Recognizing Intrapulmonary Lymph Node (IPLN) and Lymph Node in Soft Tissue Image from Low Dose Computed Tomography (LDCT) and Standard Dose Computed Tomography (SDCT): Study Using CIRS Phantom

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Abstract. Low Dose Computed Tomography (LDCT) is well-known for lung screening which administers low dose on the patient. In screening, intrapulmonary lymph node (IPLN) and lymph node in mediastinum (soft tissue) need special attention. In this research, nodule simulations with 36-85 Hounsfield units (HU) were made. IPLN was embedded inside lung simulation medium that was shaped as the module for 002LFC CIRS Thorax Phantom. The same method was also used for lymph node that was embedded in the soft tissue area. Image acquisition was conducted using LDCT and SDCT (Standard Dose Computed Tomography) methods with 100 kV and 120 kV exposure condition. The variations for mAs were 11, 25, 30, and 50 for LDCT and 70, 80, 90, 100 for SDCT. The result showed that IPLN image could be detected using LDCT method at 100 kV. Meanwhile, lymph node in soft tissue was not easily detected using LDCT because the noise in LDCT was relatively higher than in SDCT.

1. Introduction

Cancer is the world’s second biggest death cause, about 9.6 million deaths with 1 out of 6 deaths caused by cancer. GLOBOCAN reported that lung cancer is the first cause among the other cancers. Based on the data of GLOBOCAN in 2018, there were 2.09 million of lung cancer cases in the world and 1.76 million died from it in 2018 [1]. The percentage of death by lung cancer in 2018 occurred more often to men than women. For incidence, there were 14.5% of 9.5 million cases (men) and 8.4% of 8.6 million cases (women). For mortality, there were 22% of 5.4 million deaths (men) and 13.8% of 4.2 million deaths (women). For women, the biggest cancer of incidence is breast cancer and then followed by colorectal and lung cancers. One of the most commonly known cancer causes is tobacco or cigarette [2].

In order to detect lung cancer early, one has to undergo a screening examination. National Lung Screening Trial (NLST) mentioned that screening with Low Dose Computed Tomography (LDCT) is better than Chest X-Ray. Based on NLST data in 2009, LCDT screening test showed 20% mortality decrease caused by lung cancer [3]. NLST conducted a research which involved 53,454 participants who had high risk of lung cancer in 33 hospitals in the United States of America. This research involved 26,722 participants using LDCT and 26,732 participants using Chest X-Ray.
LDCT detects lung nodule by administering low dose to the patients by following the concept of as low as reasonable achievable (ALARA) \[4\]. Therefore, LDCT is relatively more suitable in detecting nodule, additionally because of the high contrast between the air and lung nodule \[5\].

Lung nodule has various types; one of them is intrapulmonary lymph node (IPLN) that is found in lymphatic subpleural and has 36-85 HU \[6\]. According to Matsuki et al (2013), the shapes of IPLN vary, such as round, oval, and lobulated with varied size ranging from 4-15 mm. The previous research by Shaham et al (2009) found IPLN nodules in round, oval, triangle, and trapezium shapes and all of them were found under the carina, with 3.5 – 8.5 mm in size \[7\]. IPLN size enlargement may occur due to various diseases, such as inhalation problem like in anthracosis and silicosis \[6\].

This research aimed to analyse the effect of kV and mAs on LDCT and SDCT in detecting IPLN and lymph node in mediastinum (soft tissue). SDCT was a method commonly used in hospitals where the research. Comparing LDCT and SDCT aimed to observe whether IPLN and lymph node in soft tissue can still be detected by using the doses lower than standard dose. Image acquisition used 100 and 120 kV, for LDCT used 11, 25, 30, 50 mAs and SCDT used 70, 80, 90, 100 mAs.

2. Material and Method

In this research, IPLN simulations were made in-house with the material mixture of wax and rice flour in round shape of 8.5 mm diameter. IPLN materials were made in variations with wax weight percentage at 60% and 55%, which were then labelled I and II respectively. The average value of CT on IPLN I and II simulations respectively were 62.53 ± 18.73 HU and 80.04 ± 20.62 HU in 120 kV. Then, IPLN samples were then embedded inside a cork cylinder with 2.5 cm diameter and 16 cm length (Figure 1). Cork cylinder was shaped in accordance with the module on 002LFC CIRS thorax phantom (Figure 2). With the same method, cylinder module with material mixture of 80% paraffin and 20% rice flour was made as the simulation for soft tissue 27 ± 11.39 HU in which was also embedded a lymph node with 62.53 ± 18.73 HU in 120 kV.

