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Original Research

Carbon Footprint in Flexible Ureteroscopy: A Comparative Study on the Environmental Impact of Reusable and Single-Use Ureteroscopes

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Abstract

Purpose: There are no comparative assessments on the environmental impact of endourologic instruments. We evaluated and compared the environmental impact of single-use flexible ureteroscopes with reusable flexible ureteroscopes.

Patients and Methods: An analysis of the typical life cycle of the LithoVue™ (Boston Scientific) single-use digital flexible ureteroscope and Olympus Flexible Video Ureteroscope (URV-F) was performed. To measure the carbon footprint, data were obtained on manufacturing of single-use and reusable flexible ureteroscopes and from typical uses obtained with a reusable scope, including repairs, replacement instruments, and ultimate disposal of both ureteroscopes. The solid waste generated (kg) and energy consumed (kWh) during each case were quantified and converted into their equivalent mass of carbon dioxide (kg of CO_2) released.

Results: Flexible ureteroscopic raw materials composed of plastic (90%), steel (4%), electronics (4%), and rubber (2%). The manufacturing cost of a flexible ureteroscope was 11.49 kg of CO_2 per 1 kg of ureteroscope. The weight of the single-use LithoVue and URV-F flexible ureteroscope was 0.3 and 1 kg, respectively. The total carbon footprint of the lifecycle assessment of the LithoVue was 4.43 kg of CO_2 per endourologic case. The total carbon footprint of the lifecycle of the reusable ureteroscope was 4.47 kg of CO_2 per case.

Conclusion: The environmental impacts of the reusable flexible ureteroscope and the single-use flexible ureteroscope are comparable. Urologists should be aware that the typical life cycle of urologic instruments is a concerning source of environmental emissions.

Keywords: flexible ureteroscopy, carbon footprint, CO_2 emissions, healthcare delivery

Introduction

Human-induced climate change through exploitation of fossil fuels is a potentially significant global environmental threat.[1–3] Carbon emissions of the National Health Service in the United Kingdom are ~20 million tons of green house gases per annum and account for 25% of all public sector emissions in that country.[4] The environmental impact of endourologic stone surgery on CO_2 emissions is contributed to by the consumption of energy by industry and transport when manufacturing, repairing, and cleaning instruments, including flexible ureteroscopes.[1] To date there have been no comprehensive comparative assessments on the environmental impact or carbon footprint of endourologic equipment. The aim of the present study is to evaluate and compare the environmental impact of single-use flexible ureteroscopes (LithoVue™; Boston Scientific) with reusable flexible ureteroscopes (Olympus Flexible Video Ureteroscope or URV-F).

Patients and Methods

Overview of study design

A review of the typical life cycle of the LithoVue (Boston Scientific) single-use digital flexible ureteroscope and URV-F was performed. In our hospital (Austin Hospital, Melbourne, Australia), reusable flexible ureteroscopes typically have 16 uses before repairs are required and approximately 180 uses before decommissioning.[5] To measure the carbon footprint, data were obtained on manufacturing of single-use and reusable flexible ureteroscopes and from typical uses obtained with a reusable scope, including repairs, replacement instruments,

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Table 1. Components and Manufacturing Costs of Flexible Ureteroscopes Per Kilogram

Material	*Equivalent mass of CO_2 per kg of material*	*Components of flexible ureteroscope (%)*	*Carbon footprint (kg of CO_2/kg of scope)*
Plastic	6[9]	90	5.4
Rubber	1.16[11]	2	0.02
Steel	1.8[10]	4	0.07
Electronics	150[8]	4	6
Total	NA	100%	11.49

Using our model we calculated the manufacturing carbon footprint as 11.49 kg of CO_2 per 1 kg of ureteroscope.
NA = Not applicable.

and ultimate disposal of either type of ureteroscope.[6,7] The solid waste generated (kg) and energy consumed (kWh) during each case were quantified and converted into their equivalent mass of carbon dioxide (kg of CO_2) released.

Measurement of carbon footprint

Standardized carbon footprint protocol guidelines were used to determine the mass of CO_2/kg emitted during the manufacturing process for single-use and reusable flexible ureteroscopes (Table 1). Flexible ureteroscopic raw materials comprised plastic (90%), steel (4%), electronics (4%), and rubber (2%). The carbon footprint (kg of CO_2 per case) of reusable flexible ureteroscopes was calculated using previously validated models by obtaining data on manufacturing, sterilization, repackaging, repair, and solid waste disposal (where 1 kg of solid waste disposal = 1 kg CO_2)[8–11] (Table 1). Repair costs of reusable ureteroscopes were calculated as a percentage of the components that failed resulting in reparation of the scope.

