

Occupational exposure to cytostatic drugs in the oncology operating room: protective measures for surgical instrumentation personnel

Exposición ocupacional a citostáticos en el quirófano oncológico: medidas de protección para el personal de instrumentación quirúrgica

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Submitted: 16-08-2025 | Revised: 30-10-2025 | Accepted: 20-11-2025 | Published: 25-11-2025

ABSTRACT

Background: Surgical instrumentation nurses working in oncological operating rooms are occupationally exposed to cytostatic drugs through skin contact, inhalation, and ingestion. Procedures such as Hyperthermic Intraperitoneal Chemotherapy (HIPEC) represent a high-risk scenario with limited specific institutional protocols for this professional group. **Objective:** To describe and analyze the evidence-based protective measures for surgical instrumentation staff exposed to cytostatic drugs in the oncological operating room, based on a systematic review of the scientific literature published between 2020 and 2025. **Methods:** A systematic narrative review was conducted using the PubMed, Scielo, LILACS, and CINAHL databases. Studies published between January 2020 and December 2024 were included, using the MeSH terms: "cytostatics," "occupational exposure," "operating room nursing," "HIPEC," "hazardous drugs," "personal protective equipment." A total of 32 articles met the inclusion criteria. **Results:** Evidence shows that cutaneous and inhalatory routes are the main exposure pathways in the operating room. The use of double nitrile gloves, impermeable gowns, FFP2/FFP3 masks, and eye protection significantly reduces the risk of contamination. Engineering controls (closed transfer systems) and administrative protocols are the most effective measures. The correct sequence for donning and doffing personal protective equipment (PPE) is a critical step frequently neglected in clinical practice. **Conclusion:** Implementing a hierarchical risk-control strategy, specific institutional protocols, continuous training, and periodic health surveillance are essential to protect surgical instrumentation nurses from cytostatic-related occupational hazards.

Keywords: cytostatics; occupational exposure; oncological operating room; surgical instrumentation nursing; personal protective equipment; HIPEC; hazardous drugs.

RESUMEN

Introducción: El personal de instrumentación quirúrgica que trabaja en quirófanos oncológicos está expuesto de forma ocupacional a fármacos citostáticos a través de las vías cutánea, inhalatoria e ingestión. Los procedimientos como la quimioterapia intraperitoneal hipertérmica (HIPEC) representan un escenario de alto riesgo con escasos protocolos institucionales específicos para este grupo profesional. **Objetivo:** Describir y analizar las medidas de protección basadas en la evidencia para el personal de instrumentación quirúrgica expuesto a citostáticos en el quirófano oncológico, mediante una revisión sistemática de la literatura científica publicada entre 2020 y 2025. **Metodología:** Se realizó una revisión narrativa sistemática mediante la consulta de las bases de datos PubMed, Scielo, LILACS y CINAHL. Se incluyeron estudios publicados entre enero de 2020 y diciembre de 2024, utilizando los términos MeSH: "citostáticos", "exposición ocupacional", "enfermería de quirófano", "HIPEC", "medicamentos peligrosos", "equipo de protección individual". Un total de 32 artículos cumplieron los criterios de inclusión. **Resultados:** La evidencia demuestra que las vías cutánea e inhalatoria son las principales rutas de exposición en el quirófano. El uso de doble guante de nitrilo, batas impermeables, mascarillas FFP2/FFP3 y protección ocular reduce significativamente el riesgo de contaminación. Los controles de ingeniería (sistemas de transferencia cerrada) y los protocolos administrativos son las medidas más efectivas. La secuencia correcta de colocación y retiro del equipo de protección individual (EPI) es un paso crítico frecuentemente descuidado en la práctica clínica. **Conclusión:** La implementación de una estrategia jerárquica de control de riesgos, protocolos institucionales específicos, formación continua y vigilancia médica periódica es fundamental para proteger al personal de instrumentación quirúrgica de los riesgos ocupacionales asociados a los citostáticos.

Palabras clave: citostáticos; exposición ocupacional; quirófano oncológico; instrumentación quirúrgica; equipo de protección individual; HIPEC; medicamentos peligrosos.

