



Quality Improvement Training in Closed System Technique Significantly Reduces OR Staff Exposure to Waste Anesthetic Gases

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Abstract

Introduction:

Exposure to waste anesthetic gases (WAGs) remains a significant occupational hazard for operating room (OR) personnel, despite longstanding ASA recommendations. Establishing causality is difficult due to confounding factors, yet hepatic and hematologic abnormalities have been repeatedly documented in exposed staff. The need for updated oversight is clear, as OSHA has not revised anesthetic gas exposure standards since 1977.

Benchmark data:

Chronic WAG exposure is associated with increased lymphocytes, granulocytes, ALT, AST, ALP, and elevated plasma fluoride and hexafluoroisopropanol, along with reduced hemoglobin, RBCs, hematocrit, platelets, and monocytes; animal studies mirror these findings. Environmental assessments also reveal elevated sevoflurane levels in anesthesia work areas and frequent exceedance of exposure limits, particularly with odorless desflurane (which has been discontinued).

Description of Intervention:

Our intervention addressed these hazards by reinforcing closed-system anesthesia techniques and implementing annual hazard-awareness training each August, emphasizing health risks, scavenging equipment, and protocol adherence through didactic and hands-on sessions.

Post-Intervention Results:

Alignment with national recommendations is supported by NIOSH data calling for regular equipment maintenance, monitoring, retraining, and exposure surveillance, and further updates to OSHA standards could substantially reduce WAG exposure and improve OR safety.

Personnel affected

Role	Exposure Source	Documented Health Risks
Anesthesia Staff	Anesthesia delivery, airway	DNA/genotoxicity, liver/hematologic changes, immunotoxicity, oxidative stress [11]
Surgeons	Near airway during surgery	Oxidative stress, DNA damage, reproductive hazards [12]
Nurses/Scrub Technicians	Patient care, equipment	DNA/genotoxicity, hepatic/hematologic changes, reproductive risks [13]
Support Staff	Cleaning, turnover	Oxidative stress, immunotoxicity [14]

Table 1. Exposed sources on OR staff and their documented health risks

Hazards

Chronic exposure to WAGs in the operating room is associated with increased risks of reproductive toxicity, neurotoxicity, DNA/genetic damage, and adverse organ effects.

Reproductive health:

Meta-analyses and systematic reviews show specifically nitrous oxide and halogenated agents, are linked to higher rates of spontaneous abortion and congenital anomalies among exposed female healthcare workers, with a risk ratio for spontaneous abortion of 1.9 in operating room nurses [1]. Chronic exposure also correlates with lower sex hormone levels in both male and female staff, suggesting impaired reproductive function.

Neurotoxicity:

WAGs can cause dose-dependent central nervous system effects, including decreased cognitive function and dexterity [2].

Genotoxicity and DNA damage:

Significantly associated with increased DNA damage and genetic instability in operating room personnel [3].

Organ effects:

Chronic WAG exposure may impair cardiac, pulmonary, liver, and kidney function, with studies reporting altered hematopoietic parameters and changes in cardiac electrophysiology [4].

