

Causes of Delay in Establishing Permanent Vascular Access in Hemodialysis Patients in Iran

İran'da Hemodiyaliz Hastalarında Kalıcı Damar Yolun Sağlanmasıdaki Gecikme Nedenleri

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ABSTRACT

Introduction: In End Stage Renal Disease (ESRD), the patient needs alternative treatments such as dialysis for survival. To perform hemodialysis, proper vascular access is required. At emergency situations, the Central Venous Catheters (CVC) are used; however, they are not ideal for long-term dialysis. Hence, the permanent methods of hemodialysis should be replaced as soon as possible. This study aimed to investigate the causes of delay in the establishment of permanent vascular access in patients undergoing hemodialysis in Guilan in 2014 to 2015.

Methods: The study was performed on 420 patients with ESRD who had been undergone hemodialysis through a CVC for more than three weeks in Razi Educational Remedial and Research Center. Data collection was done through checklist and interviews with the patients. All information entered into the SPSS 21 and analyzed by descriptive and inferential tests.

Results: Totally, 56.4% of patients were male and 25.5% were 61 to 70 years old. 42.1% had delay between 1 and 2 months. The most important predictors of delay were: Patient's unwillingness, high costs of surgery, patient's inadequate knowledge about the need to establish AVF (Arterio Venous Fistula), Patient's fear of risks of AVF, lack of proper insurance coverage, Old age, Lesions at the insertion site of vascular access and lack of access to a nephrologist.

Conclusion: Promoting the patients scientific information about establishing a permanent vascular access can have a significant role in reducing the delays in establishing permanent vascular access.

Keywords: Vascular access, End Stage Renal Disease, Hemodialysis.

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ÖZET

Amaç: Son Dönem Böbrek Hastalığında (SDBY) hastanın hayatta kalabilmesi için diyaliz gibi alternatif tedavilere ihtiyacı vardır. Hemodiyaliz gerçekleştirmek için uygun vasküler erişim gereklidir. Acil durumlarda Santral Ven Kateterleri (CVC) kullanılır; ancak, uzun süreli diyaliz için ideal değildirler. Bu nedenle kalıcı hemodiyaliz yöntemleri bir an önce değiştirilmelidir. Bu çalışma, 2014-2015 yılları arasında Guilan'da hemodiyaliz uygulanan hastalarda kalıcı damar yolu açılmasındaki gecikmenin nedenlerini araştırmayı amaçladı.

Yöntem: Çalışma, Razi Eğitim Tedavi ve Araştırma Merkezi'nde üç haftadan fazla bir süre boyunca bir CVC aracılığıyla hemodiyaliz uygulanan 420 SDBY hastası üzerinde gerçekleştirildi. Veri toplama, kontrol listesi ve hastalarla görüşmeler yoluyla yapıldı. Tüm bilgiler SPSS 21'e girildi ve tanımlayıcı ve çıkarımsal testlerle analiz edildi.

Bulgular: Toplamda hastaların %56.4'ü erkekti ve %25.5'i 61-70 yaşları arasındaydı. %42.1'i 1 ile 2 ay arasında gecikme yaşadı. Gecikmenin en önemli nedenleri: Hastanın isteksizliği, ameliyat maliyetinin yüksek olması, hastanın AVF (Arterio Venöz Fistül) kurma ihtiyacı konusunda yetersiz bilgi sahibi olması, Hastanın AVF riskinden korkması, uygun sigorta güvencesinin olmaması, Yaşlılık, damar yolu girişi yeri ve nefroloğa erişimin olmamasıdır.

Sonuç: Hastalara kalıcı damar yolu kurulması konusunda bilimsel bilgilerin verilmesi, kalıcı damar yolu açılmasındaki gecikmelerin azaltılmasında önemli bir rol oynayabilir.

Anahtar Sözcükler: Vasküler erişim, Son Aşama Böbrek Hastalığı, Hemodiyaliz.

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INTRODUCTION

The End stage renal disease is one of the most important and costly diseases in the world. In fact, ESRD is the end-stage of chronic Renal Failure (CRF) in which the kidney function is not enough to sustain the life. This means that the kidneys function is lower than their normal level(1) . If the patient progresses to the fifth stage of the Chronic kidney Disease (CKD), the stage where the Glomerular Filtration Rate (GFR) decreases to less than 15 cc per minute, a large amount of urea and other nitrogenous substances will accumulate in the blood (1, 2). Thus, the patients usually experience marked impairment in daily activities, health, nutritional status and homeostasis of water and electrolytes and finally develop uremic syndrome (3). At this stage, the patients need alternative therapies such as dialysis and kidney transplant to survive, and, if untreated, they will die (4).

