ANALYSIS OF POST PROCESSING TECHNIQUE CT RENAL ANGIOGRAPHY FOR IDENTIFICATION OF VARIATIONS OF RENAL ARTERIES IN KIDNEY DONOR PREPARATION: LITERATURE REVIEW

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ABSTRACT
Visualization of renal artery variations is a prerequisite for kidney donors. Polar variations and number of renal arteries were identified using several post processing techniques Renal CT Angiography. Objective : To identify variations in the number and polarity of the renal arteries using MPR, MIP, CPR and 3D VR based on a literature review. Analysis with a literature review approach was carried out using secondary data sources from 2012-2022 scientific publication journal articles by comparing the number and polarity of the renal arteries from the MPR, MIP, CPR and 3D VR post-processing techniques on CT renal angiography. MIP and 3D VR are the optimal combination of post-processing techniques for identification of the number and polarity of the renal arteries. The combination of MIP and 3D VR post processing techniques is the optimal post processing technique in depicting the number and polar variations of the renal arteries
Keywords: post processing techniques, renal CT angiography, kidney transplantation, renal artery variations

INTRODUCTION

Based on data from the World Health Organization (WHO), chronic kidney disease causes the death of 850,000 people every year. This figure shows that chronic kidney failure is the 12th highest cause of death in the world. In Indonesia, chronic kidney failure increased from 0.2% in 2013 to 0.38% in 2018 (RISKESDAS, 2018). Based on PERNEFRI data from 2001 to 2014, only about 237 cases of CKD received kidney transplantation therapy (PERNEFRI, 2013).

Kidney transplantation as a treatment option for chronic kidney failure requires good preparation between the recipient and the donor. (Gebremickael et al., 2021). Prospective donors must meet the requirements, including not having kidney abnormalities and more than 3 branches of the renal artery or vein. The structural factors of the recipient's good kidney anatomy, especially the donor, will help surgeons to plan operations and avoid potential damage to the renal blood vessels (Apisarnthanarak et al., 2012). Several post-processing techniques Computed Tomography Angiography (CTA) of the kidney can identify vascular non-invasively. (Apisarnthanarak et al., 2012). The purpose of this study was to analyze several post-processing techniques of renal CTA in identifying anatomic variations of the renal arteries through a literature review approach.

RESEARCH METHOD

Search for basic research data or articles using the Cochrane search engine, and pubmed publishers, and Science direct within 10 years (2012-2021).

RESULTS AND DISCUSSION

Search strategy and study selection

The search results for article data from the Cochrane, PubMed and Scient Direct search engines according to the specified keywords obtained 348 articles. A total of 316 articles entered the exclusion criteria based on title, abstract or both. 3 articles explained the comparison of CT and MRI, 6 article titles were case reports, 9 article titles did not explain details about image visualization and 4 article titles did not explain protocols or scanning procedures.

Research characteristics

Most of the articles used a retrospective study approach (60%) and 40% were prospective studies. Some articles use only 1 post pressing technique, most of them use more than 2 variations of post processing techniques. Table 1 shows the characteristics of the research that is relevant to this research topic.

