Cross-sectional Study

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Evaluation of biochemical parameters in operating room staff exposed to radiation and anesthetic gases

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Background: Exposure to ionizing radiations and other hazardous agents such as anesthetic gases pose serious risks to the health of healthcare workers. This study aimed to evaluate the changes in blood and biochemical parameters of the operating room staff exposed to ionizing radiations and remnants of anesthetic gas.

Methods: This cross-sectional study was performed at (Ayatollah Taleghani Hospital). The control group was selected from different parts of the hospital that were not exposed to ionizing radiations and anesthetics, including the office, services, and treatment. The case group included all operating room personnel. Hematopoietic parameters such as complete blood count and WBC differential, and parameters of liver function such as serum activity of liver enzymes (ALT, AST, ALP, LDH) and serum bilirubin levels, fasting blood sugar, serum lipid profile, level of vitamin D and magnesium were measured for the exposed and referent subjects. Additionally, a checklist was used to gather data regarding the occupational variables and medical histories of the studied subjects.

Results: The mean values of Hb, Hct, Vitamin D, and MCHC, as well as the RBC count, were significantly lower in the exposed individuals than in the referent subjects. In contrast, the proportion of smokers was significantly higher in the exposed group than in the referent group. No significant differences were noted between exposed and unexposed groups as far as other parameters were concerned. However, no significant differences were noted between the case and control groups as far as other measured parameters were concerned. Likewise, no significant differences were noted between exposed and referent groups as far as blood types, history of underlying diseases, work history, working hours per month, number of morning and evening shift hours, type of diet, consumption of a high-fat diet a day before blood sampling, X-ray in the recent year, history of radiotherapy, and therapeutic agents use was concerned.

Conclusions: Exposure of operating room staff to ionizing radiations and waste anesthetics gases is associated with subtle, subclinical prepathologic decreases in some hematopoietic parameters such as hemoglobin, hematocrit and MCHC levels, RBC count as well as vitamin D levels.

Keywords: anesthetic gas, biochemical parameters, hemoglobin, operating room, vitamin D

Introduction

Healthcare workers, as people in charge of caring for patients, are among the most at-risk groups in terms of occupational diseases and their risks[1,2]. Studies on the prevalence of occupational hazards in healthcare workers (especially operating room staff) have reported different results[3]. The occupational hazards include biological hazards from exposure to infectious agents, chemical and physical hazards, safety and ergonomic hazards, and psychosocial and organizational hazards[4,5].

HIGHLIGHTS

- Healthcare workers, as people in charge of caring for patients, are among the most at-risk.
- Exposure to radiation and other harmful agents such as anesthetic gases.
- Impose serious occupational hazard among healthcare worker.
- Exposure of operating room staff to radiation and anesthetics can compromise some liver and hematopoietic biochemical parameters.

Among them, the riskiest has been exposure to biological pathogens and infections. According to the results of several studies, a high percentage of medical staff have been exposed to this type of risk. Ionizing radiations and waste anesthetic gases are two of the most important occupational hazards that threaten the health of operating room personnel[7]. With the increased use of X-rays and gamma rays for various therapeutic and diagnostic purposes, potential health hazards have risen concerns[8]. The effect of ionizing radiation on increasing the risk of cancer as well as its other destructive effects on other organs of the body has

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been proven[9–11]. The main source of ionizing radiations for irradiators and other personnel is scattered or secondary ionizing radiations left over from the primary ionizing radiations[12]. Radiographic and fluoroscopic examinations are the main sources of ionizing radiation for medical staff and operating room staff due to scattered ionizing radiations[13]. The use of ionizing radiation (fluoroscopy and radiography) during surgery is an integral part of these tests[14]. It can be said that the use of fluoroscopic and radiological equipment during surgery can also affect operating room staff[15,16]. Since most staff in the operating room do not use film badge dosimeters, accurate information on the dose received is not available. This can lead to increased cumulative radiation exposure[17].

Another danger that threatens operating room staff is exposure to inhaled anesthetic gases. Anesthetic gases are a major source of air pollution in hospitals[18]. Many harmful effects such as poisoning, infertility, carcinogenicity, and genetic, kidney, liver, and respiratory complications have been reported in this aspect[19,20]. Frequent exposure to environments contaminated with these gases leads to cell damage, increased cell proliferation, hyperplasia, and ultimately tumor growth[21]. Studies have shown that inhaling more than 10 ppm of nitric oxide and more than 15 ppm of halothane and enluran can impair the functioning of the nervous system[22,23].

