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Effects of Ionizing Radiation on Immune System in Children: Meta-Analysis Study

Thesis

Submitted for Fulfillment of PhD Degree in Childhood Studies

Medical Studies Department

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قسم الدراسات الطبية للأطفال

صفحة العنوان

عنوان الرسالة: دراسة تأثير الإشعاعات المؤينة على الجهاز المناعي لدى الأطفال باستخدام تحليل – ميتا

اسم الطالب: حازم سالم عبدالعظيم أبوغازي

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Abstract

Name: Hazem Salem Abdel Azeem Abou Ghazy

Title: Effects of Ionizing Radiation on Immune System in Children: Meta-Analysis Study

PhD Thesis - Medical Studies Department for Children-Faculty of Postgraduate Childhood Studies- Ain Shams University-2020.

Background: Ionizing radiation has a serious effect on different biological systems particularly the immune system.

Aim of study: To provide a meta-analysis study regarding the effects of ionizing radiation on immune system in children.

Methodology: Online research was done for published studies focused on ionizing radiation effects on immune system from 2001 to 2018.The pool of 36 studies focused on effects of ionizing radiation on immune system, fulfilled the inclusion criteria. 11 studies in Arabic countries and 25 studies in non-Arabic countries with total study group's sample size (3963) those exposed to ionizing radiation and total control group's sample size (1293) those healthy and never exposed to ionizing radiation. Meta-analysis was done using MedCalc software ver. 12.7.7.0. **Results:** In Arabic countries, there was a decrease in the mean values of WBCs, lymphocytes, neutrophils, monocytes and CD4% in the studied groups than the controlled with significant difference ($P<0.05$). In non-Arabic, there was a decrease in the mean values of WBCs, lymphocytes, neutrophils, monocytes, CD3 %, CD4 %, CD8 %, CD16%, CD19 %, IL-2, IL-10, IgM, IgG and C3 in studied groups than the controlled with significant difference ($P<0.05$), while the mean values of IL4, IFN-γ and IgA were more affected by increase in studied groups than the controlled groups in non-Arabic countries with significant difference ($P<0.05$). **Conclusion:** It could be concluded that ionizing radiation has a significant effect on the immune cells.

Keywords: Ionizing Radiation, Immune System and Meta-Analysis.

CONTENTS

LIST OF ABBREVIATIONS

Ab	Antibody
Ags	Antigens
ALARA	As Low As Reasonably Achievable
APC	Antigen Presenting Cell
C	Complement component
CD	Cluster of Differentiation
CI	Confidence Intervals
CSFs	Colony-Stimulating Factors
CT scan	Computed Tomography scan
DNA	Deoxyribonucleic acid
EAEC	European Atomic Energy Community
Gy	Gray
HD-IR	High-Dose Ionizing Radiation
HLA	Human Leucocyte Antigen
HPS	Health Physics Society
HSCs	Haematopoietic Stem Cells
I^2	Inconsistency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiation Protection
IFN-γ	Interferon-gamma
Ig	Immunoglobulin
IL	Interleukin
INIS	International Nuclear Information System
IR	Ionizing Radiation
LCs	Langerhans cells
LD-IR	Low-Dose Ionizing Radiation
LNT	Linear No-Threshold
MD	Doctorate in Medicine
MHC	Major Histocompatibility Complex
μL.	Micro Litter

MRI	Magnetic Resonance Imaging
MSc	Master of Science
mSv	Milli-Severt
NCRP	National Council on Radiation Protection and measurements
NK	Natural Killer
PET	Positron Emission Tomography
pg/ml	Picogram/Milliliter
PHD	Doctor of Philosophy Degree
PMNs	Polymorph Nuclear Leucocytes
Q test	Cochran's Q test of Heterogeneity
SIS	Skin Immune System
RBC	Red Blood Cell
SE	Standard Error
SMD	Standardized Mean Difference
TLRs	Toll-Like Receptors
TNF	Tumor Necrosis Factor
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
WBCs	White Blood Cells
WBI	Whole-Body Irradiation
WHO	World Health Organization

LIST OF APPENDICES

INTRODUCTION

The immune system is the body's defense against infectious organisms and other invaders. Through a series of steps called the immune response, the immune system attacks organisms and substances that invade body systems and cause disease. The immune system is made up of a network of cells, tissues, and organs that work together to protect the body. The cells involved are white blood cells or leukocytes, which come in two basic types that combine to seek out and destroy disease causing organisms or substances **(Juliann and Ayodele, 2019).**

Ionizing radiation is radiation with enough energy, so that during an interaction with an atom, it can remove tightly bound electrons from the orbit of an atom, causing the atom to become charged or ionized. There are two basic types of ionizing radiation: electromagnetic and particulate. X-rays and gamma rays have discrete packets of energy called "photons" that have neither mass nor electric charge. Beta and alpha radiation are primarily produced by disintegration of an unstable atom and the energy is carried by sub-atomic particles **(Woodside and Gayle 2015).**

Severe damage occurs in biological tissues by exciting or ionizing their atoms and molecules after ionizing radiation exposure**.** It has a serious effect on the immune system **(Abaza, 2017)**.

Sanzari et al. 2013, considered WBCs to be the most sensitive to gamma radiation among the cell types. That is because the stem cells are a forerunner to all blood cell lines and a reduction can be observed in the number of mature cells. WBCs were considered to be the prime target of radiation action in the cell as they contain nucleus and DNA, that’s why WBCs

are more affected by radiation than other cells in study groups more than controls (**Devi et al., 2000**).

Furthermore, the diagnostic X-rays had a functional impairment with destructive effect on WBC. The effect of exposure to ionizing radiation is age dependent and, the immune system of children is more susceptible to this effect. Therefore, close attention should be paid to improve the diagnostic information and to reduce the children doses as much as you can (**Mohammed et al., 2014).**

The radiation exposure from a single diagnostic procedure is usually small. However, many children undergo radiological examinations, some of them rather frequently, making these procedures the highest human-made source of radiation exposure. Because of the increased lifetime risk per unit dose for children, the potentially higher doses, and the increasing frequency of pediatric computerized tomography (CT) examinations, diagnostic procedures that use radiation can affect the immune system. While these procedures are undisputedly beneficial, the magnitude of exposure of children can often be reduced without significant loss of information. An area of special concern is the unnecessary use of radiation imaging when clinical evaluation or other imaging modalities could provide an accurate diagnosis **(Serena et al., 2017).**

Justification and Optimization are the two principles of radiation protection in medical exposures to ionizing radiation. From a radiological protection perspective, clear justification of radiological examinations for children and young adults is essential. In addition, dose protocols and techniques have to be adapted to children and young adult patients while providing the

required diagnostic information, thus optimizing protection **(Strauss et al., 2010).**

Meta-analysis is a subset of systematic reviews; a method for systematically combining pertinent qualitative and quantitative study data from several selected studies to develop a single conclusion that has greater statistical power. This conclusion is statistically stronger than the analysis of any single study, due to increased numbers of subjects, greater diversity among subjects, or accumulated effects and results. The need to integrate findings from many studies ensures that meta-analytic research is desirable and the large body of research now generated makes the conduct of this research feasible **(Haidich, 2010).**

AIM OF THE STUDY

Aim of the study:

The aim of the study was to provide a meta-analysis study regarding the effects of ionizing radiation on immune system in children**.**

Importance of the study:

The result of the proposed study provided a more data related to the effects of ionizing radiation on immune system in children.

In medical field, radiation exposure for children is commonly used and may affect their immune system, so it is very important to know more data about the effects of ionizing radiation on this system.