Results

Carbon footprint per case for single-use LithoVue flexible ureteroscope

The manufacturing cost of a flexible ureteroscope was 11.49 kg of CO_2 per 1 kg of ureteroscope (Table 2). The weight of the single-use LithoVue flexible ureteroscope is 0.3 kg, and the manufacturing carbon footprint was 3.45 kg of CO_2 per scope. Sterilization during the manufacturing process with ethylene oxide (Steritech©, Melbourne, Australia) of the single-use LithoVue was calculated at 0.3 kg of CO_2. Solid waste generated from the disposal of a single-use LithoVue flexible ureteroscope was 0.3 or 0.3 kg of CO_2. The total carbon footprint of the lifecycle assessment of the LithoVue was 4.43 kg of CO_2 per endourologic case (Table 2).

Carbon footprint per case for URV-F

The weight of the URV-F is 1 kg, and the manufacturing carbon footprint was 11.49 kg of CO_2. As the lifecycle assessment was 180 endourologic cases per scope in our department, the manufacturing cost of the ureteroscope per case was 0.06 kg of CO_2 (i.e., 1 kg/180). Washing and sterilization of the URV-F were calculated from the Olympus ETD4™ endoscope washer disinfector, which can wash two ureteroscopes simultaneously.[7] The wash cycle takes 70 minutes and utilizes 165 L of water and 9.2kW per cycle equating to 7.89 kW per hour. This equates to 7.89 kg of CO_2 for simultaneous washing and sterilization of two ureteroscopes according to the carbon emission calculator or 3.94 kg of CO_2 and 82.5 L of water per ureteroscope.[6] Repackaging costs of reusable ureteroscopes are negligible in our hospital.[12] The solid waste generated from the Olympus scope per case is 0.06 kg of CO_2 (i.e., 11.49 kg of CO_2/180). The cost of repairing the URV-F was 5 kg of CO_2 and this equated to 0.31 kg of CO_2 per case (5 kg of CO_2/16 [as reusable flexible ureteropyeloscopes typically have 16 uses in our department before requiring repair]).[5] The total carbon footprint of the lifecycle of the Olympus reusable ureteroscope was calculated at 4.47 kg of CO_2 per case (Table 2).

Table 2. Components of the Life Cycle of Disposable and Reusable Flexible Ureteroscopes and the Analysis of Their Total Carbon Footprint

Process	*Carbon footprint (kg of CO_2 per case)*
Boston Scientific LithoVue™ single-use digital ureteroscope	
Manufacturing cost (weight of scope 0.3 kg)	3.83
Solid waste = 0.3kg	0.3
Sterilization (6)	0.3
Total per case	4.43
URV-F™*	
Manufacturing cost (weight of scope 1 kg)	0.06
Washing/sterilization** (165 L)	3.95
Repackaging with theatre wrap (3)	<0.005
Repair cost (estimated 5 kg CO_2/repair)	0.45
Solid waste of flexible ureteroscope = 1 kg	0.005
Total per case	4.47

*Life cycle of 180 uses and 11 repairs (i.e., 180/16).
**Sterilization machine used—Olympus ETD4. Olympus ETD4 uses 9.2 kW per cycle = each cycle takes 70 minutes and sterilizes 2 scopes = 7.9 kW/hour = 7.9 kg CO_2[7].
URV-F = Olympus Flexible Video Ureteroscope.

Discussion

Flexible ureteropyeloscopy (FURS) is an evidence-based established treatment modality for urinary tract calculi and is being performed with increasing frequency.[13] To counteract costs that are associated with repair and sterilization of conventional reusable flexible ureteroscopes, institutions are utilizing single-use disposable flexible ureteroscopes as alternatives. Advantages with single-use flexible ureteroscopes are the reduced cost of initial capital outlay on equipment, reliability, and cost-effectiveness in low-volume stone centers. Furthermore, single-use FURS has comparable stone-free rates with reusable FURS for treating nephrolithiasis.[14] Although clinical efficacy and complication rates between single-use and reusable flexible ureteroscopes have been extensively evaluated, their environmental impact has not been previously reported.[14] In the present study, we evaluated the environmental costs of reusable and single-use flexible ureteroscopes using life cycle assessment based on a previously presented study of ureteroscope usage at our hospital.[5] Our main finding is that the environmental costs of single-use and reusable flexible ureteroscopes are comparable.

