The Preparation of In Vivo Lead X-ray Fluorescence System Using ^{99m}Tc

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^{99m}Tc is widely used in hospital for nuclear medical examination such as scintigraphy of brain and thyroid. The gamma energy emitted by the ^{99m}Tc (140.50 keV) is used to produce X-ray fluorescence of the lead atoms present in bones. Being an internal source it is expected the fluorescence efficiency to increase. Using a surface barrier X-ray detection system, we have found the minimum detectable concentration (MDC), of lead in bone phantom, is 500 ppm using K-edge X-ray. The bone phantom consists of 10 ml polythene test-tube filled with saline solution and sodium (^{99m}Tc) pertechnetate of activity ranging from 7.4 – 111 MBq. The counting time varies from 1-2 hour depending on the activity and lead concentration.

1. Introduction

Over 90% of lead whole body burden is accumulated in the bones and may reside there for years [1]. It is possible to determine the lead in the bones by collecting and analyze the sample by *in vitro* technique but the procedure is painful and open to the risk of infection. On the other hand, ^{99m}Tc solution is injected into the patient for imaging purposes, so we have readily *in vivo* X-ray fluorescence from lead in the bone. So using the improve sensitivity solid state cadmium Zinc Telluride X-ray detector, XR-100T-CZT, we have developed an in vivo lead detection system using a phantom made from test-tubes filled with lead standards and ^{99m}Tc solutions.

2. Methodology

The bone phantom is represented by 10 ml polythene test-tube containing a known amount of lead solution and ^{99m}Tc activity. We also studied the effect of placing a copper collimator between the phantom and the detector. The characteristic lead lines chosen are $K_{\alpha 1}$ = 74.97 keV, $K_{\alpha 2}$ = 72.80 keV, $K_{\beta 1,3}$ = 84.50 keV and $K_{\beta 2}$ = 87.30 keV. The count rate is corrected for background and is normalized by taking the count rate of the K_α peak to that of ^{99m}Tc energy peak count rate.

3. Results and discussion

We have found that the normalized count rate increase proportionally with the lead concentration as shown in Figure 1.The use of copper collimator of inner diameter 0.290 cm and thickness of 0.650 cm has increased the system sensitivity as shown in Figure 1. This is due to the reduction from the Compton scattered radiation entering the detector. The normalized count rate as a function of ^{99m}Tc concentration is shown in Figure 2. Even though it is expected the normalized count rate to be independent of activity, however at higher activity the detector tends to saturate resulting in slight decreases in counts at low energy.

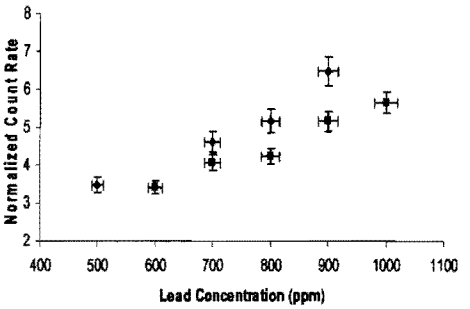

Figure 1 Normalized fluorescence count rate as a function of lead concentration with (♦) and without (■) collimator. The activity of ^{99m}Tc is 18.5 MBq.

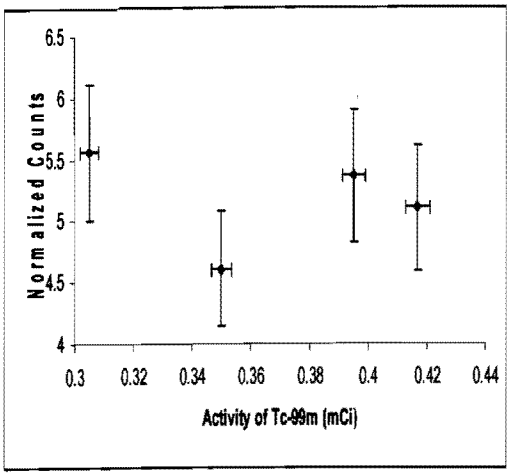

Figure 2 Normalized fluorescence count rate as function ^{99m}Tc activity. The lead concentration is 800 ppm and the counting time is 30 minutes.

4. Conclusion

It is possible to measure lead in bone using *in vivo* X-ray fluorescence induced by ^{99m}Tc. However the minimum detection concentration (MDC) of 500 ppm achieved by the present set up is too high for detection of lead in human. Further work, such as changing the shape and size of the collimator, to improve the sensitivity is now being carried out.

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References

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