Original Article

Factors associated with complications of vascular access site in hemodialysis patients in Isfahan Aliasghar hospital

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Abstract

Background: Vascular access complications are a major cause of excessive morbidity and mortality in the dialysis population. Moreover, there is not sufficient research regarding the factors correlated with vascular access complications among hemodialysis patients. This study aimed to evaluate the vascular access complications and their related factors such as nursing techniques and self-care in hemodialysis patients.

Materials and Methods: A cross-sectional study was performed on 110 patients undergoing hemodialysis in Isfahan Aliasghar hospital during 9 months from July 2010 to March 2011. The data collection tools were a demographic questionnaire and three checklists designed to assess the complications of vascular access and care techniques. Data were collected by observations and interviews with the patients. Fisher's exact test, chi-square test, Pearson correlation coefficient, and descriptive statistics were used to analyze the data through SPSS 16.

Results: Among 110 subjects, there were 63 male and 47 female subjects. Subjects' mean age was 55.88 (15.51) years. There were 72 patients undergoing hemodialysis through arteriovenous fistula and 38 through permanent intra-jugular catheters. Insufficient blood flow in the catheter was the most common complication in patients with jugular catheters. Also, aneurysm was the most prevalent complication in patients with arteriovenous fistula. Low self-care of patients and needling into the aneurysm were correlated with aneurysm size. Presence of underlying diseases was related to ischemia.

Conclusions: Nursing techniques and self-care of patients were correlated with the occurrence of complications. Therefore, it draws the attention of the nurses toward continuing professional education and patients' education, which can increase the longevity of vascular access.

Key words: Complication, correlation agents, hemodialysis, nursing techniques, self-care, vascular access

Introduction

Hemodialysis is a transient treatment for those patients who are candidates for kidney transplantation and a permanent treatment for the end-stage renal disease patients with no chance of transplantation.[1] Hemodialysis needs vascular access sites with blood flow of at least 350 ml/min.[2] Without an appropriate vascular access, the quality of dialysis is reduced and its related morbidity and mortality are increased.[3]

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Vascular access complications are the most important cause for high morbidity and mortality among these patients.[4,5] Hemodialysis patients are hospitalized once or twice a year because of vascular access site complications.[6] These treatment interventions impose a yearly burden of 1.5 billion dollars.[7] According to Minshawy's report, 16-25% of hospital admissions result from vascular access site complications among dialysis patients,[5] so 50% of hospitalization costs of end-stage renal disease patients are associated with vascular complications.[7] Although arteriovenous fistula is the most appropriate and prevalent technique of vascular access due to its long-lasting access, it is accompanied with complications.[8-14] Thrombosis, hand ischemia, edema, bleeding, aneurysm, and carpal tunnel syndrome are among the common complications of arteriovenous fistula, while infection, thrombosis, and aneurysm are among the prevalent complications of arteriovenous graft.[15] Infection, stenosis of jugular vein, and thrombosis can be mentioned as the common complications of permanent intra-jugular catheterization.[14,15]

Salahi *et al.* pointed out to aneurysm, vascular steal syndrome, venous hypertension, bleeding, infection,

and neurological complications as the most prevalent complications of arteriovenous fistula, and reported the prevalence of aneurysm as 30%.[16] Pasklinsky *et al.* believe that inappropriate use of arteriovenous fistula, such as early and frequent cannulation of the same site, and external mechanical pressures increase the incidence of complications among these patients,[17] and may lead to weakness of vascular wall and aneurysm.[11,18] Wilson *et al.* reported that unsuccessful cannulation might impose trauma to fistula and result in ruining it. They also believe that improvement of cannulation technique affects the lifetime and function of arteriovenous fistula.[14]

Graspa, in his study on the effect of age on the incidence of complications among two groups of elderly and adolescents, reported that vascular access site complications showed no difference in these two age groups, so arteriovenous fistula life was independent of age.[19] Minshawy compared the prevalence of temporary complications related to intra-jugular vein catheterization among patients undergoing dialysis to that in patients with arteriovenous fistula and undergoing chronic dialysis, and reported that complications and mortality were higher among the patients who started dialysis with catheter compared to those starting with arteriovenous fistula.[5] Meanwhile, most of the previous studies investigated either the prevalence of short-and long-term complications of hemodialysis[2,20,21] or the association between diabetes and other underlying diseases and complications of fistula.[5,10] Most of the published research in this field is associated with western countries and there is not much research available or conducted in Iran on the effect of patients' and accompanying persons' behavioral manner in relation with vascular access site and its association with the related complications.

