Sustainable Anesthesia

Susan Ryan, PhD, MD,* and Jodi Sherman, MD†

Climate change is bad for health. So is pollution. The health risks of global warming include food and water insecurity, increased transmission of infections, heat stress, more frequent and extreme weather events, threats to shelter and security, and population migration.[a] Ironically, health care contributes to global warming and environmental pollution. Health care consumes 8% of United States energy production, and produces 18% of the gross national product.[1] Operating rooms (ORs) account for 30% of the hospital waste.[2] Left unmitigated, the costs of "business as usual" will contribute to the worsening of public health and increase the demand for health services.[3,4]

As anesthesia care providers, we have worked tirelessly on behalf of patient safety, comfort, exceptional quality care, and OR expediency. We need to add environmental stewardship to our list of exemplary contributions to medicine.

Environmental stewardship requires finding balance among competing interests. First, decisions must not compromise patient safety or the quality of care. Second, this is a nascent area of research, so current decisions incorporating environmental concerns may be based on inadequate data. Third, environmental benefits are not tangibly felt (though dollar cost and sustainability are often aligned).[b3,4]

Environmental sustainability deserves our attention. Why? Resources are not infinite. Personal, patient, public, and planetary health are at stake. Changes will come. Our choices can and will influence those changes. If we choose inaction, then we have abrogated our responsibilities of stewardship. We have the opportunity to craft sustainable, safe, and evidence-based practice, and to become responsible leaders in a new field of inquiry. This issue of *Anesthesia & Analgesia* introduces several current areas of research and offers authors' perspectives on practice modifications and priorities for future research.

In their "Open Mind" commentary, McGain and colleagues outline the magnitude of solid waste production and carbon dioxide emission from ORs.[5] The authors focus their discussion on the necessity of determining the environmental and economic costs of a practice by examining manufacturing (cradle), use, disposal, and dispersal back to the environment (grave), i.e., life cycle assessment. Life cycle assessment has been applied to applications ranging from basic materials (e.g., chemicals and metals), to familiar products (e.g., diapers and packaging), to complex technological products (e.g., electronics and automobiles), to entire infrastructures and sectors of the economy.[6] Within health care, life cycle assessments have been applied to hemodialysis practices in the United Kingdom.[7] However, there are very few life cycle assessments of perioperative products and services. This methodology is fundamental to evaluating the environmental impact of clinical practice and can reveal hidden costs in manufacturing (such as energy, water, and chemical use) or disposal (most notably, the greenhouse gas emissions of waste anesthetic gases). McGain et al.'s report includes a summary of internet sustainability resources. Their report also offers suggestions for changes in current practice, a summary of current lines of inquiry, and avenues for future investigation.

McGain and colleagues surveyed anesthesia provider opinions from Australia, New Zealand, and the United Kingdom.[8] Although hampered by low response rate and uncertain sample size, this study suggests that providers overwhelmingly agree with increased recycling in ORs (93%) and would donate time toward this cause. However, only 11% of anesthesia providers indicated OR recycling is currently underway in their workplace. This survey highlights the low rate of OR recycling and delineates several barriers: inadequate recycling facilities, negative staff attitudes, and inadequate information on how to recycle ranked highest. These survey findings can be instrumental in designing studies to address the barriers and investigate whether positive attitudes toward recycling can become positive actions.

This collection includes 3 life cycle assessments for equipment and products in anesthesia and OR practice. Dr. Overcash reviews 6 separate life cycle assessments that compare reusable and disposable perioperative textiles (gowns and drapes).[9] Overwhelmingly, reusable textiles

[a] World Health Organization: Climate change and human health, http://www.who.int/globalchange/en/, accessed February 9, 2012.

[b] "Acting now for better health, A 30% reduction target for EU climate policy", HEAL & HCWHE, Brussels, September 2010, www.env-health.org and www.noharm.org/europe/, accessed February 9, 2012.

From the *Department of Anesthesia and Perioperative Care, University of California, San Francisco, San Francisco, California; †Department of Anesthesiology, Yale School of Medicine/Yale-New Haven Hospital, New Haven, Connecticut.

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Address correspondence to Jodi Sherman, MD, Yale School of Medicine, Department of Anesthesiology, 333 Cedar Street, TMP3, New Haven, CT 06520. Address e-mail to jodi.sherman@yale.edu.

