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Darkroom Chemicals – Associated Darkroom Diseases (Dd)

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ABSTRACT:
In spite of various advancements in computerised imaging radiography, the usual radiological methods abide manual processing techniques and most of the radiographs are recorded in films resulting in exposure to hazardous chemicals [1]. Darkroom assistants and technicians are continuously being exposed to toxic x-ray processing chemicals on a routine basis [2,3]. These image processing chemicals has chemical irritants which can cause some diseases to the individuals handling it. These processing chemicals are known to produce or aggravate symptoms like headache, asthma, skin itching, sore throat, nasal irritation, breathing difficulties, cough and pharyngeal irritation in exposed individuals [5]. These indications are primary diverse symptoms that are collectively termed as Darkroom Diseases (DD). Health care professionals and students should be aware of the chemical hazards and advised to take precautions during the X-ray films processing. Many studies have been conducted to evaluate the awareness about the incidence of darkroom diseases and darkroom chemicals. The green recommendations include installation of digital radiograph as an alternative to the conventional film-based X-rays. By focusing more on prevention, precaution and creating awareness, that can significantly contribute to improving the health of the workers, the community, and the environment.

INTRODUCTION :

Radiology is described as the branch of medicine that deals with the use of electro magnetic radiation spectrum (such as X-rays) or radioactive material in the investigation and treatment of disease and Radiography is described as “the art, act, or process of making radiographs” (X-rays or gamma ray photographs). A darkroom in radiology is a room mainly designed for the x-ray film development.

Inspite of various advancements in computerised imaging radiography, the usual radiological methods abides manual processing techniques and most of the radiographs are recorded in films [1] results in exposure to hazardous chemicals.

Due to the increased production and usage of chemicals in the work environment globally, there is a risk associated with hazardous chemical exposures that are detrimental to the healthcare individuals. The current trend also paves the way for growing occupational hazards related to toxic chemical usage [2,5].

Darkroom assistants and technicians are continuously being exposed to toxic x-ray processing chemicals on a routine basis [2,3]. These image processing chemicals has chemical irritants which can cause some diseases to the individuals handling it. These processing chemicals

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tend to alter latent images obtained to visible images on radiographic films [3] .

The emulsion coated on the radiographic films contains silver halide crystals are converted to silver ions and metallic silver by these chemicals. The vital contents of these processing chemicals are the developer and the fixer, that can be either present in the powdered or liquid form [4,20]. They contain hydroquinone, glycols, sulphur dioxide, glutaraldehyde, ammonium chloride, formaldehyde and acetic acid. These processing chemicals are known to produce or aggravate symptoms like headache, asthma, skin itching, sore throat, nasal irritation, breathing difficulties, cough and pharyngeal irritation in exposed individuals [5]. These indications are primary diverse symptoms that are collectively termed as Darkroom Diseases (DD). The darkroom diseases include eye irritation, nausea, cough, nasal discharge, contact dermatitis and headache .

DEVELOPER SOLUTION [11] :

The solution consisting hydroquinone and phenidone (Metol) is used to develop latent images to visible images in the darkroom is known as developer solution. For high contrast, Hydroquinone is used and for low contrast, Metol is used. During radiographic film processing, the developer is a reducing agent getting oxidized, thereby minimizing the amount of the exposed silver leading to the formation of metallic silver (black in colour). The optimal pH of 10-11 is required for proper developing of the films and for this pH to remain balanced in the developer solution an alkali is used.

Sodium sulphite, on the other hand reduces the oxidation rate of the developer, thereby acting as preservative and also aids in increasing the developer's lifetime by dissolving its contents into sulfonates. Fog formation during processing process is prevented by using a restrainer, potassium bromide by its action on unexposed silver particles. The optimum temperature for developing process is 20-22^{o}C. At low temperatures it is advised to increase the developing time to improve the image quality and vice versa. The developing time is approximately 5 minutes at 29 ^{o}C, when done manually. In case of automatic film processing, these parameters are taken care of by the processor and thus the better image quality is obtained. It is followed by rinsing in water (for about 30 seconds) to remove the excess chemicals before the film being fixed.

FIXING SOLUTION [23] :

The fixing solution comprises of a fixing agent, harderner (potassium alum) and acidifier (sulphuric / acetic acid) .The fixer is usually sodium or ammonium thiosulphate that forms the image from the reduced metallic silver. Preservative used for thiosulphate is an alkali hydrogen sulfite (bisulfite).

After the fixing procedure, the film becomes unaffected by light. Subsequently, the film is washed under running water and dried. Washing is crucial to extract the exhausted chemicals from the film or it may lead to image deterioration.

FILM PROCESSING [12] **:**

It is multistep procedure where a latent image on a film is converted into a visible radiograph. It has four major steps: development, fixing, washing, and drying.

Process:

After the film being exposed to radiation, the latent image is formed on the film that undergoes chemical development. The main aim of developing the film is bring the visible image from the formed latent image. By using all these processing chemicals, the exposed film gets converted into an ideal radiograph. These solutions play a vital role in image processing technique for better image quality and shelf -life.

