SRIWIJAYA JOURNAL OF SURGERY

Sriwijaya Journal of Surgery Volume 3, Issue 2, Page No: 135-147
Available online: www.sriwijayasurgery.com
SJS 3(2) : 135-147

Accuracy of Spiral Laminar Flow, Spectral Broadening and Murmur / Thrill as Av-Shunt Maturuty Predictors in Dr. Mohammad Hoesin General Hospital Palembang

Sefta Jaka[1], Kemas Muhammad Dahlan[1*], Jaka Fahmi[1], Erial Bahar[2]

[1] Department of Surgery, Dr. Mohammad Hoesin General Hospital, Palembang, Indonesia

[2] Department of Anatomy, Faculty of Medicine, Sriwijaya University, Palembang, Indonesia

Coressponding Author : dokterdahlanspb@gmail.com

Abstract

Background: Hemodialysis is a therapy for end-stage cornic kidney disease (ESRD) which is most often used as renal replacement therapy. Vascular access for hemodialysis is essential in the management of patients with chronic kidney disease. One type of vascular access is av fistula. A well-matured AVF is needed in order to function optimally during the hemodialysis process. The study of Srivastava et al. In India examined a predictor parameter of the maturation of AVF using Doppler ultrasound. The parameters studied were Spiral Laminar Flow (SLF), Spectral Broadening and Murmur / thrill. The results of this study state that SLF is the most important and early predictor of AVF maturation.[5] Research on the accuracy of spiral laminar flow, spectral broadening and murmur / thrill as predictors of av-shunt maturity has never been carried out in Indonesia. This encourages this research to be carried out.

Methods: This type of research is the prognostic test. The study was conducted in the vascular and endovascular subdivisions from July - September 2020 or until the number of research samples is met.

Results: There were 30 samples in this study, Murmur / thrill had high sensitivity and specificity values on day 21 while SLF and spectral broadening had very high sensitivity and specificity

values in predicting AVF maturase from day 7th and 21th, also had a significant association with AVF maturase ($p < 0.001$).

Conclusion: Murmur / thrill on 21th day can be a perdictor for maturity of AVF

Keyword : murmur / thrill, spiral laminar flow, spectral broadening, arteriovena fistula, end-stage chronic kidney disease

1. Introduction

Chronic kidney disease is an emerging public health problem worldwide. In the United States, the prevalence of end-stage kidney disease (ESRD) continues to increase. The growth of ESRD is associated with lower early detection of chronic kidney disease. Developed countries such as North America, Europe and Japan have the highest incidence of ESRD. More than 1 million patients are on dialysis worldwide with an incidence of about one quarter of a million per year. In the United States, the overall prevalence of chronic kidney disease increased from 12 to 14 percent between 1988 and 1994 and from 1999 to 2004 but has been relatively stable since 2004.[1]

Hemodialysis is an ESRD therapy that is most often used as renal replacement therapy in addition to peritoneal dialysis or kidney transplantation. Vascular access for hemodialysis is important in the management of patients with chronic kidney disease because through this access, the patient's blood can be transferred to the dialysis filter and returned to the patient in a continuous process, which usually takes three to four hours, two to three times a week. Vascular access for hemodialysis is divided into temporary and permanent vascular access. Temporary vascular access consists of tunneling and nontunneling CDL, while permanent vascular access consists of Arteriovenous fistule (AVF) and arteriovenous graft (AVG). Monitoring of such access yields better outcomes and reduces complications inherent in patients undergoing dialysis.[2,3]

The establishment and maintenance of a dialysis vascular access are important in hemodialysis because the AV shunt is a line of life. AVF is a communication made surgically

between the original artery and vein of the limb, whereas AVG is a communication made by placing a polytetrafluoroethylene (PTFE) graft on the extremity. AVF is the recommended access for patients undergoing hemodialysis because it tends to last longer, has lower rates of infection, morbidity and mortality, and reduces the likelihood of repeated interventions compared to CDL. However, access problems are a major determinant of morbidity among hemodialysis patients. Pre-operative evaluation of the veins and arteries of the upper extremities using Doppler ultrasound is a recommended adjunct, especially in obese patients, who have a history of previous vascular access surgery, or patients with suspected venous or arterial disorders.[4,5]

