Sustainable Anesthesia: Limiting Waste, Maximizing Resiliency

by Molly M.H. Herr, MD, and Leal G. Segura, MD

In anesthesiology, the use of single-use devices has sky-rocketed over the last two decades. Single-use devices used in anesthesia practice, including laryngoscopes, video laryngoscopes, blood pressure cuffs, medical gowns, operating room hats and attire, and pulse oximetry probes are often discarded immediately after one-time use. In 2019, the U.S. disposable medical device market was already a $66.9 billion industry, and the industry continues to grow, currently increasing at a compound annual growth rate of 16.7%.

Manufacturers tout the ease and safety of single-use products. Advocates suggest easier infection control with their use. Ambiguity and changes in processing requirements for medical equipment have led many health care organizations to default to disposable devices over fear of citations by accrediting bodies.

Recent pandemic-related supply chain disruptions starkly exposed the dangers of heavy reliance on disposable devices. Health care systems often keep relatively low supplies of these single-use devices, reordering only short-term supplies reflecting a “just in time” mentality focused on keeping costs low. Anesthesia professionals have faced occasional medication and product shortages in the past, but the frequent and profound shortages of equipment, supplies, and medications over the last three years is an abrupt departure from modern clinical practice in the United States. As anesthesia practices scramble for alternative equipment and supplies, they may be forced to use second- or third-line devices or medications, potentially creating significant patient safety concerns related to the frequent introduction of new and unfamiliar supplies.

These product shortages, and the supply chain fragility they expose, should prompt an evaluation of disposable device usage. Further, an increasing awareness of anesthesiology’s outsized environmental footprint, and the consequent impact on public health, has prompted many health care systems to re-evaluate purchasing processes to decrease the massive waste and greenhouse gas (GHG) emissions produced from surgical practices.

In this review, we outline methods to increase both sustainability and supply chain resiliency in anesthesiology practices based on evidence-based analysis of product safety, infection risk, and greenhouse gas emissions (GHG) related to product manufacturing, use, and disposal. Ultimately, maximizing the utilization of reusable devices promotes patient safety by reducing the risk of shortages of essential products. Reusable products confer a reduced environmental footprint by creating less physical waste and offer the potential of enormous cost benefits for health care systems.

Building sustainable, resilient, and cost-effective anesthesia practices demands an understanding of product costs and resource utilization. Life cycle costing and life cycle assessments are important concepts that are helpful for practice leaders who are evaluating purchase decisions. These life cycle concepts are dependent on the number of times a product is used and are determined by product-related energy costs, GHG emissions, and economic costs over its lifespan (Table 1). Additionally, it is imperative for health care organizations to understand waste management in the context of environmental impact, patient and community safety, and cost benefit. The Waste Hierarchy (Figure 1) is one tool practice leaders can utilize when evaluating potential device purchases. For example, the waste hierarchy suggests that a properly cleaned, re-used pulse oximetry probe offers less environmental impact (and is cheaper to hospital systems) than a recycled or discarded probe. Successful waste management improves the health of communities by reducing landfilled and incinerated waste, both of which may produce soil, water, and air toxins and other hazardous byproducts. A waste management program that...

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**Table 1: Terms Related to Sustainable Device Purchasing.**

<table>
<thead>
<tr>
<th>TERMS</th>
<th>DEFINITION</th>
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<tbody>
<tr>
<td>Life Cycle Assessment (LCA)</td>
<td>An internationally standardized modeling tool evaluating the cradle-to-grave environmental impact associated with all states of a product’s life. Includes raw material extraction and processing, manufacturing, distribution, use, and eventual waste or recycling.</td>
</tr>
<tr>
<td>Life Cycle Costing (LCC)</td>
<td>The process of compiling costs of ownership over the lifetime of a product.</td>
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Table 2: Spaulding Device Cleaning Classification.

