Quantifying entrance skin dose for early diagnose of lung cancer

A Latif, S Suryani* and B Abdullah

Department of physics, Hasanuddin University, Makassar, 90245 Indonesia
*tamalanreah3@gmail.com

Abstract. Lung cancer is disease that can cause death in a short time, but it is almost never detected at an early stage, because its symptoms are not specific, such as coughing and lack of appetite. In some patients who have a smoking habit, it is easier to be suspected of having a tumor or lung cancer. In order to detect a tumor or lung cancer, a chest X-ray examination is generally done as an early diagnosis. As we have already known, exposure of X-ray radiation to the body can have a negative impact, therefore the dose of X-ray radiation exposure must be minimized. In this study a measurement of entrance skin dose (ESD) was performed on chest X-ray examination in patients suspected of having a tumor or lung cancer. The results showed that patients who had symptoms similar to those of tumor or lung cancer had higher ESD than those who did not. Although the radiation dose is higher than dose on routine chest X-ray examination, it only shows abnormality of radiological photographic but do not accurately indicate the presence of tumor or cancer.

1. Introductions

Chest is a part of the human body that is often used as a place of examination to find out any disturbances or diseases in the human body. The flat shape of chest makes it easy to place the tool or detector. Furthermore, in the chest cavity there are only two organs, the heart and lungs compare to abdomen which is more complex.

Of the two organs in the chest cavity, the lungs receive more attention than the heart, because the lungs are part of the respiratory system that is directly related to the outside environment. Lungs receive oxygen from outside the body through inhalation. During the process of entering oxygen can be followed by bacteria and viruses that will disrupt the body. That is why disorders of the respiratory system are often associated with diseases, for example coughing and difficulty breathing are often associated with the presence of Tuberculosis (TB) bacteria.

One way to find out if there is a problem with lungs is through chest X-ray examination. The results of abnormal radiological photographs of chest X-ray examinations can describe the presence of abscesses in the lungs, fluid (blood or other) in the lungs which show pleural effusion or pulmonary edema, enlarged heart or cardiomegaly [1], cavities in the lungs indicate tuberculosis [2,3], widening of the aorta or aortic aneurysm, fractures, even lung tumors [4,5,6]. Chest X-ray examination is an easy examination and as we described above, it can detect any disturbances and infections. Therefore this examination is preliminary and routine examination performed on healthy patients (only for medical check-ups) and sick patients who suffer from cough (normal or coughing up blood), chest pain, and difficulty breathing. This is due to this simple and inexpensive examination [7,8].
Especially the presence of lung tumors, in radiological photograph is indicated by the presence of irregular and abnormal shadows in the lung area. The image formed is only a shadow because the ability of the material to absorb X-ray radiation depends on the density of the material. For example the dense bone will produce white, while lungs which is less dense will appear black (Figure 1a), while the blood fluid in the lungs due to infection and water will look the same, that is gray. Therefore, in chest X-ray photos, the doctor will only look for gray and shadowy masses. Because of lung tumors are only obscure or unclear images (Figure 1b), lung tumors in X-ray examination can only be detected if tumor diameter at least 2.5 cm or in stage T1b [9,10]. That’s why, chest X-ray examination cannot detect lung tumors at an early stage. Moreover, the certainty of a tumor or lung cancer cannot be done simply by using a chest X-ray examination, because the result of the radiological photograph only shows the presence of a mass. So, to determine whether the mass is a tumor or cancer, further testing is needed, such as a biopsy.

Figure 1. X-ray radiological photographs of (a) healthy patient (b) sick patient suspected of having lung tumor.
In this study, entrance skin dose (ESD) measurements were performed on patients who had chest X-ray examinations with suspected lung tumors as an initial diagnosis. These patients experience chest pain, coughing, and difficulty breathing. As a comparison, we also measured entrance skin dose (ESD) for healthy patients who performed medical check-ups.

2. Material and Method
The research was conducted in The Radiology Department – Teaching Hospital of Hasanuddin University Makassar Indonesia. Samples were patients who experience chest pain, coughing, and difficulty breathing and healthy patients who performed medical check-ups. Supporting data, such as body weight, height, and age of the patient were taken from the patient’s medical record. Radiological photographs were taken using Siemens Digital Radiography.

