Research Article

Journal of Nursing & Healthcare

Effects of Arterial Needle Placement in Arteriovenous Fistula on Dialysis Adequacy of End-Stage Renal Disease Patients Undergoing Maintenance Hemodialysis

Oscar R. Reyes II*

United Candelaria Doctors Hospital – Nephro Synergies Inc. Hemodialysis Center - Candelaria, Quezon, Philippines

***Corresponding author**
Oscar R Reyes II, Nursing Care Coordinator, United Candelaria Doctors Hospital - Nephro Synergies Inc. Hemodialysis Center-Candelaria, Quezon, Philippines; Tel: +639162751291; E-mail: oscarreyesii@yahoo.com

Submitted: 19 Oct 2016; **Accepted**: 04 Nov 2016; **Published**: 08 Nov 2016

Abstract

Objective: *The arterial needle placement in arteriovenous fistula (AVF) can either be antegrade (in the direction of blood flow or pointing towards the heart) or retrograde (against the direction of blood flow) while venous needle placement should always be in the same direction as the blood flow. This study determined the effects of arterial needle placement in the arteriovenous fistula on dialysis adequacy of End-Stage Renal Disease (ESRD) patients undergoing maintenance hemodialysis in United Candelaria Doctors Hospital - Nephro Synergies Inc. (UCDH-NSI) Hemodialysis Center.*

Methods: *A randomized controlled trial design was used in the study. A total of 20 non-diabetic, non-cardiac patients on maintenance hemodialysis for more than 6 months were randomized either to the intervention group (patients' AVF were cannulated in a retrograde manner) or the control group (patients' AVF were cannulated in an antegrade manner). Urea reduction ratio (URR) and Kt/V as well as access recirculation percentage were used to determine dialysis adequacy. Pre-dialysis, in the first 30 minutes of dialysis initiation and post-dialysis blood samples were obtained in each patient in 6 succeeding hemodialysis considering dialyzer reuse up to fifth reuse. Means were compared by independent t-test.*

Results: *The findings of the study revealed that the mean URR and Kt/V of the subjects cannulated in retrograde manner and antegrade manner were 69.35% and 1.45, and 74.65% and 1.70, respectively. The mean access recirculation percentage of the subjects was 4.65% in the intervention group and 3.02% in the control group. There was a significant difference on URR and Kt/V of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions. There was no significant difference on access recirculation percentage of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions.*

Conclusions: *Antegrade arterial needle placement provides more adequate hemodialysis than retrograde arterial needle placement in terms of URR and Kt/V values among non-diabetic, non-cardiac patients undergoing maintenance hemodialysis in 6 succeeding hemodialysis sessions. The directions of the arterial needle either retrograde and antegrade did not have significant effects on access recirculation.*

Keywords: Antegrade, Arterial needle placement, Arteriovenous fistula, Dialysis adequacy, Retrograde

Introduction

Chronic kidney disease (CKD) is the progressive and irreversible diminishing of kidney function, which leads to the accumulation of both toxins and fluids within the body [1,2]. CKD is a silent killer and one out of 10 people all over the world have it. In the Philippines, at least one Filipino dies every hour, specifically End Stage Renal Disease (ESRD), which ranks as the 7th leading cause of death among Filipinos [3]. An estimated 120 Filipinos per one million population develop kidney failure, which means that about 10,000 Filipinos need to undergo various kidney replacement therapies with an increase of 10% annually [4].

Based on the 2013 report from the Philippine Renal Disease Registry (PRDR), there were 23,364 patients undergoing dialysis, in which 22,458 of them were on hemodialysis (HD) and the remaining 906 were on peritoneal dialysis. Region IV-A is 2nd in the top 10 regions of having new cases of HD patients - a total of 1,975 reported patients [5]. As of March 2015, United Candelaria Doctors Hospital – Nephro Synergies Inc. (UCDH-NSI)

Hemodialysis Center had 39 patients undergoing maintenance hemodialysis. Most of their patients (79.49%) undergone twice a week HD, 15.38% were on thrice a week HD, and 5.13% were on once a week HD session.

Hemodialysis is the most common form of renal replacement therapy for ESRD worldwide due to scarcity of kidney donors and high cost of transplantation [3]. CKD is an emerging health concern in the Philippines that needs long-term care which is often costly. National Kidney Foundation- Kidney Disease Outcome Quality Initiative (NKF-KDOQI) recommended that the ESRD patients need to have a minimum of thrice a week HD [6]. Knowing that, not all Filipinos are financially capable of having their advised HD schedule, which cost about PHP 3,500 to PHP 4,500 per session. Most of the Filipino ESRD patients undergo twice a week HD, which is considered as inadequate [7].

