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Comparison of Costs and Energy Expenditure in Common Hand Surgery: Operating Theatre Versus Ward Procedure Room

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Introduction. The health care sector is the fifth largest contributor to greenhouse emissions globally. Results of several studies have demonstrated that altering surgical practices from inpatient to outpatient service was associated with cost savings, reduction of medical waste and energy expenditure. The objective of this study was a comparison of costs and energy expenditure for hand surgeries performed in an operating theatre versus a ward procedure room. The analysis included the cost of materials, cost of sterilization of surgical instruments and energy expenditure for sterilization generated at standard hand surgery operations, including carpal tunnel release, surgery for Dupuytren's disease, benign tumor and ganglion cyst excision, de Quervain's disease, or trigger finger release. Typical hand surgery operations performed in a procedure room at the surgical ward generated lower costs (amounting to 53% of main theatre costs), 1 kg less clinical waste and were associated with significant (67%) reduction in energy expenditure compared to surgeries performed in the main operative theatre.

Performing common hand surgery operations in a ward procedure room instead of the operating theatre resulted in significant economic and environmental benefits without compromising patient safety.

INTRODUCTION

Most one-day care surgeries are performed primarily in the procedure room at the surgical ward rather than in the main operating theatre. It can be assumed that the costs of operations in this setting are lower than those carried out in standard conditions (in the theatre), due to the avoidance of the "one-hour theatre fee", but also due to the lower consumption of materials (simpler drapes) and the use of fewer instruments, which is associated with a reduction in the costs of their preparation (washing and sterilization)[1-3]. It has been also proved that this model does not translate on reduction of patients' safety, particularly on a higher risk of infections[4,5]. In addition to reducing the cost, an important benefit of this model is the reduction of clinical waste and energy expenditure on sterilization of instrument kits which are smaller than standard ones. The amount of energy used to produce a product or perform an activity (e.g. washing gowns, sterilizing tools) is referred to as the "carbon footprint" and is now an important part of human efforts in reducing carbon dioxide emissions. The health and social sector is the fifth largest contributor to greenhouse emissions globally. In the United Kingdom, medical equipment and instruments form the large carbon footprint estimated on 13% of global UK CO2 emission[3]. Several studies have demonstrated that altering surgical practices from inpatient to outpatient service was associated with cost savings, reduction of medical waste and the carbon footprint[1,6,7].

The objective of the study was comparison of costs and energy expenditure for hand surgeries performed in an operating theatre versus a ward procedure room.

MATERIAL AND METHODS

The analysis included the cost of materials used at operations performed in the ward's procedure room vs main operative theatre. The patients who were operated on in the authors' department in 2023 year were non-randomly assigned to operation either in the ward procedure room or in the main operative theatre. In general, "smaller" and elective operations such as

carpal tunnel release, surgery for mild Dupuytren's disease, benign tumor and ganglion cyst excision, de Quervain's disease, or trigger finger release were performed in a ward procedure room. "Bigger" and emergency surgeries such as trapeziectomy, severe Dupuytren's disease, reconstructions of hand structures, flexor tendon repair, nerve lacerations repair, fracture fixation, or complex hand injuries were performed in the main operative theatre. We are aware that non-random patient assignment to operation site can be considered limitation of this study as it might introduce a bias. This problem will be further clarified in the Discussion section. In 2023, a total of 1435 hand surgery operations were performed in the authors' institution, of this number 982 in the main theatre ("bigger" operations) and 453 in the ward procedure room setting ("smaller" operations). Data on the cost of materials was obtained from the accounting department of the operating theatre. Data on the costs of cleaning and sterilization of surgical instruments and gowns, as well as data on energy expenditure for these processes were obtained from the office of the sterilization department. All patients were operated on under local anaesthesia or wide-awake local anaesthesia with no tourniquet (WALANT) performed by the surgeons themselves, without anesthesiologist assistance[8,9].

RESULTS

Data on the costs of considered components are presented in Table I.

