ORIGINAL PAPER

QUANTITATIVE ANALYSIS FOR ASSESSING REGIONAL FUNCTION OF LIVER BY USING ^{99m}Tc-GSA SPECT

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ABSTRACT

In the present study, we developed quantitative index for evaluating regional liver function using ^{99m}Tc diethylenetriamine-pentaacetic acid galactosyl human serum albumin (GSA). A three head SPECT equipped with a low energy high resolution parallel hole collimator was used. Used pre-filter was Butterworth and axial images were reconstructed by a ramp filter without attenuation correction. Correlation between SPECT counts and net concentration of activity of radioisotopes was evaluated in basic consideration using LKS and Nine-Ball phantoms.

SPECT Counts = 0.6 × RI concentration

There was a simple correlation among GSA receptor amounts (Cr), injected GSA amounts (S), free GSA amounts (Cf), and intra hepatic receptor ratio ((Cr ratio)).

Cr = S – Cf
(Cr ratio) = Cr/S, 0 < (Cr ratio) < 1

Injected GSA amounts can be calculated from injected net RI counts. Free GSA amounts can be evaluated from counts of the heart. GSA receptor amounts can be assumed by performing SPECT three times in series. Regional GSA receptor amounts can be evaluated from the ratio between the region's counts and whole counts. In clinical SPECT images, we could evaluate the regional GSA receptor amounts before and after chemolipiodolization. In conclusion, our method is a simple quantitative index of analyzing regional GSA receptor amounts.

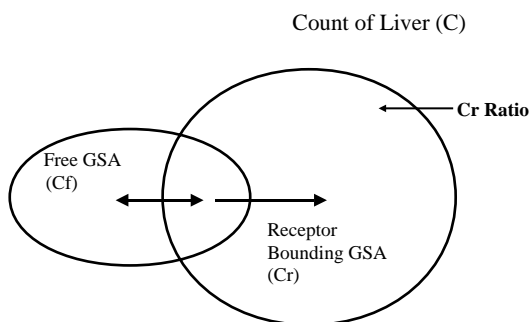Key Words: Quantitative analysis, Liver region, ^{99m}Tc-GSA, SPECT

INTRODUCTION

Technetium diethylenetriaminepentaacetic acid galactosyl human serum-albumin (^{99m}Tc-GSA), which estimates potentially to the liver asialoglycoprotein receptor index, has been shown to be useful for assessing quantitative index of hepatic function[1-7]. In recent years, some authors investigated new methods for evaluating the accumulation locally of ^{99m}Tc-GSA using single photon emission computed tomography (SPECT)[2-7]. Most of quantitative analysis studies were accurate by using Patlak-Plot, dynamic SPECT and compartment model. However their methods were complicated and the clinical approach of these methods had some difficulties.

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Count of Liver (C)

$$Cr = S - Cf$$
$$Cr\ ratio = Cr / S$$

Fig. 1   Schema of the equation between injected GSA amounts (S), free GSA amounts calculated from ROI on the heart (Cf), GSA amounts of binding with receptor (Cr), and the intra-hepatic receptor bounding ratio ((Cr ratio))

In clinical, HH15 and LHL15, which were reported by Kosuda *et al.*[1], had been used because of their conveniences. HH15 and LHL15 were introduced for evaluating residual whole liver function, not for regional liver function. The assessing regional liver function is important in managing of patients with hepatocellular carcinoma (HCC) when they undergoing hepatectomy or transcatheter arterial chemolipiodolization (TACL). Although LHL15 ratio was calculated from radioisotope (RI) count on SPECT data of the liver and the heart, the calculated ratio is underestimated due to involve intra-hepatic blood volume to receptor amounts (Fig. 1). Simple indicator which can evaluate regional liver function has been searching for in practice. In present study, we develop quantitative index for evaluating the regional GSA receptor amounts in consideration of intra-hepatic blood volume.