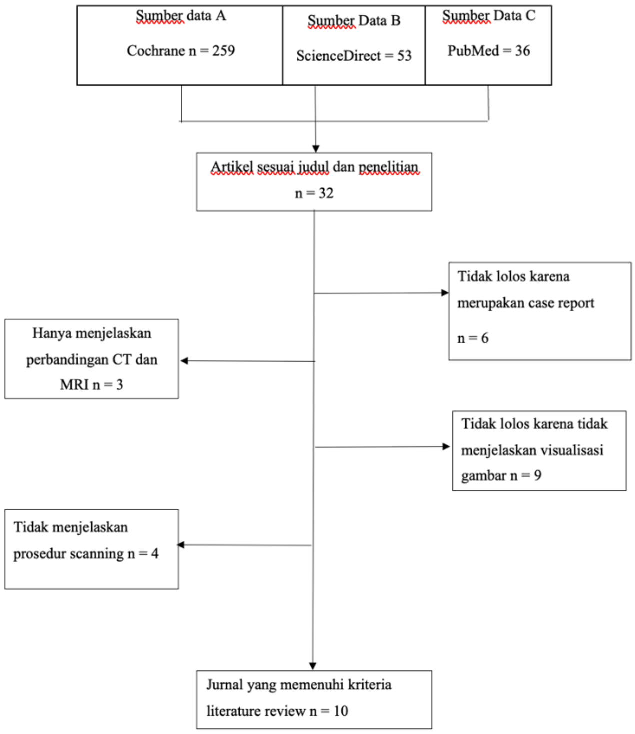

Figure 1.
Flow diagram for selecting articles to be included in this study

All articles can identify variations of the main renal artery (MRA), either using a variety of post-processing techniques, or only 1 post-processing technique. Meanwhile, not all articles discuss polar arterial variations. Identification of MRA mostly uses a variety of post-processing MIP and 3D VR techniques, followed by a variety of post-processing techniques MPR, MIP, 3D VR and only 3D VR. Some articles use different variations of post processing techniques, namely SSD and CPR. The results of image visualization in the identification of MRA and polar

MRA variations were mostly identified using a combination of MIP and 3D VR, although the combination of MIP with CPR or SSD was also used in several studies by Prevljak., S. et al 2017 and Zhao.X.Y, et al 2015.

Table 1.
Characteristics of research articles that meet the criteria based on the identification of variations of mian renal artery (MRA) and polar main renal artery

Sumber	Jumlah pasien	Jumlah multidetector CT (slices)	Variasi post processing	Variasi jumlah main renal artery (MRA)		Variasi polar main renal artery (MRA	
				Kanan	Kiri		
Gümüs, H., at al, 2012	403	64	MIP dan 3D VR	Kanan 1 MRA : 84% 2 MRA : 14.4% ≥3 MRA : 1.1 %	Kiri 1 MRA : 83% 2 MRA : 15,7% ≥3 MRA : 0.6 %	Hilus : 11 % Lower pole : 5.2%	
Apisarnthanarak, P., et al 2012	65	64	MPR, MIP, 3D VR	Kanan 1 MRA : 81.2% 2 MRA : 16.9% ≥3 MRA : 1.5%	Kiri 1 MRA : 72.3% 2 MRA : 24.6% ≥3 MRA : 3.1%	Kanan Lower pole : 46% *)	
Refaat, R., et al 2013	55	16	MPR, MIP, 3D VR	Kanan kiri 1 MRA : 87% 2 MRA : 12% ≥3 MRA : 1%		Kanan kiri : Hilus : 18.1% Lower pole : 9% Upper pole : 3.6%	
Beniwal, P., et al 2014	100	128	MIP, 3D VR	Kanan kiri 1 MRA : 73% 2 MRA : 23% ≥3 MRA : 4%		Hilus : 7% *)	
Zhao, X. Y., et al 2015	273	16	MIP, 3D VR, CPR	Kanan 1 MRA : 89.7% 2 MRA : 7.3% ≥3 MRA : 2.9%	Kiri 1 MRA : 84.8% 2 MRA : 10.6% ≥3 MRA : 4.5%	Kanan Hilus : 32.9% UP :27.6% LP: 39.5%	Kiri : Hilus : 34.2% UP :44.3% LP: 21.5%
Sharma, S., et al, 2016	110	64	MIP	Kanan 1 MRA : 69% 2 MRA : 29% ≥3 MRA : 1.8%	Kiri 1 MRA : 79% 2 MRA : 17% ≥3 MRA : 3.6%	NA	
Calle Toro, J. S., et al,2016	296	64	3D VR	Kanan kiri 1 MRA : 48% 2 MRA : 29% ≥3 MRA : 42%		Kanan kiri Hilus :42.1% UP : 28.9% LP : 28.9%	
Prevljak, S., 2017	1357	16	MIP, SSD	Kanan 1 MRA : 67.8% 2 MRA : 32.1%	Kiri 1 MRA : 65.7% 2 MRA : 34.2%	Kanan Hilus : 52.4% UP :35.4% LP: 12.1%	Kiri : Hilus : 69.5% UP :19.2% LP: 11.2%
Ikidag, M. A., & Uysal, E.2019	70	64	MIP, 3D VR	Kanan kiri 1 MRA : 71.4% 2 MRA : 29.6%		Kanan kiri UP : 13.7% LP : 13.7%	
Aremu, A. et al 2021	100	64	3D VR	Kanan 1 MRA : 80% 2 MRA : 20%	Kiri 1 MRA : 76% 2 MRA : 23% ≥3 MRA : 1%	Kanan Hilus : 87.7% UP :4.3% LP: 7.8%	Kiri : Hilus : 87.7% UP :2.6% LP: 9.6%

