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Evidence-Based Case Report

Could Hypertension in Radiographers Associated with Low Ionizing Radiation Exposure? An Evidence-Based Case Report

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ABSTRACT

Low-dose ionizing radiation exposure (<0.5 Gy) may give rise to circulation disorders. Nevertheless, it is not yet known whether low-dose ionizing radiation exposure can cause hypertension. A 27-year-old male patient, who is a radiographer, consulted regarding the result of his periodic check-up with the result of hypertension. He also said that his electrocardiogram (ECG) examination in the previous year's periodic check-up suggested a poor result, but he couldn't remember what the cardiologist told him. Could hypertension in radiographers be associated with ionizing radiation exposure at work? The literature was searched via PubMed, Scopus, and Cochrane. One relevant article was found that met the inclusion criteria. A cohort study by Preetha R, et al (2015) showed no relationship between the risk of hypertension with FGIP exposure. The selected article is quite valid but not in importance. Therefore, it did not apply to the case patient. Since research about this matter is still rare, there was only one suitable article found, so the causal relationship still cannot be proven. Further research is recommended using better exposure and outcome measures.

Introduction

World Health Organization (WHO) defines radiation as energy traveling in the form of waves or particles and is part of our daily environment.[1] We can find radiation in numerous fields such as technology, communication, medicine, and research. Radiation is classified as ionizing radiation and non-ionizing radiation. Ionizing radiation is charged particles (neutrons, beta or alpha) and electromagnetic waves (gamma or x-ray) which can ionize the media in its path, due to its energy,[2] while the term non-ionizing radiation is used for the electromagnetic spectrum with sufficient energy to excite ionization. Examples include radio waves, microwaves, ultraviolet, visible radiation, infrared, electric and magnetic fields, and infrared.[1]

The medical field utilizes ionizing radiation for x-rays, computed tomography (CT), radiation oncology, nuclear medicine, cardiac angiography, and interventional fluoroscopy or radiology.[3] The ionizing radiation can cause acute and chronic effects. Acute radiation exposure may give rise to skin rashes, organ failure, and even, acute radiation syndrome while chronic radiation exposure may cause cataracts, infertility, and cancer. The doses of radiation exposure are classified as "very high" (> 15 Gy), "high" (5 - 15 Gy), "moderate" (0.5 - 5 Gy), and "low" (< 0.5 Gy).[4] Ionizing radiation exposure within the health field, with an estimated range of effective radiation below 0.5 Gy, is found in conventional simple x-rays (0.02 - 10 mGy), conventional complex x-rays (3 - 10 mGy), CT (5 - 15 mGy), spiral CT (10 - 20 mGy), angiography (10 - 200 mGy) and interventional procedures (10 - 300 mGy).[5] Radiation exposure in the hospital has become a concern of many parties. Therefore, the government had stipulated regulations concerning the obligation to comply with health standards. The recommendation of the International Atomic Energy Agency for the individual dose limit is an average of 100 mSv in 5 years or a maximum of 20 mSv per year for radiation workers.[6] The government has required each radiation worker to wear individual dose monitoring equipment based on the source type of installation and radiation used.[7]

The epidemiological study by Bjorn B et al. (2016) showed that cardiovascular disease may be related to radiation exposure. Nevertheless, the exposure doses < 0.5 G have not yet been proven.[8] Mark P[9] conducted a meta-analysis in 2017 suggesting strong evidence of a relationship between acute and chronic exposure to high-dose and low-dose radiation with circulatory diseases. Exposure to high (5 - 15 Gy) or very high (> 15 Gy) doses can cause a deterministic effect and an inflammatory mechanism, that affects the circulatory system. Lower doses (0.5 Gy - 5 Gy) exposure may give rise to inflammatory markers in prolonged radiation exposure, whereas exposure to doses of less than 0.5 Gy indicates a linear relationship between the response dose with various types of circulatory diseases. In a study of workers at the Russian Mayak nuclear company, Tamara Azizova et al (2019) found the incidence of significant hypertension to be linearly related to the cumulative doses absorbed by life from external gamma rays.[10] There are still many parties who do not know about the effects of low-dose radiation exposure, including hospitals. Hence, circulatory diseases found in radiology workers, are mostly associated with a sedentary lifestyle, shift work, and long working hours. Therefore, the target of hazard countermeasures may not be appropriate.