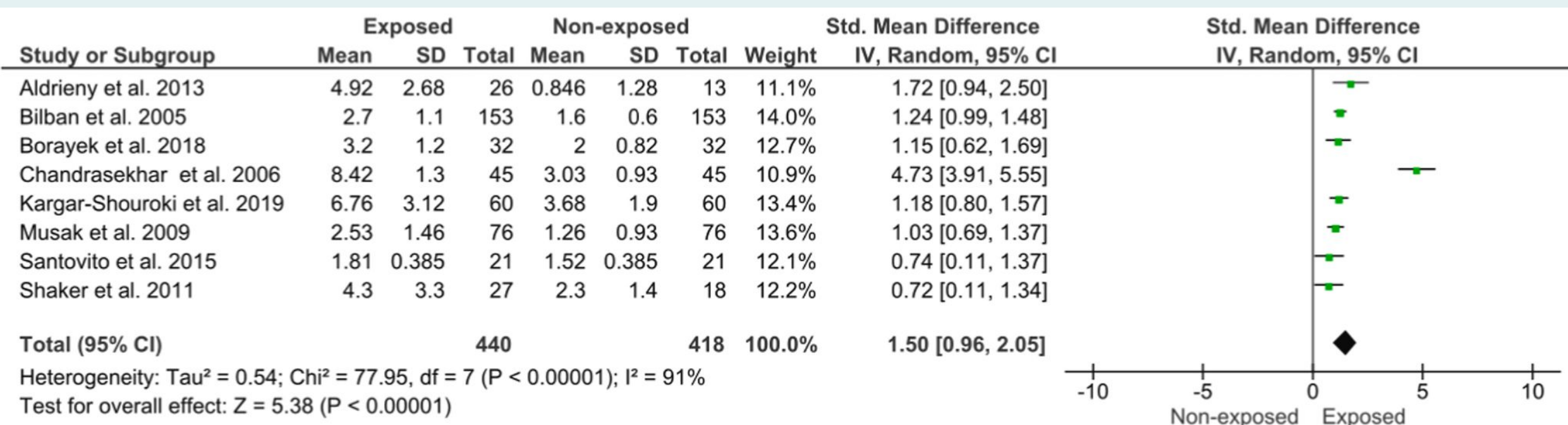


Fig.1 Total Chromosomal Aberrations per 100 Metaphase Cells in WAG-Exposed Staff [7]