Nurses are directly responsible for patients undergoing hemodialysis and they administer care to reduce the complications.[7] With respect to the effect of cannulation technique efficiency on the incidence of aneurysm,[8,11] high risk of infection,[6,22] and thrombosis, as well as the effect of following health protocols precisely in the reduction of infection incidence,[6] the importance of nurses' role in preservation of vascular access site can be emphasized.[23] There are high costs and miserable outcomes of vascular access complications and their related mortality,[24] frequent hospitalizations of patients to treat these complications[6] (thus, 25% of end-stage renal patients' care burden is associated with vascular access),[25] and shortage of new research in this field. The present study was conducted with an aim to investigate the factors correlated to the complications of vascular access site in hemodialysis patients in Isfahan Aliasghar hospital.

Materials and Methods

This is a descriptive cross-sectional study conducted on 110 end-stage renal disease patients who needed lifelong dialysis and underwent hemodialysis for more than 3 months. They frequently referred to Aliasghar Hemodialysis Center during the last 9 months of 2010. Data were collected through observations (a participant observer who limitedly helped the nurses in administering some of the cares) by the second researcher and using three checklists, which were ticked through observations and interviewing the patients. To avoid bias, some of the patients were also concurrently observed and interviewed by a research coworker, and the obtained results were compared and revealed to be identical. The first checklist contained questions on patients' demographic characteristics and the manner of patients' self-care and nurses' given care, and the other two checklists inquired the complications of two vascular access methods (arteriovenous fistula and permanent intra-jugular catheter). Checklist number 2 was ticked for the patients with arteriovenous fistula and contained four questions on the complications of ischemia, aneurysm, thrombosis, and infection. Ischemia was investigated based on the signs of coldness, numbness, and pain in distal part of the limb with fistula compared with the other limb.[15,16,26,27] Thrombosis was checked based on adhesion and stiffness during cannulation by the nurses, inadequate circulation in the artery line after a correct cannulation, existence of an air bubble in patients' dialysis line, and an increase in venous line pressure >300 mm Hg.[3,27] Infection was diagnosed based on concurrent existence of swelling, tenderness, and pain.[6,15]

The dimensions of aneurysm (height, diameter, and length) were measured based on a clinical examination[17] and with a ruler. Dilation of the vein at least 20 mm in one of the dimensions was considered as aneurysm.[17] In patients with permanent intra-jugular catheter, checklist number 3 containing six items was used. Infection of catheter site was investigated based on one of the local signs of inflammation, edema, pain, and crust, and general signs like fever and chills.[24]

Data collection tool was designed after a vast literature review, and its content validity was verified by experts' viewpoints. Reliability of the checklist was confirmed by assessors' reliability,[28] so that three nurses who had been educated for observation filled each checklist for a patient with each of three types of vascular access. Consensus index was calculated for each of the questions in the checklists. Reliability of the checklist was calculated to be 0.75-1. Descriptive and analytical statistical tests including Fisher's exact test, Chi-square test, and Pearson correlation

coefficient were used to analyze the data through SPSS. The present study was approved by the committee for ethical considerations of Kashan University of Medical Sciences and the authorities of the hospital. An informed consent form was filled by all nurses participating in the present study. Two patients withdrew from the study and three others died before researcher's access to them.

Results

Of the 110 studied patients, 47 were females and 63 were males. Subjects' mean age was 55.88 (15.51) years. Their mean time interval of dialysis was 40.02 (43.79) months and mean frequency of their weekly dialysis was 2.59 (0.49) times. Mean time interval of dialysis in patients with catheter (n = 38, 35.5%) was 18.76 (27.68) months and in patients with fistula (n = 72, 65.5%), it was 51.25 (46.63) months. In 51.4% of the patients, the direction of two needle cannulations was toward each other and in 48.6%, it was opposite. There was no significant association between complications and the direction of needle entrance. Although in both groups education of most of the subjects (about 90%) was high school or lower, there was no significant association between education and any of the complications in both groups.

