NARRATIVE REVIEWS

Ripple Effect: Safety, Cost, and Environmental Concerns of Using Sterile Water in Endoscopy

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The gastroenterology societies are committed to reducing the carbon footprint of endoscopies and hence, reexamining waste-generating practices. One such practice is the recommendation to use sterile water during endoscopy for endoscopy lens cleaning and colon irrigation. We critically reviewed all published medical literature and guidelines on the safety of the type of water used in endoscopy. We calculated the cradle-to-grave carbon footprint of a 1-L sterile water bottle and compared it to published studies on bottled drinking water. Guidelines recommending sterile water during endoscopy are based on limited evidence and mostly expert opinions. Referenced studies utilize care protocols that are not practiced. There is also considerable cross-referencing of review articles and guidelines. Two clinical studies directly comparing tap and sterile water in gastrointestinal endoscopy found tap water to be a safe and practical cost-saving alternative to sterile water. The calculated carbon footprint of bottled sterile water is 575 g CO_2 equivalent. No direct evidence supports the recommendation and widespread use of sterile water during gastrointestinal endoscopy procedures. It contributes to health-care waste and climate change and is costly. We recommend tap water be used to fill sterile water bottles until evidence shows the need for alternative practice. It would be prudent to re-evaluate guidelines and write new ones that consider harm to the environment and society in the provision of care to patients, especially when the intervention may be more harmful than the risk it aims to address.

Keywords: Endoscopy Tap Water; Endoscopy Waste; Carbon Footprint Endoscopy; Sustainability in Endoscopy

Introduction

Water is used in gastrointestinal endoscopy at multiple stages—intraprocedural lens cleaning, mucosal washing of the colon with pump irrigation, water-assisted colonoscopy, and endoscope reprocessing. Two water bottles are used during endoscopy—an air or water bottle and an irrigation water bottle. A tray is also filled with water, which is used for flushing channels using a syringe or for wet gauze to water lubricate the accessories. (Figure 1). With the growing adoption of water-assisted colonoscopy, the overall amount of water utilized in endoscopy is increasing.[1] While tap water was standard before the 1990s, most current guidelines recommend using sterile water for irrigation during endoscopy due to concerns about infection. Sterile water is a hypotonic, sterile liquid produced by distillation and contains no antimicrobial or bacteriostatic additives or included buffers. Sterile water has a lower pH of 5.7 (5.0–7.0) compared to a neutral pH of around 7.5 for tap water. The benefit of using sterile water in a bacteria-filled gastrointestinal lumen is controversial, and a return to using potable tap water has been proposed. After all, tap water is used as drinking water, and it is acceptable and common practice to use tap water enemas to cleanse the colon before sigmoidoscopies. In an older survey from 1997, 34% of the endoscopy units used tap water for the endoscopy.[2] This proportion has likely decreased following the recent multisociety guideline on endoscope reprocessing.[3]

Aside from questions regarding its benefits and reservations regarding cost and possible shortages, the

Abbreviations used in this paper: APIC, Association for Professionals in Infection Control and Epidemiology; BSG, British Society of Gastroenterology; CDC, Centers for Disease Control and Prevention; CO_2, carbon dioxide; ESGE, European Society of Gastrointestinal Endoscopy; GHGs, greenhouse gases; HYGEA, Hygiene in gastroenterology endoscope reprocessing; MNPs, microplastics and nanoplastics; SGNA, Society of Gastroenterology Nurses and Associates.

