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Analysis on the Abnormal Detection Rate of Blood Tests in 1790 Medical Radiation Workers in Nanjing

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Abstract: *Objective* To investigate the characteristics of abnormal detection rate of the Blood routine and the Serum biochemistry in medical radiation workers. *Methods* A total of 1790 medical radiologists and occupational workers taking part in a medical check-up without radiation exposure history nor toxic exposure history, were selected as the radiation group and the control group respectively. The abnormal detection rates of blood routine and serum biochemical indexes of the two groups were compared and analyzed. *Results* The top three abnormal detection rates of blood routine indexes were MONO% [177 (9.9)], NEUT% [108 (6.0)], and WBC [85 (4.7)]. The top three abnormal detection rates of serum biochemical indexes were UA [395 (22.1)], FBG [208 (11.6)], and ALT [195 (10.9)]. The percentage of monocyte, neutrophil, leukocyte, and platelet abnormalities in the female group was higher than that in the male group. The abnormal detection rates of uric acid, fasting blood glucose, γ-glutamyl transpeptidase, alanine aminotransferase, total bilirubin, globulin, creatinine, and albumin in the male group were higher than those in the female group. The detection rate of abnormal fasting blood glucose showed an increasing trend correlated with the increase in occupational working duration. Alanine aminotransferase, γ-glutamyl transpeptidase, and creatinine increased in the early stage and then fell. The Total protein (TP) was relatively higher in the group of radiologists with more than 21 years of exposure. *Conclusion* Most of the blood routine and serum biochemical indexes of radiation workers are affected by radiation, while the blood routine indexes in the female group are affected by radiation more than that in the male group, and the serum biochemical indexes in the male group are affected by radiation more than that in the female group.

Keywords: Ionizing Radiation, Medical Radiation Operation, Blood Routine, Serum Biochemistry, Abnormal Detection Rate

1. Introduction

With the improvement of the working environment and protective conditions, the radiation dose to which radiation workers are exposed in their daily work is already at a low level, but some damage to the body is inevitably caused if they keep doing this work [1]. With the increasing attention to radiation safety and the gradual improvement of radiation protection conditions, it is no longer possible to hope that health damage and diseases related to occupational exposure can be detected by occupational health examination [2]. In contrast, blood routine and biochemical indicators can reflect the functional status of the hematopoietic system and liver, kidney, and endocrine at an earlier stage, and analyzing the characteristics of changes in blood routine and serum biochemical indicators in radiation workers exposed to low doses of ionizing radiation in hospitals for a long time provides relevant references for evaluating the effectiveness of radiation protection in hospitals.

2. Objects and Methods

2.1. Subjects

Occupational health checkups were performed at Nanjing Occupational Disease Control Hospital for 1790 medical radiation workers on duty in Nanjing area hospitals (radiation group), with the age distribution of 20 to 63 (36±9.7) years, including 983 males (54.9%) and 807 females (45.1%). The age of radiation work was 1 to 49 (11.3±9.8)a; 1790 people (control group) with no history of radiation exposure and no history of toxic exposure had occupational health checkups, with an age distribution of 20 to 63 (38±9.6) years, including 983 men (54.9%) and 807 women (45.1%). The enrolled subjects were occupational health checkup personnel with complete clinical data such as age, gender, blood routine, and serum biochemical test data.

2.2. Methods and Criteria for Determining Abnormalities of Test Indicators

The blood routine tester was a Japanese Hysenmecom XT-4000i automatic five-classification blood cell analyzer, and the reagents were the supporting reagents; the serum biochemical tester was a Japanese Hitachi 7600 automatic biochemical analyzer, and the reagents were Wako reagents, and all parameters were set and tested according to the instructions. The criteria were based on the fourth edition of the National Clinical Laboratory Practice [3], and a test index above the upper limit of the reference value or below the lower limit of the reference value was considered abnormal.

2.3. Statistical Analysis

SPSS19.0 statistical software was used for data analysis [4-6]. The measurement data were expressed as mean ($\bar{x}$) ± standard deviation (s), and t-test was performed for comparison of means between groups; the count data were expressed as [n (%)], and x^2 test was performed for comparison between groups, with 0.05 as the test level and P < 0.05 as a statistically significant difference.