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require less energy and water to produce and use, and reduce volatile organic compound pollution. There appears to be no difference between reusable and disposable textiles in terms of comfort, infection control, safety, and cost. Eckelman and colleagues found that reusable laryngeal mask airways (LMAs) were environmentally preferable to disposable LMAs.[10] The authors demonstrate cradle to grave analysis by showing how operational and sterilization practices, and selection of LMA materials, affect environmental and human health impacts. Dr. Eckelman, the lead author, is an environmental engineer from a forestry department. His perspective includes soil, water, and human health consequences, all of which favor reusable LMAs. McGain and colleagues performed a life cycle analysis of reusable and single-use central venous catheter insertion kits.[11] They found that reusable kits, though less expensive, have a greater environmental cost to the environment due to the water and energy (sourced from brown coal) used in cleaning and sterilization. These results provide an important counterpoint to the LMA and textile life cycle assessments that showed reusables to be environmentally preferable. Reusable products do not necessarily have less environmental impact. The particular equipment, water and energy resources, transportation, and operational and disposal details particular to the hospital and region in question must be considered. Yet, even when disposables have a lesser footprint, the authors' conclusion is not simply that disposables are the long-term choice, but rather point to a need to improve processes within reusables to achieve minimal waste.

Anesthetic drug choices have environmental costs. Sulbaek Andersen and colleagues provide a definitive analysis of the greenhouse gas contributions of inhalation anesthetics.[12] This group from the Jet Propulsion Laboratory (yes, they are rocket scientists) provides new atmospheric lifetime measurements for our volatile agents and thereby improves the accuracy of global warming potentials of desflurane, sevoflurane, and isoflurane. As shown in previous papers,[13–15] desflurane has the highest global warming potential, followed by isoflurane and sevoflurane. These new global warming potentials will be valuable in determining the inhaled anesthetic ecological footprint and distinguishing between contributions of individual gases. Sulbaek Andersen et al.'s paper corrects several greenhouse gas calculations in earlier papers. Although the overall contribution of inhalation anesthetics to greenhouse gas emission is miniscule, the authors note that appropriate drug selection and efficient use of anesthesia gases could reduce both direct and environmental costs.

Sherman and colleagues performed a life cycle assessment[16] incorporating the global warming potentials reported by Sulbaek Anderson et al.[12] This analysis compared the entire environmental footprint of some of our most important anesthetics: the volatile gases, nitrous oxide, and propofol. With the exception of nitrous oxide, the manufacturing methodology for anesthetic gases has not been disclosed by pharmaceutical companies. Sherman et al.'s analysis included plausible drug synthesis pathways using life cycle assessment standards. All of the inhaled drugs had a startlingly larger footprint than propofol, mainly due to waste anesthetic gas emissions. Desflurane and nitrous oxide, as with prior studies, had the most significant footprint. The environmental footprint of propofol was 4 orders of magnitude lower. The authors suggest that desflurane and nitrous oxide only be used in cases where they could reduce morbidity and mortality over other agents. They further suggest that, when appropriate, techniques other than inhaled anesthesia (e.g., IV anesthesia, neuraxial, and peripheral nerve blocks) may provide a more environmentally sound approach to anesthesia.

Two articles address waste reduction. Mankes demonstrates that anesthesia providers discard large amounts of propofol into the environmental waste stream.[17] The author measured propofol waste in OR bins, then made a simple change in practice. Waste was substantially reduced simply by removing larger propofol bottles from the OR formulary and providing only 20 mL bottles. Although this was a very small study, it suggests a practical general strategy for reducing waste. It further illustrates that monetary and environmental interests can be aligned and both of these savings could be quantified with existing models.

In a special article on low flow anesthesia, Feldman explains how we can implement a cost-effective and environmentally preferable practice as suggested by Sherman et al.'s life cycle assessment and the Sulbaek Andersen et al. analysis.[18] Because inhalation anesthetics are potent greenhouse gases and costly medications, we should use no more than we need. Feldman takes us through the principles underlying lowest flow anesthesia in induction, maintenance, and emergence phases and provides clear recommendations for a safe, efficient practice at each stage. For example, turning off the fresh gas flow during intubation instead of the vaporizer minimizes environmental contamination and prevents loss of time to resume desired anesthetic concentrations within the circuit.

This collection of articles introduces some of the environmental implications of our clinical practice and offers several practical examples. The articles also demonstrate the complexity of environmental analysis. Even a seemingly simple question, such as whether we should use disposable or reusable drapes, is incredibly complex because the production, use, and disposal of health care products is complex. Because the decision must also consider economics, patient safety, and therapeutic efficacy, there will be few easy answers to even simple clinical questions that incorporate environmental sustainability.