Case Description

The patient, a 27-year-old male, visited the clinic. He was a radiographer in a hospital. He wanted to consult about the result of his periodic examination. He was said to have hypertension. He stated that he does not smoke and he does not eat any junk food. He could not understand how he could have hypertension. He wondered if it was caused by hereditary or other factors. He also said that his electrocardiogram (ECG) examination in the previous year's periodic check-up suggested a bad result, but he couldn't remember what the cardiologist told him.

The examining physician had read an article regarding exposure to low doses of ionizing radiation can cause hypertension. He wanted to investigate whether the hypertension was caused by exposure to low doses of ionizing radiation, which is associated with hazardous exposure from the patient's occupation. This is an observational study presented in the form of a case report.

Problem Formulation

Could low-dose ionizing radiation exposure be associated with hypertension in radiographers?

Evidence Search Strategy

To answer the clinical questions, the researchers searched pieces of literature using electronic databases, namely PubMed, Scopus, and Cochrane. The search keywords were 'radiology worker', 'low dose ionizing radiation', and 'hypertension'. This research used the inclusion criteria of healthcare workers, low-dose radiation, and hypertension while the exclusion criteria were articles regarding different exposures and outcomes, including articles from books or letters. The literature search was completed on April 8, 2020. Critical appraisal was conducted on the selected literature to determine the validity, importance, and applicability of the literature using relevant criteria from the worksheet for the etiology study of the Oxford Centre of Evidence-Based Medicine.[11]

Results and Discussion

Evidence Search Result

Of all databases, the search retrieved 16 articles. There was only one article that met the inclusion and exclusion criteria: A cohort study by Preetha R, et al (2015),[12] that assessed the risk of circulatory disease events and mortality among medical radiation workers performing fluoroscopically guided interventional procedures (FGIP). Information on work history on FGIP was confirmed for the first time in the second survey. The third survey deepened previous employment and risk factor information, and obtain more incident events of certain health outcomes. Estimation of circulatory disease risks was calculated with Cox proportional hazard models which compared technologists who had performed or assisted FGIP to the ones who had never worked or assisted FGIP. The analysis of incidence was limited to the 63,482 technologists who had completed both the second and third surveys. Study characteristic is shown in Table 1 while the result of the critical appraisal is shown in Table 2.