Film Developing process:

1. The first step in getting a visible image from the latent image is to expose the film to the developer solution. The process of developing the film is a manifold process. The chemical present within the developer solution reduces the exposed silver bromide crystals to black metallic silver. Firstly, the developer should penetrate the protective coating of the film to convert silver halide crystals into metallic silver. The developer solution is

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formed by combining chemicals such as alkali and metol or hydroquinone that are mixed with water. The alkali reduces the exposed silver bromide crystals to black metallic oxide by penetrating the protective coat present in the film.

2. The next step is the **stop bath** and it is made up of a glacial acetic acid and water. The prime function of the stop bath is to rapidly neutralize any extra formation of the silver crystals as it may make the images practically impossible to interpret.
3. The third step involved is the **fixing** of the image on the film, similar to the developing it is also a diverse process. The fixer primarily removes any unexposed silver crystals and then hardens the leftover silver crystals into the emulsion. This procedure makes the image for longer shelf- life period.
4. The final step is where the film is rinsed in water and dried and it is ready for visual examination.

DARKROOM DISEASES:

Medical/dental imaging technology uses a wide range of chemicals in the name of developer and fixing solutions, disinfectants and germicides. These processing solutions are primarily the developers and the fixers. These chemicals are present in the form of powder or liquid. They include glutaraldehyde, hydroquinone, formaldehyde, glycols, sulphur dioxide, ammonium chloride and acetic acid [20,7]. These chemicals are believed to cause some occupational related pathologies in exposed individual [3,6]. Improper ventilation, vulnerable methodologies and lesser awareness about these occupational hazards may contribute to many dermatological as well as respiratory diseases.

Health care professionals and students should be aware of the chemical hazards and advised to take precautions during the X-ray films processing. Many studies have been conducted to evaluate the awareness about the incidence of darkroom diseases and darkroom chemicals.

A similar study in Nigeria concluded that about 37% of the study population had knowledge about the darkroom chemicals while 68% of individuals had a past medical history of darkroom diseases [9].

Liss GM et al [10] reported that after seven years of exposure to these harmful chemicals, their darkroom technicians had suffered from chronic bronchitis and chronic asthma. Hewitt P.J in 1993 in a comparative study revealed that 39.4% of his radiographers had experienced symptoms such as headache, eye irritation, fatigue as well as sore throat [26]. A similar study had pointed out that the most notable symptoms suffered by the radiographers was ranging from headache (75.8%), followed by throat irritation (69%), rhinitis (63%) fatigue (65.5%) [24].

Darkroom disease (DD) is a phenomenon used to explain the chemical irritants or allergic reactions caused due to exposure to the toxic chemicals during processing of the film in the darkroom [14]. Darkroom technicians (DTs) are exposed to large amounts of glutaraldehyde, acetic acid, sulphur dioxide and formaldehyde in general. The important chemical involved in instigating an allergic response is the glutaraldehyde [14]. Darkroom disease has categorized as a type of multiple-chemical sensitivity. These chemical solutions enter the body through skin contact, inhalation into lungs or by ingestion [14]. Darkroom technicians are at higher risk as they can be exposed to all these chemicals when they are involved in routine film processing techniques or by cleaning of the internal parts of the film processing tanks or by inhaling the toxic vapours from the processing chemicals [15].

Ward [16] concluded a more of DD signs in a group of radiographers compared to a similar group of physiotherapists in Columbia. This finding was supported by Leacy's [17] study at two Dublin Hospitals. In a similar way, Smedley and Inskip stated that there was an excessive work related symptoms among the radiographers compared to a sample of physiotherapists [18].

The existing literature points out a gap in the reporting of incidence rates of Darkroom Diseases (DD) among the darkroom technicians. On analysing the prevalence rates of darkroom disease reported (ranging between 1.2% and 6.4%), the main focus is directed towards the radiographers regarding their knowledge

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about the precautions and preventions related to darkroom diseases [16,10].

Although both darkroom technicians and radiographers are radiology workers, the job nature of the darkroom technician demands more working time compared to other radiology workers in the darkroom in close association to the toxic disease-causing chemicals [18]. The mechanism of causation has not been completely articulated, processing chemicals such as glutaraldehyde and the fumes coming from them have been related to darkroom disease. Calder *et al* [19] reported a dose response association between exposure to glutaraldehyde and the existence of symptoms of DD.

Spicer [14] in his study identified fifteen common symptoms that comprises DD. These 15 symptoms structured the basis of his study, but it has to be emphasized that this list of symptoms is by no means exhaustive. This includes headaches, skin rashes sore-throats, unexplained fatigue, breathing problems, nausea, oral ulcers, sore eyes, painful joints, dermatitis, catarrh, arrhythmia, metallic taste, tinnitus, itchy nose and sneezing. The incidence of physician diagnosed health problems including asthma, ocular problems, nasal and sinus problems and chemical sensitivity [15].

