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Relationship between Glomerular Filtration Rate and Resistive Renal Artery Index as the Basis for Kidney Function Diagnostics

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ABSTRACT

The study of relation between the glomerular filtration rate GFR using ^{99m}Tc-DTPA renal scintigraphy and renal artery resistive index has been carried out among 211 patients of multi renal diseases with age between 20-70 years. The collected data was the resistive index versus glomerular filtration rate. Further, the ratios between the resistive index and glomerular filtration rate for each kidney and their mutual influence were evaluated. The expediency of using the obtained data to consider intellectual findings in the diagnosis of kidneys is shown.

Key words: Glomerular Filtration Rate, Resistive Renal Artery Index, Multivariate Analysis, Kidney Diagnosis, Statistical Inference.

1. INTRODUCTION

Intelligent data processing, the data extraction process is the basis for building any intelligent systems [1]–[3]. This approach occupies a special place in medical research [3]–[5]. This is due to the fact that medical research is intended to help a person, diagnose his state of health and treat diseases. Moreover, in each case, it is important to know the subject area, which is the basis for constructing the corresponding systems.

One of the examples of medical research aimed at improving human health is the diagnosis of kidney. The kidney is a vital organ that performs three main functions: excretion, regularity and endocrinology. These functions are related to each other and have the ability to remove waste from the blood without losing any important ingredients from the body [6].

Glomerular filtration rate (GFR) is considered as one of the best methods for determining renal function in relation to normal (male: 70 ±14 mL/min/ m2 - female: 60 ±10 mL/min/m2) [7]. Accurate measurement of glomerular filtration rate is considered an important parameter in the diagnosis of renal function and early monitoring of renal failure [8]. This method can also be used to evaluate the effect of therapy, adjust doses of various drugs, and ensure normal renal function in potential kidney donors [9], [10]. At the same time, it is necessary to know the assessment of the relationship between GFR and the resistive index of the renal artery. This justifies the choice of the research topic, conducting an appropriate analysis.

2. KEY APPROACHES TO KIDNEY DIAGNOSIS

The imaging with a gamma camera and computer system was begun in 1950 and the renal function can be evaluated [11].

For a particular organ image several radiopharmaceuticals are available now days as well as for renal study as in vivo and in vitro, from which valuable information about the renal morphology and physiology such as Glomerular filtration rate can be conveniently obtained in anon invasive manner. The GFR calculation carried out from the rate of clearance of tracer activity (Tc99m –DTPA) from the plasma by injection of radiopharmaceutical into the vein, the radiopharmaceutical is excreted by Glomerular filtration and not bound to plasma protein or to any other component of blood or other tissue [12].

GFR can be calculated simply by dividing the administered dose by integral of plasma time activity curve [13].

There was a problem of Tc99m (DTPA) for quantitative measurement, because of variable degree of protein [14]. The Application of radionuclide procedure has proved to be effective at evaluation of renal disorders.

A renal Doppler (blood flow indices) , also known as a is a non-invasive testing process that uses ultrasound to allow a physician to see the kidneys and surrounding blood vessels to detect renal abnormalities, and assess blood flow.

Quantitative indices such as resistive index (RI) can be a marker of renal function since it can indicate physiological change in renal vascular resistance or sympathetic stimuli [2].

However, a change in renal artery resistance directly affects renal function. Therefore, GFR of the kidney, taking into account the values of RI, can be used to assess renal function.

3. RESEARCH METHODOLOGY

3.1. Especially data collection

The study included patients who visited the nuclear medicine department for a dynamic kidney scan. At the same time, color Doppler ultrasound was performed for each patient. These were both male and female aged: 20-70 years. All patients had various kidney diseases. All patients also went through the clinical stage through physical examination. Primary data were collected from patient files and included: dynamic radionuclide scan of the kidneys with Tc99m-DTPA, high-quality Doppler PSV for a certain period of time.

For dynamic radionuclide scan with DTA all subjects well hydrated, 1-2 liter of water 60 mints before the study. Their weight and height were measured for the kidney depth to obtain normalized GFR.