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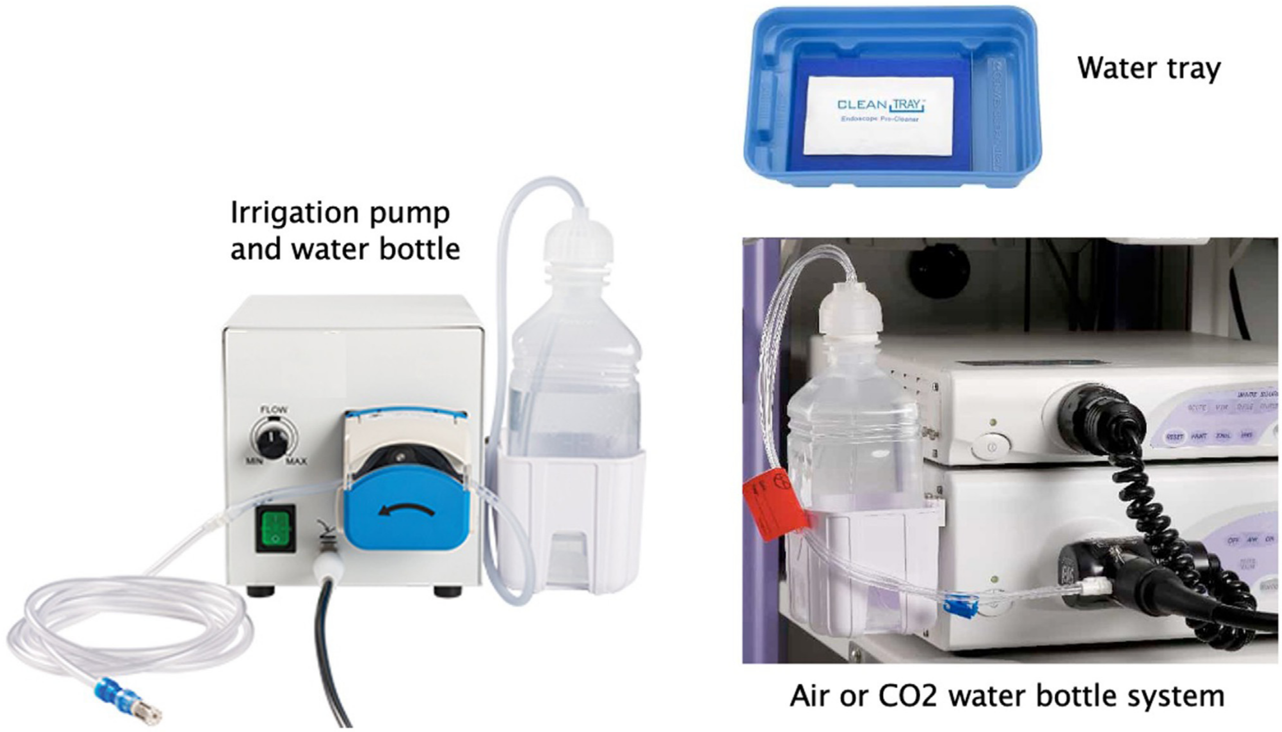

Figure 1. Water bottles and trays used in endoscopy.

environmental impact of using sterile water is a growing concern. The waste of water bottles and the carbon footprint of manufacturing and transporting the bottles to the user is considerable. Realizing that the health-care sector significantly contributes to waste and greenhouse gas (GHG) emissions, the gastroenterology societies in the US and Europe have pledged to reduce their carbon footprint.[4,5] The US Department of Health and Human Services recently invited health-care organizations to sign a voluntary pledge to halve their emissions by 2030.[6] One fundamental way to reduce the carbon footprint of gastroenterology practice is to re-examine the evidence basis and risk/benefit tradeoffs of guideline recommendations regarding resource-intense and waste-generating practices. Indiscriminate use of sterile water in endoscopy is one such practice with a large carbon footprint worth re-evaluating.

Here, we critically review the evidence evaluating the safety of using sterile water in endoscopy and then summarize current guidelines, including the references that inform them. We then discuss the environmental and cost implications of using sterile water and suggest the next steps for a safe, cost-effective, and sustainable practice.

Original Articles on the Use of Sterile Water in Gastrointestinal Endoscopy

We conducted a thorough search of the published medical literature in PubMed from 1975 to 2023 using search terms "Sterile water" and "endoscopy" and "tap water" and "endoscopy." From the 24 articles in English, we identified 2 studies that assessed the risk of contamination or infection from water use during endoscopy. We reviewed all the references listed in these 2 studies and identified 1 more study that fit the criteria. We also examined the multisociety guideline on endoscope reprocessing, including all the cited articles relevant to water use. These 3 studies addressing the type of water used in endoscopy are discussed below.

The first is a prospective US study from 1985, in which the authors evaluated the incidence of bacteremia during and 30 minutes after sclerotherapy of esophageal varices in 11 patients.[7] Five of the 9 patients grew bacteria from blood drawn during the procedure, but all postprocedure cultures were negative. No patient had any clinical findings of infection. The laboratory sink spouts and endoscopic water bottles grew the same bacteria, indicating the sink spouts as the likely source of contamination. In this study, the bottles were not sterilized, the endoscope was cleaned with iodine and 70% alcohol, and the injector needle was reused after soaking in iodine for 15 minutes. To decrease the risk of bacteremia, the authors instituted the following changes—using a sterile water bottle and sterile water and flushing iodine solution for 20 minutes through the water channel of the endoscope. No bacteremia was reported in the remaining 25 sclerotherapy sessions. The results of this study do not apply to present-day general endoscopies due to the focus on variceal sclerotherapy, use of obsolete endoscope reprocessing techniques, reuse of injection needles, different water supply and testing standards, and the use of bottles that were not sterilized.