Doppler ultrasound examinations tend to take longer than physical examinations, and require a reliable examiner and specialized tools. However, Doppler ultrasonography has been shown to be effective in the assessment of vascular anatomical features and flow measurement and has high ultrasound diagnostic value on AVF.[6] The sensitivity, specificity, and accuracy of Doppler USG were 96.55%, 61.53%, and 74.48%.[7] This examination also provides information on the superficial and deep veins in the arm and provides complete data on arterial circulation. In addition, Doppler ultrasound is completely non-invasive, safe and repeatable. Doppler ultrasound is a diagnostic imaging technique that simultaneously displays the anatomy of an area and its blood supply. This Doppler ultrasound is the only examination that can be performed directly by a doctor that will establish vascular access, and is an undeniable advantage.[8]

A well-matured AVF is needed in order to function optimally during the hemodialysis process. The study of Asif et al. Showed that the percentage of AVF that failed to develop adequately for dialysis ranged from 28% to 53%.[4,8] Generally, the term maturation refers to the development of physical characteristics that make AVF suitable for venipuncture with large needles. Failure to mature is a fistula that is difficult to cannulate or fails to produce the blood flow required (600 ml / min) for successful two-needle dialysis. In many cases, failing mature AVF is the reason why it cannot be used for dialysis. So it is often delayed by half a year or more to allow additional time for the fistula to develop.[4,8]

The study of Srivastava et al. In India examined a predictor parameter of the maturation of AVF using Doppler ultrasound. The parameters studied were Spiral Laminar Flow (SLF), Spectral

Broadening and Murmur / thrill. The results of this study suggest that SLF is the most important and early predictor of AVF maturation.[5]

Research on the accuracy of spiral laminar flow, spectral broadening and murmur / thrill as predictors of av-shunt maturity has never been done in Indonesia. This prompted a study of early predictors of maturation of arteriovenous fistulas (AVF) as hemodialysis access in patients at the Vascular Surgery outpatient of Dr. Mohammad Hoesin Hospital Palembang. Given the importance of predictors of maturation, especially in the early phase, because identification and correction of vascular access abnormalities in the early phase can predict early maturity levels and success of hemodialysis and improve function and quality of life of patients undergoing hemodialysis.

2. Methods

This type of research is the prognostic test. The research was conducted at the Vascular Surgery Outpatient at Dr. Mohammad Hoesin Palembang from July - September 2020.

The population in this study were all patients who underwent surgery for the formation of arteriovenous fistulas at Dr. Mohammad Hoesin Hospital Palembang for the period July - September 2020.

All members of the population who meet the inclusion and exclusion criteria. Determination of the sample size in this study using the rule of thumb formula, which is 5-10 times the number of independent variables studied. The sample size in this study is 10 x 3 = 30 samples.

The inclusion criteria in this study included patients who underwent surgery for the formation of arteriovenous fistulas, the patient had stated their consent to be the study sample. Meanwhile, the exclusion criteria in this study were patients who experienced primary failure in the formation of arteriovenous fistulas.

The data collected is primary data from the results of the doppler ultrasound examination (LOGIQ S7 Expert, 2016, South Korea) at the Vascular Surgery Outpatient of Dr. Mohammad Hoesin Hospital Palembang.

Doppler ultrasound examination was performed in all postoperative patients on days 0, 7, and 21. The presence or absence of three parameters was recorded on venous outflow as thrill or murmur, spectral broadening and spiral laminar flow (SLF). SLF is seen as a red blue split on

doppler. The existence of thrill as the above parameter is the criterion used to follow up the patient on day 0. On the 7th postoperative day, all three parameters were assessed and the presence of one of the three parameters above was the criterion used for patient follow-up on day 21. Then at week 6, an assessment was carried out using the rules of six as a determinant of the maturity of arteriovenous fistulas and successful hemodialysis (HD). Data were presented in 2 excel form and analyzed using SPSS version 21 program.