For a dynamic study of the kidneys, bladder data were also examined at Planer Gamma Camera model (Nucline spirit (DHV) variable angle dual head SPECT and whole body DH -503066-VO), which includes: low energy general purpose collimator; full and empty syringes are counted under the camera before and after the acquisition to measure the net dose injected to the patients after subtracted the value of empty springs from the value of full syringe.

The GFR obtained from an injection of the samples by Tc-99mTc-DTPA as 185MBq (5mc) as ideal dose for slandered weight 70 kg. The doses vary as the patients weighted. After the preparation of the dose, subject directed to void prior the study acquisition to minimize the discomfort to patients after the injection of furosemide 20–40 mg. Then the patient lay down over the camera in supine position on the examination table, the kidney area center in the camera field of view center, patient instruct to keep no movement during acquisition time .

Dynamic study requires that radiopharmaceutical to inject as bolus and the dose deliver in as small volume as possible. The acquisition starts immediately at time of injection. After the scan time is finish, the data which are collect process at computer imaging system for the GFR calculation where the region of interest drawn over the kidneys, subsequent summed frames that display in the screen simultaneously during processing observe for motion correction. Kidney region: the kidney area of interest exactly outlines. Pelvic, ureters are avoiding interest draw just under the lower pole of the kidney, ureters area carried. The clinical program includes inuine method for clearance (GFR) Region of interest is drowning around each kidney and common background area.

After a background subtraction the kidney activity are correct for attenuation using Tennesseans formula for the kidney depth correction. Image of the kidneys were generated as long as time activity curve and GFR calculation. Then the patients were transformed to the ultra sound department to obtain color Doppler quantitative image.

We used Doppler machine model medson- sonoac X8 Orgain: Korea to obtain the Doppler image. The patient lay down supine on the examination table .The image performed in the sagittal and transverse planes from the anterior approach using the liver and spleen as acoustic windows. We instruct the patients to take a deep breath and hold to obtain the corrected measurement of PSV. The frequency of transducer used was (2.5-5 Mhz).

However, for this study, we use only numerical data, which is shown below.

3.2. Data analysis tools

To analyze the numerical data that were obtained as a result of research, we use various statistical methods.

The method of descriptive statistics was used to generalize the group of patients. Comparative statistics methods are used to directly analyze the various relationships between individual data groups. We used: the method of correlation analysis, one-factor and multivariate analysis, the Cox proportional risk model. These tools provide primary data for kidney diagnosis.

4. RESULTS

We examined a group of 211 patients who have various kidney diseases. In this group there were 99 male and 122 female. Some values of the descriptive statistics of the patient group that was studied are shown in Table 1 and Figure 1.

Table 1: Quantitative indicators of male and female in the group of patients being studied

Gender	Frequency
Male	99
Female	112
Total	211

Figure 1 shows the percentage of male and female patients in the study group.

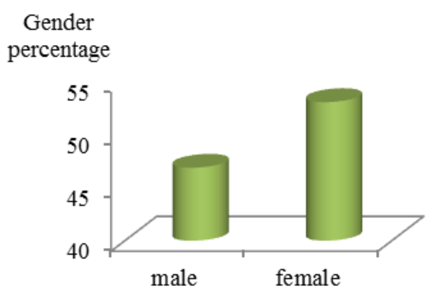

Figure 1: Percentage of male and female in the study group

Figure 2 shows the relationship between RI and GFR for the right kidney. We see that this relationship is proportionally dependent. As RI values increase, GFR values also increase. This relationship is described by the equation (significance level 0.82):

$$y = 92.74x - 4.22\,, \qquad (1)$$

where:

x – values RI for the right kidney,
y – values GFR for the right kidney.

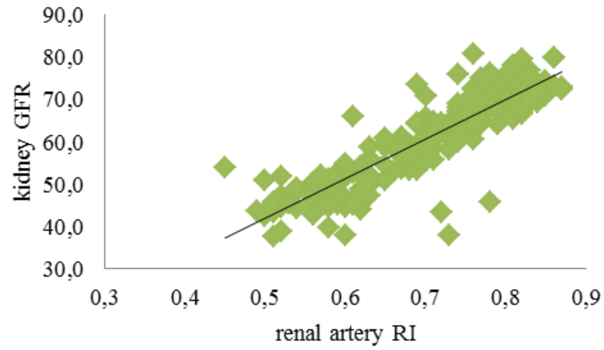

Figure 2: Relationship between RI and GFR for the right kidney

Figure 3 shows the relationship between RI and GFR for the left kidney. We see that this relationship also has a proportional relationship. As RI values increase, GFR values also increase. This relationship is described by the equation (significance level 0.64):

$$y = 100.9x - 14.14\,, \qquad (2)$$

where:

x – values RI for the left kidney,
y – values GFR for the left kidney.