Image acquisition was conducted using Philips 128 slices multi-detector computed tomography (MDCT) owned by the Central General Hospital of Cibinong. The exposure conditions were 100 kV and 120 kV with 11, 25, 30, 50 mAs for LDCT and 70, 80, 90, 100 mAs for SDCT. The other parameters used were 0.8 pitch and 1 mm slice thickness. The reconstruction used Y-Detailed (YB) algorithm with lung window standard, 1600 HU window width and -600 HU window level.

For SNR measurement, CT images were saved in DICOM format using RadiAnt software, and then imported to Image J to make the Region of Interest (ROI) with 4.026 mm² size. The SNR value was calculated by this following equation:

\[
SNR = \frac{|N_B-N_O|}{\sqrt{SD_B^2+SD_O^2}} \tag{1}
\]

\(N_B\) is the pixel mean value of the sample’s background, \(N_O\) is the pixel mean value of the IPLN object, \(SD_B\) and \(SD_O\) are the standard deviation of the respective pixels: cork background and IPLN object \[8\].

![Figure 1. IPLN simulation embedded into cork](image1)

![Figure 2. Module inserted into 002LFC CIRS Thorax Phantom](image2)
3. Result and Discussion

3.1. IPLN

The images of IPLN I and II with LDCT and SDCT can be seen in Figure 3. Visually, using LDCT and SDCT in 100 kV and 120 kV, both IPLN could be observed clearly. It showed that IPLN could be detected using LDCT under exposure condition of 100 kV.

SNR values for mAs variations of LDCT and SDCT for both exposures can be seen in Figure 4. The mean value of SNR on LDCT and SDCT increased with the improvement in mAs value [9]. For 100 kV on LDCT, SNR values on IPLN I and II were nearly the same. Meanwhile for SDCT, SNR on IPLN II was relatively higher than on IPLN I, although the difference was relatively low, which was around 2.4. This showed that for LDCT with 100 kV, change in mass did not have any effect towards the SNR. For SDCT, change in mass seemed to have an effect.

With 120 kV exposures for LDCT, IPLN mass started to affect SNR value. The SNR value of IPLN II was relatively higher. Similar difference occurred to SDCT as well. The SNR values of IPLN I and II using LDCT method with 11 mAs was different around 2.3, and the same difference occurred to SDCT with 100 mAs. Apparently, exposure condition of 120 kV was able to distinguish the IPLN’s mass change clearly, both for LDCT and SDCT. This finding added new information to the result of previous researches [6] [10] [11] which stated that IPLN could be detected using 120 kV but only through SDCT method. However, a subsequent study is required to estimate the dose level of both methods in order to further suggest which method might be clinically preferable.

![Figure 3](image_url)

**Figure 3.** The image of IPLN I (left) and II (right) with various exposure conditions (a) LDCT and (b) SDCT
3.2. Lymph Node in Soft Tissue

The image of lymph node in soft tissue can be seen in Figure 5. High noise can be seen on the image using LDCT method with 100 kV for all mAs values (11, 25, 30, and 50 mAs), while for 120 kV, the noise was lower and the nodule image could be noticed in 30 mAs. For SDCT, both in 100 and 120 kV, the noise was lower and the nodule image can be easily seen. Even so, the noise with 100 kV was still relatively higher.

Figure 6 showed the correlation between SNR value of lymph node in soft tissue with mAs for LDCT and SDCT methods. The SNR value of lymph node in soft tissue was much lower compared to the IPLN. Initially, the graph of LDCT for 100 kV and 120 kV coincided and started to separate in 50 mAs, 0.6 SNR at 100 kV and 1.2 at 120 kV. In SDCT area, SNR value seemed constant, about 2, for 120 kV, and slowly increased for 100 kV which was the same with what happened to 120 kV (SNR= 2) for 100 mAs. Even so, lymph node in soft tissue was not easily detected using LDCT because the noise in LDCT is relatively higher than in SDCT, additionally density of lymph node is close to soft tissue. Funama’s study (2009) showed that LDCT is relatively more difficult to detect Ground Glass Opacity (GGO) nodules in tube currents 21 and 45 mAs with a voltage of 120 kV [12].

![Figure 4](image4.png)

**Figure 4.** SNR graph for IPLN I and II in 100 kV and 120 kV towards the variation of mAs for (a) LDCT with dotted line (- - - -) and (b) SDCT with full line (—)}
Figure 5. Lymph node in soft tissue’s images for (a) LDCT (b) SDCT

Figure 6. Graph of SNR in lymph node in soft tissue with 100 kV and 120 kV towards mAs variations for (a) LDCT with dotted line (- - -) and (b) SDCT with full line (——)
4. Conclusion
This research provides the information that IPLN can be detected using both LDCT and SDCT under the exposure conditions of 100 kV and 120 kV. Further study is required to calculate the dose levels of both methods for information on clinical relevant. Lymph node in soft tissue is not easily detected using LDCT because the noise in LDCT is relatively higher than in SDCT.

5. References
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