Headaches and Metallic taste (90%) were the most commonly mentioned symptoms and they significantly worsened during working hours. These symptoms are connected to the usage of digital processing machines. It is also presumed that the workplace has to be culpable. For radiographers who process nearly 50 films a day and work approximately for 30 hour in a week have said to have increased darkroom symptoms [16] .

The existence of the darkroom disease phenomenon should be made aware among the darkroom radiographers and darkroom technicians as they are vital for these reasons. Firstly, the workers being more aware are they are more likely to take steps to minimise their chemical exposure. Secondly, when the workers are more conscious of the symptoms, they tend to report these symptoms in a better way. As a result of minimal awareness about the DD phenomenon, these darkroom workers are unknowingly exposing themselves to these toxic chemicals.

Darkroom disease is a man-made entity; and unlike other conditions where human force has control making it more preventable. The significant part of prevention strategy is the conscious monitoring for the presence of harmful chemical fumes. In a survey conducted by Teschke et al [20] stated that glutaraldehyde vapours can cause problems even at lower concentrations.

Kavanaugh [21] concluded that using of local exhaust devices can reduce the air contamination in the darkroom as they capture the airborne contaminants before entering the environment by incorporating high emission outlets. Regular monitoring can aid to bring limited exposure among darkroom technicians and take them further to a greater alertness level of the DD. Simple steps like behavioural modification and lesser exposure prone habits can also help these workers. In a bigger picture, the government along with occupational health and safety are advised to conduct well organized industrial hygiene surveys planned to demonstrate the darkroom conditions under which these darkroom technicians work.

Darkroom disorder associated deaths have additionally been pronounced. A living proof is the extensively suggested death of American Radiologist Robert Zach [22] . Excessive incidence of DD also has a long way fetching felony ramifications for the enterprise. Many countries have legislative frameworks that regulate the usage of hazardous materials. Similarly in Zimbabwe they have the Hazardous Substances Control Act in place to monitor this usage. Within the United States, the country wide Institute for Occupational Safety and Health has advocated exposure limit of 0.2 components consistent with million parts for glutaraldehyde vapour [22].

India Chemical Management and Safety Rules (CMSR) 2022, this regulation will replace two existing rules in India – Manufacture, Storage and Import of Hazardous Chemical Rules, 1989, and the Chemical Accidents (Emergency Planning, Preparedness and Response) Rules, 1996 relating to chemical substances handling.

Majority of the imaging darkrooms tend to be constricted and badly ventilated contributing to spread of

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darkroom diseases such as eye irritation, cough, nasal discharge, contact dermatitis and nausea. Many effective solutions for the prevention and control of these occupational hazards are currently available. In the Indian Health services, it has been observed that the professional personnel are advised to use the clinical laboratory coats and latex examination gloves as personal protective equipment (PPE), while operating in the darkroom. However, this could be insufficient to prevent dermal contact with chemical compounds. The sort of PPE will depend upon the form of processor being used. This task demands to include a respirator, goggles, plastic apron and gloves that can withstand chemical spillage.

The efficient way of reducing toxic chemical exposure in x-ray processing includes proper installation of the ventilation systems and equipment in the right place in the darkroom. In few instances, the physicians can specify the different chemicals and their way of exposure so that it can be eliminated [13]. The environmental investigation should concentrate on appropriate design and problems related to equipment installation. Regular monitoring is needed to evaluate the type of chemicals used, mechanical ventilation, the volume of exhausted air and waste disposal location in the darkroom premises for better and safe functioning . It is also crucial that chemical wastes must be cleaned cautiously and rapidly.

The darkroom ventilation should meet the standard guidelines of a minimum rate of 10 ACH (air changes per hour), calculated as air exhausted [25]. Installing an auto mixer is a better option to reduce skin and respiratory exposure seen in manual method of mixing of the chemicals.

A better operating environment can be designed to reduce the chemical exposure. OSHA's Hazard Communication Standard can be introduced for implementation in all the radiology departments. It can be made mandatory for the staffs to have a thorough knowledge regarding the details of Material Safety Data Sheets for processing the chemicals and possible occupational hazards.

The viability of indicating a processor having a glutaraldehyde-free fixer can be taken into account as it may eliminate one harmful chemical causing sensitization. But this would be a real challenge as it is a novel technology involves the purchase of a uniquely structured digital processing equipment and may not be desirable for all single emulsion films.

CONCLUSION :

The green recommendations include installation of digital radiograph as an alternative to the conventional film-based X-rays. If the usage of traditional X rays is carried out then, recycling of these chemical solutions (fixer and developer) sounds to be a better option. It is therefore recommended for us to go green and save our planet Earth from all the man-made biohazards for a desirable place to live in the promising future. By focusing more on prevention, precaution and creating awareness, that can significantly contribute to improving the health of the workers, the community, and the environment.

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