We identified only 2 clinical studies that directly compared tap and sterile water in gastrointestinal endoscopy (Table 1). In 1 US study from 1996, sterilized water bottles used for cleaning the endoscope lens were refilled each week with

Table 1. Studies Comparing the Use of Tap and Sterile Water in Gastrointestinal Endoscopy

Study author	Title of article	Brief description
Wilcox et al (1996)	Use of sterile compared with tap water in gastrointestinal endoscopic procedures	*Setting*: 3 endoscopy rooms at a university teaching hospital *Methods*: sterilized water bottles filled on a weekly schedule with sterile or tap water. Cultures obtained after one wk *Results*: Six of 24 tap water cultures and 3 of 12 (25%) sterile water cultures were positive. Bacteria were nonpathogenic and not associated with clinical complications *Conclusion*: Use of tap water as compared with sterile water may be practical, as well as provide cost savings
Puterbaugh et al (1997)	Endoscopy water source: Tap or sterile water?	*Setting*: VA hospital *Methods*: Compared clean water bottles and tap water vs steam-sterilized bottles and sterile water. Cultures taken from water in bottles at the beginning and end of the endoscopy day *Results*: Morning samples: 9% Tap water and 4% sterile water grew normal flora. Of the negative morning samples, 18% tap water and 11% sterile water grew normal flora. 3 sterile water samples grew pathogenic bacteria. *Conclusion*: Tap water is perfectly safe for use during routine endoscopic procedures where the water source is monitored and deemed safe for human consumption.

either sterile or tap water over 12 weeks.[8] At the end of each week, bacterial cultures were obtained from the 2 bottles. A total of 437 procedures were performed, including 128 endoscopic retrograde cholangiopancreatographies. Six out of 24 (25%) tap water cultures were positive compared to 3/12 (25%) sterile water cultures. The difference was not statistically significant. Bacteria isolated included *Flavobacterium* sp (n = 5), *Acinetobacter* sp (n = 4), *Pseudomonas* sp (n = 2), and Stenotrophomonas sp (n = 1). No clinical infections or other patient complications were reported after 2–4 weeks of follow-up. The authors concluded tap water was a practical and cost-saving alternative to sterile water.

A second US study published in 1997 compared bacterial contamination of water bottles either cleaned with a bacteriostatic enzymatic detergent and filled with tap water or steam sterilized and filled with sterile water.[2] Cultures were taken from the bottles in the morning and evening before and after the day's procedures were completed. From the morning samples, 7% (8 of 101) of tap water and 4% (4 of 106) of sterile water samples grew bacteria. From the evening samples, 18% of tap water and 11% of sterile water samples grew bacteria. The bacteria isolated mainly were nonpathogenic strains, except for 4 cultures from sterile water, which grew *Pseudomonas aeruginosa* (n = 2), *Klebsiella* (n = 1), and *Staphylococcus aureus* (n = 1), suggesting that "sterile" water can get contaminated from other sources. No clinical infections were identified during the follow-up. The authors concluded that using tap water and clean water bottles for routine endoscopy carries no greater risk than using sterile water and sterile bottles.

Current Guidelines and Evidence

US Multisociety Guideline

The multisociety guideline on reprocessing flexible endoscopes and accessories (2021) has 3 recommendations for using sterile water during endoscopy.[3] The first is to use sterile water for those endoscopic procedures with intended traversal of mucosa (eg, peroral endoscopic myotomy procedures, endoscopic necrosectomy, interventional endoscopic ultrasound). Biopsies or polypectomies are not listed in these examples. The second is to follow the manufacturers' instructions for the type of water to be used in the water bottle. Thirdly, in the absence of a manufacturer recommendation, the endoscopy unit performs an independent risk assessment for the use of sterile vs clean tap water for standard endoscopic procedures (eg, esophagogastroduodenoscopy and colonoscopy) in which mucosal penetration would be unusual/not anticipated.[3] These are listed as strong recommendations with low-quality evidence. The guideline states, "GI manufacturers recommend sterile water should be used for lens cleaning and in some cases, for irrigation," but cites other guidelines and not specific manufacturer recommendations. We could not find any published manufacturer recommendations on the type of water used in endoscopy. The guideline also mentions the 2 clinical studies comparing tap and sterile water (discussed in preceding paragraphs), stating, "There is no increased risk of bacterial growth within water bottles or associated clinical adverse events when either tap or sterile water is used." Additional supporting evidence is discussed below and summarized in Table 2.

