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Environmental Sustainability Abstracts

Contents

A life cycle inventory of a single injection peripheral nerve block with and without premade supply pack

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125

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INTRODUCTION

Climate change and environmental pollution has been widely recognized as a significant global public health threat.[1] Unfortunately, the provision of health care, including anesthesia care has a significant environmental impact, and disposal of single-use medical equipment represents a source of environmental harm.[2] Operating rooms are estimated to produce a quarter of all the waste generated in a typical hospital, with up to 30% of this waste attributed to anesthesia care.[3] Our group sought to examine the environmental impact of disposable equipment used for peripheral nerve blocks at two different sites, one that utilizes a pre-assembled "nerve block pack" to facilitate procedural setup and the other utilizes individually packaged items, with the goal of identifying opportunities to reduce the impact of our equipment choices.

METHODS

This study does not meet the definition of human or animal subjects research, and is exempt from ethics review requirements.

The scope of this life cycle inventory was defined as the disposables used to set up for one single-shot ultrasound-guided peripheral nerve block with a stimulating needle, not including packaging used in shipping. As the primary goal is to examine the impact of single-use supplies, ultrasound use and operating room environment and energy consumption is not within the scope. Equipment and medications used for sedation are also outside the scope. Use of 30 mL of local anesthetic for the block and 3 mL to anesthetize the skin was assumed.

Samples of disposable materials used for a peripheral nerve block were collected at two separate sites (A and B). At site A, a pre-manufactured sterile block pack contains all disposable materials with the exception of gloves and a block needle. At site B, disposable sterile items are individually wrapped. Information provided by the manufacturers was reviewed to help determine the composition of items. When the exact composition of an item was uncertain, previously published data was used to help determine an appropriate substitute.[4]

RESULTS

Total disposables used for a peripheral nerve block are summarized in the Table. Overall, more disposable materials were used at the site utilizing a pre-made block pack (202.9 g *vs* 163.3 g). This may reflect the inclusion of marking pens and labeling materials in the block kit, some of which can be repurposed after the procedure. At both sites, a significant portion of disposables is composed of various types of plastics (71.5% with a pre-made pack *vs* 64.9% with individually wrapped items). The increased use of plastics associated with a pre-made pack is driven by a larger amount of packaging film (35.6 g with a pre-made pack *vs* 16.7 g). Some of the differences may reflect regional differences in product availability; for example, a chlorhexidine prep stick packaged primarily with paper *vs* a more complicated chlorhexidine prep stick packaged in plastic and containing a glass insert.

DISCUSSION

These results provide insights into the amount of waste generated by a single peripheral nerve block, a procedure performed many times daily at thousands of sites. Our team is working to expand this project into a complete cradle-to-grave lifecycle analysis to more fully analyze the environmental impacts of our disposable equipment. However, the disproportionate use of disposable plastics in health care is already evident from this preliminary lifecycle inventory. These results also highlight an opportunity to reassess the packaging used in pre-made kits as well as the importance of avoiding the presumption that a pre-made pack contains less packaging waste.

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Table Summary of life cycle inventory of disposable materials used to set up for one single-shot ultrasound-guided peripheral nerve block with 30 mL of local anesthetic for the block and 3 mL to anesthetize the skin including a stimulating block needle

Material	Mass of materials used in premade block pack (site A)	Mass of materials used in individually wrapped items (site B)
Total – g	202.9	163.3
Total plastics – g (% total)	145 (71.5%)	106 (64.91%)
Rigid molded plastics – g (% total plastics)	79.5 (54.8%)	63.3 (59.7%)
Packaging film – g (% total plastics)	35.6 (24.6%)	16.7 (15.8%)
Synthetic rubber – g (% total plastics)	23.1 (15.9%)	23.0 (21.7%)
Other – g (% total plastics)	6.8 (4.7%)	3.0 (2.8%)
Total Liquids – g (% total)	29.0 (14.3%)	24.5 (15.0%)
Water – g (% total liquids)	21.7 (74.8%)	20.5 (83.7%)
Isopropyl alcohol – g (% total liquids)	6.3 (21.7%)	3.1 (12.7%)
Other chemicals[1] – g (% total liquids)	1.0 (3.5%)	0.9 (3.7%)
Paper – g (% total)	10.5 (5.2%)	27.6 (16.9%)
Woven cotton – g (% total)	14.5 (7.2%)	4.8 (2.9%)
Glass – g (% total)	3.6 (1.8%)	n/a
Steel – g (% total)	0.4 (0.2%)	0.4 (0.2%)

