

# The correlation between effective renal plasma flow (ERPF) and glomerular filtration rate (GFR) with renal scintigraphy $^{99m}\text{Tc}$ -DTPA study

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**Abstract.** The prevalence of chronic renal diseases in Indonesia has an increasing annual trend, because it is frequently unrecognized and often co-exists with other disease. GFR and ERPF are parameters currently utilized to estimate renal function at routine renal scintigraphy  $^{99m}\text{Tc}$  DTPA study. This study used  $^{99m}\text{Tc}$  DTPA to measure GFR and ERPF. The purpose of this study was to find the correlation between ERPF and GFR, for ERPF analysis with Schlegel's method, and GFR analysis with Gate's method, as well as to find correction factor between both variables. Analysis of renal scintigraphy has been performed at Department of Nuclear Medicine Pertamina Center Hospital to thirty patient images acquired from 2014 to 2015 which were analyzed retrospectively data, using gamma camera dual head with counting method from renal scintigraphy  $^{99m}\text{Tc}$  DTPA study. The calculation was executed by means of both display and manual calculation. Pearson's statistical analysis resulted on Positive Correlation for all data, with ERPF and GFR (display) showing Strongly Positive Correlation ( $r = 0.82$ ;  $p\text{-value} < 0.05$ ). Standard deviation was found to be 27.58 and 107.64 for GFR and ERPF (display), respectively. Our result indicated that the use of  $^{99m}\text{Tc}$ -DTPA measure ERPF was not recommended.

## 1. Introduction

The glomerular filtration rate (GFR) is the best way to estimate renal function [1]. GFR is amounts of filtrate which formed per minute at both of kidneys. For male, filtration rate around of 125 ml/minute, and for female, filtration rate around of 110 ml/minute [2]. The concept of measurement of effective renal plasma flow (ERPF) only describes a fraction of plasma flow through a nephron [3]. Normal value of ERPF in the range of 491 to 817 ml/minute for male, and in the range of around 439 to 745 ml/minute for female [4].

Two kinds of radiotracer used to renal study, there are radiotracer which is cleaned from plasma by glomerular filtration, and the others would be cleaned by tubular secretion [3]. In nuclear medicine field,  $^{99m}\text{Tc}$ Technetium-diethylene triamine pentaacetic acid (DTPA) is often used to routine renal scintigraphy and to estimate GFR, because this radiotracer would be cleaned by glomerular filtration. Whereas radiotracer which is used to estimate ERPF was cleaned by tubular secretion, such as I-123 and I-131 OIH Orthiodohippurate or 'Hippuran',  $^{99m}\text{Tc}$ -EC, and  $^{99m}\text{Tc}$ -MAG3 [5].



In clinical study (commonly Hospital in Indonesia), radiotracer or radiopharmaceutical which is commonly used to routine renal scintigraphy is  $^{99m}\text{Tc}$ -DTPA, because of the limited supply of I-131 Hippuran,  $^{99m}\text{Tc}$ -EC, and  $^{99m}\text{Tc}$ -MAG3. Additionally, in order to know the relative renal function using  $^{99m}\text{Tc}$ -DTPA only need 21 minutes, so that radiotracer is the correct choice for clinical use. Actually, the estimation of renal function is not only GFR, but ERPF was too important especially for hypertension and diabetes mellitus.[6] Concerned to this situation, it would be a necessary to do the study the use of  $^{99m}\text{Tc}$ -DTPA could be implemented to estimate ERPF or not by using Schlegel's[7] and Gate's[8] method in gamma camera.

## 2. Materials and methods

In this study, data was collected at Department of Nuclear Medicine Pertamina Center Hospital between 2014 and 2015. The collecting and processing data at least 4 months between January and April 2015. We use retrospective data in total of 30 adults, with 18 male and 12 female.  $^{99m}\text{Tc}$ -DTPA dynamic images were acquired with the patient in the supine position (until 21 minute totally after injection) and the detector of gamma camera took placed at the posterior plane. The gamma camera Skylight ADAC [Philips, USA] were equipped with low energy general purpose collimator and 59 PMTs Na(I)Tl crystal. For dose measurements, we used the dose calibrator which was calibrated on March 2015. All patients were injected in the dose range of 300 to 500  $\mu\text{Ci}$  (at least 3-5 mCi) of  $^{99m}\text{Tc}$ -DTPA. Furthermore, dynamic images were recorded in a  $512 \times 512$  matrix format per second for 1 minute which is known by pre injection and post injection counts. Relative renal function was measured and analysed in a composite image acquired at 2 minutes after injection of radiotracer.[9] Renal and semilunar background regions of interest (ROIs) were drawn manually. Relative renal function was measured using the ROIs of each kidney in the posterior image.