Broad access to dialysis has extended the life of hundreds of thousands of patients with ESRD so that globally, the mortality rate of patients with ESRD in Europe and Japan has reduced to minimal, while it is very high in developing countries due to limited access to dialysis (5). Given the increased life expectancy in patients with renal failure and the increasing number of patients requiring hemodialysis and recognition of ArterioVenous Fistulas (AVFs) as the gold standard of vascular access for hemodialysis, performing widespread researches on different techniques of establishing this type of fistulas and evaluating the efficacy and complications resulting from them are of great importance. According to the statistics, there are 35,000 cases of the disease in Iran that 16,000 of them have undergone a kidney transplant surgery, while 16,000 others are under hemodialysis treatment and 3,000 patients are treated with peritoneal dialysis. Hence, hemodialysis is the major approach of hemodialysis in Iran (6).

One of the most important conditions for doing hemodialysis is access to the patient's circulatory system so that at least 150 to 250 cc of blood per minute can be taken from the patient for delivery to the hemodialysis machine. Access to the patient's circulatory system can be temporary or permanent (7). In fact, one of the most important and controversial issues on hemodialysis is the type of selected method to access and find the vessels, retention of each of these methods and possible complications followed by using each of them(6) .

The vascular access procedures in chronic hemodialysis include: arteriovenous fistula, Synthetic grafts, Catheters without temporary cuff (CVC), Permanent catheters with cuff. In the United States of America, every year, more than 5 million CVC are used by physicians. Unfortunately, the use of CVC is associated with adverse events so that more than 15% of the patients using these catheters will develop complications(8), including infections and thrombotic complications (9). The use of temporary catheters (through Shaldon catheters) is recommended for a maximum period of 2-3 weeks due to the high risk of infection, thrombosis, venous constriction and lack of long-term performance, while the permanent catheter has been even used up to 4 years(10, 11). The CVC can be used for a shorter period than the AVF.

Although the AVF has some drawbacks, but for various reasons, it is recognized as the best method of choice, such as the lower mortality rate of patients with fistulas, lower incidence of complications, requiring less following therapeutic interventions and hospitalization, their longer life cycle than other methods and lower cost of implantation (12, 13) . Recent studies have shown that the risk of mortality in hemodialysis patients that had used the CVC was 47% more than the patients who had used the AVF (14) . It thus seems that CVC is not an ideal method for long-term dialysis, and at the first opportunity, the permanent vascular access methods should be used. Due to the fact that no study has been done so far in Guilan to evaluate the causes of delay in the establishment of permanent vascular access as well as its predictors in hemodialysis patients, then, this study was conducted to determine the causes and predictors of delay in the establishment of permanent vascular access in hemodialysis patients in one of the largest state-owned dialysis centers of Guilan.

METHODS

Study design and patients

This descriptive-analytical study was conducted on 420 patients referred to the selected hospitals in Guilan province (Razi Educational, Remedial and Research Center in Rasht and Bandar Anzali Medical Center) since 2014 to 2015 who had undergone hemodialysis through a CVC for more than three weeks with delay in the permanent vascular access. Data collection tool was a checklist consisting of three parts.

The first part of the checklist contained 9 questions about socio-demographic characteristics of the patients (such as age, gender, marital status, education level, place of residence, insurance status, income, employment status and the name of the dialysis facility center). The second part included 8 questions about the clinical characteristics of the patients (such as the primary cause of ESRD, dialysis start time, initial referring to begin dialysis, the frequency of hemodialysis, the duration of each session of hemodialysis, vascular access type at the moment, underlying diseases, the duration of the delay in permanent vascular access). The third part of the checklist contained 15 questions about the causes of delay in the establishment of vascular access, which in turn had been divided in three areas of causes related to the patient (7 questions), factors related to the physician (4 questions), and the causes related to facilities and resources (4 questions). Delay in permanent vascular access in this investigation was considered as an average of 3 weeks or more based on the conducted studies (15, 16) . The data were collected by using interviews and review of the patients' medical records. After obtaining permission from the Department of Science and Technology of Guilan University of Medical Sciences and approval of the Ethics Committee with code of IR.GUMS.REC.1395.175, the researcher visited Razi Educational, Remedial and Research Center in Rasht and Bandar Anzali Medical Center in the morning of working days and completed the questionnaires. Due to the fact that access to patients meeting the inclusion criteria for this study was not possible in Bandar Anzali Medical Center, all the samples of this study were selected from the dialysis center of Razi Educational, Remedial and Research Center. The aim of this study was explained to all patients and Informed consent was obtained from all individual participants included in the study. It was explained to the patients that participating in this study is completely optional, and the results will be published generally without mentioning the names of them. It was also announced that the reluctance of patients to participate in the study will not make a dent in their treatment process.

