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Research Article

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The direct environmental impact of hip arthroscopy for femoroacetabular impingement: a surgical waste audit of five cases

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ABSTRACT

Health care facilities produce significant waste (2200 kg/bed/year) creating 2% of greenhouse gas emissions and 1% total solid waste nationwide, with 20–70% of waste coming from operating rooms. We performed a waste audit of hip arthroscopy for femoroacetabular impingement (FAI) to understand its environmental impact and identify areas for greening practices. A waste audit of five hip arthroscopy procedures for FAI was performed. All waste was collected and separated into six waste streams in real time: (i) normal/landfill waste; (ii) recyclable cardboards and plastics; (iii) biohazard waste; (iv) sharp items; (v) linens and (vi) sterile wrapping. The surgical waste (except laundered linens) from five FAI surgeries totaled 47.4 kg, including 21.7 kg (45.7%) of biohazard waste, 11.7 kg (24.6%) of sterile wrap, 6.4 kg (13.5%) of normal/landfill waste, 6.4 kg (13.5%) of recyclable plastics and 1.2 kg (2.6%) of sharp items. An average of 9.4 kg (excluding laundered linens) of waste was produced per procedure. Given the considerable biohazard waste produced by FAI procedures, additional recycling programs, continued adherence to proper waste segregation and an emphasis on 'green outcomes' is encouraged to demonstrate environmental responsibility and effectively manage and allocate finite resources.

KEYWORDS: femoroacetabular impingement, hip, arthroscopy, medical waste, recycling

INTRODUCTION

Waste production and the concept of an 'ecological footprint' have increasingly become a global issue as there has been a renewed awareness of the lack of storage space for the accumulating waste. This has turned the spotlight towards health care facilities which are estimated in the United States to produce 1 814 369 480 kg of waste annually [1]. In Ontario, Canada's largest province with a population of 13.6 million, it is estimated that hospitals generate 2200 kg of conventional waste, per hospital bed, per year, which creates 67 000 000 kg of non-hazardous waste that goes to landfill per year in Ontario [2]. It has been estimated that operating rooms (ORs) produce anywhere from 20 to 70% of a hospital's waste, accounting for 1.46% of greenhouse gas emissions and 1% of total solid waste in Canada, which has put emphasis on the need for 'greening practices' in the OR [1, 3]. ORs create significant waste in an effort to maintain absolute sterility for the safety of patients, as well as the added necessity of disposing of non-hazardous versus hazardous waste separately for safety reasons. With over 3000 medical facilities and surgical centers in Canada and 80–90% of the waste produced being non-hazardous, it is imperative that this waste be disposed of appropriately and recycling should occur whenever possible [4].

Hip arthroscopy is a minimally invasive technique used for addressing hip pathology and the Millennium Research Group estimated over 30 000 hip arthroscopy procedures were performed in the United States in 2008 and expects

an annual growth rate of over 15% over the next 5 years [5]. Furthermore, there was an 18-fold increase in the number of hip arthroscopy board examinees in the United States between 1999 and 2009 and a 600% increase between 2006 and 2010 showing hip arthroscopy to be an increasingly popular procedure [6–8]. In Ontario, there are approximately 10 surgeons at academic institutions performing together, approximately 500 hip arthroscopy procedures per year. Extrapolating this to the Canadian population as a whole, approximately 2000 procedures are being performed per year in Canada.

Currently, no database exists for hip arthroscopy patients in Ontario. As this procedure becomes increasingly prevalent, it is the primary objective of this study and of paramount importance to identify potential waste reduction practices in the OR to decrease the overall waste production and 'ecological footprint'.

MATERIALS AND METHODS

A waste audit of five consecutive femoroacetabular impingement (FAI) hip arthroscopic procedures (all including osteochondroplasty and labral repair) was performed to examine the type and quantity of waste produced in these procedures, using the protocol by Stall *et al.* [9] for a waste audit of five total knee arthroplasties as a guide.

The five procedures were performed by a single surgeon in March and April 2015. All OR personnel (including the scrub team, circulating nurses and custodial staff) were informed of the study to ensure all waste was accounted for. The OR personnel, however, were not trained in the different categories of waste segregation, and the allocation into different receptacles was done by two independent study members not part of the OR team. These two independent allocators also were also responsible for appropriate cataloging and weighing in real time of all waste. The staff varied among each OR day, however, all were aware of the procedure and the waste was cataloged and weighed by the same two individuals following each procedure. This was to ensure no biases were introduced, and to ensure that the OR case times, and room changeovers were not affected by the study (i.e. appropriate sorting did not add to the operative time or pose any risk to patient safety). For each case, the scrub team included one staff surgeon, one surgical fellow, one surgical resident and two nurses (one scrub nurse and one circulating nurse).