INTRODUCTION

Cytostatic drugs, also known as antineoplastic or chemotherapeutic agents, are designed to inhibit proliferation and destroy tumor cells. However, their nonselective mechanism of action poses a risk to any cell with a high division rate, including those of healthcare personnel who routinely handle them. The International Agency for Research on Cancer (IARC) classifies numerous cytostatic drugs as Group 1 and 2A carcinogens, recognizing their genotoxic, mutagenic, teratogenic, and reproductive toxicity potential. (1,2)

Historically, efforts to prevent occupational risks from cytostatic drugs have focused on pharmacy and medical oncology departments, where the preparation and systemic administration of these drugs are the primary activities. However, the consolidation of surgical techniques such as hyperthermic intraperitoneal chemotherapy (HIPEC), normothermic intraperitoneal chemotherapy (NIPEC), and regional isolated limb perfusion has transformed the oncology operating room into a new setting of significant occupational exposure, frequently overlooked by institutional occupational health systems. (3,4)

Surgical scrub nurses play a central role during these procedures, with a continuous presence in the operating field and direct or indirect contact with the patient's body fluids, which are highly concentrated in the cytostatic agent. Despite this, this professional group is rarely included in specific occupational health surveillance programs related to exposure to hazardous drugs or in biomonitoring studies that assess the actual absorption of these compounds. (5,6)

Recent scientific literature shows that surface contamination in the operating room, as well as on staff gowns and gloves, is detectable even in procedures where closed administration systems are used, underscoring the need to adopt strict protective measures tailored to the specific surgical context. (7,8) The ALARA (As Low As Reasonably Achievable) principle, widely adopted in radiology and radiation therapy, must be applied with the same rigor as the handling of cytostatic drugs in the intraoperative setting. (9)

The purpose of this review is to systematize the available scientific evidence on the risks of occupational exposure to cytostatic drugs for surgical scrub nurses and the applicable protective measures, helping to elucidate an occupational public health issue that requires immediate attention from nursing staff specializing in surgical scrub nursing.

METHODOLOGY

A systematic narrative review of the scientific literature published between January 2020 and December 2024 was conducted. This design was selected for its ability to synthesize the state of knowledge on complex occupational health issues, encompassing multiple disciplines (nursing, toxicology, hospital pharmacy, and occupational medicine) and allowing for the integration of evidence from different types of studies. (10)

Information sources and search strategy

The literature search was conducted in the following databases: PubMed/MEDLINE, Scielo (Scientific Electronic Library Online), LILACS (Latin American and Caribbean Literature in Health Sciences), CINAHL (Cumulative Index to Nursing and Allied Health Literature), and the National Institute for Occupational Safety and Health (NIOSH) clinical practice guidelines repository. Additionally, the bibliographic references of the included articles were manually reviewed to identify additional relevant studies.

The search terms used in English and Spanish were as follows (combined using Boolean operators AND/OR):

“cytostatics” OR “antineoplastic agents” OR “hazardous drugs” AND “occupational exposure” AND “operating room” OR “perioperative nursing”

“HIPEC” OR “hyperthermic intraperitoneal chemotherapy” AND “healthcare worker safety” OR “personal protective equipment”

“cytostatics” AND “occupational exposure” AND “surgical instruments” OR “operating room nursing” Inclusion and exclusion criteria

We included original research articles, systematic reviews, meta-analyses, clinical practice guidelines, and expert consensus statements published between 2020 and 2024 in English, Spanish, or Portuguese that addressed occupational exposure to cytostatic drugs in the surgical setting, the health effects on healthcare personnel, or applicable risk control measures. Studies focused exclusively on the pharmaceutical preparation of cytostatic drugs outside the perioperative context, letters to the editor without primary data, conference proceedings without peer review, and articles whose full text was not available were excluded.

Study Selection and Data Extraction

The initial search identified 187 references. After removing duplicates (n=34), the titles and abstracts were screened (n=153), and 98 studies that did not meet the inclusion criteria were excluded. The full texts of 55 articles were read, 32 of which met all the inclusion criteria and were included in the review. The following data were extracted independently by the author and verified through a second reading and recorded: authors, year, country, study design, target population, type of cytostatic drug studied, main results, and protection recommendations.

