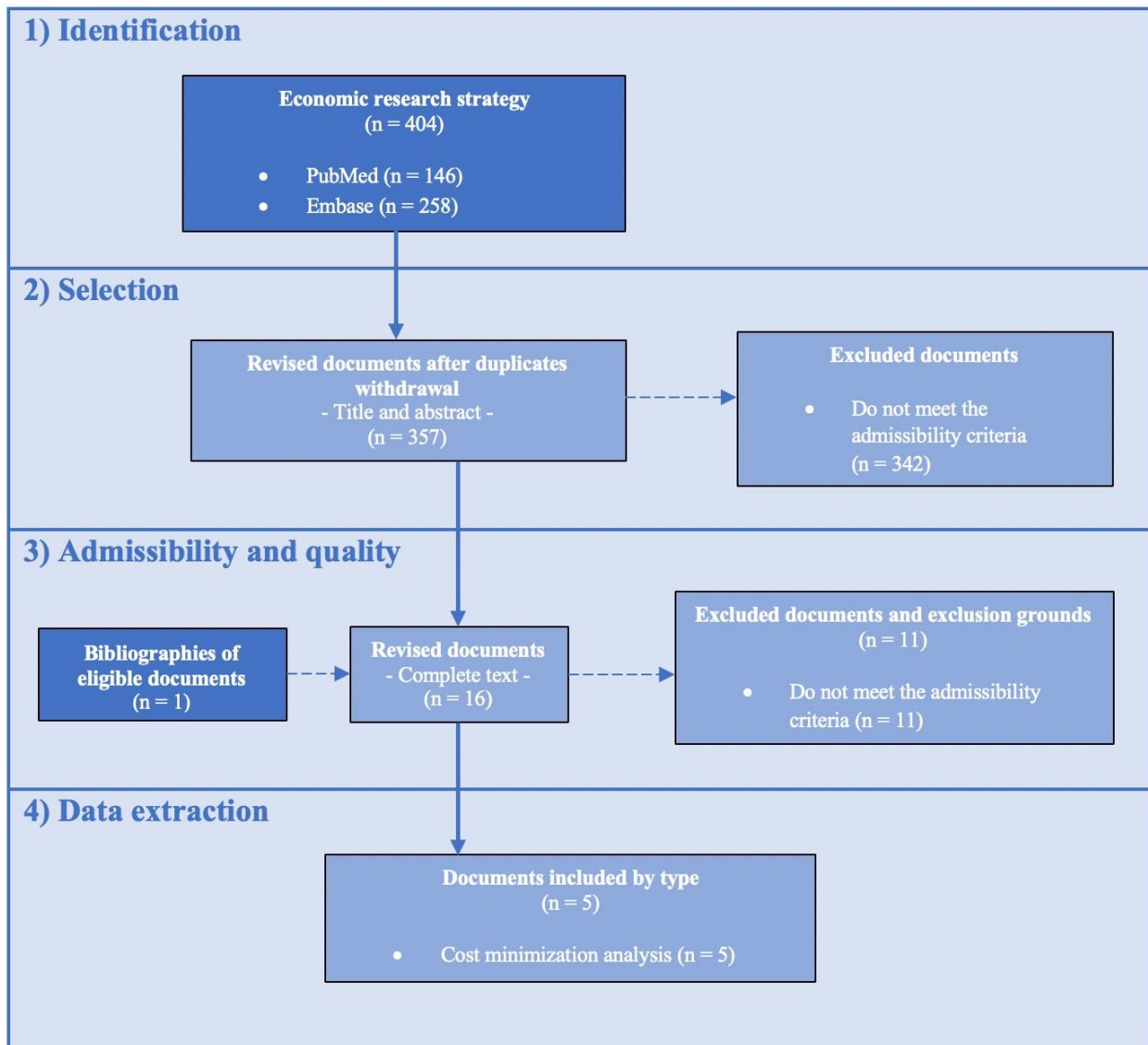
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Competing interests: Jonathan Cloutier is a consultant for Boston Scientific.