Very few studies have focused on early biochemical alteration in response to exposure to gas anesthesia and ionizing radiation exposure in the operation room. Considering the importance of operating room staff health and studies showing the effect of ionizing radiations and anesthetic gases on operating room personnel, this study aimed to investigate whether occupational exposure to waste anesthetic gases and ionizing radiations by operating room staff under normal working conditions is associated with any significant changes among operating room staff.

Methods

This cross-sectional study was conducted at (Ayatollah Taleghani Hospital) from January 2020 to December 2020. In this study, the control group was selected from different departments of the hospital that were not exposed to ionizing radiations and anesthetics, including the office, services, and treatment (nurses). The case group was all operating room personnel.

The information was obtained using a checklist-based questionnaire. Based on previous studies[24], the sample size in this study was 61 people (30 operating room staff and 31 people from different departments of the hospital who are not exposed to ionizing radiations and anesthetics). The inclusion criteria were having 5 years of work experience, having at least 6 h of daily work in the operating room (for operating room staff). Exclusion criteria were based on personnel with underlying problems that disrupted the test results, including liver problems, anemia, and a variety of allergies, and those who did not consent to participate in the study.

The studied variables included demographic characteristics (age, sex, education, and work experience), underlying diseases, biochemical factors (WBC, Hb, Ht, Platelets, RBC, MCV, MCH, MCHC, RDW, neutrophil, lymphocyte, monocyte, eosinophil), and liver factors (Vit D, FBS, total cholesterol, triglyceride, SGOT, SGPT ALP, total bilirubin, direct bilirubin, LDH, Mg, GGT).

Data were analyzed by SPSS-22 (IMB) software. Quantitative variables were reported as mean with SD or median (quartile range) and qualitative variables were reported as number (percentage). An independent sample *t*-test or its nonparametric equivalent Mann–Whitney *U* or ANOVA test was used to compare quantitative variables between the two groups according to their normality status (depending on the result of the Shapiro–Wilk test of normality). The χ^2test was also used to compare qualitative variables. The significance level in all cases was considered less than 0.05.

The study was approved by the board of the ethical committee of Kermanshah University of Medical Sciences.

The work has been reported in line with the STROCSS criteria[25].

Results

In this study, 31 staff members of the operating room (as a case group) and 30 staff members from different parts of the hospital who are not exposed to ionizing radiations and anesthetics, including office, services, and treatment (as a control group) who met the inclusion criteria entered the study.

Descriptive characteristics and comparisons of age, sex, weight, height, level of education, and employment status of personnel in case and control groups are summarized in Table 1. The two groups were significantly different only in terms of smoking, $P = 0.032$. There was a significant difference between the workplace, job, and the number of staff night shift hours in the case and control groups ($P < 0.05$). There was no significant difference between the use of personnel protective equipment in the case and control groups ($P < 0.05$).

There was no significant difference between regular exercise, exercise time during the week, exercise 4 days before blood sampling, and exercise time during the day in the case and control groups ($P < 0.05$).

The χ^2test was used to compare the history of underlying diseases of personnel in the case and control groups. Descriptive characteristics and comparisons of the history of underlying disease groups are summarized in Table 2. There was no significant difference between the underlying disease history among the two groups ($P < 0.05$).

The χ^2-test was used to compare diet status, history of radiotherapy, and medication use in the case and control groups. Descriptive characteristics and comparison of diet status, history of radiotherapy, and medication use of personnel are summarized in Table 3. There was no significant difference between the type of diet, consumption of high-fat foods the day before blood sampling, imaging in a recent year, history of radiotherapy, and therapeutic agents used in the case and control groups ($P < 0.05$).

To compare the hematological parameter among the two groups, independent t, and Mann–Whitney tests were used. Descriptive characteristics and comparison of hematological factors are summarized in Table 3. The hemoglobin, MCHC, and hematocrit levels were significantly different in the two groups, $P = 0.006$, $P = 0.002$, and $P = 0.02$, respectively. Other parameters were not significantly different in the two groups, $P > 0.05$.

To compare the liver function test among the two groups, independent t, and *U* Mann–Whitney tests were used, as reported in Table 4. There is no significant difference between other liver and biochemical parameters among the two groups, $P > 0.05$.

