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Preliminary Microdosimetry Analysis of a BNCT Treatment for Liver Cancer Based on PHITS Code Simulation

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A B S T R A C T

Cancer is a disease characterized by the growth and spread of abnormal cells that are not controlled. Liver cancer is in second position (788,000 deaths) as the cause of death after lung cancer. In resolving this chalenge, the BNCT method can be a solution. Boron Neutron Capture Therapy (BNCT) is a therapeutic technique based on irradiation from neutrons to boron-borne cancer cells (for liver cancer using 10boronophenylalanine (10BPA)) by utilizing neutron capture interactions with Boron-10. This study aims to analyzed microdosimetry of a BNCT treatment for liver cancer in different concentration of boron using PHITS code.

1. INTRODUCTION

Cancer is a disease characterized by the growth and spread of abnormal cells that are not controlled (American Cancer Society, 2015). According to the World Health Organization (WHO) in 2015 some 8.8 million people died from cancer. The most common causes of cancer death are lung cancer, liver cancer, colorectal cancer, stomach cancer and breast cancer. Liver cancer is in second position (788,000 deaths) as the cause of death after lung cancer (WHO Media Center, 2017). With 700,000 more people diagnosed with liver cancer each year. The majority of patients with liver cancer are male (American Cancer Society, 2018). In Indonesia, out of the 103,100 men who die of cancer, 12.3% are deaths because of liver cancer which is the second rank after lung cancer by 2014 (WHO, 2014).

Liver cancer is a cancer that occurs in the liver which is a very heterogeneous disease. occurs in the liver. Primary liver cancer occurs in the liver called Primary Liver Cancer or Hepatocellular carsinoma. Secondary liver cancer is referred to as liver metastasis (Metastastic liver cancery) Liver cancer is caused by metastases from other organ cancers such as breast, colon and others. The causes of liver cancer are environmental or genetic susceptibility, morphological diversity and microenvironmental differences (Arzumanyan et al., 2013; Irhas et al., 2014; Tu et al., 2014).

Most patients are diagnosed with liver cancer by the time it reaches an advanced stage, this is because of difficulties in early diagnosis. Because rapid cancer development and lack of targeted drugs lead to very low survival rates of liver cancer (Fu, 2017).

Therapies already used to cure diseases, radiotherapy (protons, neutrons, gamma, electrons, x-rays), chemotherapy, brachytherapy, immunotherapy through increased immunity, and hormone therapy through drugs or surgery. The treatment still has a risk that should be damaged surrounding normal tissue and palliative care that only one generation of patients about 75 percent and patients will die after the prognosis. (Benjamin, 2014, Greten & Sangro, 2017; Priambodo, et al., 2017; Sharma et al., 2013; Susilowati & Sardjono, 2016). Research conducted on Therapeutic Appearance Boron Neutron (BNCT) for healing liver cancer.

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BNCT's nuclear applications have been developed by 56 countries including Indonesia (Bavarnegin, Kasesaz, & Wagner, 2017). For liver cancer itself was first used BNCT ie in 2001 in Pavia, Italy (Krstic et al., 2014). In addition to liver cancer some of the other cancers that have been studied for treatment with BNCT such as brain cancer (Khajeali et al., 2015), lung cancer (Razetti et al., 2014), oral cancer (Ozaki et al., 2017) cancer larynx (Haapaniemi et al., 2016), breast cancer (Gadan et al., 2015), skin cancer and other cancers.

Boron Neutron Capture Therapy (BNCT) is a therapeutic technique based on irradiation from neutrons to boron-borne cancer cells (for liver cancer using 10boronophenylalanine (10BPA)) by utilizing neutron capture interactions with Boron-10 (Ganjeh, 2013; Garabalino et al., 2014; Dragana Krstic et al., 2014). The reaction latitude with high thermal neutrons by Boron-10 when irradiated with thermal neutrons is a neutron catchment interaction which then produces Lithium-7 and alpha particles with 2.33 MeV energy. Alpha particles have a large linear energy transfer (LET) in the body and a very short alpha particle range of ± 5-9 μm whose doses are accepted by localized tissue (Nurwati & Prasetya, 2014). Both of these particles have a high LET and also a close proximity of about one cell diameter resulting in a lethal dose only on cancer cells or tumors (Kasesaz et al., 2014). This is known as a dose of boron, which is the main dose administered to tumor cells or cancer. In addition to the boron dose, other major dose components such as nitrogen doses, gamma doses, and neutron doses are considered in the calculation of BNCT dosimetry (Ziegner et al., 2014)

This study aims to calculate the microdosimetry of BNCT in liver cancer using the Particle Transportation and Ion Transport (PHITS) File System program by varying the concentration of boron. The PHTS code has been used for research related to BNCT (Kumada et al., 2015; Takada et al., 2014).

2. EXPERIMENTAL METHOD

In this study, patient of liver cancer was defined as ORNL MIRD phantom (Eckerman et al,. 1996) which is only used the part of body that was simulated in the PHITS code. The ORNL MIRD phantom has been used for BNCT-related research (Krstic et al., 2014). The outline of the phantom without skin made with the PHITS code in three dimensions shown in Fig. 1.

The Monte Carlo code PHITS version 2.81 was applied to calculate BNCT dosimetry and estimate the particle emissions from a beam line for clinical cases (Hashimoto et al., 2015; Ntoy & Sardjono, 2017).