Centers for Disease Control and Prevention (CDC) Guidelines for Disinfection and Sterilization in Health-Care Facilities

The Healthcare Infection Control Practices Advisory Committee wrote the guidelines for CDC. Three small retrospective studies reported ear, wound, or pulmonary infections traced to bacteria on taps or hospital water supply.[9–11] In 2 other studies, the authors investigated Legionella infection associated with hospital water.[12,13] The first examined Legionella pneumonia in guinea pigs exposed to aerosols of concentrated potable water from a hospital

Table 2. References in the 2021 US Multisociety Guideline on Reprocessing Flexible Gastrointestinal Endoscopes and Accessories That Are Relevant to Water Use in Endoscopy

US Multisociety guideline recommendation (2021):

1. Use sterile water for those endoscopic procedures with intended traversal of mucosa
2. Follow the manufacturer's instructions for the type of water to be used in the water bottle.
3. In the absence of a manufacturer recommendation, the endoscopy unit performs an independent risk assessment for the use of sterile vs clean tap water for standard endoscopic procedures

Reference in the guideline	Supporting statement in the article	Supporting reference	Study description
CDC (2008)	Sterilize or high-level disinfect the water bottle used to provide intraprocedural flush solution once daily and then fill it with sterile water	Mennhorst (1985)	Investigated *Legionella pneumophilia* in bronchial secretions. Source traced to hot potable hospital water supply.
		Wright (1985)	Investigated growth of mycobacteria in urine and sputum cultures in hospitalized patients. *M xenopi* and *M Kansasii* were recovered from taps in the wards.
		Lowry (1988)	Cases of otitis medical by *M chelonae*, which were isolated from water source. Otologic instruments were cleaned in an ultrasonic bath with tap water and a liquid detergent; the bath was cleaned once weekly
		Lowry (1991)	Survey study on use of tap water during ear examinations and disinfection practices of otologic instruments
		Mitchell (1997)	Investigated outbreak of *Legionella pneumophila* contaminating bronchoalveolar lavage specimens and traced the source to contaminated tap water used to rinse disinfected bronchoscopes
		Wallace (1998)	Review on how municipal and hospital water supplies can act as reservoirs for nontuberculous mycobacteria. Most studies from 1960s to the 1970s and not following current infection prevention recommendations
		Atlas (1999)	Review on nosocomial *Legionella pneumophilia* infection and role of biofilms
		APIC (2000)	Guideline paper on infection control in endoscopy
		Nelson (2003)	Review article that discusses all published studies to date on the transmission of infection during endoscopy. For sterile water, it mentions the study by Brayko et al (1985)
SGNA (2020)	Sterile water must be used in water bottles and irrigation systems for endoscopic procedures	ESGE (2008)	ESGE guideline: cleaning and disinfection in endoscopy
		Kovaleva (2013)	Review of transmission of infection in endoscopy and the impact of biofilm on endoscope reprocessing. Just mentions sterile water should be used to fill water bottle with no reference
		Dickey (2014)	Review of water-borne pathogen risks, particularly prevention and control of *Legionella* contamination of water distribution systems
		Loveday (2014)	Systematic review of association between health-care water systems and *Pseudomonas Aeruginosa*
		Kanamori (2016)	Review of health-care outbreaks with water reservoir
		Multisociety (2017)	Sterile water should be used to fill water bottle.

Table 2. Continued

Reference in the guideline	Supporting statement in the article	Supporting reference	Study description
APIC (2000)	Sterile water should be used to fill the bottle for endoscopic irrigation	Axon (1974)	Compared the efficacy of ethyl alcohol and glutaraldehyde to disinfect fiberoptic endoscopes when soaked for 10 min.
		Lindstaedt (1978)	Compared endoscope disinfection after glutardialdehyde and polyvidone-iodine. After disinfection with polyvidone-iodine, *P. aeruginosa* was grown from channels of the endoscope. The source was ultimately traced to a contaminated water tap.
AORN (2018)	Sterile water should be used to fill water and irrigation bottles	APIC (2000) CDC (2008) ESGE (2008) American Association of Gastrointestinal Endoscopy (2011) SGNA (2011)	Details Included in this table separately
		Kovaleva (2013)	An overview of the infections and cross-contaminations related to endoscopy and bronchoscopy and the impact of biofilm on endoscope reprocessing. Mentions use sterile water during endoscopy (no reference)
ESGE (2008) ESGE (2018)	The water bottles should be filled with sterile water and changed after each endoscopy session.	Bader (2002)	Evaluated the quality of endoscope reprocessing by microbiological testing at hospitals and private practices. Found bacterial contamination due to use of contaminated final rinsing water and incomplete drying of the endoscope. Study did not evaluate type of water for irrigation.
BSG (2000)	Water bottles should be filled with fresh sterile water immediately prior to use.	No reference given	