Table 1

Descriptive characteristics and comparison of age, sex, weight, height, level of education and employment status of personnel in case and control groups

	Group		
Characteristics	Control	Case	P
Age (year)			
Mean ± SD	39.2 ± 8.37	40 ± 8.97	0.72
Sex, n (%)			
Female	19 (63.3)	14 (45.2)	0.202
Male	11 (36.7)	17 (54.8)	
Weight (kg)			
Mean ± SD	69.66 ± 14.2	75.08 ± 12.58	0.063
Height (cm)			
Mean ± SD	167.4 ± 10.31	169.32 ± 9	0.441
Level of education, n (%)			
Diploma >	1 (3.3)	4 (13.3)	0.202
Diploma	7 (23.3)	3 (10)	
Associate degree	0 (0)	4 (13.3)	
Bachelor's degree	20 (66.7)	18 (60)	
Master	2 (6.7)	0 (0)	
PhD	0 (0)	1(3.3)	
Employment workplace, n (%)			
Surgery room	0 (0)	31 (100)	< 0.001
Intensive care	27 (90)	0 (0)	
Other	3 (10)	0 (0)	
Work experience (year)			
Mean ± SD	15 ± 7.1	17.48 ± 8.92	0.241
Job, n (%)			
General surgeon	0 (0)	1 (3.3)	< 0.001
Surgical technologist	0 (0)	5 (16.7)	
Anesthesia technician	0 (0)	8 (26.7)	
Nurse	21 (70)	5 (16.7)	
Official	2 (6.7)	2 (6.7)	
Other	7 (23.3)	9 (30)	
Working hours per month			
Mean ± SD	53.8 ± 206.1	236.03 ± 81.32	0.071
Smoking, n (%)			
No	26 (86.6)	31 (100)	0.032
Yes	4 (13.3)	0 (0)	
Cigarettes smoked per day, n (%)			
No	25 (86.6)	31 (100)	1
3 cigarrete butts	3 (10)	0 (0)	
7 cigarrete butts	1 (3.3)	0 (0)	
Hookah consumption, n (%)			
No	30 (100)	30 (96.8)	0.329
Yes	0 (0)	1 (3.2)	
Alcohol consumption, n (%)			
No	30 (100)	30 (96.8)	0.329
Yes	0 (0)	1 (3.2)	
Drink alcohol one week before blood sampling, n (%)			
No	30 (100)	30 (96.8)	0.329
Yes	0 (0)	1 (3.2)	

Similarly, TSH, T3, and T4 were also not significantly different among the two groups, $P > 0.05$(Table 5). The results showed that the amount of vitamin D in the case group was significantly lower than in the control, $P = 0.01$.

Discussion

In this study, we observed significant differences in certain blood and biochemical parameters between the case group (operating room staff exposed to ionizing radiations and anesthetic gases) and the control group (nonexposed individuals). Specifically, the case group showed lower levels of hemoglobin, hematocrit, red blood cells, MCHC, and vitamin D compared to the control group. However, no significant differences were found for other biochemical parameters and various demographic and lifestyle factors between the two groups.

In the case and control groups, there were no significant differences between blood groups, history of underlying diseases (including liver, heart, kidney, etc.), work history, working hours per month, number of morning shift hours, number of evening shift hours, type of diet, consumption of high-fat foods during the day before blood sampling, imaging in a recent year, history of radiotherapy, therapeutic agents use, use of personnel protective equipment, number of cigarettes smoked per day, hookah usage, alcohol consumption, and alcohol consumption one week before blood sampling.

The exposure of healthcare workers, especially operating room staff, to ionizing radiations and anesthetic gases is a subject of concern due to potential health risks[8–10]. The amount of ionizing radiation received by staff during radiographic examinations depends on several factors, including the duration of radiography, the distance from the ionizing radiation source, and the use of protective equipment. It has also been shown that the amount of ionizing radiation received by patients and staff depends to a large extent on the skill of the physician and the extent to which he uses radiographic and fluoroscopic tests[26]. The level of excess anesthetic gases in the ambient air, even in modern operating rooms, can exceed some permissible limits. This means that operating room staff are constantly in contact with the remnants of anesthetic gas concentrations, and this is a matter of concern due to the chronic and persistent exposure to small amounts of these anesthetics and their adverse health effects. The scientific community recommends measures such as the existence of a cleaning system, an efficient ventilation system, checking the operating cycles of the ventilation system, using modern anesthesia machines with less leakage probability, continuous control of the remaining concentration of anesthetic vapors and staff training can greatly minimize contact these anesthetics[27].