Statistical analysis

After collecting the data, all the information was entered into the SPSS software, Ver. 21. The indices of frequency and frequency percentage were used to determine the factors related to the patients, physician and resources and facilitating involved in the delay in the permanent vascular access. The independent t-test and ANOVA were used to compare the delay time durations in terms of individual and social variables and the studied causes in the univariate analysis test. Also, the linear regression model by stepwise method in the multivariate analysis was used to determine predictors associated with length of delays in the establishment of permanent vascular access. The $P < 0.05$ was considered significant.

RESULTS

Totally, 56.4% of patients were male, 87.6% of patients were married and 25.5% were 61 to 70 years old (Table 1). Of the 420 patients studied, 388 of them had underlying diseases, of which, high blood pressure (33%), and diabetes (20.5%) accounted for the largest percentage of the underlying diseases (Table 2). In 66.1% of patients (278 patients), the vascular graft and in 33.8% of patients (142 people), the AVF was used for hemodialysis.

Table 1: Demographic characteristics of the patients

Variable	Status	Number (percent)
Gender	Female	183 (43.6)
	Male	237 (56.4)
Age range (years)	Years < 40	65 (15.5)
	41-50 years	46 (11)
	51-60 years	102 (24.3)
	61-70 years	107 (25.5)
	Years > 70	100 (23.8)
Marital Status	Single	33 (7.9)
	Married	368 (87.6)
	Divorced	6 (1.4)
	Widow/Widower	13 (3.1)
Education level	Under diploma	80 (19)
	Diploma	161 (38.3)
	University degree	179 (42.6)
Location of residence	City	303 ()
	Village	117 (27.1)
Insurance Status	Insured	402 (95.7)
	Uninsured	18 (4.3)
*Economic status	Low	23 (5.5)
	Average	160 (38.1)
	Good	15 (3.6)
	Without answer	222 (52.9)
Employment status	Employed	149 (35.5)
	Unemployed	55 (13.1)
	Housewife	140 (33.3)
	Retired	76 (18.1)
Total	-	420 (100)

* Low economic status: Income below 8,000,000 Rial per month

Moderate economic status: Income of 8,000,000 to 16,000,000 Rial per month

Good economic status: Income above 16,000,000 Rial per month

Table 2: Underlying diseases in the patients

Underlying condition	Number (percent)
Diabetes	166 (20.5)
Hypertension	267 (33)
UTI*	5 (0.6)
CAD**	24 (3)
CHF***	97 (11.9)
Liver Disease	28 (3.4)
Dementia	22 (2.7)
Vascular disease	23 (2.8)
Respiratory disease	18 (2.2)
Other	160 (19.8)
Total	810 (100)

*UTI: Urinary Tract Infection

**CAD: Coronary Artery Disease

***: Congestive Heart Failure

The high costs of surgery and the poor economic situation of the patients (45%), the presence of lesions in the site of establishing site of permanent vascular access (42.6%), accounted for the highest causes of delay in the establishment of permanent vascular access, respectively (Table 3).

Table 3. Causes of delay in providing permanent vascular access

Causes of delay in providing permanent fistula	Frequency (percentage)
Lack of access to the vascular surgeon	2 (0.5%)
Lack of access to a nephrologist	7 (1.7%)
Late referral of nephrologist to vascular surgeon	1 (0.2%)
Delay in vascular surgeon visit to provide vascular access	1 (0.2%)
Patient's fear of sided effects and risks of AVF	88 (21%)
Lesions at the insertion site of vascular access	179 (42.6%)
Patient's delay	67 (16%)
Unwillingness to establish AVF	67 (16%)
Medical contraindications	58 (13.8%)
Patient's inadequate knowledge	140 (33.3%)
Old age	134 (31.9%)
Hesitation in deciding other treatments	69 (16.4%)
Lack of adequate insurance coverage	126 (30%)
High costs of surgery and patient's poor economic situation	189 (45%)
The long waiting time for vascular access since diagnosis	23 (5.5%)

The mean delay duration was statistically significant in terms of age group, marital status, education level, having insurance and economic status ($P = 0.05$). The mean delay duration in the permanent vascular access was also statistically significant in terms of underlying diseases ($P = 0.021$) so that the patients with underlying diseases had higher more delay time in the vascular access (71.3 ± 29.9 day versus 58.75 ± 4.25 days) (Table 4).