3. Results

3.1. Abnormalities of Test Indexes

Among the 1790 hospital occupational health examination reports of medical radiology staff on duty, the order of abnormal detection rates of blood routine and serum biochemical indexes from highest to lowest are shown in Table 1. The top three abnormal detection rates of blood routine indicators were MONO% [177 (9.9)], NEUT% [108 (6.0)], and WBC [85 (4.7)], and the differences of MONO% and WBC were statistically significant (P < 0.05) when compared with the control group, and all of them were mainly lower than the reference value, and all of them were statistically significant (P < 0.05) when compared with the control group; The difference between NEUT% and the control group was not statistically significant (P>0.05). The top three abnormal detection rates of serum biochemical indexes were UA [395 (22.1)], FBG [208 (11.6)], and ALT [195 (10.9)], and the differences were statistically significant (P < 0.05) when compared with the control group, and UA and FBG were statistically significant (P < 0.05) when they were lower than and higher than the reference values. The abnormal detection rates of UA (21.2%) and FBG (11.5%) were predominantly higher than the reference values; there was no statistically significant difference between the higher-than-reference values of ALT (P>0.05). The detection rates of abnormalities below the reference value were [n (%) blood routine] 18.9%, [n (%) Serum biochemistry] 11.3%, above the reference value abnormalities were [n (%) blood routine] 17.8%, [n (%) Serum biochemistry] 69.1%, abnormalities were [n (%) blood routine] 36.8%, [n (%) Serum biochemistry] 80.3%.

Table 1. Indicator abnormalities in 1790 test reports.

Test items	Abnormality detection rate ranking				Detection rate below the reference value [n (%)]				Detection rate above the reference value [n (%)]			
	Radiology Group	Control group	X^2	P	Radiology Group	Control group	X^2	P	Radiology Group	Control group	X^2	P
Percentage of monocytes (MONO%)	177 (9.9)	99 (5.5)	23.89	0.000	160 (8.9)	70 (3.9)	37.64	0.000	17 (1.0)	29 (1.6)	3.17	0.075
Percentage of neutrophils (NEUT%)	108 (6.0)	102 (5.7)	0.18	0.670	25 (1.4)	26 (1.5)	0.02	0.888	83 (4.6)	76 (4.2)	0.32	0.570
Leukocytes (WBC)	85 (4.7)	49 (2.7)	10.05	0.002	45 (2.5)	21 (1.2)	8.89	0.003	40 (2.2)	28 (1.6)	2.16	0.142
Red blood cells (RBC)	81 (4.5)	55 (3.1)	5.17	0.023	11 (0.6)	6 (0.3)	1.48	0.224	70 (3.9)	49 (2.7)	3.83	0.050
Percentage of lymphocytes (LY%)	78 (4.3)	70 (3.9)	0.45	0.502	31 (1.7)	30 (1.7)	0.02	0.897	47 (2.6)	40 (2.2)	0.58	0.447
Haemoglobin (Hb)	74 (4.1)	66 (3.7)	0.48	0.490	40 (2.2)	33 (1.8)	0.69	0.408	34 (1.9)	33 (1.8)	0.02	0.902
Blood platelets (PLT)	55 (3.1)	47 (2.6)	0.65	0.422	27 (1.5)	33 (1.8)	0.61	0.435	28 (1.6)	14 (0.8)	4.72	0.030
Uric acid (UA)	395 (22.1)	240 (13.4)	45.99	0.000	16 (0.9)	27 (1.5)	2.85	0.091	379 (21.2)	213 (11.9)	55.77	0.000
Fasting blood glucose (FBG)	208 (11.6)	117 (6.5)	28.02	0.000	1 (0.1)	59 (3.3)	57.02	0.000	207 (11.5)	58 (3.2)	90.47	0.000
Alanine aminotransferase (ALT)	195 (10.9)	160 (8.9)	4.04	0.044	45 (2.5)	16 (0.9)	14.03	0.000	150 (8.4)	144 (8.0)	0.13	0.715
γ-glutamyl transpeptidase (GGT)	183 (10.2)	148 (8.3)	3.84	0.050	8 (0.4)	5 (0.3)	0.70	0.405	175 (9.8)	143 (8.0)	3.53	0.060
Total bilirubin (TBIL)	140 (7.8)	138 (7.7)	0.02	0.901	0 (0)	0 (.0.0)	/	/	140 (7.8)	138 (7.7)	0.02	0.901
Urea nitrogen (BUN)	125 (7.0)	102 (5.7)	2.49	0.115	36 (2.0)	18 (1.0)	6.09	0.014	89 (5.0)	84 (4.7)	0.15	0.697
Globulin (GLO)	72 (4.0)	35 (2.0)	13.19	0.000	69 (3.8)	35 (2.0)	11.45	0.001	3 (0.2)	0 (0.0)	3.00	0.083
Creatinine (Cr)	60 (3.3)	59 (3.3)	0.01	0.926	18 (1.0)	27 (1.5)	1.82	0.177	42 (2.3)	32 (1.8)	1.38	0.240
Albumin (ALB)	43 (2.4)	6 (0.3)	70.37	0.000	3 (0.2)	0 (0.0)	3.00	0.083	40 (2.2)	6 (0.3)	25.46	0.000
Total protein (TP)	17 (0.9)	10 (0.6)	1.83	0.176	6 (0.3)	6 (0.3)	0.00	1.000	11 (0.6)	4 (0.2)	3.28	0.070