3. Results

General Characteristics

Based on gender, there were 23 (76%) male and 7 (24%) female. The mean age in months was 13 months, the youngest was 34 years old and the oldest was 77 years old.

Table 1. Sample Characteristics as Predictors of AV Shunt Maturity Accuracy

Variable	n=30
Murmur/Thrill (H-0)	
Yes	29 (96.7%)
No	1 (3.7%)
Murmur/Thrill (H+7)	
Yes	29 (96.7%)
No	1 (3.7%)
Murmur/Thrill (H+21)	
Yes	28 (93.3%)
No	2 (6.7%)
Spiral Laminar Flow (H+7)	
Yes	29 (96.7%)
No	1 (3.7%)
Spiral Laminar Flow (H+21)	
Yes	28 (93.3%)
No	2 (6.7%)
Spectral Broadening (H+7)	
Yes	29 (96.7%)
No	1 (3.7%)
Spectral Broadening (H+21)	
Yes	28 (93.3%)
No	2 (6.7%)
AV Shunt Maturity (H+6 weeks)	
Yes	27 (90%)
No	3(10%)

Table 2. Murmur/*Thrill* Distribution To AVF Maturity

Murmur/thrill	AV Maturity at 6th week		p
	Yes	No	
Day 0			0.002
Yes	27(100%)	2(66.7%)	
No	-	1(33.3%)	
Day 7			0.002
Yes	27(100%)	2(66.7%)	
No	-	1(33.3%)	
Day 21			0.000
Yes	27(100%%)	1(33.3%)	
No	-	2(66.7%)	

Chi square test. significant if p<0.05

Table 3. Sensitivity of Murmur/thrill to AV maturity

AV Maturity	Murmur/thrill		
	Day-0	Day-7	Day-21
Sensitivity	100%	100%	100%
Spesificity	33.3%	33.3%	66.7%
Positive predictive value	93.1%	93.1%	96.4%
Negative predictive value	100%	100%	100%
Positive false value	6.9%	6.9%	3.6%
Negative false value	0%	0%	0%

Table 4. Distribution of SLF to AVF maturity

Spiral Laminar Flow	AV Maturity at 6th weeks		P
	Yes	No	
Day-7			0.002
Yes	27(100%)	1(33.3%)	
No	-	2(66.7%)	
Day-21			0.000
Yes	27(100%)	2(66.7%)	
No	-	1(33.3%)	

Chi Square test, p value significant if p <0.05

Table 5. SLF Accuracy To AVF Maturity

AV Maturity	Spiral Laminar Flow	
	Day-7	Day-21
Sensitivity	100%	100%
Spesificity	33.3%	66.7%
Positive predictive value	93.1%	96.4%
Negative predictive value	100%	100%
Positive false value	6.9%	3.6%
Negative false value	0%	0%

Table 6. Distribution of *Spectral broadening* To AVF Maturity

Spectral Broadening	AV Maturity at 6th week		P
	Yes	No	
Day-7			0.002
Yes	27(100%)	1(33.3%)	
No	-	2(66.7%)	
Day 21			0.000
Yes	27(100%)	2(66.7%)	
No	-	1(33.3%)	

Table 7. Spectral Broaderning Accuracy To AVF Maturity

AV Maturity	Spiral Laminar Flow	
	Day-7	Day-21
Sensitivity	100%	100%
Spesificity	33.3%	66.7%
Positive predictive value	96.9%	96.3%
Negative predictive value	100%	100%
Positive false value	7.1%	3.7%
Negative false value	0%	0%

Table 8. Accuracy Value on AVF Maturation Predictor Parameters

Parameters	Sensitivity			Spesificity		
Day	0	7	21	0	7	21
Murmur/*trhill*	100%	100%	100%	33.3%	33.3%	66.7%
SLF	-	100%	100%	-	33.3%	66.7%
Spectral broadening	-	96.3%	100%	-	33.3%	66.7%