The correlation between ERPF and GFR measurement using  $^{99m}\text{Tc}$ -DTPA renal scintigraphy was performed by Pearson Correlation (table 1) [10]. The correlation results were expressed with Schlegel – Gate analysis, ERPF using Schlegel's analysis, which need physical data of patients such as weight and height because it is the important to calculate renal depth [11]. Comparison of relative renal function measurement using ERPF and GFR parameter was performed with display (Gamma camera integrated program calculation) and manual (Microsoft Excel calculation). The statistical analysis was performed using Statistica Software Version 10.

**Table 1.** Meaning of Pearson correlation coefficient value ( $r$ ).

Correlation Coefficient Value ( $r$ )	Direction and Strength of Correlation
-1	Perfectly negative
-0.8	Strongly negative
-0.5	Moderately negative
-0.2	Weakly negative
0	No association
0.2	Weakly positive
0.5	Moderately positive
0.8	Strongly positive
1	Perfectly positive

The calculation in related to dosimetry, radiation counts of gamma camera detector has information about activity per unit times. Conversion factor from radiation counts to activity is much needed because we need to convert to international unit (MBq). In order to calculate the conversion factor, the detector was placed at the anterior plane upon the source  $^{99m}\text{Tc}$ -Pertechnetat with distance between detector and source at about 7 centimeters. The activity of source is 1.2 mCi which normalized 1 mCi, counting was carried out 1 minutes for  $N = 12$  of measurement. The calibration factor was found to be 6010 cps/mCi.

### 3. Results and discussion

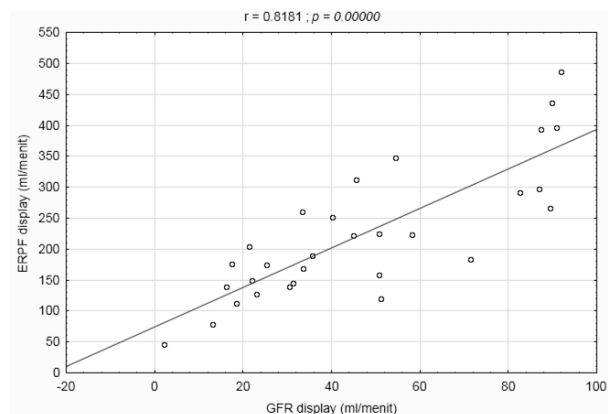
The hospital recorded 30 adults (18 male and 12 female) patients with kidney function would be analyzed. The age of patient was in the range of 17 to 81 with mean of patient age of  $54 \pm 15$  years. Furthermore, the data was grouped by gender between male and female. The mean age of male was  $55 \pm 15$  years, and was  $53 \pm 16$  years for female.

Pearson correlation was founded with the analysis of ERPF Schlegel and GFR Gates with parameter  $r$  and  $p$ -value. Data presented was divided into three groups, include all patients, male, and female without grouping on the type of their kidney diseases as indicated in figure 1–8. The correlation of ERPF Schlegel based on display and manual calculation, data of all patients was resulted on positive correlation ( $r = 0.5350$ ;  $p < 0.05$ ), include male ( $r = 0.363$ ;  $p > 0.05$ ), and female patients ( $r = 0.7545$ ;  $p < 0.05$ ). The correlation of ERPF for all patients had significant positive correlation, with standard deviation of ERPF display and ERPF manual was found to be 107.64 and 2529.47, respectively. If the data was grouped by a gender, there was a shifted in  $r$  and  $p$ -value, which is correlation of ERPF for male had not Significant Positive Correlation ( $p > 0.05$ ). Then, the correlation of GFR Gates based on display and manual calculation, data of all patients was resulted on Positive correlation ( $r = 0.8333$ ;  $p < 0.05$ ), include male ( $r = 0.8039$ ;  $p < 0.05$ ), and female patients ( $r = 0.8991$ ;  $p < 0.05$ ). GFR measurement for both calculation (display and manual) was resulted on significant positive correlation, with standard deviation of GFR display and GFR manual was found to be 27.58 and 14.61, respectively. In outline, the correlation between ERPF and GFR would be discussed according to the parameters of Pearson. Firstly, based on display calculation was resulted on significant and strongly positive correlation ( $r = 0.8181$ ;  $p < 0.05$ ). Secondly, based on manual calculation was resulted on not significant and weakly positive correlation ( $r = 0.2030$ ;  $p > 0.05$ ). As a correction factor, standard deviation which is obtained from GFR was recommended for clinical use, but for ERPF was not recommended as a correction factor, because it was out of the range. Some values were out of the range was because these were mostly related to non-uniform kidney disease with different renal function measured by  $^{99m}\text{Tc}$ -DTPA in renal scintigraphy. Discussed about formula used on the ERPF and GFR calculation, there was a difference in body surface area (formula used European's anatomical sizes) to measure the renal depth which is invented by Tonnesen [12]. He measured the renal depths of 55 subjects by ultrasonography with the patient in the sitting position and the probe positioned at an oblique angle to the kidney. It turned out the Tonnesen's method which is couldn't be used in Indonesia.