As in the study of Stall *et al.* [9], we categorized waste into six streams: (i) normal/landfill waste, (ii) recyclable cardboards and plastics, (iii) biohazard waste (i.e. surgical gauze, sponges, gloves and gowns), (iv) sharp items, (v) linens and (vi) sterile wrapping (used to drape patient on OR table as well as some surgical supplies). During each procedure, each item was catalogued intraoperatively before being placed in an appropriate receptacle. Cataloguing began when the staff began prepping for the case at the conclusion of room cleaning from the previous procedure and ended once the patient had left the OR, all equipment used in the procedure was disposed of, and the custodial staff returned to clean the room for the next procedure. The different streams were then weighed using a standard infant scale accurate to the nearest full kg. It was confirmed with our Integrated Research and Ethics Board that ethics approval was not required for this study, as the waste audit was completed on a prospective basis and was considered a quality improvement initiative, examining institutional practices with the intent of potentially improving the same.

Statistical analysis

All data were collected in a Microsoft Office 2013 Excel (Version: 15.0.4753.1003) spreadsheet. The average weights of each waste stream along with standard deviations were calculated for the five FAI procedures.

RESULTS

The surgical waste (except laundered linens, which are cleaned and re-used) from the five FAI procedures totalled 47.4 kg for all five procedures, of which 21.7 kg (45.7%) was biohazard waste, 11.7 kg (24.6%) was sterile wrap, 6.4 kg (13.5%) was normal/landfill waste, 6.4 kg (13.5%) was recyclable plastics and 1.2 kg (2.6%) was sharp items. Scale accuracy was $\pm$ 0.01 kg.

The average waste produced per FAI procedure (excluding laundered linens) was 9.4 kg. Biohazard waste had the most significant contribution to total waste with an average weight of 4.3 kg, followed by 2.3 kg of sterile wrapping, 1.3 kg of normal/landfill waste, 1.3 kg of recyclable plastics and 0.2 kg of sharp items average weight from each procedure. The average weight and percentage of waste for each stream over the five procedures are shown in Table 1 and the mass of each waste stream for each of the five procedures is presented in Table 2. A catalogue of every item collected for one FAI procedure is shown in Table 3 and Figure 1 shows the waste collected for one procedure.

With current estimates of 500 procedures being performed per year in the province, this would estimate that 4700 kg of waste is produced from FAI hip arthroscopy every year in Ontario. This would project to an annual production of 650 kg of normal/landfill waste, 650 kg of recyclable plastics, 2150 kg of biohazard waste, 1150 kg of sterile wrapping and 100 kg of sharp items total waste production for the 500 procedures performed in Ontario every year for a population of 13.6 million. Therefore, in Canada, 18 800 kg of waste is produced from the approximately 2000

Table 1. Average mass of waste streams for five FAI procedures

Waste stream	*Mass, kg/FAI*	*Percentage of total waste*	*Standard deviation, kg/FAI*
Normal/landfill	1.3	6.9%	0.3
Recyclable plastics	1.3	6.8%	0.3
Biohazard waste	4.3	23.2%	1.7
Sterile wrap	2.3	12.5%	0.3
Laundered linens	9.2	49.1%	1.5
Sharps	0.2	1.3%	0.1

Table 2. Mass of waste streams for each FAI procedure

Waste stream	*Surgery 1, kg*	*Surgery 2, kg*	*Surgery 3, kg*	*Surgery 4, kg*	*Surgery 5, kg*
Normal/landfill	1.3	1.1	1.5	0.9	1.6
Recyclable plastics	1.5	1.6	1.3	1.0	1.0
Biohazard waste	4.3	3.5	4.7	6.9	2.3
Sterile wrap	2.1	2.2	2.2	3.0	2.2
Laundered linens	10.0	9.4	10.8	8.9	6.8
Sharps	0.2	0.3	0.3	0.2	0.2

FAI hip arthroscopy procedures performed in the country every year.

The term surgical 'overage' was used to refer to items that were prepared for surgery yet remained unopened by the end of the procedure. Overall, the surgical overage per case included 15 green sterile towels, 10 sterile surgical gloves and one small unsterile towel.