4. Discussion

AV maturation can be calculated through the rule of six, namely after 6 weeks of surgery, the diameter of the fistula on the body is about 6 mm with a depth of not more than 6 mm and the mean blood flow must be 600 ml / min or more and also the length of the fistula must be 6 cm.[46]

In most cases, the etiology of AVF failure remains largely undetermined. After AVF was made, initially the prediction of maturation was based on the presence of a thrill or murmur, although prediction of AVF maturation using a murmur / thrill was still a debate, but Srivastava et al. In his book entitled "The pediatric anesthesia handbook" Nasr et al. 2017 states that murmur / thrill examination is more recommended for pediatric patients.[41] In line with Nasr et al. maturation of AVF especially in children

Consistent with this study, Srivastava et al in 2019 also found that there was a significant relationship between SLF and AVF maturation not only on day 0 but also on day 7.5 In line with this study and Srwivastava et al, Remuzzi et al. 2017 also used SLF. to predict AVF maturase and found a significant association on day 0 postoperatively.

The spiral flow pattern is easily identified using Doppler by interrogating the vessel in the true transverse plane at a low velocity setting. This approach results in a characteristic "red / blue" split onto a transverse Doppler image. If SLF is disturbed for physiological and anatomical reasons, turbulent flow will occur. There will appear to be a loss of blue-redshift in the turbulence area.

Consistent with this study, Srivastava et al. 2019 also found that spectral broadening was significantly associated with AVF maturation in HD patients, but only on days 0 and 7

postoperatively.[5] Park et al 2017 stated that the use of spectral broadening parameters in predicting more AV maturation effective compared to other examinations.44 Scharbele et al 2018 also concluded that the use of spectral broadening has high accuracy (sensitivity and specificity) in predicting AV maturation.

In this study SLF and spectral broadening both have high accuracy values, this study is in line with Srivastava et al who concluded that SLF has a high level of accuracy with high sensitivity and specificity, consistent with this, Zambolli et al 2018 and Remuzzi et al 2017 also found that SLF and broadening spectra have high accuracy in predicting AV maturation. [5,38,43]

In contrast to this study, Srivastava et al concluded that SLF and spectral broadening were associated with AVF maturation with high accuracy values with the earliest clinical parameters.[5] However, Nasr et al 2015 is in line with this study where the murmur / thrill still has high accuracy. In predicting AV maturation, Nasr et al 2015[41] and Tewelde et al 2017[42] state that murmurs / thrills can be used for emergencies and are suitable for pediatrics and can be performed in limited health facilities, however Schaberle et al[45] and Srivasta et al[5] further concluded that SLF is more accurate in assessing AVF maturation.

5. References

1. Sanyaolu A, Okorie C, Annan R, et al. Epidemiology and management of chronic renal failure: a global public health problem. Biostatistics Epidemiol Int J. 2018;1(1): 11-16.
2. Queeley GL, dan Campbell ES. Comparing Treatment Modalities for End- Stage Renal Disease: A Meta-Analysis. Am Health Drug Benefits.2018;11(3):118-127
3. Junior JHF, Pitta GBB, dan Junior FM. Accuracy of Doppler Ultrasonography in The Evaluation of Hemodialysis Arteriovenous Fistula Maturity. Rev. Col. Bras. Cir. 2015; 42(3): 138-142
4. Siddiqui MA, Ashraff S, Santos D, Rush R, Carline T, dan. Raza Z. Predictive parameters of arteriovenous fistula maturation in patients with end-stage renal disease. Kidney Res Clin Pract. 2018; 37(3): 277–286.