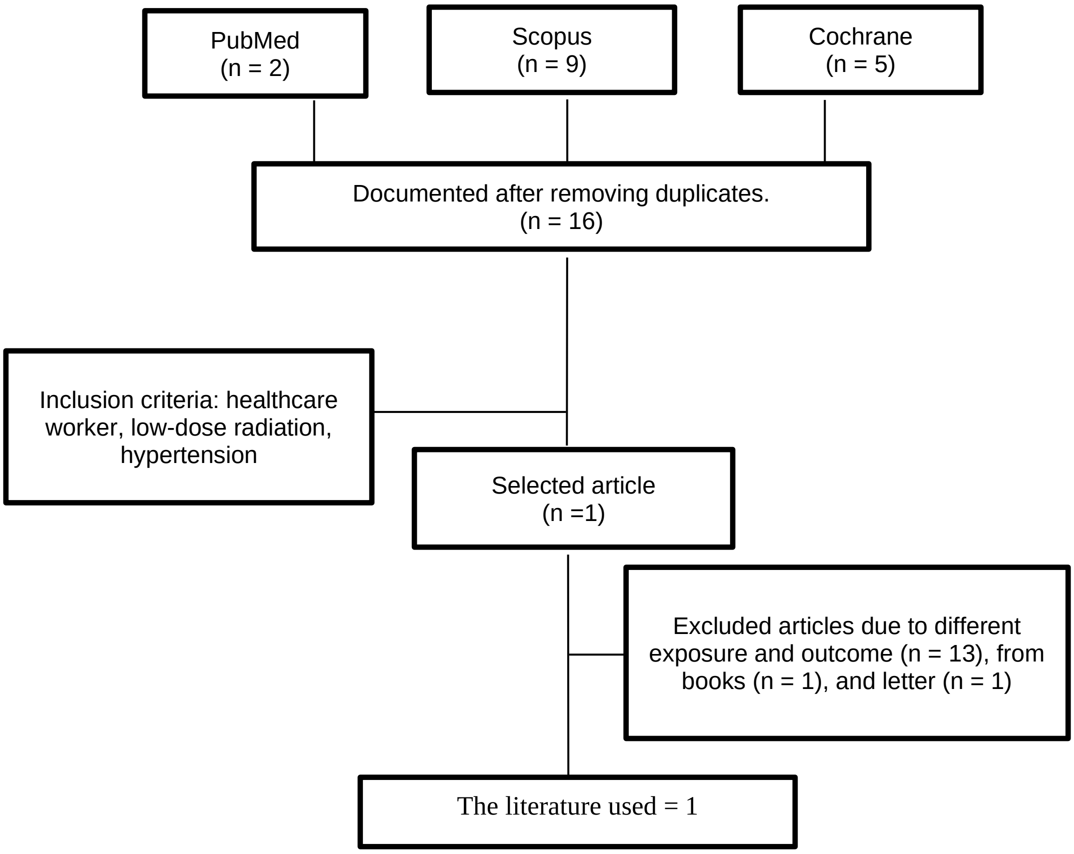

Figure 1. Flowchart of literature research

Table 1. Study characteristics

Author	Year of publication	Study design	Intervention	Follow up time	Responders (63.482)		Result
					Case	Control	
Preetha R, et al	2015	Cohort	Perform or assist fluoroscopy-guided interventional procedures (FGIP)	9 years	8.903	54.579	No statistically significant excess risk of FGIP with hypertension

Different population determinations made the articles obtained valid. The population was taken from the registered US Radiological Technologist in the American Registry of Radiologic Technologists and had been certified for at least 2 years. Although there was a 30.2% reduction in the sample, bringing the total sample to 63,482, the number of samples was still quite large and they received a long follow-up from 1994 to 2005. In addition, if the selected population has not developed hypertension, the article would state that the population had no circulatory diseases (eg, stroke, hypertension, ischemic heart disease, and myocardial infarction).

Both groups were measured for the exposure and outcome in the same way, namely by filling out a questionnaire. The sample for the case and control groups was not well defined because the basis for sample determination was the category of questionnaire results regarding questions about the subject's experience working with FGIP, either monthly, weekly, or daily. If the sample answered with one of the periods, then the sample would be classified as a case and if not, then the sample would be classified as a control. Exposure in this article is measured qualitatively, based on the estimated amount of radiation obtained from the FGIP frequency, whether monthly, weekly, or daily. For that reason, the dose gradient measurement was not conducted. The exposure measurement would be better if the number of exposure doses received can be calculated, to ensure the number of exposures received was within the low dose range. Therefore, environmental exposure factors or other types of tasks performed by radiographers need to be taken into account.

Table 2. The critical appraisal of etiologic study

Article: Incidence and mortality risks for circulatory diseases in US radiologic technologists who worked with fluoroscopically guided interventional procedures, 1994-2008	
Level: 3 (On-randomized controlled cohort/follow-up study provided there are sufficient numbers to rule out common harm)[11]	
Is the result of this harm study valid?	
Were there clearly defined groups of patients, similar in all important ways other than exposure to the treatment or other causes?	YES. The US Radiologic Technologists (USRT) was identified from the records of the American Registry of Radiologic Technologists (ARRT) and consists of technologists who resided in any US state or territory and were certified for at least two years
Were treatments/exposures and clinical outcomes measured in the same ways in both groups (was the assessment of outcomes either objective or blinded to exposure)?	YES. Exposures and clinical outcomes were measured in the same ways, by filling out the questionnaires. Assessment of outcomes was objective to exposure (self-reported incidence data: Has any doctor ever told you that you had any of the following cardiovascular conditions: high blood pressure, stroke, transient ischaemic attack, angina pectoris?)
Was the follow-up of study patients sufficiently long and complete?	NO. 126.628 respondents on the first survey (1983-1989), 90.955 respondents on the second survey (1994-1998), and 63.482 respondents on the third survey (2003-2005). For incidence, analyses were restricted to the 63.482 (69.8%) technologists who completed the second survey and third survey.
Do the results satisfy some "diagnostic tests for causation"?	
Is it clear that the exposure preceded the onset of the outcome?	YES. For all the incidences of circulatory disease and mortality outcomes, individuals had to be free of the particular circulatory disease to be used as a baseline (1994-1998).
Is there a dose-response gradient?	NO. Dose-response was measured using a questionnaire contained questions regarding the frequency of doing or assisting FGIP (daily, weekly, monthly).
Is there positive evidence from a "dechallenge-rechallenge" study?	NO. All responders who stated to have ever worked FGIP, considered working FGIP.
Is the association consistent from study to study?	NO. The earlier cohort study in 1983-1989 analyzed the risk of circulatory disease incidence without dividing the types of circulatory disease.
Does the association make biological sense?	YES. There is convincing evidence of radiation-related heart disease among patients receiving high doses of radiotherapy to the thorax. The evidence is less clear at moderate to low doses of radiation. Potential biological mechanisms underlying radiation-related circulatory disease risks include cell-killing effects on capillaries and endothelial cells at high radiation doses (>5 Gy), and inflammation effects for exposures <0.5 Gy.
Are the valid results from this harm study important?	
What is the magnitude of the association between the exposure and outcome?	HR = 0,99. We observed no difference in outcome between the exposed and unexposed.
What is the precision of the estimate of the association between exposure and outcome?	95% CI = 0.94 to 1.04. There was no difference in disease incidence in the exposed and unexposed groups.
Should these valid, potentially important results change the treatment of your patient?	
Do the results apply to our patients?	NO. We can't continue checking the applicability in this article because we found the article it's not importance.