Several categories of items contributed disproportionately to the surgical waste. Per procedure, there was an average of nine adhesive backings, 14 non-sterile gloves, 19 sterile surgical gloves, 14 sterile towels and 13 small sterile wraps.

DISCUSSION

The most important results from this waste audit have shown that FAI procedures produce a substantial amount of surgical waste. Per FAI procedure (excluding laundered linens which are cleaned and re-used), an average of 13.5% of waste per weight was normal solid waste, which requires transportation to a landfill site and appropriate disposal. 45.7% was biohazard waste, which requires expensive and high energy treatment processes, 38.1% of the waste by weight is recycled (13.5% recyclable plastic and 24.6% sterile wrap) and 2.6% of the waste was sharp items. This is in harmony with the Stall *et al.* [9] audit of five total knee arthroplasty procedures, which produced 64.5% normal solid waste, 19.2% biohazard waste, 12.1% sterile wrap, 2.2% recyclables and 2.0% sharp item waste. In this study, there was a much larger proportion of biohazard waste compared with normal/landfill waste then in the Stall *et al.* study, and this may be due to the nature of the procedure or to differences in institutional guidelines for waste disposal, specifically what is considered recyclable or biohazardous and how each of these are disposed of.

Non-hazardous OR waste that is inappropriately classified as biohazard waste increases the total high energy treatment required to dispose of biohazardous OR waste. A recent study revealed that biohazard waste should not exceed 15% of OR hospital waste [10]. However, biohazard waste was the single greatest contributor to FAI surgical waste at our institution (23.3%). This may indicate that this institution is not maximally segregating waste into appropriate streams or that FAI procedures may produce more biohazardous waste than other procedures. Clarifying this is essential, given that studies have shown that proper segregation of waste in the OR may have the single most substantial impact on the cost of disposal [3].

It is possible that the addition of documenting and reporting of 'green outcomes' in a surgical procedure may be beneficial in encouraging green practices at health care institutions. This would be a helpful addition to normal procedure outcomes and would require formal OR staff training to ensure no significant increases to operative time, room changeover and/or patient risk occurs.

With the rapid growth of FAI procedures being performed around the world, it is important early on to develop safe and ecologically friendly practices as the procedure grows to decrease its environmental burden. Several studies looking at waste production in ORs have encouraged 'greening behaviors' which they define as behaviors or activities that improve environmental outcomes [11]. Lausten *et al.* [11] used the three R's and applied them to the OR: (i) reduce by using environmentally friendly materials, reducing energy consumption and reducing overage by rethinking surgical packs; (ii) reuse by sterilizing equipment instead of using disposable equipment (which we expand to also include processing and reusing laundered linens) and (iii) recycle via a coordinated institution-wide effort. In addition, upon examining their institution's waste production

Table 3. Catalogue items from 1 FAI impingement procedure

Waste	*Units*
Normal/landfill waste	
Adhesive backings	12
Prep sponges	2
Protective padding	1
Boot covers	2
Foley catheter kit	0
Mepore gauze pads	3
Gauze roll	1
Surgical face masks	9
Abdominal gauze pad	1
Miscellaneous from anesthesia (approximately 150g/bag)	1
Miscellaneous tips	8
Shoe covers	2
Indicator strips	10
Surgical air warming blanket	1
Sponge packaging	1
Marker	1
Non-sterile gloves	10
Recyclable plastics and cardboard	
Wrapper for surgical gloves	10
Wrapper for Tubovac cautery	2
Wrapper for Uromatic TUR series set	1
Wrapper for arthroscopy pump	1
Wrapper for Tiberon Cesarean birth drape	1
Adrenalin packaging	1
Wrapper for syringe	2
Wrapper for drape	2
Wrapper for OPSITE	1
Wrapper for Warming blanket	1
Wrapper for boot cover	1
Wrapper for suture	2
Shaver cover (Prebent Great White Concave)	1
Hip preservation system conmed switch stick cover	2
Needle counter package	1
Wrapper for shaver	1
Wrapper and cover for blade (Southmedical Surgical Blade)	1
Wrapper for banana blade	1
Marker wrapper	1
Foil blade package	1
Wrapper for hip access needle pack 17G	1
Wrapper suction tubing	3
Wrapper for surgical gown	1
Wrapper for spherical bur	1
Wrapper for disposable cannula and obturator	1
Wrapper for Linvatec battery	1
Wrapper for suture anchor	2
Bandage packaging (Mepore gauze pads)	3
Wrapper for abdominal pad	1
Suture packages	2
Wrapper for NaCl solution	7
Wrapper for Mayo stand	1
Biohazard waste	
8” by 4” sponges	9
Suction fluids (ml)	7947
Electrocautery and suction irrigator with tubing	1
NaCl bag (3000ml) and tubing	7
8″ × 4″ gauze	9
Sterile surgical gloves	10
Disposable surgical gown	1