Comparing Figure 2 and Figure 3, we can see that the relationship between RI and GFR for the right kidney is more significant than the relationship between RI and GFR for the left kidney. At the same time, the relationship between RI and GFR for the left kidney is stronger than for the right kidney. This is because in Figure 3 we see some non-standard outliers in the data. Apparently, this is due to the fact that we are considering patients with various kidney diseases.

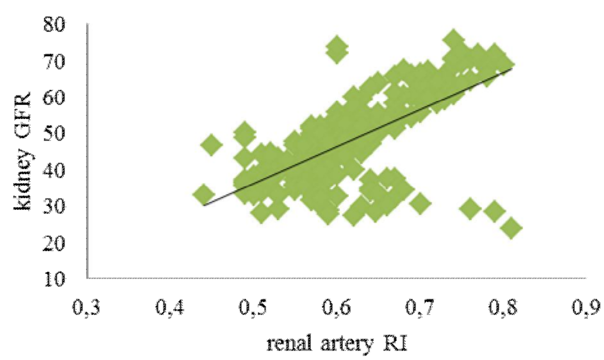

Figure 3: Relationship between RI and GFR for the left kidney

Figure 4 shows the relationship between RI for the right kidney and total renal GFR. This relationship also has a proportional relationship, which is a logical consequence of the data in Figure 2 and Figure 3. We can also note a wider range of changes in the relationship between RI for the right kidney and total kidney GFR. This is due to the fact that we have a wider range of GFR for the left kidney (see Figure 3). The relationship, which is shown in Figure 4, is described by the equation (significance level 0.77):

$$y = 105.3x + 35.76 \ , \qquad (3)$$

where:

x – values RI for the right kidney,

y – total values GFR.

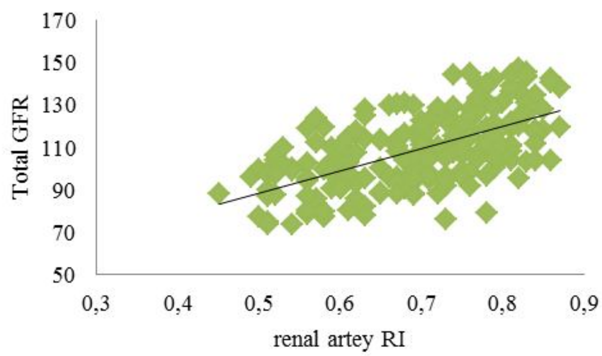

Figure 4: Relationship between RI for the right kidney and total values GFR

Figure 5 shows the relationship between RI for the left kidney and total renal GFR. In general, we have a wider range of relationships between the corresponding RI and GFR values. This is explained by the general dynamics of the data shown in Figure 2 and Figure 3. The data values in Figure 4 and Figure 5 also showed that there was a significant difference between the RI and the total GFR between the right and left kidneys. The relationship, which is shown in Figure 5, is described by the equation (significance level 0.73):

$$y = 119.9x + 34.41 \ , \qquad (4)$$

where:

x – values RI for the left kidney,

y – total values GFR.

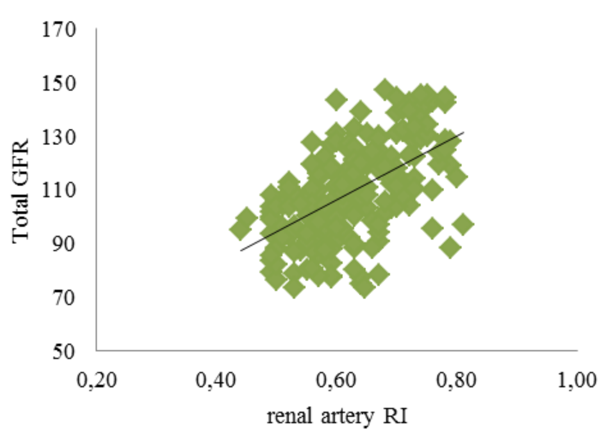

Figure 5: Relationship between RI for the left kidney and total values GFR

One-factor analysis using the Cox proportional hazard model showed that GFR and RI were effective prognostic factors for declining renal function, and the hazard ratio of the patients with RI=0.7 was 5.83 (95% confidence interval (CI), 2.65–12.85).