Entrance skin dose is calculated using the equation below [11,12]:

\[ ESD = IN \times AK \times mAs \times \left( \frac{100}{FSD} \right)^2 \times BSF \]  

(1)

where a focus skin to dose (FSD) value of 130 cm for the position of chest X-ray examination of posterior to anterior (PA), backscattering factor (BSF) equals 1.4 [12,13], and the incident air kerma (IN AK) value is calculated using the equation below:

\[ IN \times AK \left( \frac{\mu mGy}{mAs} \right) @ 100cm = a \times kVp^b \]  

(2)

where values of a and b are taken from the constant values in the graph of specific yield of the X-ray tube at a distance of 100 cm (Figure 2).

\[ \text{Figure 2. Graph of specific yield of the X-ray tube at a distance of 100 cm.} \]

2.1 Result and Discussion
Medical record data illustrates that the patients who are suspected of having lung tumors mostly have a productive age with the body mass index in underweight category. This is in accordance with the symptoms of a tumor or lung cancer are chest pain, chronic cough, difficulty breathing, smoking more than 10 packs a day, and lack of appetite which results in weight loss [14]. Whereas in patients who have a body mass index in the normal category have older age. They don’t have specific symptoms, but they are only suffering from cough and chest pain (table 1).
### Table 1. Characteristics samples.

| Body mass index | Percentage (%) | Age Group | Percentage (%) |
|-----------------|----------------|-----------|----------------|
| 15 – 18.4       | 57             | 20 - 40   | 52             |
| 18.5 – 20       | 43             | 41 - 70   | 48             |

Figure 3 shows the entrance skin dose (ESD) in for patient with the lowest body mass index was 0.092 mGy, and the highest ESD value for patient with underweight category was 0.389 mGy, and an average value of ESD was 0.202 mGy. While the ESD for patient in the lowest normal body mass index category was 0.129 mGy and the highest was 0.285 mGy with an average of 0.187 mGy. The ESD for these two groups of patients was still lower than the ESD limit value sets by Indonesia Nuclear Energy Regulator Agency (INERA) for the position of the posterior to anterior (PA) which is 1.500 mGy [15].

![Figure 3](image_url)

**Figure 3.** Entrance skin dose value as a function of body mass index.

These data show that radiation doses received by patients with underweight category are higher than those of normal weight patients. The reason for the difference in ESD value is on the purpose of the chest X-ray examination. Patients with normal body mass index category do the chest X-ray examinations just to know the condition of their lungs or they don’t have specific things to know [5], so low radiation doses are used. On the other side, patients with underweight category usually have specific history such as smoking and chest pain, so the purpose of the chest X-ray examination is to know the presence of specific things, such as the presence of mass, cavity, or fluid. Therefore, higher radiation dose is needed to be used, in order to have good image quality.

### 3. Conclusions.

Chest X-ray examination is a routine examination used to support the diagnosis of disorders or diseases in the chest, especially the lungs and heart. In some cases, chest X-ray examination can detect the presence of lung tumors or cancer, although it is difficult to know the size of the tumors or cancer, because lung tumors or cancer in radiological photographs are only in the form of shadow masses. So, for the case of lung cancer where the development of cancer cells is very fast, chest X-ray examination is not good, although, high radiation doses are used to have more clear image. This thing can be seen
from ESD in patients with suspected of having lung tumor is higher than ESD in normal patients. Therefore, further examination such as CT scan or biopsy is recommended.

References
[1] R Singh, M K Karla, C Nitiwarangkul, J A Patti, F Homoyaunieh, A Padole, et al. 2018 *PloS ONE* **13** (10) 1
[2] Hashmi S, Bahman P 2002 *Arch. Surg.* **137** (10) 1193
[3] Bhalia A S, Goyal A, Guleria R, Gupta A K 2015 *Indian J Radiol Imaging* **25** (3) 213
[4] Kelly B 2012 *Ulster Med.* **81** (3) 143
[5] Gossner J 2014 *World J. Radiol.* **6** (4) 116
[6] Neal R D, Barham A, Borngrd E, Edwards R T, Fitzgibbon J, et al. 2017 *Br. J. Cancer* **116** (3) 293
[7] De Hoop B, Schaefer-Prokop C, Gietema H A, de Jong P A, Bram van Ginneken, et al. 2010 *Radiology* **255** (2) 629
[8] Raoof S, Feigin D, Sung A, Raoof S, Irugulpati L, Rosenow III E C 2012 *CHEST* **141** (2) 545
[9] Del Ciello A, Franchi P, Contegiacomo A, Chicchetti G, Bonomo L, Larici A R 2017 *Diagn. Interv. Radiol.* **23** (2) 118
[10] Carson J 2011 *Semin Rontgenol* **46** (3) 187
[11] Kofi O, Gordon S W, Akrobortu E, Ampene A A, Darko E O 2014 *Journal of Radiation Research and Applied Sciences* **7** (4) 459
[12] Rasuli B, Pashazadeh A M, Ghorbani M, Juybari R T, Naserpour M 2016 *J Appl Clin Med Phys* **17** (1) 374
[13] Sharma R, Sharma S D, Pawar S, Chaubey A, Kantharia S, Babu D A R 2015 *J Med Phys* **40** (1) 29
[14] Hammerschmidt S, Wirtz H 2009 *Dtsch. Arztebl. Int.* **106** (49) 809
[15] Indonesia Nuclear Energy Regulator (INERA) 2003 no. 01-p/ka-bapeten/i-03/2003