(continued)

(continued)

Table 3. Continued

Waste	*Units*
Perineal protecting covering	1
Suture box	1
Airway filter	1
Suture overage	2
Disposable cannula and obturator	1
Laundered linens	
Blankets	2
Bed sheet	1
Green sterile towel	15
Small unsterile towel	0
Surgical gown	5
Sterile cloth wrapping	12
Wash cloth	0
Sharps	
Scalpel blades	1
Syringes	2
Spinal needles	2
Suture needles	2
Red sharps container	1
Banana blade	1
Shaver	1
Beaver blade	1
Surgical anchor driver	2
Guide-wires	2
Spherical bur	1
Hip preservation system conmed switch sticks	2
Cannula	1
Cautery	1
Sterile wrap	
This category is for the polypropylene wrap used to cover surgical products during sterilization	
Extra large	2
Large	4
Medium	1
Small	12
Mayo stand cover	1

Figure 1. Waste collected from one FAI procedure. From left to right, waste has been sorted as landfill waste, sterile wrap, laundered linens (two green bags), recyclable plastics, biohazard waste and sharps (yellow container).

habits, Kwakye *et al.* [12] suggested five green recommendations for surgical practices: (i) OR waste reduction and segregation, (ii) reprocessing of single-use devices, (iii) environmentally preferred purchasing, (iv) energy consumption management and (v) pharmaceutical waste management. Kagoma *et al.* [3] also suggest the use of reusable sharp items containers, examining fluid waste management, the use of light-emitting diode (LED) surgical lamps, reusable hard cases and purchasing 'greener' equipment packaging, all of which form the foundation to 'greening' an institution's OR practices.

This is one of few studies in the literature that closely examines both the quantity and quality of waste produced in the OR for a given procedure in a controlled environment. To our knowledge, this is the first study to examine the waste production following arthroscopic procedures, and certainly the first in the hip arthroscopy literature. Every surgical instrument, linen, packaging and fluid was counted in duplicate, cataloged and distributed into the appropriate waste stream in real time to ensure all waste was accounted for in each of the five procedures. This study looks specifically at the waste production in our institution and will give us relevant data on where the waste reduction

practices are lacking and where OR practices to decrease waste production further can be improved.

Future directions

Based on the results of this study, and that the amounts and types of waste production may vary by institution and individual surgeon, a first critical step will be collect similar data on other high-volume institutions. Looking specifically at proper segregation of waste (which was not addressed in this study but is reported to be a problem in the literature), maximizing recycling at each institution, and decreasing the amount of surgical overage for procedures are all important next steps. We believe the inclusion of 'green outcomes' in addition to patient outcomes would be beneficial to facilitate a multi-department initiative to 'green' ORs. Similarly, exploring the quality and performance of both standard and 'green' materials before switching medical practices to ensure parity at a minimum, would be prudent. There is no doubt of the additional value to performing cost-benefit evaluations of the 'green approach' to further aid in effecting substantial, environmentally-friendly changes to clinical practices.

Limitations

There are several limitations to this study. First of all, the results are specific to one institution as well as to the study surgeon's operative equipment preferences/hospital contracts. It may also be recognized that everything that was classified as recyclable may not be recycled at every institution and that each institution must look at their own practices to maximize the materials they can potentially recycle. However, we still claim that examining waste production and disposal practices for a procedure with such a steadily increasing prevalence is valuable in informing us on how much waste is produced and directing surgeons and other institutions to areas where 'green outcomes' can be implemented and improved.

CONCLUSION

Given the considerable biohazard waste produced by FAI procedures, additional recycling programs, continued adherence to proper waste segregation, and an emphasis on 'green outcomes' is encouraged to demonstrate environmental responsibility and effectively manage and allocate finite resources.

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CONFLICT OF INTEREST STATEMENT

None declared.

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