Catatan : NA : Not Available . *) Berasal dari renal artery acessorius. UP : Upper Pole. LP : Lower Pole.

The combination of MIP and 3D VR post-processing techniques is not only able to identify MRA variations, but also the renal artery accessory. In fact, the polar of the accessory renal artery can also be identified. (Beniwal et al 2014). (Figure 2).

In Figures A and B below using 3D VR and MIP post-processing techniques, the white arrows show the accessory renal arteries originating from the abdominal aorta entering the kidney through the renal hilus. Meanwhile, the yellow arrows indicate the accessory renal artery which originates from the main renal artery branching into the upper pole of the kidney.

A B

Figure 2.
3D VR Post Processing Technique (a) and MIP Post Processing Technique (b) (Refaat et al., 2013).

Using only 1 variation of post-processing techniques, both 3D VR and MIP alone are less able to identify the details of small arteries. (Picture 3).

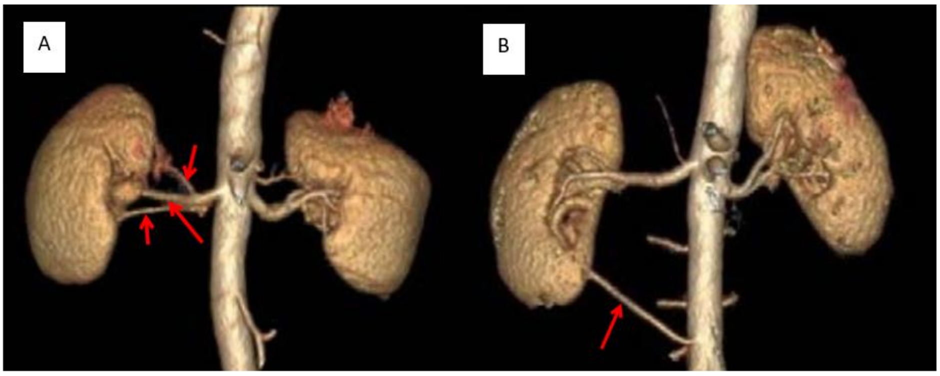

Figure 3.
Post Processing 3D VR showing variations of the renal arteries (Aremu et al., 2021)

The advantages of 3D VR besides being able to display a very clear 3D image of blood vessels, 3D VR is able to display the complex anatomy of overlapping vessels.

Renal CT Angiography Protocol

Table 4. 13 Renal CT Angiography Scanning Parameters

Parameter	Multidetector CT Scan		
	16 Slices	64 Slices	128 Slices
FOV	diafragma-symphysis pubis	diafragma-symphysis pubis	diafragma-symphysis pubis
Slice Thickness	0.625 mm	0.9 - 1 mm	1.25 mm
kVp	120 kV	120 kV	120 kV
mAs	225 mA	220-250 mA	220 mA
Penggunaan Kontras	1,5 ml/kg	1,5 ml/kg	1,5 ml/kg
Flowrate	3-4 ml/s	4-5 ml/s	4-5 ml/s

Most of the selected research articles use 64 slices. In general, the Renal CT Angiography procedure using CT Scan modalities 16, 64, and 128 did not have a significant difference. Only found in the slice thickness used. The taller the MDCT slice, the larger the slice thickness used. If the MDCT slice is low, the slice thickness used is thinner. The thinner the slice thickness used, the more detailed the identification of MRA and polar MRA variations will be