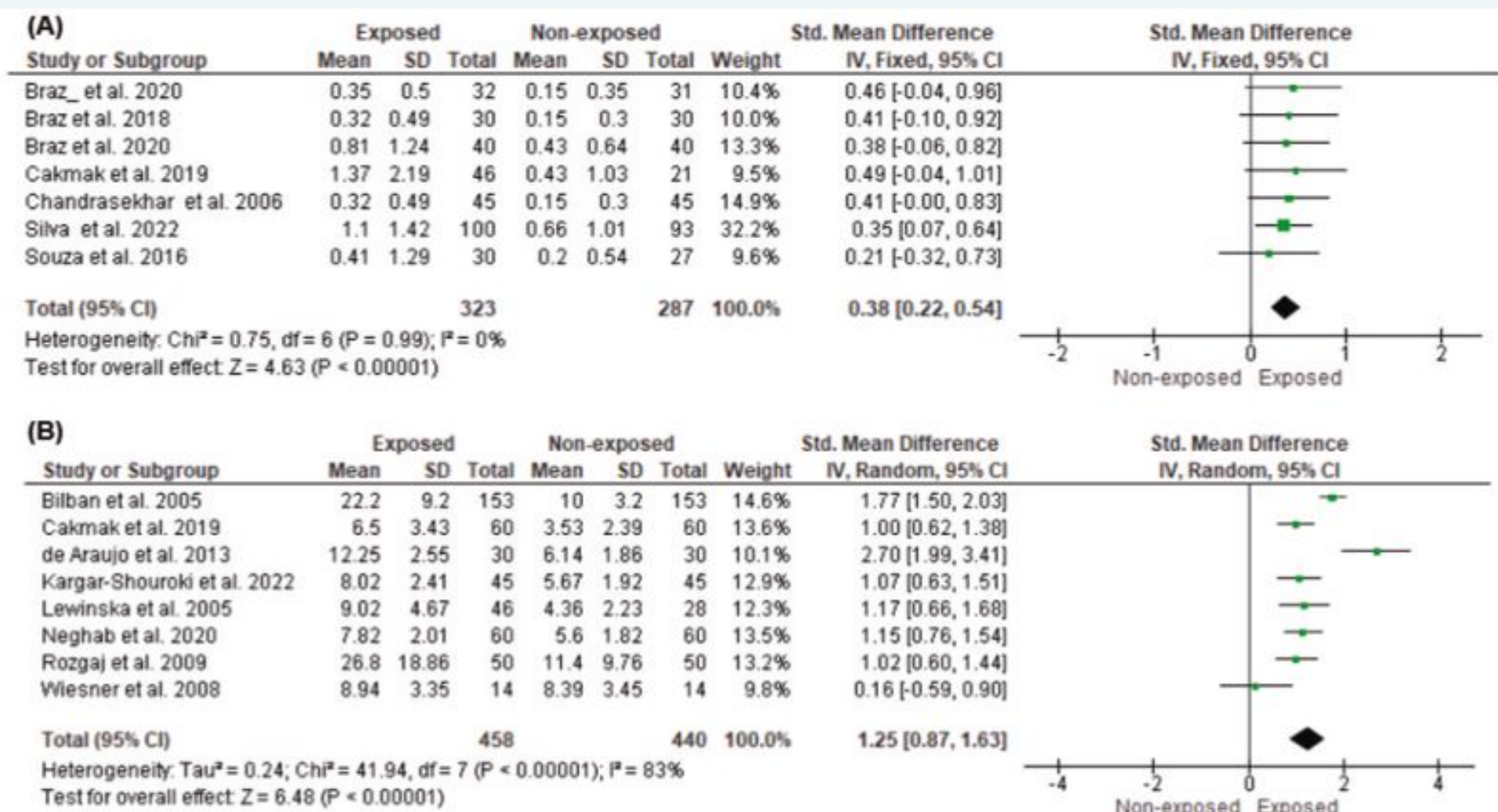


Fig.1 Effect of WAGs exposure to (A) Micronuclei (buccal), (B) Micronuclei (lymphocyte). Data was presented per 1000 cells [7]

Reinforcing the Closed Circuit Technique

Closed-circuit anesthesia represents an evidence-based, resource-conserving practice that aligns with quality and sustainability goals in perioperative care. In this technique, exhaled gases are recirculated after CO₂ removal, while fresh-gas flow (FGF) is reduced to approximate the patient's metabolic oxygen consumption (≈200–250 mL/min). This minimizes anesthetic gas waste, reduces operating room emissions, and lowers cost without compromising patient safety or anesthetic depth.

Our QI project emphasizes optimizing anesthetic delivery through precise monitoring, system integrity checks, and reeducation on closed-circuit management. The workflow begins with a wash-in phase (FGF 4–6 L/min) to denitrogenate the circuit and achieve target anesthetic and O₂ concentrations. Once stable, the circuit is closed, and flow is reduced to metabolic O₂ demand plus agent uptake. Continuous monitoring of O₂, CO₂, anesthetic concentration, pressures, and volume ensures physiologic stability and early detection of leaks or CO₂ absorber exhaustion.