AORN, The Association of Perioperative Registered Nurses; BSG, British Society of Gastroenterology.

with nosocomial Legionnaires' disease.[12] The second investigated the presence of *Legionella pneumophila* in bronchoalveolar lavage specimens and traced the source to contaminated tap water used to rinse disinfected bronchoscopes.[13] The Healthcare Infection Control Practices Advisory Committee guidance also references 2 review articles from 1998 and 1999. Atlas et al. reviewed sporadic outbreaks of nosocomial legionellosis and opined on the importance of biofilms in eliminating these infections.[14] Wallace reviewed nosocomial outbreaks and pseudo-outbreaks caused by the nontuberculous mycobacteria and how municipal and hospital water supplies can act as reservoirs for these infections.[15] None of these references address the question of the safety of tap water in irrigation bottles during endoscopy.

The Association for Professionals in Infection Control and Epidemiology (APIC) Guideline

The APIC guideline on infection prevention in endoscopy (2000) references 2 distant articles on the disinfection of endoscopes from 1974 and 1978, which evaluated endoscope reprocessing techniques of practice at that time and did not evaluate the use of sterile water during endoscopy.[16,17] One study compared the efficacy of ethyl alcohol and glutaraldehyde to disinfect fiberoptic endoscopes when soaked for 10 minutes.[16] The second study compared microbiological cultures obtained from endoscopes after disinfection with polyvidone-iodine after each endoscopy vs more detailed glutardialdehyde disinfection performed only after multiple endoscopies.[17] After disinfection with polyvidone-iodine (but not after glutardialdehyde), *P. aeruginosa* was grown from endoscope channels, water bottles, and connection tubes. The source was ultimately traced to a contaminated water tap. Unlike the methods used in these studies, the updated endoscope reprocessing protocols use high-level disinfection with attention to the complete drying of endoscopes.

The European Society for Gastrointestinal Endoscopy (ESGE) Guideline

The 2008 and 2018 ESGE guidelines[18,19] on endoscope reprocessing reference the HYGEA (Hygiene in gastroenterology—endoscope reprocessing) study, which prospectively evaluated the quality of endoscope reprocessing at 25 endoscopy units and 30 private practices.[20] The study aimed to assess the quality of endoscope reprocessing by determining the bacterial load on the endoscopes and using the results to improve endoscope reprocessing. The study did not evaluate the type of water for irrigation during endoscopies.

The Society of Gastroenterology Nurses and Associated (SGNA) Position Statement

The 2018 and 2020 SGNA position statements on water and irrigation bottles cite the 2017 multisociety[21] and 2008 ESGE guidelines.[18] The other referenced studies are not related to water type in endoscopy or current practice. For example, a study on reusing baths with 2% alkaline glutaraldehyde for 14 days to decontaminate endoscopes between patients or a review on wound infections from mycobacteria in water. The SGNA guidelines, in turn, are cited by the current multisociety guideline.

The Association of Perioperative Registered Nurses Guideline

The 2017 Association of Perioperative Registered Nurses guideline on perioperative practice cites the APIC, CDC, American Association of Gastrointestinal Endoscopy, and SGNA guidelines, one review on the impact of biofilm on endoscope reprocessing, and the 2 trials comparing tap water and sterile water discussed above. The guideline concludes, "the collective evidence conflicts regarding the need for sterile water in the water and irrigation bottles, and further research is warranted." However, they still consider the evidence "strong" to support the recommendation that "sterile water should be used to fill water and irrigation bottles".[22]

Among all guidelines, the main argument for using sterile water during endoscopic procedures is related to the concern for water-borne infections in hospitals. Water-borne pathogens, especially those associated with biofilms such as *Legionella*, nontuberculous mycobacterium, and *Pseudomonas*, are ubiquitous in the water supplies (water tanks, pipes, sinks, faucets, heater–cooler units, showerheads, etc.) of hospital and home but rarely cause disease.[8] This is true even for immunocompromised patients, for whom infection from aerosolization rather than water ingestion is the primary concern. Despite the lack of evidence, the multisociety guideline recommends the use of sterile water in irrigation bottles for immunosuppressed patients undergoing endoscopic procedures,[3] referring to 2 studies that suggest installing disposable sterile point-of-use filters for faucets and shower heads to eradicate water-borne pathogens in the tap water, but that did not address the use of sterile water in endoscopy. The new (2022) Joint Commission water management standards for hospitals acknowledge the complexity of water systems and the risk of infections.[23] The new standards require an individual or team to oversee and implement the water management program in addition to risk assessment and testing protocols. Implementation of these standards should further ease the concerns about using tap water.