Cost of materials. For the operation performed in the main operating theatre, a kit consisting of 2 regular foliodrapes and one large drape for operated hand was used. In addition, one additional regular foliodrape was placed on a table with instruments (Fig. 1). The standard set of tools for hand surgery in the operating theatre consisted of 31 instruments (Fig. 2). The operator and the assisting nurse were equipped with reusable gowns, which were re-sterilized. In the procedure room setting, only 2 regular foliodrapes were used (Fig. 3). The standard set of tools for hand surgery in the ward dressing room consisted of 8 instruments (Fig. 4). Only the operator wore a disposable gown.

A comparison of the costs of these materials shows that the surgery performed in the out-patient setting generates costs lower by 14 Euro than in the main theatre (Euro 21 vs 7, Table I). A "one-hour theatre fee" was not included in this calculation.

The cost of sterilization. For sterilization, the instruments and other materials are packed in kits. According to the information obtained from the sterilization department's office, the cost of sterilization of 1 kit, both from the main operating theatre (larger) and from the ward (smaller) is on average 5 Euro. The cost of sterilizing an operating gown is 6 Euro in average. Therefore, the costs of sterilization of surgical tools and gowns were also higher in the operating theatre by about 6 Euro.

The total cost of materials and sterilization in the main theatre was 32 Euro (21+5+6) per case, and in the ward procedure room 17 Euro (7+5+5) per case, which accounted for 53% of the costs in the main theatre.

Generation of clinical waste. All disposable items (surgical drapes and gown) were weighed at the end of the operation. The weight of clinical waste in the operating theatre was 1,5 kg and in the ward procedure room was 0,5 kg. All clinical waste in the main theatre was placed in red (infectious) bags and disposed of as contaminated (Fig. 5a). In the ward procedure room, only one foliodrape (from the table), surgical gloves and contaminated swabs were put into a red bag, but the rest of materials (disposable gown and a foliodrape from the patient) were put into a blue bag (not contaminated) (Fig. 5b).

Energy expenditure for sterilization. The sterilization process is carried out in steam autoclaves. For the autoclave, kits of surgical instruments and gowns are placed in so-called sleeves, which have 2

Table I. — Cost calculation of materials and sterilization used at operations performed in the operative room in the theatre and in a procedure room at the surgical ward.

Variable	Costs in EURO	
	Operative room in the theathre	Ward procedure room
Operation draps	21	7
Disposable surgeon's gown	-	5
Instrtuments sterilization	5	5
Surgeon's gown sterilization	6	-
Total costs	32	17

Fig. 1 — Operative draping used for carpal tunnel release in the main operating theatre.

Fig. 2 — Instruments set for the operation in the theatre.

sizes. The larger sleeve holds 24 kits and the smaller holds 12 kits. Sterilization of the larger one is an energy expenditure of 20.1 kWh, and the smaller one is 9.8 kWh. The average energy expenditure per 1 kit is therefore 0.83 kWh, regardless of the size of the kit. Since the reusable gowns used in the operating theatre were re-sterilized, the energy required to sterilize them increased the energy expenditure of sterilization in the operating theatre by 1.7 kWh (equivalent of 2 kits). The energy expenditure for sterilization of surgical instruments from ward procedure room constituted 33% of the energy used to sterilize the instruments and clothes form the main theatre. Assuming that in the adopted calculation model the amount of energy expressed in kWh is proportional to the amount of CO2 emissions, the reduction in the carbon footprint in an out-patient setting was 67% in average.

However, such calculation of the carbon footprint is not complete, because the only ingredient here was energy, with no including the amount of CO2 generated for the production of all disposable materials such as surgical gown, operative drapes, syringes, surgical gloves, hypodermic needles, surgical sutures and blades. The authors had no precise data about these variables, therefore we did not consider them in this analysis. However, number of all disposable materials necessary to operations were almost the same in the procedure room and the theatre settings.