In Imani[28] study, they found that there is a direct and positive relationship between the concentration of nitrous oxide gas in the operating room space and the amount of cortisol in employees. In the study by Casale *et al.*, it was found that hepatic blood markers were statistically significantly different in operating room staff exposed to anesthetic gases compared to the control, neutrophil count decreased significantly, and lymphocytes increased. The prevalence of out-of-range values for GPT, GGT, total, lymphocytes, and neutrophils was statistically significant compared among the two groups. The results show that exposure of staff and personnel to anesthetic gases caused by anesthetic agents can alter some liver and hematopoietic biochemical parameters[29].

In the study of Akhavan Akbari *et al.*, it was reported that the mean of ALT and AST enzymes in the operating room was significantly higher than in personnel who do not work in the operating rooms. However, mean GGT, ALP, and bilirubin were not significantly different between the two groups. Meanwhile, the levels of ALT, AST, and GGT enzymes increased significantly with the increasing age of operating room staff and greater work experience[30].

Table 2

Descriptive characteristics and comparison of the history of underlying diseases of personnel in case and control groups

Characteristics	Group Control, *n* (%)	Case, *n* (%)	*P*
Liver disease			
No	30 (100)	30 (96.8)	0.321
Yes	0 (0)	1 (3.2)	
Pancreatic disease			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Gallbladder disease			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Myocardial infarction			
No	30 (100)	30 (96.8)	0.321
Yes	0 (0)	1 (3.2)	
Other heart disease			
No	29 (96.7)	30 (96.8)	0.981
Yes	1 (3.3)	1 (3.2)	
Thyroid disease			
No	29 (96.7)	31 (100)	0.305
Yes	1 (3.3)	0 (0)	
Kidney disease			
No	29 (96.7)	27 (87.1)	0.173
Yes	1 (3.3)	4 (12.9)	
Lung disease			
No	29 (96.7)	31 (100)	0.305
Yes	1 (3.3)	0 (0)	
Rheumatoid and autoimmune diseases			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Gastrointestinal disease			
No	28 (93.3)	29 (93.5)	0.973
Yes	2 (6.7)	2 (6.5)	
Anemia			
No	26 (86.7)	30 (96.8)	0.153
Yes	1 (3.3)	0 (0)	
Iron deficiency	3 (10)	0 (0)	
Thalassemia	0 (0)	1 (3.2)	
Pregnancy			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Recent surgery			
No	27 (90)	27 (87.1)	0.722
Yes	3 (10)	4 (12.9)	
Splenectomy			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Blood transition			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Severe bleeding in the last 2 months			
No	29 (96.7)	31 (100)	0.305
Yes	1 (3.3)	0 (0)	
Infectious diseases			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Flu			
No	28 (93.3)	31 (100)	0.144
Yes	2 (6.7)	0 (0)	
Pneumonia			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
HIV			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Hepatitis			
No	30 (100)	31 (100)	1
Yes	0 (0)	0 (0)	
Allergy			
No	25 (83.3)	30 (96.8)	0.104
Yes	5 (16.7)	1 (3.2)	

Regarding ionizing radiation exposure, different studies have shown varying results. Some reported no significant difference in radiation dose between surgeons and operating room staff in spinal surgeries[31]. However, others indicated that the radiation dose received by operating room staff remains below the annual dose limit recommended by international radiation protection organizations. The dose received by anesthesiologists and operating room staff was estimated to be lesser than the annual dose limit recommended by international radiation protection organizations. However, the use of radiation recording equipment to be aware of excess radiation seems necessary[32].

Optimizing radiation techniques and using protective measures play a crucial role in minimizing personnel exposure to radiation. In a review study by Azimi *et al.*, it was reported that the effect of radiation on increasing the risk of cancer could be associated with chromosomal damage and genetic mutations due to DNA damage. Radiation damage is one of the most fundamental causes of gene mutation. Methods to minimize personnel exposure to radiation have been obtained, which include the maximum distance from the radiation source, the use of appropriate protectors, control, and division of staff. In addition, optimization of fluorescence settings and techniques can be used

Table 3

Descriptive characteristics and comparison of biochemical factors of personnel in case and control groups