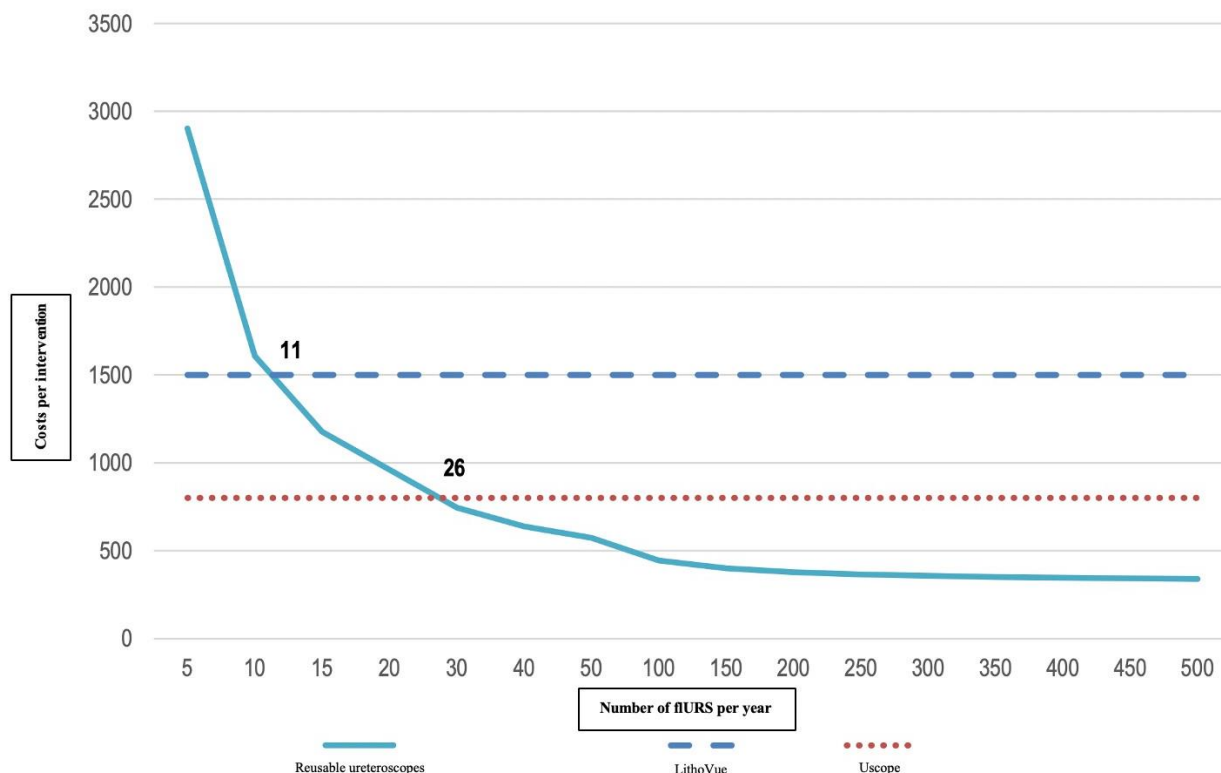
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FIGURES AND TABLES

Figure 1. Schematization of document selection concerning economic analysis of SUFDU.

Last research conducted on September 19th, 2018

Figure 2. Estimation of the mean cost per intervention according to the number of ureteroscopies realized per year comparing five flexible digital reusable ureteroscopes (fIURS) in CHU de Québec to a SUFDU (LithoVue™ or Uscope).



Inclusion criteria	
Population	Adults and children undergoing a ureteroscopy
Intervention	Use of a SUFDU or a semi-reusable URS
Comparison	Use of a fIURS
Outcomes	<ul style="list-style-type: none"> • Cost per intervention, considering: <ul style="list-style-type: none"> ▪ Purchase costs of fIURS and SUFDU ▪ Repair costs of fIURS ▪ Costs and human resources related to sterilization and preparation of fIURS • Frequency and reasons of breakage related to any components of the fIURS • Mean number of interventions before fIURS breakage or elimination

Study designs ranked in order of strength	<ol style="list-style-type: none"> I. ETMIS reports, systematic reviews (SR) with or without meta-analysis, practice guidelines II. RCT III. Observational studies IV. Case reports V. Case studies VI. Laboratory studies VII. Notice or expert consensus
Limits	Exclusion criteria
<ul style="list-style-type: none"> • Language: French or English • Period: from the beginning of indexed database until September 19, 2018 	Summaries of congress, publicity material, and editorials

ETMIS: Évaluation des Technologies et des Modes d'Intervention en Santé; fIURS: flexible digital reusable ureteroscope; SUFDU: single-use flexible digital ureteroscope; URS: ureteroscope