5. Srivastava A, Mittal V, Lal H, Javali T, Patidar N, Sureka S, et al. Spiral Laminar Flow, the Earliest Predictor for Maturation of arteriovenous fistula for hemodialysis access. Indian J Urol 2015;31:240-4.
6. Pietur R, Janczare M, Zaluska W, Szymanska A, Janicka L, Bednarek AS, dan Trojanowska MS. Colour Doppler ultrasound assessment of well-functioning mature arteriovenous fistulas for haemodialysis access. European Journal of Radiology 2005;55: 113–19
7. Hirsch AT, Haskal ZJ, Hertzer NR, et al; American Association for Vascular Surgery/Society for Vascular Surgery; Society for Cardio-vascular Angiography and Interventions; Society for Vascular Medicine and Biology; Society of Interventional Radiology; ACC/AHA Task Force on Practice Guidelines. ACC/AHA Guidelines for the Management of Patients with Peripheral Arterial Disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Associations for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (writing commitee to develop guidelines for the management of patients with peripheral arterial disease) summary of recommendations. J Vasc Interv Radiol. 2006; 17(9): 1383-1397.
8. Zamboli P, Fiorini F, Amelio AD, Fatuzzo P, dan Granata A. Color Doppler Ultrasound and Arteriovenous Fistulas for Hemodialysis. J Ultrasound. 2014;17:253–263
9. Shenoy, Surendra. Surgical Anatomy for Upper Arm: what is needed for AVF planning. The Journal of Vascular Access 2009; vol 10: 223-232.
10. Snell, Richard S. Anatomi Klinik untuk Mahasiswa Kedokteran Edisi 6. Jakarta: EGC. 2012.
11. S. Wolowczy L, Williams AJ, Donovan KL, Gibbons CP. The Snuffbox Arteriovenous Fistula for Vascular Access. Eur J Vasc Endovasc Surg. 2000. 19:p 70–76
12. Bohannon WT, Silva MB. Venous Transposition in the Creation of Arteriovenous Access in Rutherford: Vascular Surgery, 6th ed. Editor: Rutherford RB. New York: Elsevier. 2005: 1677-84.

13. Khwaja KO. Dialysis Access Procedure in Atlas of Organ Transplantation 2nd ed. Editor: Humar A, Matas AJ, Payne WD. London: Springer. 2009: 35-58.
14. Himmelfarb, Jonathan dan Talp Ikizler. Hemodialysis. New England Journal of Medicine. 2010. 363 (19): 1833-1845
15. National Kidney Foundation Disease Outcomes Quality Initiative (NKF DOQI). . Available at: http://www.kidney.org/professionals/KDOQI/guidelines_commentaries.cfm. Accessed October 5, 2015
16. Perhimpunan Dokter Spesialis Penyakit Dalam Indonesia. 2014. Buku Ajar Ilmu Penyakit Dalam Jilid II. 6th ed. Jakarta: Interna Publishing.
17. Foote, Edward F & Harold J. Manley. 2008. Hemodialysis and Peritoneal Dialysis. Dalam Pharmacotherapy. The Mc Graw Hill companies: Ha.l 103-117
18. Tan CS, Schainfeld RM, Wu S. Hemodialysis Access: Types. Dalam: Wu S, Kalva SP (Editors). Dialysis Access Management. New York: Springer. 2015: 73-75.
19. Sales CM., Goldsmith J, Veith FJ. Handbook of Vascular Surgery. New York: Taylor & Francis Group. 1994: 307-30.
20. Bakari A, Nwankwo E, Yahaya S, Mubi B, Tahir B. Initial Five Years of Arterio-Venous Fistula Creation for Haemodialysis Vascular Access in Maiduguri, Nigeria . The Internet Journal of Cardiovascular Research. 2007; 4(2): 1-6.
21. Berge MGT, Yo TI, Kerver A, de Smet AAEA, Kleinrensink GJ. An Anatomical Approach to Arteriovenous Fistula Performance in the Forearm. Eur J Vasc Endovasc Surg. 2011; 81-82.
22. Sofocleus CT, Cho KJ. Dialysis Fistulas. Medscape Reference. 2015.
23. McMonagle, M and Stephenson, M. Vacular and Endovascular Surgery at Glance. Philedelpia. Wiley Blackwell. 2011
24. Rowse JW, Kirksey L. Surgical Approach to Hemodialysis Access. Semin Intervent Radiol. 2016; 33: 21-24.
25. Parekh VB, Niyyar VD, Vachharajani TJ. Lower Extremity Permanent Dialysis Vascular Access. Clin J Am Soc Nephrol .2016 05(1) : p1-9