Characteristics	Group Case mean ± SD	Control mean ± SD	*P*
WBC (10^3/μl)	6415 ± 1263.21	6570.64 ± 1809.58	0.699
Hb (g/dl)	13.25 ± 1.3	14.45 ± 1.87	0.006
Ht (%)	40.09 ± 3.17	42.21 ± 3.71	0.02
Platelets (10^3/μl)	235.03 ± 38.56	232.77 ± 56.79	0.649
RBC (10^6/μl)	4.72 ± 0.46	5.01 ± 0.6	0.041
MCV (fl)	85.09 ± 5.36	84.6 ± 6.97	0.954
MCH (pg)	28.13 ± 2.43	28.64 ± 2.8	0.078
MCHC (g/dl)	32.78 ± 1.15	33.8 ± 1.34	0.002
RDW (%)	13.02 ± 1.31	12.43 ± 1.19	0.314
Neutrophil (%)	56.8 ± 7.41	55.8 ± 5.35	0.775
Lymphocyte (%)	36.07 ± 7.04	35.2 ± 4.32	0.792
Monocyte (%)	3.11 ± 0.9	3.4 ± 1.14	0.658
Eosinophil (%)	3.69 ± 2.05	4.6 ± 2.07	0.235

Table 4

Descriptive characteristics and comparison of personnel liver factors in case and control groups

	Group		
Characteristics	Case mean ± SD	Control mean ± SD	*P*
FBS (mg/dl)	88.22 ± 17.46	82.5 ± 11.03	0.328
Total cholesterol (mg/dl)	184 ± 63.64	189.47 ± 36.47	0.793
Triglyceride (mg/dl)	147.6 ± 135.52	96.65 ± 40.11	0.684
SGOT (U/l)	22.9 ± 5.32	23.24 ± 7.64	0.778
SGPT (U/l)	22.67 ± 9.65	20.86 ± 10.74	0.253
ALP (U/l)	176.8 ± 50.95	155.63 ± 47.12	0.116
Total Bilirubin (mg/dl)	0.77 ± 0.35	0.77 ± 0.22	0.412
Direct Bilirubin (mg/dl)	0.21 ± 0.12	0.18 ± 0.06	0.47
LDH (U/l)	436.38 ± 103.88	456.17 ± 109.89	0.484
Mg (mg/dl)	2.15 ± 0.1	2.1 ± 0.16	0.239
GGT(U/l)	6.12 ± 3.23	6.01 ± 2.61	0.21

as an effective method of reducing the radiation dose. New imaging techniques have also been used to replace conventional fluoroscopy and reduce the radiation dose. It was also shown that the amount of radiation received by employees depends to a large extent on the skill of the physician and the use of radiographic and fluoroscopic tests[33].

Despite the important findings in our study, there are certain limitations to consider. First, the number of similar studies in this area is limited, making direct comparisons challenging. Secondly, our findings are based on data from a single healthcare system, and conducting similar studies in diverse hospital settings could provide valuable evidence for clinicians and healthcare authorities. Nevertheless, the results emphasize the impact of ionizing radiation and anesthetic gas exposure on certain biochemical parameters. It is recommended that future studies encompassing different hospital setups be designed to establish protocols and guidelines for managing radiation dosage and anesthesia exposure in operating room staff effectively.

Conclusion

Overall, the study concludes that exposure of operating room staff to radiation and anesthetics can alter some of the liver and blood parameters, including hemoglobin, hematocrit, red blood cells, MCHC, and vitamin D.

Ethical approval

No animals were used in this research. All human research procedures followed were by the ethical standards of the committee responsible for human experimentation Kermanshah University of Medical Sciences, Kermanshah, Iran (IR.KUMS.REC.1398.743), and with the Helsinki Declaration of 1975, as revised in 2013.

Table 5

Descriptive characteristics and comparison of thyroid factors and vitamin D levels of personnel in 2 case and control groups

	Group		
Features	Control mean ± SD	Case mean ± SD	*P*
TSH (μIU/ml)	3.5 ± 6.73	2.4 ± 1.99	0.588
T4 (μg/dl)	7.45 ± 1.04	7.6 ± 1.15	0.613
T3 (ng/ml)	2.63 ± 5.61	1.69 ± 0.28	0.304
Vit D(ng/ml)	16.99 ± 9.89	25.2 ± 13.69	0.01

Consent for publication

Written informed consent was obtained from the patient for publication of this case report and accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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None.

Author contribution

Dr B.R.: conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript; Dr S.S.Z. and Dr F.D.: designed the data collection instruments, collected data, conducted the initial analyses, and reviewed and revised the manuscript; Dr A.S. and Dr B.H.: coordinated and supervised data collection, and critically reviewed the manuscript for important intellectual content.

Conflicts of interest disclosures

The authors deny any conflict of interest in any terms or by any means during the study.

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Availability of data and materials

All relevant data and materials are provided in manuscript.

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