Multivariate analysis with stepwise selection, including GFR was independent risk factors for the progression of renal dysfunction. Evaluation of only clinical or non-invasive markers revealed that high RI at renal biopsy, low GFR was independent risk factors for the progression of renal dysfunction.

Thus, the above approach for analyzing the relationship between glomerular filtration rate and resistive index of the renal artery may be the basis for conducting an intelligent analysis to diagnose renal function.

5. SOME POINTS FOR DISCUSSION

C. Parolini, A. Noce, E. Staffolani, G. F. Giarrizzo, S. Costanzi, and G Splendiani examine changes in the blood velocity in the renal artery [15]. Such an analysis is based on the resistive index of the renal artery and various manifestations of renal dysfunction. However, this analysis does not take into account the GFR factor, which is important in the diagnosis of kidney function.

F. Viazz, G. Leoncini, L. E. Derchi, and R. Pontremoli also focus on the resistive renal artery index in the diagnosis of kidneys [16]. However, such an analysis would be more complete taking into account other factors, in particular, taking into account GFR.

The importance of the GFR factor in relation to other markers in the diagnosis of kidneys is considered in [17]. But in this context, the factor of the resistive index of the renal artery is not taken into account. This narrows the diagnosis of kidney function.

The paper [18] also noted the importance of accounting for GFR in the diagnosis of human diseases. Such conclusions are based on the analysis of different combinations of GFR data with other markers. However, the RI values are not considered in this context.

Thus, it should be noted the importance of considering the relationship between glomerular filtration rate and resistive renal artery index for diagnosing the disease. Moreover, the significance of such an analysis is determined by the possibility of intelligent data output for the purposes of appropriate diagnostics.

6. CONCLUSION

We examined the relationship between glomerular filtration rate and resistive renal artery index for a group of 211 patients. This group includes patients with various kidney diseases. It is shown that this relationship can be used in the diagnosis of renal function. To evaluate GFR, a color Doppler resistance index was used instead of Tc99m-DTPA renal scintigraphy. Limiting effect – it is necessary to take into account the dose of radiation that was administered to patients in order to assess GFR.