In summary, guidelines recommending sterile water during endoscopy are based on limited evidence and mostly expert opinions. Referenced studies utilize care protocols that are no longer in line with current practice, and many are not directly related to gastrointestinal endoscopy. There is also considerable cross-referencing of review articles and guidelines. The references used in different guidelines are summarized in Table 2.

Environmental and Health Effects

Multiple studies have shown that climate change affects human health, although accurately calculating the scale and impact of many climate-sensitive health risks remains challenging. The World Health Organization estimates that between 2030 and 2050, climate change will cause 250,000 additional deaths per year from undernutrition, malaria, diarrhea, and heat stress alone.[24] The direct damage costs to health are estimated to be between US$ 2 and 4 billion annually by 2030.[24] The health-care activities in the US contribute roughly 8.5% to this crisis; thus, every action to mitigate the carbon footprint is helpful and necessary.

A plastic sterile water bottle creates more waste than a plastic bottle that can be refilled with tap water. The sterile plastic bottles are mostly made of polyethylene, polypropylene, or polyolefins (copolymers of ethylene and propylene) derived from fossil fuels and emit GHGs at every stage of their lifecycle (Figure 2). There have been many studies on the environmental impact of disposable bottled drinking water, but none on sterile water bottles in health care. The carbon footprint of disposable bottled water for drinking has been estimated to be 100 g–500 g of CO_2,[25–28] which is considered wasteful. Manufacturing a typical single-use bottle requires 3–6 liters of water.[29] *One study* estimated that bottled water production is up to 2000 times more energy intensive than tap water.[30] The carbon footprint of sterile water bottles is much greater than that of disposable drinking water plastic bottles; since sterile water bottles are made of heavier plastic, the water must undergo extra sterilization steps, and the bottles are rarely recycled.[31,32]

To augment this review, we conducted a life cycle analysis of a 1-L water bottle filled with sterile water (as used in endoscopy) to understand the cradle-to-grave environmental impact of using sterile water during endoscopy and helping endoscopists make informed decisions about their practices. The material composition data and manufacturing site were obtained from the company. We assumed an average transport distance of 932 miles in a lorry and landfill disposal. The resultant carbon footprint of a 1 L sterile water bottle was 575 g CO_2 equivalent. Transport of sterile water bottles accounted for 61%, while materials and manufacturing accounted for 37% of the total emissions.