<table>
<thead>
<tr>
<th>Level</th>
<th>Infection Risk</th>
<th>Description</th>
<th>Examples</th>
<th>Required Processing Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>High</td>
<td>Enter sterile areas, including the vascular system</td>
<td>Surgical instruments, implants</td>
<td>STERILIZATION High-pressure steam</td>
</tr>
<tr>
<td>Semi-critical</td>
<td>Moderate</td>
<td>Contact mucous membranes or broken skin</td>
<td>Laryngoscope blades, rigid/flexible endoscopes, video laryngoscope blades</td>
<td>HIGH-LEVEL DISINFECTION (HLD) Chemical reprocessing, vaporized hydrogen peroxide, glutaraldehyde, etc.</td>
</tr>
<tr>
<td>Non-critical</td>
<td>Low</td>
<td>Contacts intact skin</td>
<td>Laryngoscope handles*, blood pressure cuffs, stethoscopes, video laryngoscope handles</td>
<td>LOW-LEVEL DISINFECTION (LLD) Wipe disinfection, Sani-cloths, 70% isopropyl alcohol, quaternary ammonium</td>
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*There is some controversy over laryngoscope handle cleaning between organizations: some designate handles as noncritical devices, while others do not delineate between the blade and handle, and therefore, designate the entire device as semicritical. Some laryngoscope manufacturers have new handles compatible with HLD that do not require disassembly and are immersible, along with LLD options in the Instructions for Use (IFU).5,6

Reusable vs. Disposable Anesthesia Equipment

Commonly Used Disposable and Reusable Anesthesia Products

Laryngoscope Handles and Blades

Evaluations of the life cycle assessment and total life cycle costs of reusable and disposable laryngoscope handles and blades show significant environmental and cost savings with reusable equipment,6 without compromising patient safety when cleaned according to established guidelines.

According to the Spaulding Classification, laryngoscope handles may be considered either low or moderate infection risk as consensus varies between professional organizations, requiring either “low-level” disinfection, using chemical wipes or 70% alcohol, or “high-level” disinfection, using chemical reprocessing. Either protocol still confers environmental benefit over single-use laryngoscope handles. For example, a disposable metal handle produces 20 times more GHG emissions per use than a low-level disinfected handle and nearly 27 times more GHG emissions than a high-level disinfected reusable steel handle, assuming a life span of 4000 uses. Reusable laryngoscope blades, which require high-level disinfection at minimum, are still environmentally preferable over single-use metal blades. These reusable blades produce between 2–7 times less GHG emissions per use, depending on sterilization or high-level disinfection, respectively.5

Safety data showing a clear benefit of disposable laryngoscopes over adequately cleaned reusable laryngoscope handles and blades are lacking. Further, there is no evidence to suggest infection transmission in the US from reusable handles or blades, appropriately cleaned according to Spaulding Classification criteria and the manufacturer’s instructions for use.7

Case reports of infection transmission in neonatal intensive care units describe inadequately disinfected laryngoscopes where current cleaning protocols were not followed.8 Older data show contamination of reusable blades and handles, but the majority of studies were judged to be very low or low quality, with inconsistent cleaning protocols.9 A study examining laryngoscope handles cleaned with low-level techniques demonstrated no pathogenic bacterial or viral colonies and only rare to few non-pathogenic bacterial colony growth, which decreased in samples as the study continued, perhaps reflecting increased attention to handle cleaning during the study period.10 Further, this bacterial contamination is of unclear significance, given that 50% of sterile fields are contaminated within a few hours, even in empty operating rooms,11 and bacteria have been cultured from sterile trays immediately after opening.12 In addition, anesthesia personnel routinelly use laryngoscope handles without sterile gloves and even single-use devices are opened, touched, and contaminated during OR set-up. These studies highlight the importance of high-quality, careful protocolized cleaning and reprocessing.

When the lifetime costs of reusable laryngoscopes, including those related to reprocessing and device attrition, are evaluated against disposables, a reusable handle needs to be used only 4–5 times for cost benefit compared to a disposable handle, and reusable blades only 5–7 times compared to single-use blades. In one year of clinical practice, reusable handles and blades confer significant savings to health systems, regardless of cleaning protocol, despite initial higher upfront costs.6

Reusable products do not just confer cost benefit, they also may improve patient safety by safeguarding against critical shortages. The SARS-CoV-2 pandemic led to widespread shortages in single-use plastic video laryngoscope blades. Many institutions adapted by reprocessing blades internally or through third-party reprocessing companies, demonstrating the supply chain vulnerability of single-use products versus reusable products, particularly during periods of high demand. The pandemic experience highlighted that reprocessing of single-use devices can be performed safely. External third-party reprocessing is highly regulated by the FDA, designed to restore products to their original quality, function, and sterility, while maintaining safety warranties. Even with stringent protocols, reprocessed device costs are still half the price of new equipment.13
Similar analyses confirm the environmental benefit from reusable isolation gowns, which confer a 28% reduction in energy consumption, a 30% decrease in GHG emissions, a 41% reduction in blue water consumption, and a 93% reduction in solid waste generation.