METHODS AND MATERIALS

A three head SPECT (GSA9300A, Toshiba, Japan) equipped with a low-energy, high-resolution, parallel-hole collimator centered on the liver and then on the precordium was used. The SPECT images acquired with one minute rotation were obtained. Used pre-filter was Butterworth (cut-off frequency 0.12, order 8). Axial images were reconstructed by a filtered back projection method, with a ramp filter without attenuation correction.

Basic consideration

To establish the correlation between SPECT counts and net activity of radioisotopes, LKS and Nine Ball phantoms were used.

LKS phantom was filled with $^{99m}TcO_4$ with the concentration of 1kBq/ml. Eight round ROIs from one pixel to 12 pixels were placed on the liver of the phantom of the SPECT images. Nine Ball phantom was filled with $^{99m}TcO_4$ with the nine steps of the concentration from 1kBq/ml to 100 kBq/ml. Nine round ROIs of 8 pixels were placed on the center of the balls of the SPECT images.

Clinical SPECT images

SPECT was performed in patients after a bolus injection of a dose of about 1mg/185MMq of ^{99m}Tc-GSA via an antecubital vein. SPECT images were obtained at 5, 15, and 30 minutes after injection. From measuring dose in the syringe prior and after injection, the net quantity of dose was calculated. All 10 patients underwent ^{99m}Tc-GSA liver scintigraphy before and after TACL.

RESULTS

Correlation between SPECT counts and net activity of radioisotopes

In the LKS phantom study, there was a linear correlation between size of ROIs and SPECT count (Fig. 2). In the Nine Balls phantom study, the equation between count (C) and RI density (RI) was as follows C = 0.6 (±1.2) × RI (Fig. 3).
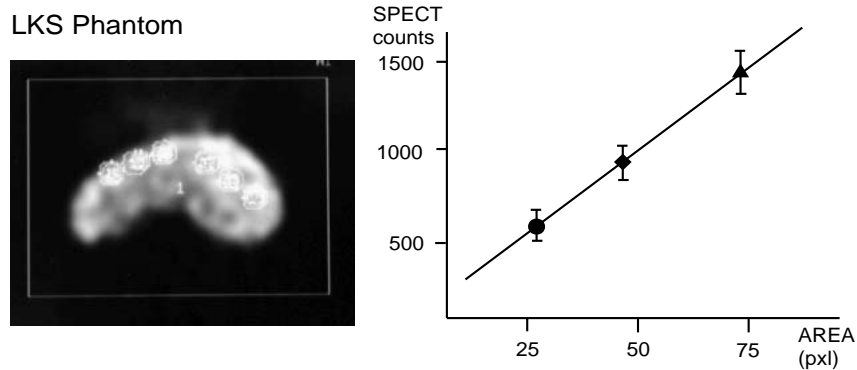

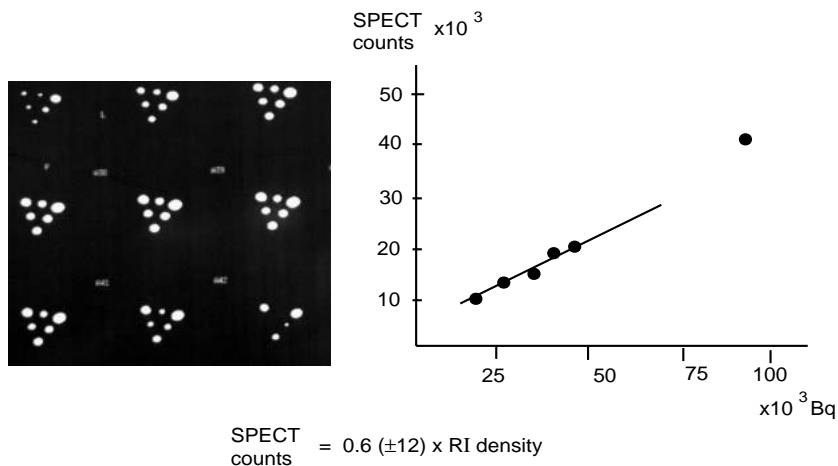Fig. 2   Results of LKS phantom study, showing a linear correlation between size of ROIs and SPECT count