[1]"Other chemicals" includes additional ingredients in isopropyl alcohol-based chlorhexidine prep solution (chlorhexidine digluconate, FD and C Yellow No. 6), and in water-based ultrasound gel (propylene glycol, carbomer, triethanolamine)

Advancing environmental sustainability in anesthesia: challenges and future directions

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82

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INTRODUCTION

The environmental impact of anesthesia is increasingly recognized, with anesthetic gases and single-use equipment contributing significantly to greenhouse gas emissions and medical waste. Volatile anesthetics, particularly desflurane and nitrous oxide, are potent contributors to climate change, with global warming potentials thousands of times that of CO_2.[1,2] Single-use items, including laryngeal mask airways (LMAs) and syringes, exacerbate waste generation. As health care systems account for up to 5% of national carbon emissions, anesthesiology has a unique opportunity to lead sustainability initiatives.[2,3]

This study explores strategies to reduce the environmental footprint of anesthesia through evidence-based practices, including reusable equipment, low-flow anesthesia, and alternative gas usage, and evaluates their feasibility and impact on patient care. Additionally, it identifies future directions for sustainable practices, emphasizing education, policy development, and interdisciplinary collaboration.[4,5]

METHODS

A systematic review was conducted to assess the environmental impact of anesthetic practices and identify sustainable solutions. Databases including PubMed, Scopus, and Web of Science were searched for peer-reviewed literature published between January 2010 and December 2024. Keywords included "anesthetic gases," "environmental sustainability," "green anesthesia," "low-flow anesthesia," and "reusable medical devices." The review included studies that quantified the carbon footprint or environmental impact of anesthetic agents, evaluated the efficacy of sustainable practices like reusable equipment or gas alternatives, and assessed cost-effectiveness.[1,4] Studies without robust environmental metrics or specific relevance to anesthetic practices were excluded. Data extraction focused on three primary areas: emissions from volatile anesthetics, waste generated by single-use equipment, and the effectiveness of interventions such as low-flow techniques and recycling programs.[2,3] Additional emphasis was placed on barriers to implementation, including institutional policies, cost, and provider attitudes.[5] Quality assessment was performed using Critical Appraisal Skills Programme checklists to ensure methodological rigor, and thematic analysis categorized findings into actionable strategies. Stakeholder perspectives, including clinicians and hospital administrators, were integrated to evaluate the feasibility of proposed solutions. The synthesis aimed to provide evidence-based recommendations for aligning anesthetic practice with sustainability goals while maintaining patient safety and care standards.[1,4]

RESULTS

Sustainable anesthetic practices can significantly reduce environmental impact. Low-flow anesthesia and replacing desflurane with sevoflurane or propofol reduced greenhouse gas emissions by up to 50% (Figure).[1,2] Reusable LMAs decreased waste generation by 40% compared to single-use devices while maintaining safety and efficacy.[4,5] Advanced waste segregation and recycling initiatives cut landfill contributions by 30%.[3] However, barriers include higher initial costs of reusable equipment, lack of awareness among providers, and limited institutional support.[4] Studies highlight that educational programs and departmental policies are effective in driving change. Greenhouse gas reduction initiatives, such as scavenging systems and alternative anesthetic techniques, showed potential to align environmental goals with clinical efficiency, emphasizing the role of anesthesiologists in promoting systemic change.[2,5]

DISCUSSION

Environmental sustainability in anesthesia demands a multifaceted approach. Key strategies include adopting low-impact anesthetic agents, promoting reusable equipment, and integrating sustainability into clinical workflows.[3,4] Educational efforts and institutional policies are pivotal in overcoming barriers.[5] Future research should focus on the lifecycle impact of anesthetic practices, exploring innovative materials, and engaging stakeholders across disciplines. By prioritizing sustainability, anesthesiologists can lead the health care sector in reducing its carbon footprint while ensuring high-quality patient care.[1,2] A collective commitment to green practices will not only mitigate climate impact but also align anesthesia with global sustainability goals.[4,5]

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Figure Actionable steps and estimated impact of sustainable practices in anesthesia

Sustainable Practice	Actionable Step	Estimated Impact
Reduce Inhalational Agent Use	Implement low-flow anesthesia (1 L/min vs. 4 L/min).	75% reduction in volatile anesthetic emissions
Transition to TIVA	Prefer total intravenous anesthesia over volatile agents.	Eliminates inhalational agent emissions; avoids nitrous oxide use
Switch to Lower Global Warming Potential (GWP) Agents	Use Sevoflurane over Desflurane or Nitrous Oxide.	Desflurane has 10-20x higher GWP compared to Sevoflurane
Reusable Equipment	Opt for reusable LMAs and breathing circuits.	80% reduction in equipment-related waste
Digital Waste Auditing	Track and monitor OR waste with AI-based tools.	20-30% reduction in non-recyclable waste through data-driven interventions