Table 4. Comparing the length of delay in terms of individual and social variables, underlying diseases, causes of ESRD, the referral of the patient and vascular access

Variable	Length of Delay (days)		P
	Mean $\pm$ SD		
Age range (years)	Age		
	Years < 40	60.62 $\pm$ 24.76	
	41-50 years	65.11 $\pm$ 27.40	
	51-60 years	70.39 $\pm$ 29.27	
	61-70 years	71.54 $\pm$ 30.79	0.0004
Marital Status	Years > 70	77.90 $\pm$ 31.34	
	Single	60.45 $\pm$ 20.25	
	Married	70.72 $\pm$ 30.32	
	Divorced	67.50 $\pm$ 21.15	0.046
	Widow/Widower	87.31 $\pm$ 29.90	
Education level	Under diploma	66.87 $\pm$ 26.14	
	Diploma	81.43 $\pm$ 33.80	
	University degree	62.01 $\pm$ 23.77	0.001
Economic status	Low	87.17 $\pm$ 35.02	
	Average	63.59 $\pm$ 24.86	
	Good	61.00 $\pm$ 14.04	0.0001
Underlying disease	Yes	71.34 $\pm$ 29.89	
	No	58.75 $\pm$ 25.40	0.021

The length of delay in establishing permanent vascular access was statistically significant based on all causes related to the patient except for the presence of lesions at the site of establishing vascular access (ulcers, thrombosis, fractures) and medical contraindications (inappropriate vascular condition, poor physical condition, mental illness, etc.). In addition, the length of the delay in permanent vascular access was also significant in terms of the causes related to the patient in general ($P = 0.001$). The dialysis patients whose cause of delay in permanent vascular access was due to causes related to the patient, had higher mean $\pm$ SD values of delay (4.74 ± 30.5 days versus 2.52 ± 4.16).

The length of delay in the permanent vascular access was statistically significant in terms of all causes related to the facilities and resources. In addition, the comparison of the length of delay was generally significant in terms of causes related to the facilities and resources ($P = 0.001$) so that 239 of the cases whose cause of delay was due to facilities and resources had higher mean and SD values of delay in the permanent vascular access (6.80 ± 31.9 days versus 8.56 ± 7.19).

The length of delay in the establishment of permanent vascular access was as follows: 42.1% ($n = 177$) of the patients: Between 1 and 2 months, 31.9% ($n = 134$) of the patients: Between 2 and 3 months, 17.4% ($n = 73$) of the patients: More than 3 months, 8.6% ($n = 36$) of the patients: Less than 1 month. The most important predictors of delay in the permanent vascular access were shown in Table 5 by using stepwise method in multivariate analysis.

Table 5. Predictors of Delay in the permanent vascular access

Predictors of Delay in the permanent vascular access	Regression coefficient) B(	Standard error S.E(	P value	95% confidence interval coefficient B Lower level	Upper level
Patient's unwillingness to establish AVF*	23.069	3.031	0.0001	17.110	29.027
High costs of surgery and poor economic situation of the patient	7.582	2.537	0.003	2.595	12.569
Patient's inadequate knowledge about the need to establish AVF for hemodialysis patients	12.347	2.370	0.0001	7.687	17.006
Patient's fear of sided effects and risks of AVF	16.455	2.659	0.0001	11.228	21.682
Lack of proper insurance coverage of the patients	13.879	2.673	0.0001	8.625	19.133
Old age	9.124	2.128	0.0001	4.673	13.485
Lesions at the insertion site of vascular access	6.500	2.099	0.002	2.375	10.625
lack of access to a nephrologist	24.877	8.242	0.003	8.675	41.079
(Constant Value)	45.466	1.834	0.0001	41.862	49.071

*AVF: Arterio Venous Fistula

DISCUSSION

CVC are used for dialysis in an emergency situation; but these devices are not seen as an ideal method for long-term dialysis. Thus, the use of permanent hemodialysis methods should be replaced as soon as possible (6). It was found in this study that with increasing age, the length of delay will increase in the establishment of permanent vascular access. This finding is in line with the Wright's study (17). This might be due to the lack of information among older patients regarding the advantages of permanent vascular access or higher probability of developing underlying disease in older patients, which reduces the possibility of re- surgery for establishing the permanent vascular access.