Note: Data in brackets are percentages (%)

3.2. Distribution of Abnormal Detection Rate of Test Indexes

In the blood routine and serum biochemical tests, except for RBC, LY%, Hb, BUN, and TP, which were not statistically significant between men and women (χ^2=0.54-0.75, P=0.385-0.461), the remaining items MONO%, NEUT%, WBC, PLT, UA, FBG, GGT, ALT, TBIL, GLO, Cr, and ALB abnormalities were statistically significant (χ^2=4.23 to 248.30, P=0.000 to 0.040) between men and women, the abnormal detection rates of MONO%, NEUT%, WBC, and PLT abnormalities were higher in females than in males (χ^2=4.23-49.48, P=0.000-0.040); while the detection rates of UA, FBG, GGT, ALT, TBIL, GLO, Cr, and ALB abnormalities were higher in males than in females (χ^2=6.77-248.30, P=0.000- 0.009), see Table 2 for details.

Table 2. *Distribution of abnormal detection rate of test indicators.*

Test items	Male n=983 people	Female n=807 people	Total n=1790 people	x^2	*P*
Percentage of monocytes (MONO%)	89 (9.1)	88 (10.9)	177 (9.9)	49.48	0.000
Percentage of neutrophils (NEUT%)	49 (5.0)	59 (7.3)	108 (6.0)	4.23	0.040
Leukocytes (WBC)	34 (3.4)	51 (6.3)	85 (4.7)	8.02	0.005
Blood platelets (PLT)	29 (2.9)	26 (3.2)	55 (3.1)	19.89	0.000
Uric acid (UA)	302 (30.7)	93 (11.5)	395 (22.1)	94.98	0.000
Fasting blood glucose (FBG)	170 (17.3)	38 (4.7)	208 (11.6)	68.35	0.000
γ-glutamyl transpeptidase (GGT)	147 (14.9)	36 (4.4)	183 (10.2)	248.30	0.000
Alanine aminotransferase (ALT)	134 (13.6)	61 (7.5)	195 (11.1)	16.84	0.000
Total bilirubin (TBIL)	103 (10.5)	37 (4.6)	140 (7.8)	21.35	0.000
Globulin (GLO)	54 (5.5)	18 (2.2)	72 (4.0)	12.22	0.000
Creatinine (Cr)	43 (4.3)	17 (2.1)	60 (3.4)	7.04	0.008
Albumin (ALB)	32 (3.3)	11 (1.3)	43 (2.4)	6.77	0.009
Red blood cells (RBC)	48 (4.9)	33 (4.1)	81 (4.5)	0.65	0.421
Percentage of lymphocytes (LY%)	46 (4.7)	32 (4.0)	78 (4.4)	0.54	0.461
Haemoglobin (Hb)	25 (2.5)	49 (6.1)	74 (4.1)	0.75	0.385
Urea nitrogen (BUN)	73 (7.4)	52 (6.4)	125 (7.0)	0.66	0.417
Total protein (TP)	11 (1.1)	6 (0.7)	17 (0.9)	0.66	0.415