In 2023, a total of 1435 hand surgery operations were performed in the authors' institution, of this number 982 in the main theatre and 453 in the ward procedure room setting. Assuming that one operation in the procedure room was of 15 Euro cheaper than in the operative room, the total savings in material costs amounted to 6,795 Euro. Three superficial wound infections requiring short course of antibiotic therapy were identified among the operated patients: no infection after operations in the procedure room and three after operations in the operative room in the theatre. It should be mentioned, that spectrum of operations in the theatre's operating room was wider than in the ward procedure room and included also

Fig. 3 — Operative draping used for carpal tunnel release in a ward procedure room.

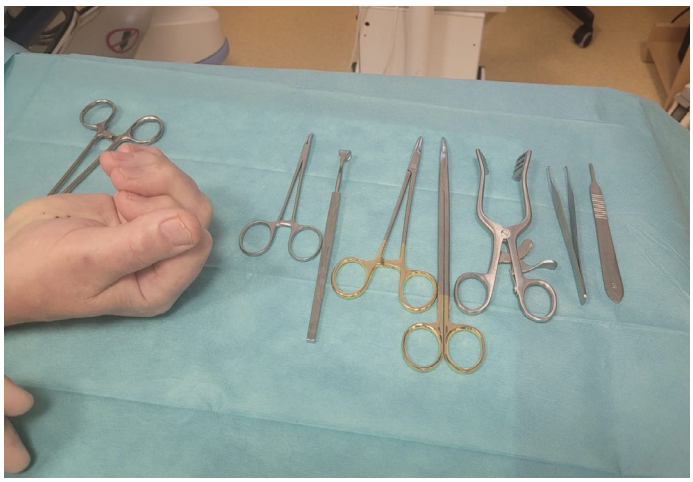

Fig. 4 — Instruments set for the operation in the dressing room.

emergency operations after hand trauma (complex wounds and bone fractures) which were obviously burdened a greater risk of infection. Nevertheless, our results show that surgery in an outpatient setting did not translate into an increased risk of infections.

DISCUSSION

Organizations researching the impact of human activity in various fields, including healthcare, have called on the health care community to take a leadership role for emissions reduction. It concerns also surgeons, who should have a responsibility to understand the impact of their clinical activities on the health of the environment and by extension the ultimate impact for human health[3,7]. The results of our study have shown that typical hand surgery operations performed in the ward procedure room generated lower costs, less clinical waste and lower energy expenditure compared to surgeries performed in the main operative theatre. It did not translated on decreasing of the patients' safety, particularly on increased risk of infections.

It is important to understand the idea of this study that it was not based on the analysis of a group of patients, but on the analysis of specific elements of procedures performed in two different settings: in ward procedure room vs main operative theatre. Therefore, the authors did not analyse the data of patients or their diseases, because this information was not the subject of this study. The variables that were analysed were the cost of materials used at operations, the cost of sterilization of packs of tools, energy expenditure and indirect evaluation of carbon footprint. These analyses were converted to one standard procedure, but not to the patient with his/her specific condition. Therefore we did not used any inclusion and exclusion criteria for subjects of the study and did not used random allocation of patients to operation setting. It has been mentioned in the Materials and Methods section that non-random patient assignment to operation site can be considered

Fig. 5a — Amount of clinical waste generated in the main thearte after one operation.

limitation of this study as it might introduce a bias. It needs to be clarified here that randomization was not possible at present design of the study. Serious injuries and diseases required operation in the main theatre for obvious reasons (better equipment, more staff, access to fluoroscopy, etc.) whereas common hand surgeries were less demanding and could be performed in the procedure room. It is not possible to random i.e. trapeziectomy with trigger finger release. But contrary to appearances, lack of randomization did not introduce significant bias in this study, because in the main theatre expenses are very similar for bigger and smaller operations, i.e. for trapeziectomy and trigger finger release. It is because all reusable materials (instruments) are packed in standard kits. Similarly, consumption of all disposable materials is comparable. Therefore, in our opinion, results of our study are not burdened with significant bias.