Table 1 shows that concerning self-care of vascular access site, 53 subjects (73.6%) did not follow the forbidden issue of sleeping on the fistula limb. The findings showed that the dimensions of aneurysm were significantly more among the patients who did not follow fistula exercises and were not sleeping on the fistula limb ($P < 0.05$).

Table 2 shows that 2 (2.8%) subjects had thrombosis and 26 (36.1%) had ischemia of the limb with fistula. Aneurysm was observed in 51.4% of the patients. In addition, in patients with permanent intra-jugular catheter, infection of the catheter site was observed in 5 (13.2%) subjects and history of inadequate circulation was found in 7 (18.4%) subjects with the catheter, which was investigated by existence of inadequate circulation and an air bubble in the artery line.

Table 3 presents nursing technique obedience. In 40.3% of the cases, the distance between needle entrance and fistula was less than 5 cm. In 34 subjects (47.2%), the needle was inserted into the aneurysm.

Aneurysm dimensions in cases with the needle inserted into their aneurysm during cannulation were significantly less ($P = 0.001$). In addition, aneurysm dimensions were significantly less when the machine revolution was <150 ml/min in the beginning of dialysis ($P = 0.01$). Pearson correlation coefficient showed no significant association between the speed of machine pump and dimensions of aneurysm. Among the patients with an underlying disease, ischemia was more significantly observed ($P = 0.05$).

In patients who used vascular access for a longer time, aneurysm was more significantly observed ($P = 0.001$). Pearson correlation coefficient showed a significant association between the months of hemodialysis treatment and each of the aneurysm dimensions including aneurysm diameter ($r = 0.356$, $P = 0.002$), height ($r = 0.301$, $P = 0.010$), and length ($r = 0.480$, $P = 0.001$). There was no association between the former vascular access and

Table 1: Quality of self-care in patients with arteriovenous fistula

Self-care technique	*n* (%)
Does not permit injections in the limb with fistula	
Yes	72 (100)
Does not control blood pressure in the limb with fistula	
Yes	72 (100)
Exercising using the limb with fistula	
Yes	35 (48.6)
No	37 (51.4)
Not laying on the limb with fistula	
Yes	53 (73.6)
No	19 (26.4)
Not taking up heavy things	
Yes	58 (80.6)
No	14 (19.4)

Table 2: Vascular access complications

Vascular access	Complication	*N* (%)	
		Yes	No
Central venous catheter	Inadequate circulation in catheter	7 (18.4)	31 (81.6)
	Catheter site infection	5 (13.2)	33 (86.8)
	Spontaneous catheter exit during dialysis	0	38 (100)
	Spontaneous catheter exit at home	4 (10.5)	34 (89.5)
	Breaking line during connection	3 (7.9)	35 (92.1)
	Fever and chill during dialysis	2 (5.3)	36 (94.7)
Arteriovenous fistula	Ischemia	26 (36.1)	46 (63.9)
	Aneurysm	37 (51.4)	35 (48.6)
	Thrombosis	2 (2.8)	70 (97.2)
	Infection	2 (2.8)	70 (97.2)

Table 3: Nursing technique

Result technique of care	*N* (%)	
	Yes	No
Negligence in aseptic technique[27]	9 (8.2)	101 (91.8)
Wearing gloves[27]	106 (96.4)	4 (3.6)
Wearing a mask[27]	80 (72.7)	30 (27.3)
Heparin bolus injection[27]	66 (60)	44 (40)
Adjusting the correct dose of heparin based on the physician's order[29]	61 (55.5)	49 (44.5)
Appropriate priming[30]	105 (95.5)	5 (4.5)
Closing the end of venous line while connecting the patient to the machine[24]*	32 (84.2)	6 (15.8)
Closing one line while washing the other line*[31]	28 (73.7)	10 (26.3)
Closing the end of arterial catheter while disconnecting patient from the machine*[31]	23 (60.5)	15 (39.5)
Sterile dressing on the catheter site*[24]	23 (60.5)	15 (39.5)
Inserting the needle correctly**[27]	69 (95.8)	3 (4.2)
The rate of blood flow at the start of the hemodialysis<150**	20 (27.8)	52 (72.2)
Needling of the aneurysm**[27]	34 (47.2)	38 (52.8)
The distance between needle entrance and fistula**[15,17]	29 (40.3)	43 (59.7)
Needling cannulations toward each other**	37 (51.4)	35 (48.6)

*AVF: Arteriovenous fistula, **CVC: Central venous catheter

complications ($P > 0.05$). It should be noted that there was no significant association between any of the nursing techniques and personal characteristics of the patients with permanent intra-jugular catheter, and the complications ($P < 0.05$).