This study used the beam source from the design of collimator in the radial piercing beam port of Kartini Reactor for BNCT (Ilma et al., 2014). It was operated at 100 kW. It have four source components, namely thermal neutron, epithermal neutron, fast neutron, and primary gamma-ray.

Types of material compositions for this research of liver cancer is skin, bone, liver, and the cancer cell. Cancer cell have a part too, namely, clinical target volume (CTV) included the gross tumor volume (GTV), planning target volume (PTV) around the CTV. All macroscopic tumors were included in the CTV, but no attempt was made to irradiate sub-clinical metastases (Kankaanranta et al., 2012).

The boron compound administration protocols were selected based on the previously reported boron biodistribution data. Absolute boron concentration in tumor >20 ppm, boron concentration ratio tumor/normal liver ≥ 1 (Pozzi et al., 2013). Therefore, the 10B concentration in the cancer target was reasonably taken as 47 and 8 ppm for the normal organs assuming that the 10B concentrations in normal tissue and in blood are the same. In experimental of rats, the top of boron-10 concentration occurs two hours after injection to the body (Irhas, Widi Harto, & Sardjono, 2014).

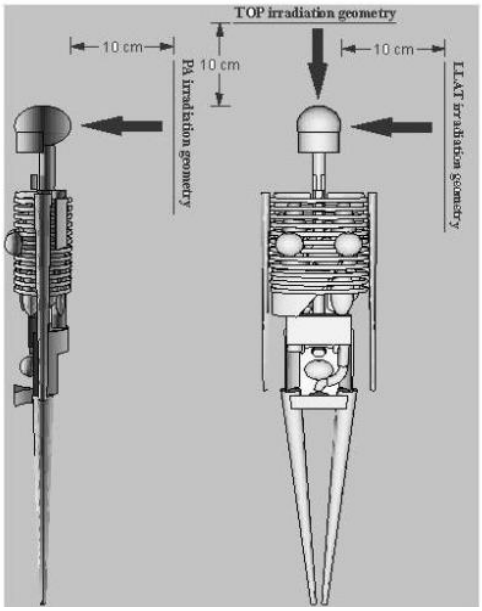

Fig 1.Outline and irradiation geometries of the ORNL MIRD phantom.

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3. RESULTS AND DISCUSSION

In this study, liver cancer located in right lobe which is have a diameter 3 cm. Geometry of the body inserted in PHITS program and setting the *tally* in PHITS by adjusting the geometri. Tally that used to looking for the geometri and it is also can see when it is shooted namely tally track (T-Track). The simulatian of this shot using PHITS Code can be seen in the Figure 2.

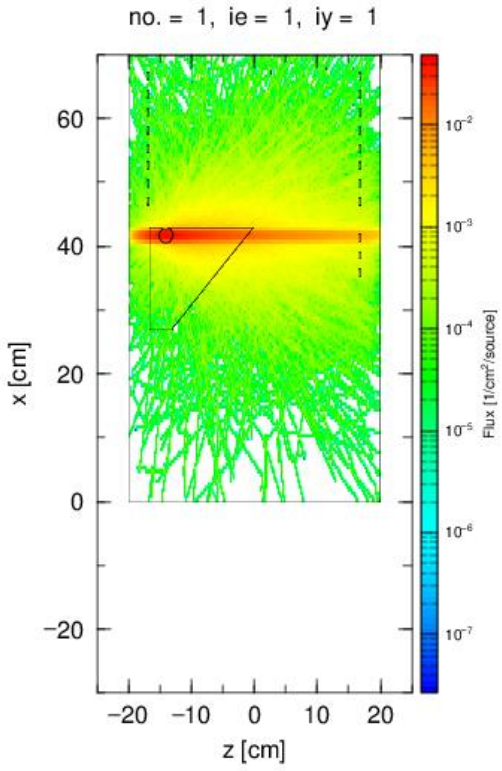

Fig 2. A liver Simulation Shot by a neutron using PHITS Code.

In PHITS program, to know the dose of proton, alpha, and neutron in the body when its shooted is used the *tally* deposit (T-Deposit).

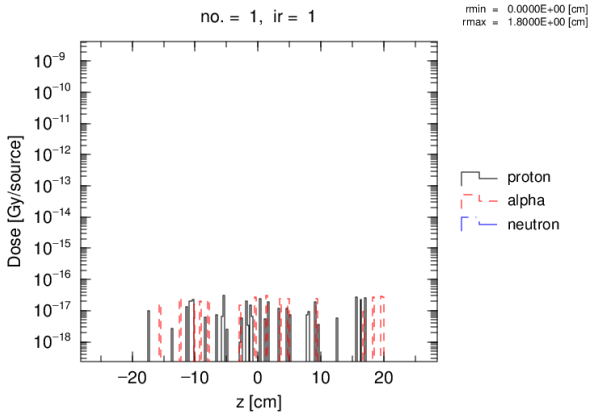

Fig 3. Energy Deposition in r-z mesh using PHITS Code.

According to the Figure 3 energy deposition in r-z mesh is still strange. The chart of the result is still many errors.

4. CONCLUSION

The research about microdosimetry analysis of a BNCT treatment for liver cancer based on PHITS code simulation still can not be concluded because still many errors with the coding.

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