Fig. 3   Results of Nine Balls phantom study, the equation between count (C) and RI density (RI) was C = 0.6 (±0.12) × RI

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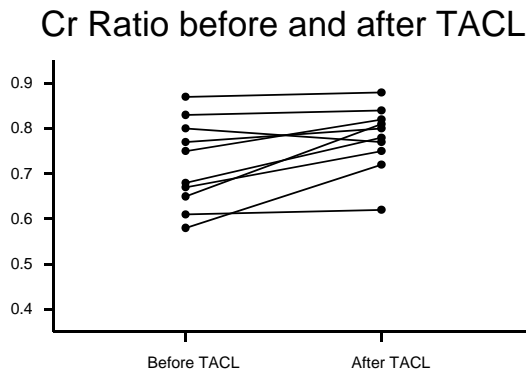
Cr Ratio before and after TACL

Fig. 4   Cr ratios of 10 patients examined before and after TACL were shown

Clinical SPECT images

In figure 1, the equation between GSA amounts of binding with receptor (Cr) and injected GSA amounts (S), free GSA amounts (Cf), intra hepatic receptor bounding ratio ((Cr ratio)).

$$Cr = S - Cf$$
$$(Cr\ ratio) = Cr\ /\ S\ ,\ 0 < (Cr\ ratio) < 1\ (Fig.\ 1).$$

If total liver counts could be calculated from all slices of SPECT (C), Cr = C × (Cr ratio). Cr could calculated from Eq: C – (Cf/pixel) × (Liver total pixel).

In this method, Cr ratio could be calculated from SPECT data. However, when SPECT was performed three times, Cr ratio could be suspected as approaching to the accurate results. The Cr of examined 10 patients before and after TACL were shown in figure 4 (Fif.4). We placed ROIs on the liver of TACL area. Cr ratio were 0.718±0.096 before TACL and 0.789±0.083 after TACL, Cr ratios were increased after TACL (p<0.05).

DISCUSSION

The assessment of regional liver function by ^{99m}Tc-GSA is important for the clinical management of patients with hepatocellular carcinoma[2,9], because TACL results in the deterioration of normal liver tissue in the embolized region. HH15 and LHL15 have been used for the evaluating of function of whole or the left or right lobe[1]. But HH15 and LHL15 calculated from regional SPECT data did not always reflect regional receptor quantity because of the effects of regional liver blood volume, which contains free ^{99m}Tc-GSA in the liver region and makes errors. Quantitative evaluation of regional liver function analysis methods of SPECT scintigraphy using ^{99m}Tc-GSA has been reported. But most of them are very complex, the volume of their data is huge and impractical in routine clinical works. In clinical, HH15 and LHL15 are still used because of these methods being inconvenient. Pre-TACL assessment of regional functional reserve offers important strategic information for TACL.

Indexes, which could be used as regional liver function in clinical needed the following characteristics: 1) Possibility for calculating in the region of the liver, 2) Simple and rapid, 3) Reflecting the quality of receptors and 4) Good correlation with another liver function data.

We proposed an easy quantitative analysis method of SPECT scintigraphy using ^{99m}Tc-GSA in this paper. Our method needs only net doses of injected GSA, which calculated from

measured counts before and after injection, and SPECT three times. By our method, amounts of regional GSA receptors can be calculated in quantitative from regional SPECT of liver data and regional SPECT of heart data. Our method based on consent of ^{99m}Tc-GSA was equal between heart and liver. Our method evaluated in ten patients, who underwent scintigraphy befor and after TACL, revealed increased numbers of GSA ratio of the regional liver after TACL. Our previous result of regional GSA-ratio, which was calculated without considering intra-hepatic free GSA, showed various results. Some patients' results showed decreased GSA ratio. Many authors have reported increased numbers of GSA receptors of a regional liver after TACL because of a hepatocyte growth factor[2,10]. This results shows our method is accurate and useful. We can recognize our method will be useful to calculate the amounts of GSA receptors in regional liver before TACL.

CONCLUSION

Our method was considered to be useful index in evaluating regional GSA receptor amounts using SPECT.

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