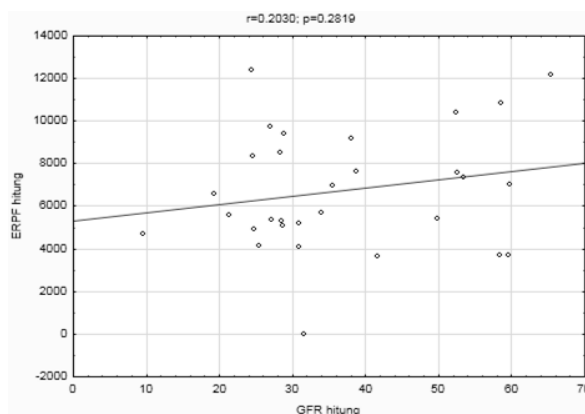
Discussed about the correlation between ERPF and GFR, we must know that these parameters have the different measurement at the part of kidney. GFR was occurred at glomerular, but ERPF was at tubular.  $^{99m}\text{Tc}$ -DTPA acts like a plasma, hence it can measure flow system or 'Perfusion' [5].  $^{99m}\text{Tc}$ -DTPA emitting gamma-ray with mean energy 140 keV, which is this radiotracer was suitable using at routine renal scintigraphy. Discussed about ERPF, it was more suitable using radiotracer worked at tubular like I-131 or I-123 OIH which is known by 'Hippuran'. It was emitting beta particle with mean energy 193 keV, and it was not suitable at routine renal scintigraphy. I-131 Hippuran has a beta radiation that could be penetrate larger than gamma radiation. At the ERPF measurement,  $^{99m}\text{Tc}$ -DTPA acts like a plasma which is filtrated by glomerular frequently in all nephrons. The tubular was existed after glomerular as a plasma flow in kidney. Therefore,  $^{99m}\text{Tc}$ -DTPA which is flew at the tubular, occurred only a few amounts for 2 minutes images acquired (renal uptake GFR and ERPF was at 2-3 minutes after injection) [7, 8].

In the study related to this work, Celik *et al* was compared the use of  $^{99m}\text{Tc}$ -DTPA and  $^{99m}\text{Tc}$ -DMSA for relative renal function in pediatric patients, their concluded that for patients who needs renogram curve and GFR calculations  $^{99m}\text{Tc}$ -DTPA could be a choice for the calculation of relative renal function although  $^{99m}\text{Tc}$ -DMSA is the gold standard method for the calculation of relative renal function [13]. On the other study, Suapang *et al* who estimated of GFR and ERPF in dynamic renal scintigraphy, the clearance of  $^{99m}\text{Tc}$ -DTPA and  $^{99m}\text{Tc}$ -MAG3 were the relatively index of GFR and ERPF in the clinical evaluation of patients with acute and chronical renal failure using camera-based methods [11]. This study used  $^{99m}\text{Tc}$ -DTPA for measure GFR, and  $^{99m}\text{Tc}$ -MAG3 for measure ERPF.

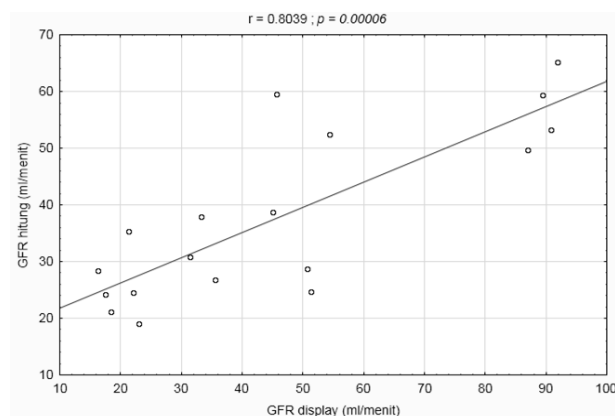
Equals with our study, they use ERPF Schlegel and GFR Gates for the analysis. However our study using an original formula of Schlegel's analysis without R (the predicted 32 minutes return of the injected radionuclide) because our examination time was performed at 21 minutes only.



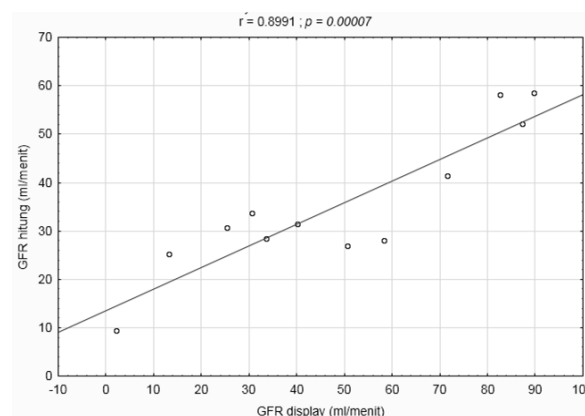
**Figure 1.** ERPF and GFR (display).