Discussion

The results showed that the complication of ischemia occurred in 36.1% of the patients with arteriovenous fistula. Ghane *et al.* reported the incidence of ischemia as 11.2% among 68 diseased children.[26] In the present study, existence of one of the three signs of tingling, numbness, and pain in the limb with fistula was a reason for the presence of ischemia,[15] while Ghane considered concurrent existence of all the three above-mentioned sings for ischemia.[26] The difference in prevalence of ischemia in the present study and Ghane's study may be due to the difference in the study method.

Aneurysm was the most prevalent complication (51.4%), which is consistent with the results obtained by Kanani *et al.* (58.5%).[7] Graspa showed that among 149 studied patients, 24 suffered from aneurysm.[19] Mehrabi reported the prevalence of aneurysm to be 23.17%[31] and Hong-Yee reported it as 6%.[18] Higher prevalence of aneurysm reported in the present study may be associated with various factors including cannulation techniques or the length of existing area for cannulation in the limb,[22] level of self-care, and the criteria related to diagnose aneurysm. Doppler sonography, used in the diagnosis of aneurysm in Pasklinsky's study and some other studies, has made it possible to differentiate true aneurysm form the false cases.[17,32] Meanwhile, in the present study, this differentiation was impossible due to use of clinical signs for diagnosis of aneurysm.

Previous research reveals that inappropriate cannulation and frequent needling in the same site weaken the vascular wall and predispose the patient to thrombosis, aneurysm, and venous rapture. Appropriate area for cannulation is also reduced by development of aneurysm area.[17,22,33] Our obtained results showed that at least one of the needles had been inserted into the aneurysm area in more than 50% of the cases and, in 40% of the cases, the needle was inserted near the fistula (with distance <5 cm). These two factors could have played a role in higher aneurysm development in the present study compared to previous studies.

In the present study, the cases in which the needle was inserted into the aneurysm were significantly more. This finding is in line with those of Hong-Yee, Woo *et al.*, and van Loon *et al.*[18,22,33] It seems that nurses can prevent these complications or their development through their careful cannulation on an appropriate vascular access site. Although in 95.8% of the cases, the needle was correctly inserted into the skin during cannulation, so that the needle hole was upward, in more than 40% of the cases, it was inserted near or into the aneurysm area. This issue could worsen the related complications such as hematoma, infection, and enlargement of aneurysm.[6,22] In addition, the guideline of renal patients' care recommends changing the needle insertion site to prevent aneurysm.[27] Pasklinsky argued that frequent close needling is another cause for aneurysm.[17] Wilson *et al.* and Lee *et al.* reported that cannulation is an essential skill for all nurses working in hemodialysis ward, as unsuccessful cannulation results in ruining the fistula and imposed use of permanent intra-jugular catheter.[14,34] This finding reveals the necessity for nurses' education to use a standard protocol for cannulation of the patients with arteriovenous fistula.

The findings obtained in the present study showed a significant association between the number of months of undergoing hemodialysis and each of the dimensions of aneurysm. In addition, previous studies have shown that the size of aneurysm is a specific index to predict the longevity of

arteriovenous fistula,[35] and can seriously threaten patients' quality of life.[11] Although Battaglia has stated the possible association between brachial artery dilation and time in his study,[33] Pasklinsky has also indicated the development of arteriovenous fistula years after its formation,[17] but this issue has not been considered in any of these studies. So, it is suggested to investigate this issue in future studies.

In the present study, among the patients with an underlying disease, ischemia was more significantly observed. This finding is expected with regard to the effect of diabetes and hypertension on vessels and their related complications.[31] Mehrabi *et al.* reported that the history of diabetes and hypertension was more significantly existing in patients with complications compared to the patients without complications.[31] Meanwhile, Salahi *et al.* reported that the history of diabetes, hypertension, and hypercholesterolemia had no effect on arteriovenous fistula complications.[16] This finding is not consistent with the one obtained by the present study. Therefore, further studies are needed to investigate the effect of underlying diseases on vascular access complications.