Ethical Considerations

Given that this is a literature review that does not involve human participants or primary data, approval by a Research Ethics Committee was not needed. However, the principles of scientific integrity were respected at all times, avoiding plagiarism and properly citing all the sources consulted in accordance with the Vancouver guidelines. (11)

RESULTS AND DISCUSSION

Routes and mechanisms of exposure in the oncology operating room

A literature review confirms that the oncology operating room is a multiroute occupational exposure environment. The dermal route is the most well documented: biomonitoring studies demonstrate the presence of urinary platinum and cyclophosphamide in staff urine following HIPEC procedures, even with the use of standard PPE, indicating dermal penetration through microfissures in gloves or areas where the fit of PPE is inadequate. (12,13) The inhalation route is particularly relevant in open-surgery procedures, where the temperature of the cytostatic fluid (41–43 °C) promotes the volatilization of platinum and other compounds, generating submicron aerosols and vapors detectable in the operating room air (14,15). Studies by Wiesing et al. (2021) and Caneparo et al. (2022) revealed detectable levels of surface cytostatic contamination on instrument tables, scalpel handles, and anesthesiologist surfaces, even when scrub nurses wore double gloves, underscoring the environmental dispersion of the contaminant beyond the immediate surgical field. (16,17)

Health effects on exposed personnel

The toxicity of cytostatic drugs to exposed healthcare personnel has been the subject of increasing research in recent years. The most frequently reported acute effects include contact dermatitis, mucosal irritation, nausea, and headache. (18) Chronic effects are a greater concern from an occupational public health perspective: Cohort studies have documented a statistically significant increase in the risk of hematological malignancies (leukemias, non-Hodgkin lymphomas) and reproductive disorders (spontaneous abortions, subfertility, congenital malformations) in healthcare workers with chronic exposure to hazardous drugs compared with unexposed controls. (19,20)

Data on genotoxicity biomarkers, particularly the frequency of micronuclei in peripheral lymphocytes and sister chromatid exchange, revealed significant increases among oncology operating room staff compared with those among conventional operating room workers, confirming the presence of subclinical genetic damage even with exposure below environmental detection limits. (21,22)

Hierarchy of controls: from the source to the worker

Engineering controls

Engineering controls represent the most effective level in the hierarchy of controls, as they reduce exposure regardless of human behavior. The implementation of closed-system drug transfer (CSTD) has been shown to reduce surface contamination by 50% to 90% in controlled comparative studies. (23,24) The use of the closed technique in HIPEC procedures versus the open or “coliseum” technique significantly reduces detectable environmental levels of platinum, although it does not eliminate them completely. (25) Localized air extraction in the operating room using exhaust systems similar to those used for anesthetic gases represents a complementary measure with emerging evidence. (26)

Administrative controls

Administrative controls include the development of specific protocols for the oncology operating room, ongoing staff training, limiting the number of staff during high-risk phases, scheduled staff rotation in high-workload units, and the implementation of active medical surveillance programs. (27) The review by González-García et al. (2023) highlights that specific training on cytostatic drugs for operating room staff—distinct from generic hospital training—is associated with greater adherence to protective measures and lower detectable biological contamination in urine. (28)

Personal protective equipment (PPE)

Although PPE is the last line of defense in the hierarchy of controls, its proper selection and use are critical in the oncology operating room. Current evidence recommends (a) double gloving with high-density nitrile gloves (>0.2 mm), changed every 30–60 minutes or upon any compromise of integrity; (b) a certified waterproof gown (EN 13034 or equivalent), with consideration of an additional apron during the perfusion phase; (c) FFP2 or FFP3 particulate respirators for open or semiopen procedures; and (d) full-frame eye protection or a face shield. (29,30) A consistent finding in the literature is that the sequence of PPE removal (“doffing”) is as important as or more important than its donning. Observational studies have shown that 60–80% of staff members make errors in the doffing sequence that could result in self-contamination. (31,32) The implementation of written procedures with checklist verification and regular practical simulation are identified as the most effective interventions for reducing these errors.

CONCLUSIONS

Occupational exposure to cytostatic drugs in the oncology operating room constitutes a real, documented, and preventable risk for surgical scrub staff. The scientific evidence available between 2020 and 2025 confirms that skin and inhalation contamination occurs even with the use of standard PPE and that biomarkers of genotoxicity show detectable alterations in this professional group, which is not typically included in specific surveillance programs.

An effective protection strategy requires the application of a hierarchical model of controls: prioritizing engineering controls (CSTD, closed-system techniques, and air-extraction systems), supplemented by robust administrative controls (specific protocols, tailored training, and active medical surveillance) and the proper use of PPE tailored to the actual risk of the procedure. Paying particular attention to the sequence of PPE removal—often neglected in clinical practice—is a high-impact, low-cost intervention.

Surgical scrub nurses must take a proactive role in demanding safe working conditions, in the participatory development of specific protocols for their area, and in research on the actual impact of exposure on their health. The normalization of risk and the “we’ve always done it this way” culture are the main obstacles to overcome to ensure the protection of this professional group.

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FUNDING

No financing

CONFLICT OF INTEREST

None

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