The total carbon footprint of the lifecycle of both flexible ureteroscopes investigated was <5 kg of CO_2 per case. The emission levels of both flexible ureteroscope options compare favorably with other medical equipment and surgical procedures. In a similar study, Chen and associates[15] investigated CO_2 emission rates among peritoneal dialysis regimes and found values that ranged from 363.5 to 409.5 kg of CO_2 per patient per year. Carbon footprint costs were primarily attributable to packaging materials, transportation, electricity, and waste.[15] Woods and colleagues[16] compared the carbon footprint of open, laparoscopic, and robotic surgery in 150 surgical procedures. The sum of the carbon footprint was 40.3 kg of CO_2 per case for robot-assisted laparoscopic surgery, 29.2 kg of CO_2 per case for conventional laparoscopy, and 22.7 kg of CO_2 per case for open surgery.[16] Conversely, other studies that compared the life cycle of single-use and reusable theatre gowns, laparotomy pads, surgical drapes, and laparoscopic instruments found that reusable items had lower CO_2 emissions and water use than did single-use variants.[17–19]

McGain and coworkers[12] compared the carbon footprint of reusable Central Venous Catheter Insertion Kits with the single-use Central Venous Catheter Kit. Similarly, they found that the environmental costs of the reusable kit were considerably greater. The authors also emphasize the importance of reducing the environmental footprint of reusable items by aiming to decrease water and energy consumption during cleaning and sterilization. The reusable central venous catheter set required 10 times the volume of water of the single-use set per life cycle with sterilization contributing to most of the environmental effects.[12] The volume of water required for resterilization of the reusable flexible ureteroscope is concerning, particularly in global regions that are predisposed to water shortages. In such areas water is often generated by desalination, which further increases CO_2 emissions. Investigation into more efficient washer disinfector systems are merited to develop methods for water recycling in these circumstances.

The burning of fossil fuel has produced three quarters of CO_2 emissions globally, and levels are forecast to be 90%–250% increased by the year 2100 compared to baseline levels from 1750.[3] These findings have prompted repeated cautions from the scientific community regarding potential irreversible consequences of global warning. Woods and coworkers[16] quantified the environmental impact of minimally invasive surgery in the United States per year and found that the total estimated CO_2 emission was 355,924 tons of CO_2 per year. This amounts to more CO_2 emission per year than yearly CO_2 emissions of 27 entire countries as listed by the United Nations.[20] Although the carbon footprint of both flexible ureteroscopes was relatively low at <5 kg of CO_2, these findings were on a case by case basis. Our data suggest that carbon footprint amounts are likely to become more relevant per annum in high volume stone centers. Our findings also highlight the energy and waste disposal associated with flexible ureteroscopy in general and urologists should be increasingly aware of these factors so that healthcare delivery can be maximally sustainable. A significant proportion of CO_2 emissions could potentially be reduced by developing resource efficiency mechanisms to optimize the preparation of reusable equipment and maximize single-use device recycling protocols and by investing in low-carbon energy products.[4,21]

We acknowledge that our study has limitations. First, some data were sourced indirectly from reputable online databases; however this is a limitation with the majority of carbon footprint life cycle assessment studies. Our study is also limited in that it was conducted at a single stone center. In future, we aim to expand on our findings by comparison to other centers not specifically focused on stone disease and by identifying and evaluating additional healthcare interventions that can decrease CO_2 emissions in our department.

Conclusions

Healthcare delivery services in developed countries are a concerning source of environmental emissions, but the carbon footprint of single-use and reusable ureteroscopes is comparable. Healthcare research in urology should include the development of policies to reduce the environmental effects of CO_2 emissions, based on the knowledge of how these emissions are accrued in the course of patient treatment. Informed clinicians should be willing to advocate for changes within the healthcare delivery and within the manufacturing industry to maintain healthcare quality, cost-effectiveness, and safety in future.

Author Disclosure Statement

No competing financial interests exist.

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Abbreviations Used

FURS = flexible ureteropyeloscopy
URV-F = Olympus Flexible Video Ureteroscope

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