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Review

Exposure to anesthetic gases among operating room personnel and risk of genotoxicity: A systematic review of the human biomonitoring studies☆

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Abstract

Background and objective: Anesthetic gases have been used for a long time. Adverse effects of anesthetic gases to occupationally exposed people have been well documented in the literature. Due to low solubility, these gases are rapidly eliminated from the human body. Nevertheless, neurotoxic, immunosuppressive, hepatotoxic and reproductive toxicological effects have been shown in many of the scientific works. However, there is no detailed systematic bio-monitoring review about genotoxicity risk among occupationally exposed people. We herein performed systematic review based on relevant studies.

Methods: This work reviews the published literature about the genotoxic effects of anesthetic gases among operating room personnel published between 1989 and September 2015. We performed a computerized search of articles on Pubmed, Scopus, Web of Science, and Google Scholar.

Results: Analyzed works have shown us that chromosomal aberration, sister chromatid exchanges, micronucleus and comet assays were the most frequently used genotoxicity end-points. In almost all data, occupational exposure to anesthetic gases has been associated with statistically significant increase in genotoxic damage among operating room personnel.

Conclusion: Health care workers are exposed to wide variety of agents including biological, physical and chemical factors. Among them anesthetic gases seems to be deserve special attentions since their genotoxic, mutagenic activities. In addition, chronic exposure to all anesthetic gases instead of alone induces cumulative genotoxic effects.

1. Background

Anesthetic gases have been used for a long time. The first anesthetic agent is nitrous oxide and used since 1844. Subsequently diethyl ether and formaldehyde were approved for most surgical procedures. A major shift occurred in the

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1950s with the discovery of the modern inhaled anesthetics, that is, anesthetics halogenated partly or solely with fluorine. The first successful modern inhaled anesthetic, halothane, rapidly displaced all previous inhaled anesthetics except nitrous oxide [1]. Later, new inhaled anesthetics isoflurane, enflurane, desflurane, and sevoflurane have come into use.

Adverse effects of anesthetic gases to occupationally exposed people have been well documented in the literature. Due to low solubility, these gases are rapidly eliminated from the human body [2]. Nevertheless, neurotoxic, immunosuppressive, hepatotoxic and reproductive toxicological effects have been shown in many of the scientific works [3-7]. Anesthetic gases related hepatic and renal dysfunctions are generally reported in most data. Especially intermediate metabolites of these gases are responsible for such effects. Anesthetics enhance the risk of infection through depression of phagocytosis, probably by rendering neutrophils less deformable and hence less able to undergo transvascular diapedesis. Furthermore reduced fertility, spontaneous abortus, congenital anomalies, degeneration of sperm quality has been also suggested by several authors [8-10]. In 1991, Yagiela [11] conducted a comprehensive review of the literature and looked at occupational exposure to nitrous oxide and its potential health consequences. Yagiela's [11] review cited epidemiologic studies that showed reproductive effects including increased risks of spontaneous abortion, premature births, and infertility in individuals in exposed situations. Saurel-Cubizolles et al [12] showed that female nurses working in operating rooms at 17 hospitals in Paris, France had a significant higher rate of spontaneous abortion. Pour-Jafari et al [13] investigated the pregnancies of spouses of all male workers and also pregnancies of female workers of operating rooms in hospitals in Hamadan, Iran. Frequency of fetal deaths in spouse of the male workers were about the same value in general population in Hamadan, but frequency of the fetal deaths in female workers were statistically different from the same value in the general population of Hamadan. Öztin Öğün et al [14] investigated the long-term harmful effects of chronic exposure to anesthetic waste gases on the operating room personnel. They carried out an investigation using a detailed and descriptive questionnaire on the population consisting of 65 anesthetists, 49 surgeons and 42 physicians. In the group of anesthetists and surgeons they noted many illnesses, especially viral diseases. Smith [15] reports short-term and long-term effects related to waste anesthetic gases exposure. Immediate inhalation effects commonly experienced by workers include fatigue, dizziness and lethargy; when the exposure is removed these symptoms dissipate. Chronic long-term effects show a relationship with the gas concentration (measured in parts per million) and duration of exposure.

Several human bio-monitoring studies have suggested that there is strong relationship between exposure to anesthetic gases and risk of genotoxicity among operating room personnel since they spend considerable time in the operation room. But these topics have remained controversial, and there has been no bio-monitoring review about this topic. Genotoxicity tests are very important tools in human populations to estimate genetic risk caused by their work place conditions. Although a number of biomarkers are available to assess transient and permanent genotoxic responses [16], chromosomal aberrations, sister chromatid exchanges, micronuclei and comet assays are often used in human bio-monitoring studies. Especially chromosomal aberrations, micronuclei in peripheral blood and exfoliated buccal cells and comet assays are reliable marker to detect potential DNA damage and cancer susceptibility. In the current study, we performed a systematic review of bio-monitoring works to examine the anesthetic gases associated genetic damage among health-care workers.

2. Material and methods

This work reviews the published literature about the genotoxic effects of anesthetic gases among operating room personnel.

2.1. Inclusion and exclusion criteria

This systematic review included all cytogenetic biomonitoring studies investigating the genotoxic effects of anesthetic gases in view of chromosomal aberrations, sister chromatid exchanges, micronucleus and comet assays. The results were restricted to articles written in English. We excluded in vitro/in vivo results in cell cultures and in animal models.

2.2. Information sources

Owing to the medical nature of the question, the search was confined to Pubmed, Scopus, Web of Science, and Google Scholar. Over 300 abstracts published from 1989 to September 2015 including studies in bio-monitoring, animals, humans and in vitro were found. After a careful screening process of both authors, 17 of these articles were considered as appropriate, and reviewed. The search terms included combination of anesthesia, anesthetic gases, operating room personnel, genotoxicity, genotoxic effects, genetic effects, DNA damage, bio-monitoring, chromosomal aberrations, sister chromatid exchanges, micronuclei, comet.

3. Results

Lamberti et al [17] evaluated the sister chromatid exchanges and chromosomal aberration frequencies in peripheral bloods of 45 hospital workers: 15 exposed to anesthetic gases, 15 exposed to both anesthetic gases and ionizing radiations and 15 controls. Significant increase was observed in chromosomal aberration assays while sister chromatid exchanges did not highlight significant differences. Authors have also reported that there was a positive correlation for chromosome