There are several articles in the literature presenting results of analyses of costs, energy expenditure and amount of the carbon footprint. Some of these articles present results of investigating the cost-effectiveness and environmental effect of changing a standard model of surgery to so called "lean and green" model. The "lean and green" model of surgery consists in use of smaller instrument trays, smaller drapes, fewer disposables and aims to limit waste generation, financial costs and carbon footprint. The essential elements of this model were used in the presented study in the part concerning operations in

Fig. 5b — Amount of clinical waste generated in the procedure room after one operation.

the procedure room setting. Kodumuri et al. (2023) reported significant reduction in CO2 emissions of 80%, clinical waste reduction of 65%, and an average cost reduction of 66% when "lean and green" model was used compared to the standard one. The authors conclude that a "lean and green" model provides a safe, cost-effective and sustainable service for patients undergoing carpal tunnel surgery[3]. In an another study the authors found that the mean average carbon footprint of products used for carpal tunnel release was 12.0 kg CO2e (carbon dioxide equivalents), and product with greatest carbon contribution for this operation was the single-use hand drape. The authors conclude that efforts should be targeted towards minimalizing use of single-use items and switching to reusables, alongside optimising processes for decontamination and waste disposal[10]. Other authors found that endoscopic and open carpal tunnel release (CTR) generated similar total carbon footprint, of 83 kg CO2 per case[6]. Results of this study are significantly different from the previous one by Rizan et al. (2023), however this discrepancy can be explained by different calculations of the ingredients included in the composition of carbon footprint.

There are some studies investigating cost analysis of operations performed in the operative theatre versus surgical ward settings. Results of these studies show generally significantly lower costs of surgeries performed in the ward procedure room vs the main theatre. For percutaneous fixation of hand fractures these costs were three times lower, and almost five times lower if performed under local anaesthesia delivered by surgeons themselves[2]. Similar study was conducted by Leblanc et al. (2007) for analysis of cost of CTR in the operating theatre vs the ambulatory setting. The authors found that in a three-hour surgical

block, they were able to perform 9 CTRs in the procedure room versus 4 in the theatre. The cost of CTR in the ambulatory setting was almost four times lower per case than in the theatre[1]. In an another study the authors analysed cost drivers in CTR. They found that operations in the theatre caused a 48% increase in the total costs, compared with procedure room, and surgery under general anaesthesia generated higher charges than under local anaesthesia (differences statistically significant)[11]. Another authors noticed that despite the obvious benefits of the outpatient setting, the majority of common minor hand surgeries were performed in the operation room setting, and the procedure room utilization increased slightly[12].

An important factor of the effectiveness of surgery is the minimization of the risk, i.e. complications and revisions due to unsatisfactory outcome. Kronlage et al. (2023) compared infection and revision rates after mini-open carpal tunnel release performed in hospital setting and outpatient setting. No patients were diagnosed with deep infections post-procedurally, irrespective of surgery setting. The authors conclude that the outcomes of open CTR are the same when performed in the ambulatory setting vs in the hospital[13]. Results of this study are similar to the present study.
This study had some limitations. One is that's we did not include calculations of the amount of CO2 generated for the production of all disposable materials such as surgical gown, operative drapes, syringes, surgical gloves, hypodermic needles, surgical sutures and blades. Another limitation is that the procedures performed in both settings were not the same: generally smaller in the procedure room, compared to the operative theatre. Nevertheless, most of components used for calculations of considered variables (cost of materials, sterilization, energy expenditure and carbon footprint) were similar in both types of surgery.

CONCLUSION

This study demonstrates that performing common hand surgeries in ward procedure rooms significantly reduces costs, clinical waste, and energy expenditure without increasing patient risk. We believe that these findings, alongside with other studies could apply to other hospitals and healthcare settings for the benefit of patients, hospitals and healthcare system.

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