Health professionals should promote education, and strategies and policies to lower greenhouse-gas emissions in their own working environment,[3] provided the policies are compatible with patient safety goals. The American Society of Anesthesiologists recently established an Environmental Task Force within their Equipment and Facilities Committee to examine these issues and advocate for more evidence-based inquiry. Further research will include development of economic models that incorporate sustainability and life cycle analysis, innovative collaborations with environmental scientists to understand OR-related environmental impact, and work with public health researchers to understand how the environmental consequences of our practice affect human health.

Anesthesiologists put patients first. That is what responsible doctors do. However, the "patient" is more than the human being under our immediate care. The patient includes the family, the neighbors, the community, the country, and the world. Our patient is all of humanity. Accepting responsibility for environmental stewardship puts patients first.

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REFERENCES

1. Chung JW, Meltzer DO. Estimate of the carbon footprint of the US health care sector. JAMA 2009;302:1970–2
2. Sherman JD, Ryan S. Ecological responsibility in anesthesia practice. Int Anesthesiol Clin 2010;48:139–51
3. Costello A, Maslin M, Montgomery H, Johnson AM, Ekins P. Global health and climate change: moving from denial and catastrophic fatalism to positive action. Philos Transact A Math Phys Engl Sci 2011;369:1866–82
4. Costello A, Abbas M, Allen A, Ball S, Bell S, Bellamy R, Friel S, Groce N, Johnson A, Kett M, Lee M, Levy C, Maslin M, McCoy D, McGuire B, Montgomery H, Napier D, Pagel C, Patel J, de Oliveira JA, Redclift N, Rees H, Rogger D, Scott J, Stephenson J, Twigg J, Wolff J, Patterson C. Managing the health effects of climate change: Lancet and University College London Institute for Global Health Commission. Lancet 2009;373:1693–733
5. McGain F, Story D, Kayak E, Kashima Y, McAlister S. Workplace Sustainability: The "cradle to grave" view of what we do. Anesth Analg 2012;114
6. Hendrickson C, Lave L, Matthews H. Environmental Life Cycle Assessment of Goods and Services: An Input-Output Approach. Resources for the Future Press, Washingon, DC, 2006
7. Connor A, Lillywhite R, Cooke MW. The carbon footprints of home and in-center maintenance hemodialysis in the United Kingdom. Hemodialysis International 2011;15:39–51
8. McGain F. White S, Mossenson S, Kayak E, Story D. A survey of anesthesiolgists' views of operating room recycling. Anesth Analg 2012;114
9. Overcash M. A comparison of reusable and disposable medical textiles: state-of-the-art: 2012. Anesth Analg 2012;114
10. Eckelman M, Mosher M, Gonzalez A, Sherman J. Comparative life cycle assessment of disposable and reusable laryngeal mask airways. Anesth Analg 2012;114
11. McGain F, McAlister S, McGavin A, Story D. A life cycle assessment of reusable and single-use central venous catheter insertion kits. Anesth Analg 2012;114
12. Sulbaek Andersen MP, Nielsen OJ, Wallington TJ, Karpichev B, Sander SP. Assessing the impact on global climate from general anesthetic gases. Anesth Analg 2012;114
13. Ryan SM, Nielsen CJ. Global warming potential of inhaled anesthetics: Application to clinical use. Anesth Analg 2010;111:92–8
14. Sulbaek Andersen M, Sander S, Nielsen O, Wagner D, Sanford T, Wallington T. Inhalation anaesthetics and climate change. Br J Anaesth 2010;105:760–6
15. Sulbaek Andersen MP, Nielsen OJ, Karpichev B, Wallington TJ, Sander SP, Atmospheric Chemistry of Isoflurane, Desflurane, and Sevoflurane: Kinetics and mechanisms of reactions with chlorine atoms and OH radicals and global warming potentials. J Phys Chem A. Epub ahead of print, December 6, 2011
16. Sherman J, Le C, Lamers V, Eckelman M. Life cycle greenhouse gas emissions of anesthetic drugs. Anesth Analg 2012;114
17. Mankes RF. Propofol wastage in anesthesia. Anesth Analg 2012;114:1091–2
18. Feldman JM. Managing fresh gas flow to reduce environmental contamination. Anesth Analg 2012;114:1093–101