26. National Kidney Foundation. KDOQI clinical practice guidelines and clinical practice recommendations for hemodialysis adequacy, peritoneal dialysis adequacy, and vascular access: 2006 Updates.Am J Kidney Dis 2006;48:S1–S322
27. Malovrh M. Approach to patients with end-stage renal disease who need an arteriovenous fistula. Nephrol Dial Transplant 2003;18(Suppl 5):v50–v52
28. Ocak G, Halbesma N, le Cessie S, et al. Haemodialysis catheters increase mortality as compared to arteriovenous accesses especially in elderly patients. Nephrol Dial Transplant 2011;26(8):2611–2617
29. Reynolds TS, Zayed M, Kim KM, et al. A comparison between oneand two-stage brachiobasilic arteriovenous fistulas. J Vasc Surg 2011;53(6):1632–1638, discussion 1639
30. Lok CE, Sontrop JM, Tomlinson G, et al. Cumulative patency of contemporary fistulas versus grafts (2000-2010). Clin J Am Soc Nephrol 2013;8(5):810–818
31. Woo K, Doros G, Ng T, Farber A. Comparison of the efficacy of upper arm transposed arteriovenous fistulae and upper arm prosthetic grafts. J Vasc Surg 2009;50(6):1405–11.e1, 2
32. Greenberg JI, May S, Suliman A, Angle N. The brachial arterybrachial vein fistula: expanding the possibilities for autogenous fistulae. J Vasc Surg 2008;48(5):1245–1250, 1250.e1–1250.e2
33. Niyyar VD. Anterior chest wall arteriovenous grafts: an underutilized form of hemodialysis access. Semin Dial 2008;21(6):578–580
34. Al-Jaishi AA, Oliver MJ, Thomas SM, et al. Patency rates of the arteriovenous fistula for hemodialysis: a systematic review and meta-analysis. Am J Kidney Dis 2014;63(3):464–478
35. Stolic R. Most Important Chronic Complications of Arteriovenous Fistulas for Hemodialysis. Medical Principle and Practice. 2013; 22: 220-228.
36. Mickley, Volker. Steal Syndrome. Strategies to preserve vascular and extremity. Nephrology dialysis Transplantation. 2008:1(1):p19-24
37. Neville, RF et al. Venous Hypertension associated with arteriovenous hemodialysis access.Seminars in Vascular Surgery, Vol 17, No 1 (March), 2004: pp 50-56

38. Zamboli P, et al. High-flow arteriovenous fistula and heart failure: could the indexation of blood flow rate and echocardiography have a role in the identification of patients at higher risk?. J Nephrol. 2018 Dec;31(6):975-983.
39. Shenoy, Surendra dan Darcy Michael. Ultrasound as a Tool for Preoperative Planning, Monitoring, and Interventions in Dialysis Arteriovenous Access. AJR 2013; 201:539–543
40. Chavhan GB, Parra DA, Mann A, Navarro OM. Normal Doppler Spectral Waveforms of Major Pediatric Vessels: Specific Patterns. RG. 2008; 28(3): 691-692.
41. Nasr, Viviane G., and James A. DiNardo. The Pediatric Cardiac Anesthesia Handbook. John Wiley & Sons. 2017.
42. Tewelde, Semhar Z. Cardiovascular Emergencies, An Issue of Emergency Medicine Clinics of North America. Vol. 33. No. 3. Elsevier Health Sciences, 2015.
43. Remuzzi, Andrea, and Michela Bozzetto. "Biological and physical factors involved in the maturation of arteriovenous fistula for hemodialysis." Cardiovascular Engineering and Technology 8.3. 2017; 273-279.
44. Park, Hoon Suk, et al. "Usefulness of assisted procedures for arteriovenous fistula maturation without compromising access patency." Hemodialysis International. 2017;21(3): 335-342.
45. Schaberle, Wilhelm. Arteriovenous Fistulas. In: Ultrasonography in Vascular Diagnosis. Springer, Cham, 2018. p. 263-290.