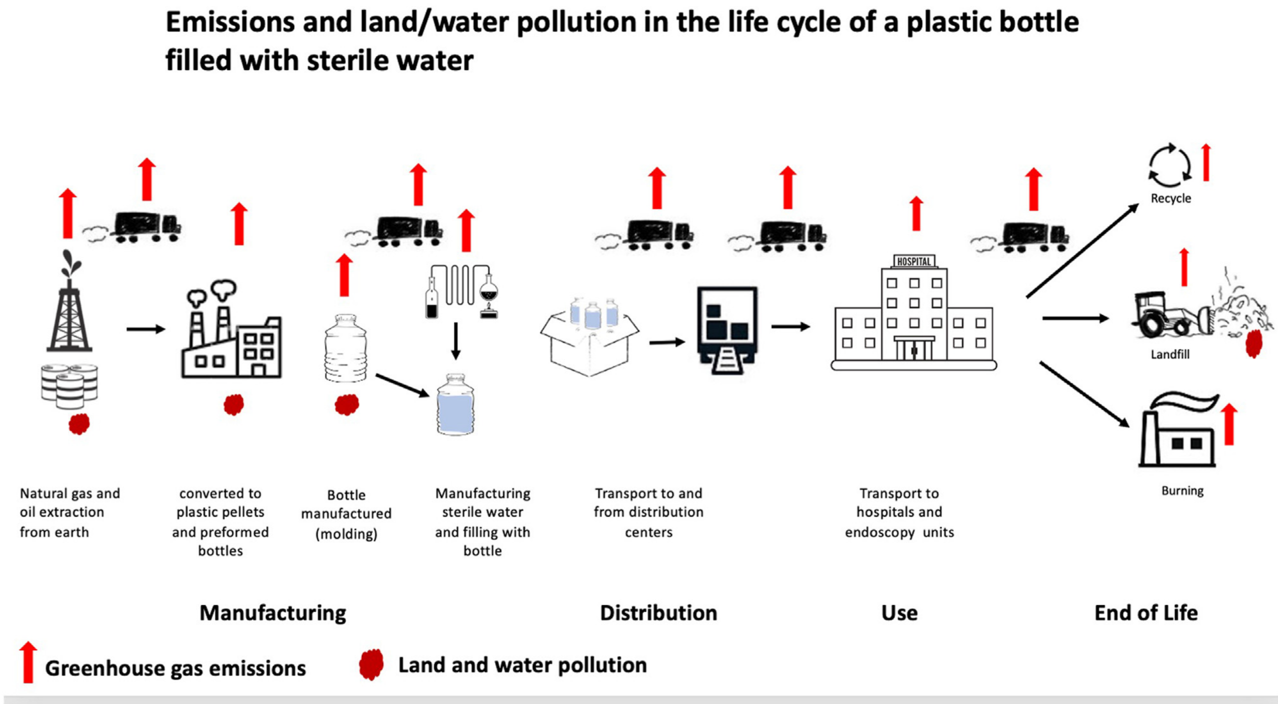

Figure 2. GHGs during the life cycle of a water bottle with sterile water.

Environmental pollution causes insidious, inexorable, and irreversible harm to the population's health.[33] In landfills, plastic bottles take hundreds of years to decompose, and even then, they do not disappear; they just breakdown into smaller particles, microplastics, and nanoplatics (MNPs), which are ubiquitous in all environments and can enter the human body through ingestion, inhalation, or skin contact.[34] As the plastic eventually decomposes, it emits potent GHGs such as methane and ethylene. Beyond GHGs, plastics often include hazardous additives such as plasticizers, ultraviolet stabilizers, dyes, and flame retardants, which cause soil, air, and water contamination.[33]

Water stored in plastic bottles may also directly pose health risks. In a recent study, Qian et al. showed that, on average, a liter of bottled drinking water contains 240,000 MNPs.[35] Research on the health effects of MNPs is still evolving.[36] In a recent prospective study, MNPs were detected in the atheromas of patients undergoing endarterectomy, and these patients had a higher risk of myocardial infarction, stroke, and death compared to patients who did not have MNPs.[37] Higher concentrations of MNPs have been found in the feces of patients with inflammatory bowel disease compared to healthy people, suggesting a positive correlation between MNPs and the severity of inflammatory bowel disease.[38] Further, bottles made from polyvinyl chloride contain phthalates, which are classified as endocrine-disrupting materials and are implicated in endocrine, neurological, and reproductive disorders.[39,40] Thus, to prevent an unproven risk to patients, we may be causing inadvertent, irreversible harm to individual patients and the population.

With a conservative estimate of using half of a 1-L sterile bottle for irrigation per endoscopy, 22 million yearly endoscopies in the US could result in an additional 6000 tons of eCO_2.[41,42] Based on the mortality cost of carbon—defined as the number of expected temperature-related excess deaths globally from 2020 to 2100 caused by 1 additional ton of CO_2 equivalent emissions in 2020—emissions from bottled sterile water could lead to 4 excess deaths.[43] In comparison, no mortality has been reported from using tap water for irrigation.

While more people will be sick due to the direct and indirect effects of plastic, the health-care system's capacity to take care of them will be lower. It is projected that without efforts to decrease carbon emissions, 1 in 12 hospitals, or almost 16,000 hospitals, would be at risk of shutting down due to extreme weather events by the end of the century.[44] Unless incinerated or recycled, every plastic bottle ever made likely still exists somewhere on this planet, affecting many generations' health.

Costs of Using Sterile Water

Sterile water is also an expense for the endoscopy unit and the hospital. A 1-L bottle of sterile water costs $3–$10. For an endoscopy unit performing 30 procedures daily and a conservative estimate of half a water bottle per case, the average monthly direct costs could be $1000–$3000. If endoscopy units practice changing bottles after every procedure, their costs would be much higher. There are additional costs of stocking and disposal. These figures suggest that the US health-care system could save tens of millions annually by switching from sterile water to tap water for routine endoscopies. There are additional costs from environmental pollution borne by society. Rennet et al.

estimated the societal cost of carbon to be $185 per ton of CO_2, which translates to more than half a million dollars.

Discussion

There is no direct supporting evidence for using sterile water during endoscopy. The few original studies referenced in the guidelines are irrelevant to the current practice and do not conclude that sterile water is necessary. The multisociety guideline acknowledges the lack of evidence but, in the final recommendation, adopts a seemingly conservative stance of using sterile water when mucosal penetration is anticipated and urges endoscopy units to make an independent assessment in other situations. These recommendations are mainly expert opinions. The ambiguity of recommendations results in most endoscopy units using sterile water for all their procedures with concerns for safety or compliance with rules.