Note: Data in brackets are percentages (%)

3.3. Abnormalities of Test Indicators in Men and Women

The indicators with a higher detection rate for men than women below the reference value were: NEUT%, PLT, GLO, and Cr; the indicators with a higher detection rate for men than women above the reference value were: MONO% and the biochemical indicators UA, FBG, GGT, ALT, TBIL, GLO, Cr, ALB with statistically significant differences between men and women, as detailed in Table 3.

Table 3. *Abnormalities in test indicators.*

Test items	Detection rate below the reference value [n (%)]		Detection rate above reference value [n (%)]		Abnormal detection rate [n (%)]	
	N_{Male}=983 people	N_{Female}=807 people	N_{Male}=983 people	N_{Female}=807 people	N_{Male}=983 people	N_{Female}=807 people
Percentage of monocytes (MONO%)	78 (8.0)	82 (10.2)	11 (1.1)	6 (0.7)	89 (9.1)	88 (10.9)
Percentage of neutrophils (NEUT%)	16 (1.6)	9 (1.1)	33 (3.4)	50 (6.2)	49 (5.0)	59 (7.3)
Leukocytes (WBC)	12 (1.2)	33 (4.1)	22 (2.2)	18 (2.2)	34 (3.4)	51 (6.3)
Blood platelets (PLT)	20 (2.0)	7 (0.9)	9 (0.9)	19 (2.3)	29 (2.9)	26 (3.2)
Uric acid (UA)	6 (0.6)	10 (1.2)	296 (30.1)	83 (10.3)	302 (30.7)	93 (11.5)
Fasting blood glucose (FBG)	0 (0)	1 (0.1)	170 (17.3)	37 (4.6)	170 (17.3)	38 (4.7)
γ-glutamyl transpeptidase (GGT)	3 (0.3)	5 (0.6)	144 (14.6)	31 (3.8)	147 (14.9)	36 (4.4)
Alanine aminotransferase (ALT)	11 (1.1)	34 (4.2)	123 (12.5)	27 (3.3)	134 (13.6)	61 (7.5)
Total bilirubin (TBIL)	0 (0)	0 (0)	103 (10.5)	37 (4.6)	103 (10.5)	37 (4.6)
Globulin (GLO)	51 (5.2)	18 (2.2)	3 (0.3)	0 (0)	54 (5.5)	18 (2.2)
Creatinine (Cr)	17 (1.7)	1 (0.1)	26 (2.6)	16 (2.0)	43 (4.3)	17 (2.1)
Albumin (ALB)	1 (0.1)	2 (0.2)	31 (3.2)	9 (1.1)	32 (3.3)	11 (1.3)

Note: Data in brackets are percentages (%)

3.4. Comparison of Abnormal Detection Rate of Test Indexes Among Different Radiological Work Experience Groups

There was no statistically significant difference in the detection rate of abnormalities in blood routine indicators MONO%, NEUT%, WBC, RBC, LY%, Hb, PLT, and serum biochemical indicators UA, TBIL, BUN, GLO, ALB among the radiographic age groups (x2=0.43-7.64, P=0.054-0.935), but the differences in the abnormal detection rates of serum biochemical indicators FBG, ALT, GGT, Cr and TP were statistically significant among the radiological age groups (x2=8.97-168.04, P=0.000-0.030). The abnormal detection rate of FBG showed an obvious increasing trend with the increase of radiological work experience; the abnormal detection rate of ALT, GGT, and Cr showed an increasing and then decreasing trend; The abnormal detection rate of TP was higher after 21a of radiological work experience, as detailed in Table 4.

