

177\textsuperscript{Lu} Effect of Geometry Factors in Radionuclide Calibrator

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Abstract. The accuracy of radiopharmaceutical activity which will be administered to the patients is very important in nuclear medicine, especially in the case of therapeutic procedure. Hence, all safety aspects should be considered, including the standardization of the dose calibrator. From the reference, the accuracy of dose calibrator is influenced by various factors, such as the geometrical factors of the syringes or vials. The aim of this work was to investigate the effect of different container such as syringes and vials on the accuracy of dose calibrator. The initial work was done by preparing 5 cc glass ampoule and 1 cc syringes containing 177\textsuperscript{Lu}. Both samples was measured using the Capintec CRC 7-BT dose calibrator. The ampoule and syringe activity was measured at the base of the chamber and 5 cm above the base of the chamber, respectively. The result shows that the correction factor was 2.5 % for the syringe and 1.03 % for the ampoule. The correction factor should be considered when the dose calibrator will be used for measuring the administered to the patient to get more accurate activity measurement and patient safety.

1. Introduction
The accuracy of radiopharmaceutical activity which will be administered to the patients is very important in nuclear medicine, especially in the case of the therapeutic procedure. Recently, there are some growing needs to use 177\textsuperscript{Lu} in Indonesia for cancer treatment. 177\textsuperscript{Lu} is an isotope that decays by emitting beta (79.3 %) and gamma with the energy of 208.4 KeV (10.3 %) and 112.9 KeV (7.2 %) to 177\textsuperscript{Hf}, as shown in Figure 1. [1]. These 177\textsuperscript{Lu} properties are very suitable in radionuclide therapy and imaging with planar gamma camera or SPECT techniques [2].
Accurate measurement of activity before administration is one of several important processes needed to ensure that patients receive the correct radiopharmaceutical dose [3]. Measured activity depends on intrinsic and extrinsic factors. Intrinsic factors such as spatial geometry, device calibration, and electronic responses. extrinsic factors such as location and source geometry where the activity is being measured and its emission spectrum [4]. The source geometry factor must be considered especially in low-energy isotopes. Numerous studies on the effects of geometry on measurements using dose calibrator have been carried out, such as application of measurements of quasi-point source activity curves for accurate correction of $^{99m}$Tc activity in several syringes, and compared with theoretical geometric efficiency models [4]. M. Bauwens et al. examined the accuracy of four different radionuclides calibrators for the measurement of $^{99m}$Tc, $^{111}$In, $^{68}$Ga and $^{18}$F in various vials and syringes used clinically [5]. A. Ceccatelli et al. use the UK(NPL) approach to determine the specific calibration factor of dose calibrator used commercially which no data in the literature, with traceability to national standards for different types of glass vials, solid capsules and plastic syringes using three radionuclides $^{99m}$Tc, $^{111}$In and $^{131}$I [6].

Dose calibrator is a relative counter system that requires a standard source and must be calibrated before use. To get the right activity measurement results, activity measurements are should in the same conditions as the calibration time conditions. However, there are often differences in the geometry of the container during calibration with the container used clinically. This difference will increase the measurement error and will result in inaccurate radiopharmaceutical measurement results. This study aims to determine the influence of the geometry of 1 cc syringe and 5 cc ampoules on $^{177}$Lu activity measurements.

2. Materials and Methods

2.1. $^{177}$Lu samples preparation
The $^{177}$Lu master solution in chemical composition $^{177}$LuCl$_3$ was obtained from the Center for Technology of Radioisotope and Radiopharmaceutical-National Nuclear Energy Agency (PRR-BATAN). The Master $^{177}$Lu solution was measured using a 4π Capintec CRC 7BT ionizing counter system to measure the specific activity. The $^{177}$Lu solution was diluted by adding the Lu$_2$O$_3$ carrier solution in 1 M HCl. Two samples were prepared from a diluted solution each in a 5 cc vial container and a 1 cc syringe. Both samples were weighed gravimetrically. Each sample was tightly wrapped using thin plastic to avoid the possibility of contamination at the time of measurement.
2.2. \textit{177}Lu samples measurement

Both samples were measured using a 4πγ Capintec CRC 7BT ionizing counter system calibrated with standard sources from the American National Institute of Standards and Technology (NIST). The position of the sample in the chamber is shown in Figure 2. The ampoule activity was measured at the base of the chamber while the syringes were measured at a height of 5 cm above the bottom of the chamber. The \textit{177}Lu activity in the ampoule was used to determine the correction factor for \textit{177}Lu activity measurement in the syringes.