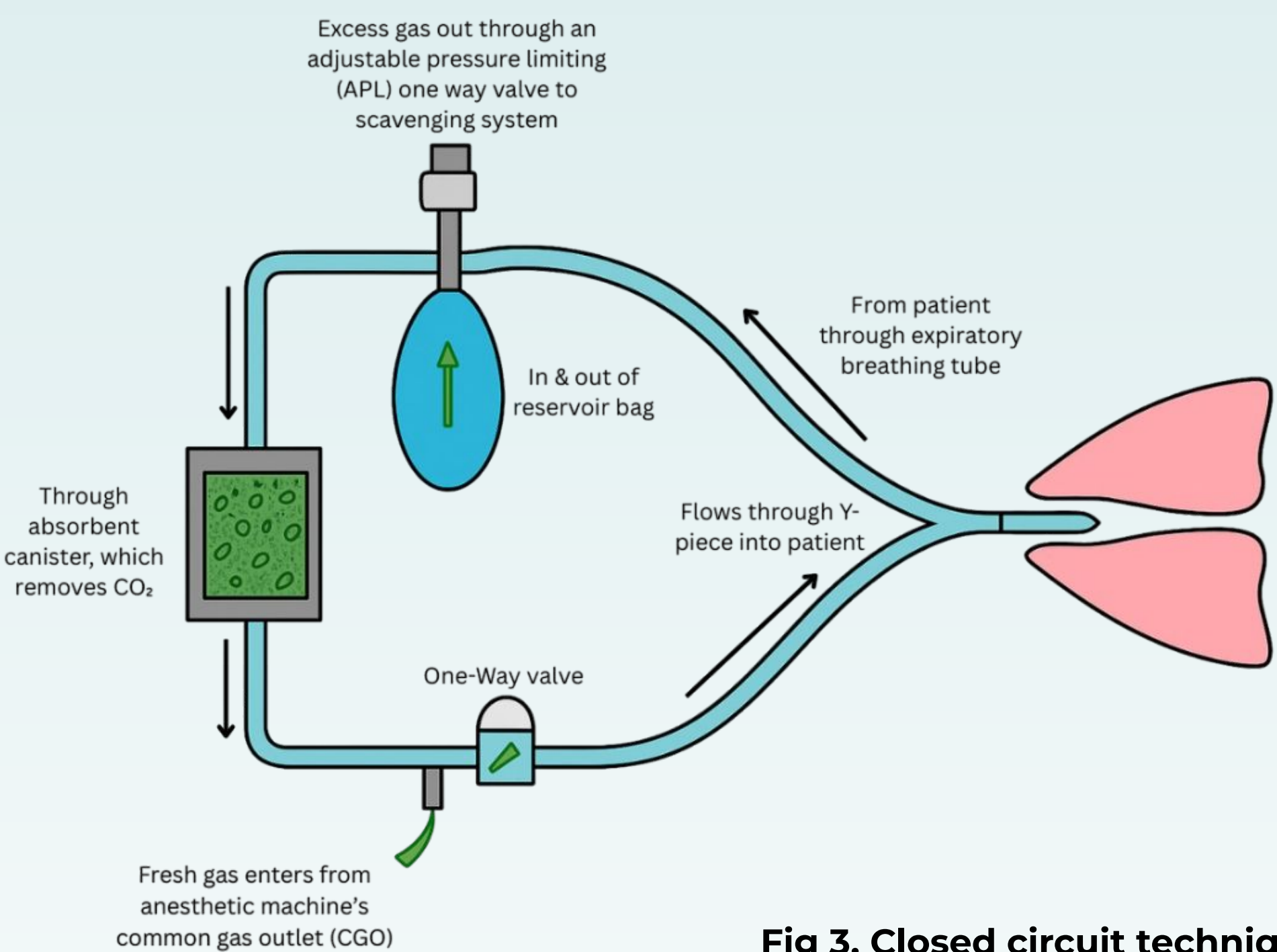


Fig 3. Closed circuit technique

Each component of the circle system plays a role in quality and safety:

- Unidirectional valves & CO₂ absorber – ensure effective rebreathing without CO₂ retention.
- Reservoir bag/ventilator bellows – accommodate tidal volume and compliance changes.
- Analyzers & leak testing – prevent hypoxia and anesthetic under-delivery.

Implementation of closed-circuit anesthesia supports the Triple Aim, improving patient outcomes, reducing costs, and minimizing environmental impact. Educational reinforcement, equipment standardization, and outcome tracking serve as measurable QI metrics.

Conclusion

WAGs remain a significant occupational health risk for operating room personnel, with evidence linking chronic exposure to DNA damage, oxidative stress, and adverse reproductive outcomes [1, 3, 12]. Interventions such as closed system training, annual hazard awareness retraining, and implementation of OSHA protocols are effective in reducing WAG exposure and associated health risks, but optimal protection requires consistent application and institutional commitment. Regular environmental monitoring, prompt equipment maintenance, and comprehensive education are critical components of a successful WAG management program. There is a need for updated occupational exposure standards and improved adherence to safety protocols to ensure the health and safety of all operating room personnel. Future efforts should focus on enhancing surveillance and advocating for evidence-based revisions to regulatory guidelines.



Fig 4. Closing the Loop: How Training Reduces OR Staff Exposure

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