In this study, the mean length of delay had a direct relationship with the underlying diseases so that the patients with underlying diseases had longer delays in the permanent vascular access. Compared with Wasse et al. study, the patients with Ischemic Heart Diseases and peripheral vascular diseases were respectively 35% and 39% more likely to have 90 days delay in CVC vascular access to a permanent vascular access (18). The presence of underlying diseases may reduce the possibility of surgeries to establish a permanent vascular access due to higher risk of postoperative complications.

In this study, hypertension (33%), followed by diabetes (20.5%), accounted for the highest rate of underlying diseases. In Wright's study, the same two underlying diseases had the highest percentage (In 28.4% of cases, the cause of ESRD was reported as hypertension, and in 46.7% of cases, the diabetes was mentioned as cause of ESRD) (17).

Comparing the duration of delay was significant in terms of causes related to the facilities and resources ($p = 0.001$). Thus, among the causes related to the facilities and resources, expenditures and high costs of the surgery, the poor economic situation of the patients and lack of adequate insurance coverage of the patients are the predictors of length of delay. It seems that developing a solution to reduce the expenditures and high costs of the surgery and the

establishment of appropriate insurance coverage can be highly effective for all the patients.

According to the reasons of delays in the permanent vascular access, providing information to the patients about the necessity of establishing permanent vascular access and its benefits, reducing the costs of surgery and the adoption of measures to make periodic visits by nephrologists can be helpful in reducing the duration of delay in the establishment of permanent vascular access.

Among the causes related to the patients, physicians, facilities and resources, the patient's unwillingness to establish AVF, the expenditures and high costs of surgery, and the poor economic status of the patients predicted the highest percentage of the delays in this study.

In evaluation of causes related to the physician, only the patient's lack of access to a nephrologist due to the shortage of nephrologists was determined as a predictor of the duration of delay in the permanent vascular access. Avorn et al in their study, found that in patients with CRF, the late referral to a nephrologist was significantly associated with lower probability of a timely establishing of permanent vascular access for chronic hemodialysis. According to this study, the patients who had been referred late to a nephrologist or those rarely seen by a nephrologist more likely required temporary vascular access for hemodialysis initiation (19). It seems that the presence of a specialist in nephrology and conducting periodic visits of hemodialysis patients in dialysis centers can play a crucial role in reducing the duration of delay to establish a permanent vascular access.

It was revealed in the study by Mendelssohn et al. (20) that the suboptimal start of dialysis was common in Canada, and this also took place in both groups of patients with early and late referrals. The suboptimal start was associated with higher mortality rate in the first 6 months of dialysis initiation and negates the beneficial effect of early referral. According to this study, in Canada, efforts have been made to promote the awareness of the value of initial referral of patients with potentially serious and advanced kidney disease to a nephrologist. It is very

disturbing that the optimal start of dialysis usually occurs even when the patients are referred to a nephrologist early.

The limitations of this study were the shortage of similar and related studies in this area and the difficulty in reaching the patients with the right conditions to participate in the study. To control this limitation, the samples were taken from the dialysis center of Razi Educational, Remedial and Research Center.

CONCLUSION

According to the findings of this study, the duration of delay in the permanent vascular access in terms of the causes related to the patient implies that the increase in patients' awareness about the benefits of early permanent vascular access and its advantages can play a very effective role in reducing the duration of establishment of permanent vascular access. Increased educational features, increased awareness of patients and increasing the number of nephrologists as well as creating a strategy to reduce the high costs and expenditures of surgery can significantly reduce the duration of establishing a permanent vascular access. It appears that providing appropriate facilities for training and improving the patients' scientific knowledge level can effectively reduce the duration of permanent vascular access establishment. It is recommended to perform further research to assess and analyze the effective factors in establishing a permanent vascular access. Also, since the patients with delayed permanent vascular access were only examined in this study, it is suggested to assess both patients with and without delay in a permanent vascular access in future studies.

Conflict of interest

No conflict of interest was declared by the authors.