The outcome measures are less reliable as well because they were self-reported. If the respondent developed one of the circulatory diseases, the respondent would write it in the questionnaire. The first circulatory disease developed among the respondents was the outcome used for the analysis. Meanwhile, the article did not only analyze hypertension but other circulatory diseases as well, namely strokes, ischemic heart disease, and myocardial infarction. These self-reported results can lead to inaccurate data collection as hypertension may not manifest or be caught early and thus not detected quickly. As a result, it can cause hypertension not to be recorded afterward.

This article showed no difference in outcome between those exposed and not exposed to FGIP (HR 0.99, 95% CI 0.94-1.04) after adjusting for other factors such as age, sex, smoking, alcohol consumption per week, body mass index, total years worked as a radiological technologist in different periods and experience working with brachytherapy and other radionuclide procedures. Our recalculated RR was 0.69, with a 95% CI of 0.635-0.735. The difference between RR and HR can be caused by the calculation of RR has not been adjusted for other factors such as HR assessment.

Discussion

A strong association between high-dose acute radiation exposure and low-dose chronic radiation exposure with most types of circulatory disease has been shown in previous studies.[8] From the searches, only one article was found that could answer whether low-dose radiation exposure could cause hypertension.[12] The same article also found a greater risk for stroke in radiology workers exposed to low-dose radiation. We all know stroke is one of the circulation diseases. Nevertheless, it was found that there is no difference between exposed and unexposed radiation. This may be caused by a lack of studies on the related subject.

What made this evidence-based case report (EBCR) strong is that the selected article was a cohort study that was sufficiently qualified to answer the etiological search, to determine the causal relationship between risk and outcome. To find clear evidence, questions were formulated in the form of PICO such as the exposure population and the outcome sought. We used electronic databases more than once and we developed search strategies. The exclusion and inclusion criteria were clearly defined. While the weakness of this EBCR is that the search was not comprehensive, where the search did not include gray articles or unpublished articles. Moreover, this EBCR only appraises articles regarding workers exposed to fluoroscopy whereas exposure to low-dose radiation in health care may be acquired from CT, angiography, X-rays, and other intervention procedures.

To seek the causal relationship in a study, in this matter, between occupational exposure and outcome, researchers have to know the period of the outcome. Hence, it is appropriate to use the Cox proportional hazard analysis method in this study. The conclusion of this article appraisal showed that the article was not applicable to the case patient due to its unimportance, even though it has a similar population to the case patient, who is a radiology worker and assists with fluoroscopy interventions. However, low-dose ionizing radiation exposure in hospitals does not only come from fluoroscopy but also from other sources such as x-ray, CT, angiography, and interventional procedures.

Conclusion

The single article found for this EBCR showed that there is no causal relationship between low-dose ionizing radiation exposure with the cause of hypertension among radiology workers. Even though it did not apply to the patient's case due to its unimportance, the radiology personnel is still recommended to comply with the provisions of working with radiation exposure, that is, to wear PPE and a personal dose monitoring device. Further research is advised, to measure the amount of exposure objectively by using data on the amount of exposure from individual dose monitoring devices, such as TLD (thermoluminescent dosimeter).

Further research is recommended to measure the amount of exposure objectively by using data on the amount of exposure from individual dose monitoring equipment, such as TLD (thermoluminescent dosimeter). These data should be interpreted and read by accredited agencies appointed by the Regulatory Federal. Furthermore, it is important to ensure the compliance of radiology workers to always wear TLD while working. Another recommendation related to the method of outcome measurement is to include the measurement of blood pressure by the physician and to include other circulation diseases such as stroke, ischemic heart disease, and myocardial infarction.

Declaration

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