Table 4. *Comparison of the detection rate of abnormal test indicators [n (%)] among different radiological work experience groups.*

Test items	1~5a	6~20a	21~35a	36~ a	x^2	*P*
	n=674	n=778	n=289	n=49		
Fasting blood glucose (FBG)	27 (4.0)	82 (10.5)	74 (25.6)	25 (51.0)	168.04	0.000
Alanine aminotransferase (ALT)	76 (11.3)	97 (12.5)	20 (6.9)	2 (4.1)	9.13	0.028
γ-glutamyl transpeptidase (GGT)	39 (5.8)	96 (12.3)	43 (14.9)	5 (10.2)	25.08	0.000
Creatinine (Cr)	12 (1.8)	26 (3.3)	19 (6.6)	3 (6.1)	15.56	0.001
Total protein (TP)	4 (0.6)	5 (0.6)	7 (2.4)	1 (2.0)	8.97	0.030
Uric acid (UA)	134 (19.8)	178 (22.8)	69 (23.8)	14 (28.5)	3.93	0.270
Total bilirubin (TBIL)	55 (8.1)	61 (7.8)	21 (7.2 ()	3 (6.1)	0.43	0.935
Urea nitrogen (BUN)	43 (6.4)	57 (7.3)	17 (5.9)	8 (16.3)	7.64	0.054
Globulin (GLO)	27 (4.0)	27 (3.4)	15 (5.1)	3 (6.1)	2.20	0.533
Albumin (ALB)	23 (3.4)	16 (2.1)	4 (1.4)	0 (0)	5.81	0.121
Percentage of monocytes (MONO%)	53 (7.8)	93 (11.9)	27 (9.3)	4 (8.1)	7.09	0.069
Percentage of neutrophils (NEUT%)	42 (6.2)	45 (5.7)	17 (5.8)	4 (8.1)	0.54	0.911
Leukocytes (WBC)	36 (5.3)	32 (4.1)	16 (5.5)	1 (2.0)	2.41	0.492
Red blood cells (RBC)	35 (5.1)	33 (4.2)	12 (4.1)	1 (2.0)	1.63	0.652
Percentage of lymphocytes (LY%)	33 (4.9)	35 (4.5)	9 (3.1)	1 (2.0)	2.21	0.530
Haemoglobin (Hb)	37 (5.4)	29 (3.7)	7 (2.4)	1 (2.0)	6.13	0.106
Blood platelets (PLT)	14 (2.0)	26 (3.3)	12 (4.1)	3 (6.1)	5.09	0.165

Note: Data in brackets are percentages (%)

4. Discussion

Although the working environment and protective conditions for radiation workers have been greatly improved, hospital medical radiation workers on duty may still be exposed to a certain amount of ionizing radiation in various aspects of their daily work operations and at the site of radiation treatment sites. The main medical applications of ionizing radiation are diagnostic and therapeutic, and long-term exposure to low doses of ionizing radiation can cause damage to the human body and have long-term effects [7]. Regular occupational health checkup management, early detection, prevention, diagnosis, and treatment are the most cost-effective ways to cope with occupational health. Alterations in the blood picture are an early sign of radiological damage [8]. In the 1790 medical examination reports of hospital medical radiology staff on duty in this study, the abnormal detection rate of routine blood indicators was 36.8%, with MONO% and WBC as the main indicators and the differences were statistically significant compared with the control group (P < 0.05), in which WBC decreased slightly (2.5%); MONO% decreased in the majority (8.9%), and the differences were statistically significant compared with the control group (P < 0.05). All the differences were statistically significant (P < 0.05) compared with the control group. It is possible that long-term low doses of ionizing radiation can cause DNA damage, prevent DNA synthesis, affect cell division due to cellular GO/G1 blockage, and cause a decrease or increase in WBC [9], which is related to the fact that ionizing radiation can directly damage blood cells and destroy hematopoietic tissue leading to a decrease in white blood cells [10]. Long-term low-dose exposure to ionizing radiation also has an effect on serum biochemical indexes. The abnormal detection rate of serum biochemical indexes was 80.3% in 1790 hospital medical radiologists on duty in this study, with UA [395 (22.1)], FBG [208 (11.6)], and ALT [195 (10.9)] as the main findings and the differences were statistically significant when compared with the control group (P < 0.05), with UA (21.2%) and FBG (11.5%) were higher than the reference value, and the difference was statistically significant when compared with the control group (P < 0.05).