Patients did not follow some of the self-care techniques such as doing fistula exercises, not sleeping on the hand with fistula, and not lifting heavy things with the limb with fistula. Meanwhile, Mortaz *et al.* have emphasized on the increase of fistula function efficiency.[36] The results of the present study reveal that the dimensions of the aneurysm among the patients who followed doing fistula exercises and were not sleeping on the limb with fistula were significantly less. This issue not only shows unawareness of the patients about the caring process of vascular access site and the necessity for patient education in this regard but also reveals the association between the quality of self-care and the incidence of aneurysm and expansion of its diameters. Hooland emphasized not only on the necessity of cooperation among the surgeons, physicians, nurses, and patients to take care of and preserve vascular access but also on patient education and appropriate care of vascular access and its effect on longevity of the vascular access.[23]

In the present study, in less than 30% of cases, pump revolution was observed to be <150 ml/min during the beginning of dialysis, while it is experimentally recommended to start dialysis with low pump revolutions and to increase the speed after being assured about cannulation. Meanwhile, in the present study, the average of the pump revolutions at the beginning of dialysis was 206.41 ml/min (66.81). The findings showed that the diameters of aneurysm in the patients whose pump speed was <150 ml/min at the beginning of dialysis were significantly less. Although Vanloon *et al.* investigated the factors effective on cannulation and its complications among the patients with arteriovenous fistula,[22] and with regard to renal patients' care guideline recommending no cannulation on any point of the aneurysm site,[27] no study investigated the association between blood pump speed at the beginning of dialysis and the dimensions of aneurysm. Therefore, it is suggested to be investigated in future studies.

In the present study, frequency of infection among the patients with intra-jugular catheter was 13.2%, which is consistent with the study of Beigi *et al.* (13.6%).[35] Almost 32% of the patients with intra-jugular catheter and 9% of the patients with arteriovenous fistula have history of taking antibiotics to treat infection of vascular access site in the past 6 months. Bachelda, in a literature review study, reported the prevalence of infection as 20-50% among patients with intra-jugular catheter.[11] Minshawy reported the level of infection as 20%.[5] Meanwhile, in the present study, no significant association was observed between nursing techniques and the complications in patients with intra-jugular catheter, which can be due to low number of subjects with this type of vascular access in the present study. Lower frequency of infection in the present study compared to some other studies can be possibly due to more obedience of patients and nurses concerning aseptic and caring techniques during patients' connection to and separation from the hemodialysis machine. Clinical practice guidelines for vascular access issued by KDOQI with emphasis on wearing a mask to prevent contamination of infection to catheter by the patients and nurses during connection to and separation from the dialysis machine and during dressing the catheter site reveal the importance of this issue.[27] However, it seems that the patients with intra-jugular catheter are more predisposed to infection and need more self-care education and appropriate care from vascular access compared to the patients with arteriovenous fistula. This finding is in line with Ghane *et al.* and Vazquez reporting the highest incidence of infection among intra-jugular catheter patients and the lowest among the patients with arteriovenous fistula.[4,26]

Conclusion

The present study shows that there was a significant association between some nursing techniques including cannulation technique, being aware of the pump speed at the beginning of dialysis, and some patients' self-care techniques including doing fistula exercising and not sleeping on the limb with fistula, and the dimensions of aneurysm. Therefore, nursing authorities are recommended to pay more attention to the necessity of continuing education for nurses and to increase patients' awareness. Ignoring some factors like the effect of nurses' experience in cannulation and the effect of buttonhole and rope

ladder cannulation techniques on arteriovenous fistula complications can be mentioned as the limitations for the present study. Further research can clarify the judgments about the findings in this field.

Acknowledgments

We wish to acknowledge all the patients and nurses who participated in this research. This research was documented in a thesis for fulfillment of Master of Science in critical care nursing. We thank the authorities at Kashan University of Medical Sciences and Ali Asghar Hospital for their support.

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How to site: Adib-hajbagheri M, Molavizadeh N, Alavi NM, Abadi MH. Factors associated with complications of vascular access site in hemodialysis patients in Isfahan Aliasghar hospital. Iranian Journal of Nursing and Midwifery Research 2014;19:208-14

Source of Support: Kashan University of Medical Sciences, **Conflict of Interest:** Nil.