Author (year) [ref.]	Country	Study duration	SUFDU		fIURS			
			Model	Number of cases	Type (n)	Number of cases	Breakage (%)	Mean number of cases before breakage
Martin et al (2017) [48]	United States	1 year (February 2014 to February 2015)	LithoVue™	N/A	Digital (4)	160	6.9	12.5
Taguchi et al (2018) [50]	United States	2 non-consecutive weeks (July and August 2016)	LithoVue™	9	Optic (12) ²	14	N/A	N/A

Ozimek et al (2017) [51]	Germany	4 years (January 2013 to December 2016)	LithoVue™	N/A	Optic (10)	423	7.6	14.4
Mager et al (2018) [25]	Germany	1 year ¹ (December 2015 to December 2016)	LithoVue™	68	Optic or digital (6)	68	13.2	7.5
Hennessey et al (2018) [49]	Australia	2 and a half years (NR)	LithoVue™	N/A	Optic (7)	234	6.4	11

¹Six months with a fIURS and then six months with a SUFDU. ²During the last three years. fIURS: flexible digital reusable ureteroscope; N/A : not applicable; NR: not reported; SUFDU: single-use flexible digital ureteroscope.

Table 3. Estimation methods used in the studies for calculation of the mean repair cost per intervention of the fIURS	
Author (year) [ref.]	Calculation method
Martin et al (2017) [48]	$\frac{\text{Repair costs per breakage}}{\text{Mean number of cases completed before breakage}}$
Taguchi et al (2018) [50]	$\frac{\text{Total repair costs}}{\text{Total number of cases}}$
Ozimek et al (2017) [51]	$\frac{\text{Mean repair costs} + \text{workforce related costs before and after repair}}{\text{Total number of cases}}$
Mager et al (2018) [25]	$\frac{(\text{Mean repair costs}) \times (\text{number of breakage implying repair})}{\text{Number of cases completed before breakage}}$
Hennessey et al (2018) [49]	$\frac{\text{Mean repair costs} > 10\,000 \text{ \$ US}}{\text{Number of cases completed before breakage}}$

fIURS: flexible digital reusable ureteroscope.

Authors (year) [ref.]	fIURS							Total mean cost per intervention (\$ CA) ¹	
	Total purchase costs (\$ CAD) ¹	Number of ureteroscopes	Number of cases	Mean cost per intervention (\$ CAD) ¹				fIURS	LithoVue™
				Purchase	Repair	Reprocessing-sterilization	Others		
Martin et al (2017) [48]	84 716	4	160	530	1059	64	N/A	1 652	1986
Taguchi et al (2018) [50]	NR	12	~1000 ⁵	154	1268	142	2 144 (operating room)	3 707	3777 ⁶
Ozimek et al (2017) [51]	77 717	10	423	183	373	221	N/A	779	1548 ²
Mager et al (2018) [25]	69 903 ² 93 203 ³	6	68	1021 ² 1370 ³	434 ² 794 ³	143	N/A	1604 ² 2308 ³	1721 ² 211 ³
Hennessey et al (2018) [49]	24 792	1	28	886 ⁴	653	25	N/A	1154 ⁴	1 128 ² 1156 ³

¹Conversion into Canadian dollar (\$ CAD) according to the conversion rate of Bank of Canada into force in November 13, 2018 (1 \$ USD = 1.3241 \$ CAD). Costs rounded to the nearest dollar. ²Costs of an ureteroscope according to the negotiated price. ³Costs of an ureteroscope according to the manufacturer's suggested price. ⁴Estimation realized according to available data in the study. ⁵Non-reported activity data on a 3-year period (n=331 during the last year). ⁶ Purchase: 1986 \$ CAD, operating room: 1786 \$ CAD, recycling: 5 \$ CAD. fIURS: flexible digital reusable ureteroscope; N/A: not applicable; NR: not reported.

Fiscal years	Hospitals in CHU de Québec					CHU de Québec (total)
	HSFA	HDQ	HEJ	CHUL		
				Children	Adults	
2015-2016	749	9	121	13	1	893
2016-2017	881	11	0	13	2	907
2017-2018	1000	11	0	11	0	1022

Data sources : GIC computer software of CHU de Québec, CIM-9. CHUL: Centre hospitalier de l'Université Laval; HDQ: Hôtel-Dieu de Québec; HEJ: Hôpital de l'Enfant-Jésus; HSFA: Hôpital St-François d'Assise.