REFERENCES

1. Levey AS, Coresh J, Balk E, Kausz AT, Levin A, Steffes MW, et al. National Kidney Foundation practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Ann Intern Med* 2003;139(2):137-47.
2. Dabla PK. Renal function in diabetic nephropathy. *World J Diabetes* 2010;1(2):48-56.
3. Di Iorio BR, Bellizzi V, Cillo N, Cirillo M, Avella F, Andreucci VE, et al. Vascular access for hemodialysis: the impact on morbidity and mortality. *J Nephrol* 2004;17(1):19-25.
4. Knoll G, Cockfield S, Blydt-Hansen T, Baran D, Kiberd B, Landsberg D, et al. Canadian Society of Transplantation: consensus guidelines on eligibility for kidney transplantation. *Cmaj* 2005;173(10):S1-25.
5. Prasad N, Jha V. Hemodialysis in Asia. *Kidney Dis (Basel)* 2015;1(3):165-77.
6. Nafar M, Mousavi SM, Mahdavi-Mazdeh M, Pour-Reza-Gholi F, Firoozan A, Einollahi B, et al. Burden of chronic kidney disease in Iran: a screening program is of essential need. *Iran J Kidney Dis* 2008;2(4):183-92.
7. Vinsonneau C, Allain-Launay E, Blayau C, Darmon M, Ducheyron D, Gaillot T, et al. Renal replacement therapy in adult and pediatric intensive care : Recommendations by an expert panel from the French Intensive Care Society (SRLF) with the French Society of Anesthesia Intensive Care (SFAR) French Group for Pediatric Intensive Care Emergencies (GFRUP) the French Dialysis Society (SFD). *Ann Intensive Care* 2015;5(1):58.
8. McGee DC, Gould MK. Preventing complications of central venous catheterization. *N Engl J Med* 2003;348(12):1123-33.
9. Merrer J, De Jonghe B, Golliot F, Lefrant JY, Raffy B, Barre E, et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. *Jama* 2001;286(6):700-7.
10. Chan CT, Covic A, Craig JC, Davenport A, Kasiske BL, Kuhlmann MK, et al. Novel techniques and innovation in blood purification: a clinical update from Kidney Disease: Improving Global Outcomes. *Kidney Int* 2013;83(3):359-71.
11. Beigi AA, Ghaheri H, Jazi AHD, Alavi L. The Efficacy and Complications of Temporary and Permanent Central Venous Catheters in Patients with Renal Failure. *J Isfahan Med Sch* 2012;29(163).
12. Lok CE, Oliver MJ. Overcoming barriers to arteriovenous fistula creation and use. *Semin Dial* 2003;16(3):189-96.
13. Asif A, Cherla G, Merrill D, Cipleu CD, Briones P, Pennell P. Conversion of tunneled hemodialysis catheter-consigned patients to arteriovenous fistula. *Kidney Int* 2005;67(6):2399-406.
14. Astor BC, Eustace JA, Powe NR, Klag MJ, Fink NE, Coresh J. Type of vascular access and survival among incident hemodialysis patients: the Choices for Healthy Outcomes in Caring for ESRD (CHOICE) Study. *J Am Soc Nephrol* 2005;16(5):1449-55.
15. Goodkin DA, Pisoni RL, Locatelli F, Port FK, Saran R. Hemodialysis vascular access training and practices are key to improved access outcomes. *Am J Kidney Dis* 2010;56(6):1032-42.
16. Lilly MP, Lynch JR, Wish JB, Huff ED, Chen SC, Armistead NC, et al. Prevalence of arteriovenous fistulas in incident hemodialysis patients: correlation with patient factors that may be associated with maturation failure. *Am J Kidney Dis* 2012;59(4):541-9.
17. Wright S, Klausner D, Baird B, Williams ME, Steinman T, Tang H, et al. Timing of dialysis initiation and survival in ESRD. *Clin J Am Soc Nephrol* 2010;5(10):1828-35.
18. Wasse H, Speckman RA, Frankenfield DL, Rocco MV, McClellan WM. Predictors of delayed transition from central venous catheter use to permanent vascular access among ESRD patients. *Am J Kidney Dis* 2007;49(2):276-83.
19. Avorn J, Winkelmayer WC, Bohn RL, Levin R, Glynn RJ, Levy E, et al. Delayed nephrologist referral and inadequate vascular access in patients with advanced chronic kidney failure. *J Clin Epidemiol* 2002;55(7):711-6.
20. Mendelssohn DC, Curtis B, Yeates K, Langlois S, MacRae JM, Semeniuk LM, et al. Suboptimal initiation of dialysis with and without early referral to a nephrologist. *Nephrol Dial Transplant* 2011;26(9):2959-65.