The recommendations for sterile water contradict observations in other medical care scenarios, for example, for the irrigation of open wounds. Randomized controlled trials[45,46] and Cochrane review[47] show no difference in infection risk when using tap or sterile water to irrigate wounds. In a prospective trial, tap water was safe and cost-effective compared with sterile water for low-flow oxygen humidification. Notably, wounds and lungs have a higher propensity for infection compared to the gastrointestinal tract. More specific to gastroenterology include studies that show no benefit of neutropenic diets, which omit fresh fruits and vegetables and tap water, for immunosuppressed patients.[48] Similarly, there is no benefit in using sterile water for enteral feeds in immunosuppressed patients,[49] and tap water enemas are routinely acceptable for colon cleansing before sigmoidoscopies in all patients, irrespective of immune status.

Notably, in November 2023, the U.S. Food and Drug Administration issued a recall of sterile water for irrigation manufactured by Nurse Assist, LLC, and sold under 13 brands, including some of the most widely used brands, since the products may not be sterile. Therefore, intending to use sterile water without gaining the theoretical benefits may cause much harm.

The urgency of addressing climate change and decreasing waste and the carbon footprint of endoscopy, acknowledged by gastroenterology societies, mandates that we cannot afford to ignore the environmental consequences of our actions. In this scenario, the evidence of harm prevention from sterile water is limited. In contrast, the evidence of environmental, social, and economic harm from using sterile water in plastic bottles is clear. The endoscopy units also have compelling financial benefits from using tap water instead of sterile water.

Recommendation

Based on the lack of evidence for using sterile water and the ambiguous recommendations that permit tap water, we suggest the following practice.

1. Start the first procedure of the day with a new sterile plastic water bottle. Alternatively, use a reusable bottle that is commercially available and reprocessed per the manufacturer's guidance.
2. When empty, fill it with tap water.
3. Empty the sterile water bottle at the end of the day and recycle it, if possible. Many sterile water bottles (if not all) are made of Polypropylene, which is recyclable (number "5" as its resin identification code).

Refilling water bottles should be performed using clean hands while taking care not to contaminate the irrigation tube connected to the cap. The bottle can be carried over to the faucet for filling, or another bottle filled with tap water can be used to fill it, as is common practice with new sterile water bottles. *Emptied plastic water bottles, if recyclable, should be recycled. Endoscopy units that adopt these practices should be encouraged to report their results to assist in formulating better evidence-based guidelines in the future.*

The hospitals need to ensure that the tap water at their institutions meets quality standards, such as the new 2022 Joint Commission water management standards for hospitals.[23] This standard requires that, in addition to risk assessment and testing protocols, an individual or a team be responsible for overseeing and implementing the new detailed water management plan.

Conclusion

No direct evidence supports the widespread use of sterile water during gastrointestinal endoscopy procedures. It contributes to health-care waste and climate change and is costly. Given the potential for harm to the environment and human health and the stated goal of all gastroenterology societies to decrease the environmental impact of our practice, tap water should be used to fill sterile water bottles until evidence shows the need for alternative practice. It would be prudent to re-evaluate guidelines and write new ones that consider harm to the environment and society in the provision of care to patients, especially when the intervention may be more harmful than the risk it aims to address.

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Deepak Agrawal contributed to conceiving and designing the paper, collected data, critically reviewed the article, and wrote the paper. Seth Crockett contributed to critically reviewing the article and wrote the paper. Sonali Palchaudhuri contributed to critically reviewing the article and wrote the paper. Lyndon Hernandez contributed to critically reviewing the article and wrote the paper. Kevin Skole contributed to critically reviewing the article and wrote the paper. Rahul Shimpi contributed to critically reviewing the article and wrote the paper. Jim Collins contributed to critically reviewing the article and manuscript revision. Daniel Von Renteln contributed to critically reviewing the article and manuscript revision. Heiko Pohl contributed to conceiving and designing the paper, collected data, critically reviewed the article, and wrote the paper.

Conflicts of Interest:
These authors disclose the following: Seth D. Crockett has clinical trial agreements with Guardant, Exact Sciences, and Freenome. Lyndon V. Hernandez owns stock options in Iterative Health and Liquiglide. Heiko Pohl receives research support from Steris and Cosmo; advisory board for Inter-Venn. The remaining authors disclose no conflicts.

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