REFERENCES

1. P. Orobinskyi, D. Petrenko, and V. Lyashenko. **Novel Approach to Computer-Aided Detection of Lung Nodules of Difficult Location with Use of Multifactorial Models and Deep Neural Networks**, in *15th International Conference on the Experience of Designing and Application of CAD Systems (CADSM),* 2019, pp. 1-5. https://doi.org/10.1109/CADSM.2019.8779340
2. A. Erraissi, and A. Belangour. **Meta-Modeling of Big Data visualization layer using On-Line Analytical Processing (OLAP)**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no. 4, pp. 990-998, 2019. https://doi.org/10.30534/ijatcse/2019/02842019
3. E. B. Panganiban, A. C. Paglinawan, W. Y. Chung, and G. L. S. Paa. **A Novel Technique in Classifying Heart Diseases based on Electrocardiogram (ECG) Signals using Deep Learning and Spectrogram Image Analysis**, *International Journal of Advanced Trends in Computer Science and Engineering*, Vol. 8, no. 4, pp. 1734-1740, 2019. https://doi.org/10.30534/ijatcse/2019/102842019
4. V. Lyashenko, O. Kobylin, and M. Minenko. **Tools for Investigating the Phishing Attacks Dynamics,** in *International Scientific-Practical Conference Problems of Infocommunications. Science and Technology (PIC S&T),* 2018, pp. 43-46. https://doi.org/10.1109/INFOCOMMST.2018.8632100
5. A. Rabotiahov, O. Kobylin, Z. Dudar, and V. Lyashenko. **Bionic image segmentation of cytology samples method**, In *International Conference on Advanced Trends in Radioelecrtronics, Telecommunications and Computer Engineering (TCSET)*, 2018, pp. 665-670. https://doi.org/10.1109/TCSET.2018.8336289
6. E. L. Boulpaep, W. F. Boron, M. J. Caplan, L. Cantley, P. Igarashi, P. S. Aronson, and E. Moczydlowski. **Medical physiology a cellular and molecular approach**, *Signal Transduct*, Vol. 48, pp. 27-34, 2009.
7. M. H. Haenggi, J. Pelet, and J. P. Guignard. **Estimation of glomerular filtration rate by the formula K×T/Pcr**, *Archives de pediatrie*, Vol. 6, no. 2, pp. 165-172, 1999. https://doi.org/10.1016/S0929-693X(99)80204-8
8. A. S. Levey, and et al.. **National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification**, *Annals of internal medicine*, Vol. 139, no. 2, pp. 137-147, 2003. https://doi.org/10.7326/0003-4819-139-2-200307150-00013
9. E. B. Sokole, A. Kugi, H/ Bergmann. **High count rates cause nonuniformities in cobalt-57 flood images**. *European Journal of Nuclear Medicine and Molecular Imaging*, Vol. 20, pp. 896-911, 1993.
10. G. S. Grewal, and G. M. Blake. **Reference data for 51Cr-EDTA measurements of the glomerular filtration rate derived from live kidney donors**, *Nuclear medicine communications*, Vol. 26, no. 1, pp. 61-65, 2005.
11. J. S. Fleming. **A technique for the absolute measurement of activity using a gamma camera and computer**, *Physics in Medicine & Biology*, Vol. 24, no. 1, pp. 176, 1979.
12. W. M. Ali, E. Z. Dalah, L. H. Ahmed, and M. M. Abuzaid. **Modification of 99m Tc-Thyroid Scan Protocol to Decrease the Radiation Dose to Salivary Glands**, *Journal of Clinical & Diagnostic Research*, Vol. 12, no. 10, pp. 1-4, 2018. https://doi.org/10.7860/JCDR/2018/37216.12128
13. G. J. Schwartz, G. B. Haycock, C. M. Edelmann, and A. Spitzer. **A simple estimate of glomerular filtration rate in children derived from body length and plasma creatinine**, *Pediatrics*, Vol. 58, no. 2, pp. 259-263, 1976.
14. A. Must, J. Spadano, E. H. Coakley, A. E. Field, G. Colditz, and W. H. Dietz. **The disease burden associated with overweight and obesity**. *Jama*, Vol. 282, no. 16, pp. 1523-1529, 1999. https://doi.org/10.1001/jama.282.16.1523
15. C. Parolini, A. Noce, E. Staffolani, G. F. Giarrizzo, S. Costanzi, and G. Splendiani. **Renal resistive index and long-term outcome in chronic nephropathies**, *Radiology*, Vol. 252, no. 3, pp. 888-896, 2009. https://doi.org/10.1148/radiol.2523080351
16. F. Viazzi, G. Leoncini, L. E. Derchi, and R. Pontremoli. **Ultrasound Doppler renal resistive index: a useful tool for the management of the hypertensive patient**, *Journal of hypertension*, Vol. 32, no. 1, pp. 149, 2014. https://doi.org/10.1097/HJH.0b013e328365b29c
17. T. Deis, and et al.. **Relation between invasive hemodynamics and measured glomerular filtration rate by 51Cr-EDTA clearance in advanced heart failure**, *Scandinavian journal of clinical and laboratory investigation*, Vol. 79, no. 3, pp. 194-201, 2019. https://doi.org/10.1080/00365513.2019.1576221
18. J. Alizargar, C. H. Bai, N. C. Hsieh, S. F. V. Wu, S. Y. Weng, and J. P. Wu. **Association of Kidney Function Tests with a Cardio-Ankle Vascular Index in Community-Dwelling Individuals with a Normal or Mildly Decreased Estimated Glomerular Filtration Rate**, *Medicina*, Vol. 55, no. 10, pp. 657, 2019. https://doi.org/10.3390/medicina55100657