Indicators	flURS		
	Karl-Storz (n=224)	Olympus (n=104)	Total (n=328)
Breakage, n (%)	12 (5.4)	9 (8.7)	21 (6.4)
Mean number of cases before breakage	13.3	9.6	11.8
Mean duration of repair in days (range)	9 (1–21)	22 (2–55)	14 (1–55)

flURS: flexible digital reusable ureteroscope.

Table 7. Estimation of purchase and amortization costs of flURS in HSFA and mean cost per intervention, between May 28, 2017 and May 27, 2018

	Available number	Number of interventions	Total purchase cost (\$)	Total annual cost related to 6-year amortization (\$)	Mean cost per intervention (\$)
Karl-Storz URS	3	224	44 940	7490	33
Olympus URS	2	104	28 000	4667	45
Transport unit (one by URS)	5	----	4750	791	2
	Total	328	77 690	12 948	39

flURS: flexible digital reusable ureteroscope; HSFA: Hôpital St-François d'Assise; URS: ureteroscope.

Table 8. Estimation of total annual repair costs and mean repair costs per breakage and intervention of flURS, between May 28, 2017 and May 27, 2018

	Number of breakages	Number of interventions	Repair costs (\$)		
			Total	Mean cost per breakage	Mean cost per intervention
Karl-Storz (n=3)	12	224	85 610	7134	382
Olympus (n=2)	9	104	10 025	1114	96
Total (n=5)	21	328	95 635	4554	292

flURS: flexible digital reusable ureteroscope.

Cost components	Cost per reprocessing (\$)
Enzyme-based cleaner, 150 ml (\$33.75/gallon)	1.35
Single-use brush	2.50
Mechanical decontamination of the box	1.72
Packaging supplies	0.85
Low-temperature sterilization cycle with Sterrad 100 NX (\$19.58 for two endoscopes)	9.79
Paid working time, 15 minutes (\$21.21/h)	5.25
Total	21.46

fIURS: flexible digital reusable ureteroscope.

	Total annual costs (\$) (2017–2018)	Mean cost per intervention (\$)
Purchase with a 6-year amortization	12 948	39
Repair	95 635	292
Reprocessing and sterilization	7216	22
Total	115 799	353

fIURS: flexible digital reusable ureteroscope; HSFA: Hôpital St-François d'Assise.

SUFDU	Number of flexible ureteroscopies performed per year where SUFDU is cost-effective			
	Number of fIURS available (Karl-Storz)		Number of fIURS available (Olympus)	
	1	2	1	2
LithoVue™	≤2	≤4	≤2	≤3
Uscope	≤6	≤13	≤3	≤

fIURS: flexible digital reusable ureteroscope; SUFDU : single-use flexible digital ureteroscope.

Table 12. Scenarios comparing annual costs according to the usage proportion of a LithoVue™ model (SUFDU) and the rate of avoided breakages

LithoVue™	Number of flexible digital ureteroscopies		Total annual costs according to the level of breakage reduction				
	fIURS	SUFDU	0%	25%	50%	75%	100%
0%	328	0	115 799	115 799	115 799	115 799	115 799
5%	312	16	135 256	112 543	101 063	67 117	53 511
10%	295	33	154 714	133 196	110 236	90 160	68 642
15%	279	49	174 171	153 849	119 409	113 204	92 882
20%	262	66	193 629	174 502	128 582	136 248	117 121
30%	230	98	213 086	215 808	199 071	182 335	165 599
40%	197	131	271 459	257 113	242 768	228 432	214 078
50%	164	164	310 373	298 419	286 465	274 510	262 556

fIURS: flexible digital reusable ureteroscope; SUFDU : single-use flexible digital ureteroscope.

Table 13. Scenarios comparing annual costs according to the usage proportion of a Uscope model (SUFDU) and the rate of avoided breakages

Uscope	Number of flexible digital ureteroscopies		Total annual costs according to the level of breakage reduction				
	fIURS	SUFDU	0%	25%	50%	75%	100%
0%	328	0	115 799	115 799	115 799	115 799	115 799
5%	312	16	123 776	101 063	78 350	55 637	42 031
10%	295	33	131 754	110 236	88 718	67 200	45 682
15%	279	49	139 731	119 409	99 086	78 764	58 442
20%	262	66	147 709	128 582	109 455	90 328	71 201
30%	230	98	155 686	146 928	130 191	113 455	96 719
40%	197	131	163 664	165 273	150 928	136 583	122 238
50%	164	164	171 641	183 619	171 665	159 710	147 756

fIURS: flexible digital reusable ureteroscope; SUFDU : single-use flexible digital ureteroscope.