Analysis of Renal CT Angiography Post Processing Techniques

The combination of MIP and 3D VR post processing techniques is able to visualize almost all variations of MRA, either 1, 2 or more than 3 MRAs on several multidetector CT scans. Zhao et al., (2016) revealed that MIP has a degree of attenuation of reconstructed images similar to conventional angiography. MIP post processing techniques can present MRA reconstructions in axial, coronal and sagittal views. The resulting attenuation is able to show detailed anatomy of small arteries. The combination with 3D VR can display the complex anatomy of MRA which sometimes overlaps. Another use of 3D VR post processing techniques is to show abnormalities and variations of arteries and veins which are very important to detect before surgery. In practice, 3D VR post processing, it is possible to remove unwanted organ structures. (Refaat et al., (2013).

Most of the human population has a polar MRA to the hilum. Polar variations to the upper and lower poles need to be observed for surgeons in planning kidney transplants. This polar variation of the renal arteries is not a contraindication for kidney transplant surgery, but knowledge of the anatomy and polar MRA will prevent possible injury or prolonged bleeding during surgery.

Variations in the number of these renal arteries differ by ethnicity or race. Prospective donors who have more than three MRA variations do not meet the requirements for a kidney donor. This is because it will complicate the kidney transplant process. Left kidney donors are preferred because they have a longer vascular pedicle than the right. The right kidney is an option if the left kidney has a more complex vascular anatomy.

Renal Angiography CT protocol analysis

Selection of optimal scanning parameters and application of good post-processing techniques are two important steps in renal CT angiography imaging. (Zhao et al., 2015) stated that the factors that influence optimal scanning in vascular imaging are the type of contrast agent used, the amount, and the injection speed of the contrast agent; delayed scanning time; structural characteristics of the kidney and kidney function. The quality of renal CT Angiography images is also influenced by operator-controlled preprocessing techniques, sample characteristics, and the use of post-processing techniques in image visualization.

In the CT 16 slice multidetector, it uses more than two post processing techniques. On the other hand, the 64-slice and 128-slice CT multidetectors only use two post-processing techniques, and some journals even use only a single post-processing technique. This is because the more detector rows used, the smaller the slice thickness is, the better the image will be. Therefore, one or two post-processing techniques are sufficient to evaluate both MRA and polar MRA variations.

Accuracy of Sensitivity and Specificity Values of Renal CT Angiography

The gold standard for evaluating blood vessels, including the renal arteries, is angiography. Renal Angiography CT examination as a non-invasive diagnostic option must have a good accuracy value. Selected articles were assessed by the sensitivity and specificity of CT renal angiography. Refaat et al., (2013) CT renal angiography was able to visualize 37 of 40 renal arteries with a diagnostic value of 93%. In a study by Beniwal et al., (2014), which compared CT Angiography with intraoperative findings, it showed an accuracy value of 93%. Platt et al reported a concordance rate of 87%-95% among 117 patients, and the second Del Pizzo et al found a concordance rate of 93% among 157 cases. The research conducted by Hassan et al., (2014) stated that the accuracy value of the CT multidetector for identifying renal artery arrhythmias was 97.8%, approaching the results of the study by Satomi et al; he stated that MDCT is 99% accurate in the evaluation of renal artery variation.

This study seeks to explore the differences that arise from several variations of post processing techniques. The sensitivity and specificity as well as the accuracy values between post processing techniques are not well described from the existing articles. The limitation of this study is that not all articles include variations in the number of MRA and polar MRA. There are no articles that discuss the renal vein as additional information in preparation for kidney transplantation

CONCLUSION

Renal CT Angiography is the main diagnostic examination to assess the vascular anatomy of the kidney in addition to conventional angiography as the gold standard. Renal CT Angiography using a combination of post-processing techniques is able to provide accurate and sufficient information about the anatomy and variants of the renal arteries, as well as extrarenal anatomy. The use of a single post-processing technique is not recommended, because it is necessary to have a comparison with the results of the appropriate post-processing technique.

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