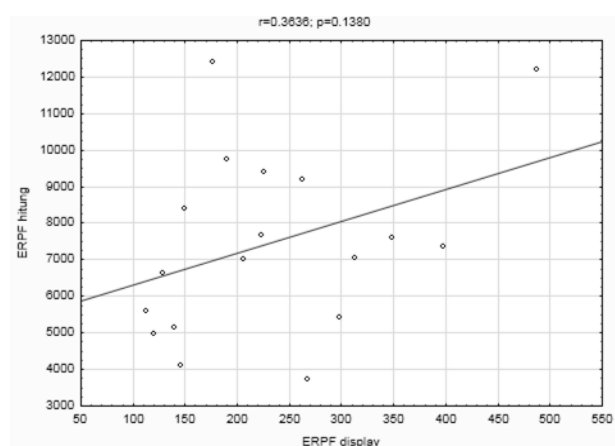
**Figure 2.** ERPF and GFR (manual).



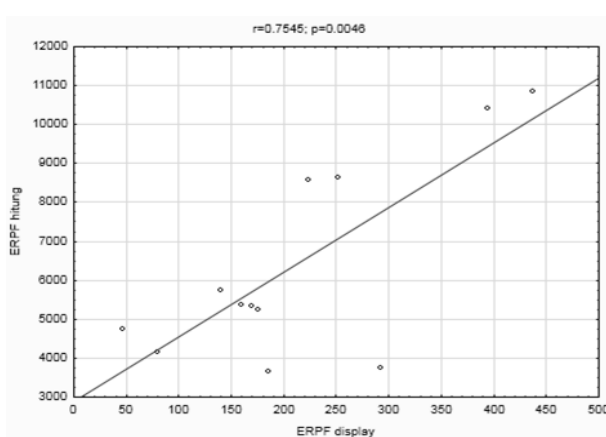
**Figure 3.** Male's GFR.



**Figure 4.** Female's GFR.



**Figure 5.** Male's ERPF.



**Figure 6.** Female's ERPF.

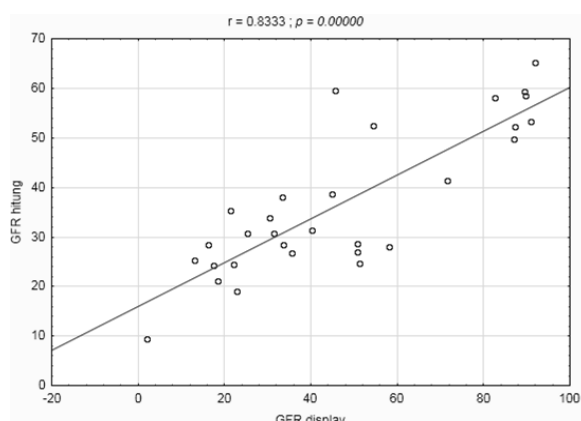


Figure 7. All patient's GFR.

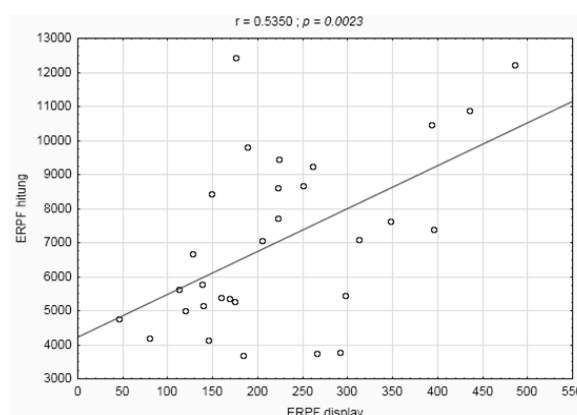


Figure 8. All patient's ERPF.

#### 4. Conclusion

The correlation between ERPF and GFR with renal scintigraphy  $^{99m}\text{Tc}$ -DTPA study showed Positive Correlation, which means that both of these parameter was related to estimate relative renal function. By using  $^{99m}\text{Tc}$ -DTPA, more effective result to measure GFR than ERPF based on correlation formed from display and manual will be obtained.

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**Acknowledgements**

I would like to express my sincere thanks to Duta Kamesworo and Chavid Varuna of Department of Nuclear Medicine, Pertamina Center Hospital, for their helps to preparing manuscript data. We also thanks to Laboratory of Medical Physics and Biophysics for supporting to attend SEACOMP 2015 though Hibah PUPT Directorate General of Higher Education, Ministry of Education and Culture, Republic Indonesia 2015.