AI = artificial intelligence; LMA = laryngeal mask airway; OR = operating room; TIVA = total intravenous anesthetic

Comparison of the clinical performance and usage patterns of disposable and reusable membrane carbon dioxide absorbers: a prospective observational study

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113

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INTRODUCTION

Volatile inhalational anesthetic agents are known contributors to green house gases and global warming. “Low flow” ventilator settings for volatile anesthetics have been recommended to reduce excess gas venting to the atmosphere through scavenge systems.[1,2] However, when using Sevoflurane and disposable carbon dioxide (CO_2) absorbers at flows under 2 $L \cdot min^{-1}$ there are *theoretical* concerns over the formation of the nephrotoxic byproduct compound A.[1,3] Reusable membrane-based CO_2 absorbers (mem*sorb*™, DMF Medical Inc., Dartmouth, NS, Canada) have the environmental advantages of reducing the volume of disposable equipment waste and avoid the compound A issue irrespective of flow rate settings. These advantages must be balanced with the initial purchase cost of mem*sorb* and additional equipment requirements, specifically medical air-oxygen sweep gases and a blender device. The purpose of this pragmatic study was to examine the natural usage of the mem*sorb* device by our staff and compare costs and waste generated by the two absorber types.

METHODS

The Nova Scotia Health Authority research ethics board granted a waiver for this quality improvement study. This prospective observational study compared standard disposable CO_2 absorbers (Drägersorb CLIC Absorber 800+, Drägerwerk AG & Co. KGaA, Lübeck, Germany) to the reusable mem*sorb* CO_2 absorber on Fabius® ventilators (Drägerwerk AG & Co. KGaA, Lübeck, Germany). The 12 week-long study was conducted in two neurosurgery suites, with a CO_2 absorber cross over between operating rooms after six weeks. Inclusion criteria were general anesthesia cases utilizing either sevoflurane alone or a combination of sevoflurane with propofol infusions. The exclusion criteria were patients under 18 yr old, COVID-19 infection, malignant hyperthermia susceptibility, or pregnancy. Staff were given an orientation to the mem*sorb* device prior to initiating the study. There were no prescribed fresh gas flow (FGF) rates for either CO_2 absorber, FGF was at the discretion of the individual physician. The FGF rates, inspired and expired CO_2 levels (F_ICO_2, $EtCO_2$) were collected from our electronic anesthetic records (Innovian® Anesthesia, Dräger Medical Canada Inc., Mississauga, ON, Canada). Custom software differentiated the maintenance phase from induction and emergence periods for analysis of the mean FGF and CO_2 levels during the steady state portion of each case. The number of circuits, water traps, filters and CO_2 absorbers that were used in each room were also recorded.

RESULTS

There were 63 general anesthesia cases using the mem*sorb* device and 82 cases with disposable CO_2 absorbers included for analysis. The FGF and CO_2 data were not normally distributed and are reported as median [interquartile range (IQR)] and analyzed using Kruskal–Wallis analysis of variance (SigmaStat, Systat Software, Inc., San Jose, CA, USA). There were no significant differences in FGF between mem*sorb*, 1.3 [1.1 to 1.5] $L \cdot min^{-1}$ and disposable absorber, 1.2 [1.0 to 1.5] $L \cdot min^{-1}$ groups ($P = 0.11$). The $FiCO_2$ for the mem*sorb* group, 1.4 mm Hg (0.8 to 2.5) was significantly higher ($P < 0.001$) than the disposable absorber group, 0.4 mm Hg (0.3 to 0.5). There was no significant difference between the $EtCO_2$ levels for mem*sorb*, 36.6 [35.0 to 39.5] mm Hg, and disposable CO_2 absorber groups, 36.1 [34.4 to 38.8] mm Hg ($P = 0.32$). During the initial six-week period, 7 standard absorbers were disposed of from the control room, and during the second six-week period, 14 absorbers were disposed of from the other control room.

DISCUSSION

There were no differences in the FGF rate employed between absorber types. Our staff all used flow rates less than 2 $L \cdot min^{-1}$, which can be attributed to knowledge of the Canadian Anesthesiologists' Society guideline recommendations[3] and previous educational rounds on environmental practices given to our staff. Although the F_ICO_2 levels were higher for the mem*sorb* device, the $EtCO_2$ levels were equivalent between absorbers and the higher inspired CO_2 levels were likely clinically insignificant.[4,5] Disposable CO_2 absorber consumption varied between the two control rooms because of differing elective and emergent case volumes. The consumption of other associated disposable circuit equipment will be discussed.

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