Gender differences in the variation of certain blood routines in radiologic workers. The present study showed that except for RBC, LY%, and Hb abnormal detection rates, which were not statistically significant between men and women (χ^2=0.54-0.75, P=0.385-0.461), MONO%, NEUT%, WBC, and PLT abnormal detection rates were statistically significant between men and women (χ^2=4.23-49.48, P=0.000-0 0.040), were higher in females than in males, which is basically consistent with that reported by Xu Fang [11], and MONO%, NEUT%, and WBC were predominant, indicating that long-term low-dose exposure to ionizing radiation has an effect on the function of the hematopoietic system in both males and females in radiation workers, and the effect on the function of the hematopoietic system in females is heavier than that in males, suggesting that the hematopoietic system in females may be more sensitive to ionizing radiation [12], which may be related to women's higher subcutaneous fat and higher sensitivity to radiation [13].

There were also gender differences in the changes of serum biochemical indicators in the radiological staff. The study showed that except for BUN and TP, which were not statistically significant between men and women (χ^2=0.66,

P=0.415-0.417), UA, FBG, GGT, ALT, TBIL, GLO, Cr and ALB were statistically significant between men and women (χ^2= 6.77 - 248.30, P=0.000 - 0.009), all higher in men than in women, which is basically consistent with the report by Liu Yachi [14]. Although non-radiological factors such as dietary habits, lifestyle, and stress exposure had a greater impact on men, the ranking of serum biochemical indicators that were less affected than men showed that the more influential serum biochemical indicators were GGT and FBG, and both remained within the top five rankings, rising from fifth and third in the female ranking to third and second in the male ranking respectively, with the remaining indicators not yet found to have a significant impact. UA and Cr are indicators of renal function; FBG is an indicator of endocrine function; GGT, ALT, TBIL, GLO, and ALB are indicators of liver function, and GGT is also an indicator of sensitivity to alcohol, suggesting that because men are more affected by both non-radiation and radiation factors than women, long-term low-dose exposure to ionizing radiation has a heavier impact on liver, kidney and endocrine function than women, which is basically consistent with the report by Li Haiyue et al [15].

The changes in peripheral blood picture among different age groups were not significant, and the difference in abnormal detection rate among the exposure age groups was not statistically significant (χ^2=0.54-7.09, P=0.069-0.911), which is basically consistent with that reported by Jinxia Gao [16], and the reason may be related to the fact that the effect of long-term small doses of ionizing radiation on the hematopoietic system is a dynamic change process of damage and repair [17]. Temporary removal of radiation workers from radiation exposure will facilitate the repair of blood cells [18].

The study showed that the abnormal detection rates of some serum biochemical indexes FBG, ALT, GGT, Cr, and TP varied significantly among different working age groups with the increase of radiation working age (χ^2=8.97-168.04, P=0.000-0.030), and the abnormal detection rates of FBG showed a significant increasing trend; the abnormal detection rates of ALT, GGT, and Cr showed an increasing trend and then a decreasing trend; the abnormal detection rates of TP The abnormal detection rate was higher after 21a of receiving age. It is further suggested that long-term low-dose ionizing radiation exposure has effects on liver, kidney, and endocrine function serum biochemical indexes in radiation workers, which is basically consistent with that reported by Yang Chunwang [19], and the effects on some serum biochemical indexes are related to the length of exposure.

5. Conclusion

Long-term low-dose ionizing radiation exposure can cause a variety of biological effects on the human body, the hematopoietic system and liver, kidney, endocrine and other functions have certain effects, that still need to pay further attention and strengthen protection, regular occupational health examination, the use of the radiation-sensitive hematopoietic system, liver, kidney, endocrine and other detection indicators reflect the early damage effects of radiation-sensitive organs, early detection of radiation hazards and implementation of intervention measures.

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