OR Hats and Arm Coverings
Over the last decade, guidelines regarding head coverings for operating room personnel have shifted, with current recommendations favoring clean, but not necessarily disposable head wear. Further, from a patient safety perspective, most published evidence suggests that reusable hats confer at least equivalent, if not better, infection protection with a far smaller environmental footprint.

In 2015, the Association of periOperative Registered Nurses released guidelines on OR attire directed at decreasing surgical site infection (SSI) risk. The guidelines, requiring disposable bouffant hats and long sleeves among all nonscrubbed personnel, were accepted by accrediting bodies, including the Centers for Medicare and Medicaid Services, despite no definitive evidence to support the recommendation. These guidelines were based on a series of published studies demonstrating no infection benefit with disposable versus reusable hats. One study of 70 surgeons performing over 6,000 ventral hernia repairs showed no significant difference in surgical site infection with respect to surgeon head wear. Another study showed potential safety benefit for non-disposable hats, showing that airborne particle contamination was significant lower with cloth "skull" hats versus disposable bouffants. Passive microbial shedding was also significantly higher with disposable bouffants compared to disposable skull caps and other cloth hats. In fact, disposable bouffant hats were the most permeable and had largest pore size.

Current guidelines from multiple organizations, including the American Society of Anesthesiology, American College of Surgeons, and Association of periOperative Registered Nurses, now confirm the lack of scientific evidence showing any association between head covering type, extent of hair coverage, and SSIs, with new recommendations simply favoring clean surgical coverings during procedures.

It is unclear why the use of disposable hats and gowns remains so entrenched, despite the lack of evidence for improved infection control. While disposable products may seem cheaper, cost analyses demonstrate that these items confer high costs to health care systems. In a recent study of over 12,000 matched pairs of surgical patients, more strict attire of disposable bouffants, disposable beard covers, and disposable long-sleeved jackets among non-scrubbed operating room personnel drove total attire costs up 10 to 20 times per person entering the OR without improving surgical site infection risk.

Pulse oximetry probes
The use of disposable pulse oximetry probes is widespread and reflexive in anesthesiology practices. From an individual patient safety standpoint, there is a paucity of data showing any difference in the safety profile and accuracy between reusable versus disposable pulse oximetry probes, nor any data showing increased infection risk with appropriately cleaned reusable probes versus disposable probes. Further, increased availability of reusable pulse oximetry probes may improve safety in resource-poor countries. Pulse oximetry has been included on the World Health Organization’s Surgical Safety Checklist since 2007, but is still missing from 15% of operating rooms in resource-poor settings. Further, decreased waste generation and resource utilization with the use of reusable pulse oximetry probes can lead to improved community and planetary health.

The potential clinical benefits of reusable probes are matched by cost savings to clinical practices, as well. Data from emergency medicine literature suggest that reusable pulse oximeters may provide equivalent monitoring without safety concerns and with less costs. One quality improvement project performed by an emergency department with roughly 70,000 annual patient visits showed a 56% reduction in cost with reusable pulse oximeters. Likewise, monthly pulse oximeter acquisition costs dropped by $30,000. Another analysis of an emergency medicine department with 55,000 annual visitors demonstrated annual savings of $129,000 with reusables. To generate cost-savings, a reusable monitor needed to be used 22 times.

CONCLUSIONS
As highlighted, no evidence suggests that single-use devices in anesthesiology with low or intermediate infection risks provide better or safer care for our patients compared to appropriately cleaned reusable devices. Rather, patient safety is put at risk when heavy reliance on disposable clothing, equipment, and devices renders hospital systems vulnerable to severe supply chain shortages, prompting scrambles for products which may be inferior, unfamiliar, and more costly. Further, massive amounts of disposable medical equipment are either incinerated or
Disposable vs. Reusable Perioperative Devices (cont’d)

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go to landfills, with obvious environmental and public health consequences. As such, sustainability standards, greenhouse gas emissions, lifetime costs, and supply chain resiliency should be emphasized during purchasing decisions in hospital systems, along with evaluation of device quality, safety, and ease of use.

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REFERENCES