![Image of ampoule and syringe position](image_url)

\textbf{Figure 2.} \textit{177}Lu sample position, (a) 5 cc Ampoule, and (b) 1 cc Syringe.

3. Result and Discussion

The mass of \textit{177}Lu samples in 5 cc ampoule and 1 cc syringe was 1.2 g and 0.3 g respectively. The activity measurement results of \textit{177}Lu samples in syringes and ampoules are shown in Table 1. The average of the total activity of \textit{177}Lu in 5 cc ampoules on March 13rd, 2019 at 09.40 was 42.95 ± 0.05 mCi with an error of 0.1 %. While, the average of the total activity of \textit{177}Lu in 1 cc syringe on March 13, 2019 at 09:31 was 10.78 ± 0.01 mCi with an error of 0.1%.

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
No. & 5 cc Ampoule (mCi) & 1 cc Syringe (mCi) & \\
\hline
 & Background & Activity & Background & Activity \\
\hline
1 & 0.00 & 42.90 & 0.00 & 10.80 \\
2 & 0.00 & 43.00 & 0.00 & 10.79 \\
3 & 0.00 & 42.90 & 0.00 & 10.79 \\
4 & 0.00 & 42.90 & 0.00 & 10.78 \\
5 & 0.00 & 42.90 & 0.00 & 10.79 \\
6 & 0.00 & 43.00 & 0.00 & 10.78 \\
7 & 0.00 & 43.00 & 0.00 & 10.76 \\
8 & 0.00 & 43.00 & 0.00 & 10.76 \\
9 & 0.00 & 42.90 & 0.00 & 10.79 \\
10 & 0.00 & 42.90 & 0.00 & 10.78 \\
11 & 0.00 & 42.90 & 0.00 & 10.78 \\
12 & 0.00 & 43.00 & 0.00 & 10.77 \\
13 & 0.00 & 43.00 & 0.00 & 10.79 \\
14 & 0.00 & 43.00 & 0.00 & 10.80 \\
15 & 0.00 & 42.90 & 0.00 & 10.79 \\
\hline
Average & 0.00 & 42.95 & 0.00 & 10.78 \\
StdDev & 0.05 & & 0.01 & \\
Error & 0.12 & & 0.11 & \\
\hline
\end{tabular}
\caption{Activity measurement results of \textit{177}Lu samples in a 1 cc syringe and 5 cc ampoules}
\end{table}
Specific activity is obtained by dividing the measured total activity by the mass of the sample. Table 2. Show the results of $^{177}$Lu sample specific activities obtained in 1 cc syringe and 5 cc ampoules. Specific activity of $^{177}$Lu samples in 1 cc syringe and 5 cc ampoules measured were 36.33 mCi/g and 35.79 mCi/g respectively. The ratio of specific activity between $^{177}$Lu samples in syringes and ampoules was 1.02. This means that the measured activity of the sample in the syringe is 1.5% greater than the sample in the glass ampoule. This effect might be due to the low energy gamma absorbed by the glass ampoule were greater than the 1cc syringe [5].

**Table 2.** Specific activity of $^{177}$Lu in 1 cc syringe and 5cc glass ampoule container

| 1 cc Syringe | 5 cc Ampoule |
|--------------|--------------|
| Total Activity (mCi) | Mass (g) | Specific activity (mCi/g) | Total Activity (mCi) | Mass (g) | Specific activity (mCi/g) |
| 10.78 | 0.30 | 36.33 | 42.95 | 1.2 | 35.79 |

4. Conclusion

The measurement results of $^{177}$Lu activity with the syringe container compared to the glass ampoule container obtained a ratio of 1.02 meaning that the measured activity using a 1 cc syringe requires a correction factor of 1.5% against the 5cc ampoule container. This correction factor is needed to get accurate radionuclide measurement results.

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