Ensuring the adequacy of hemodialysis is important because it minimizes disease complications and hospitalization, improves the quality of life, and the survival of the patient. Borromeo et al. reported that an estimated 19 to 24% mortality in patients due to inadequacy of dialysis [1]. Despite all the technological advancements in the treatment of patients with ESRD, the quality of hemodialysis being provided may still be improved.

Arteriovenous fistula (AVF) is the surgical connection between an artery and vein, which makes hemodialysis possible. AVF cannulation is one of the fundamental skills required for dialysis nurses in the initiation of HD treatment. In UCDH-NSI Hemodialysis Center, there were 34 out of 39 patients using AVF for HD, and as of 2015, there is no institutional best practice guideline concerning arterial needle placement, where dialysis nurses use either retrograde or antegrade arterial needle placement for AVF cannulation. The researcher observed that the cannulation practice of the dialysis nurses was based on personal preference and training acquired.

Arterial needle placement can either be antegrade (up or in the direction of blood flow or pointing towards the heart) or retrograde (down or against the direction of blood flow or pointing towards the surgical anastomosis of the AVF) while venous needle placement should always be in the same direction as the blood flow (NKF-KDOQI, 2006). This study evaluated if there is a difference between the adequacies of hemodialysis being delivered through an antegrade arterial needle placement from a retrograde arterial needle placement.

NKF-KDOQI guidelines recommend individualizing the hemodialysis prescription based on monthly assessment of single-pool Kt/V and urea reduction ratio (URR). It also recommends that the minimum adequate dose of hemodialysis should be a single-pool Kt/V of 1.20 with a URR of 65% per dialysis session [8]. In addition, an access recirculation percentage is an essential measure for the quality of hemodialysis, which should be less than 10%. The measurement of access recirculation percentage in HD patients is an important concern as it appears as an important cause of inadequate hemodiaysis [9].

In line with this, the conduct of this study was largely fueled by the researcher's bold aim to contribute to the existing pool of knowledge with arteriovenous fistula cannulation by developing a nursing best practice guide that would provide insights to dialysis practitioners on arterial needle placement that would ensure and improve the efficiency of hemodialysis being provided.

Methods

Design and setting

This randomized controlled trial was conducted over a 3-week period from June 22 to July 10, 2015 in United Candelaria Doctors Hospital – Nephro Synergies Inc. (UCDH-NSI) Hemodialysis Center.

Subjects and sampling

All patients in the Dialysis Registry of UCDH-NSI Hemodialysis Center began with a screening phase, which consists of chart review, patient interview, and thorough physical examination by their attending physician. During this time, a series of tests were done to assess the current status and stability of patients under study. These tests include complete blood counts and determination of serum albumin levels.

A total of 39 adult hemodialysis patients in UCDH-NSI Hemodialysis Center Renal Registry at the beginning of the study were considered for inclusion, consisting of 27 males (68.23%) and 12 females (30.77%). The majority (41.03%) of the patients was 65 years and above with the mean age of 57.4 years old. The type of HD vascular accesses included arteriovenous fistula (87.18%), arteriovenous graft (2.56%) and central venous catheter (10.26%). Regarding the underlying cause of End Stage Renal Disease, diabetic nephropathy was reported as the most frequent underlying cause (28.21%). Other causes were reported as hypertensive nephropathy (23.08%), chronic glomerulonephritis (23.08%), obstructive nephropathy (10.26%), NSAID nephropathy (5.13%), chronic tubulo-interstitial nephritis (5.13%), urate nephropathy (2.56%) and IgA nephropathy (2.56%). The mean duration of patients on hemodialysis was 1.9 years.

The researcher applied a non-probability scheme using purposive sampling design. In the selection of the subjects, the following inclusion criteria of this study were considered: End Stage Renal Disease (ESRD) of non-diabetic etiology patients diagnosed by their respective licensed nephrologists and on maintenance hemodialysis for more than 6 months; with functional arteriovenous fistula (AVF) and an adequate AVF length for either retrograde or antegrade arterial needle insertion; receiving regular twice session of hemodialysis per week, each session lasting four hours and using synthetic hollow fiber, low-flux polysulfone dialyzer with surface area of 1.8 m^2; clinically stable and having good tolerance to hemodialysis; does not present serious medical conditions or any associated severe cardiovascular disease; those patients whose hemoglobin level is between 10 to 12 mg/dl, and albumin level between 3.5 to 5.5 g/dl; shows willingness and interest to participate in the study and provided informed consent.

The exclusion criteria were patients who are unable to give consent, clinically unstable patients or with chronic diseases that lead to a direct effect on dialysis adequacy and vascular system such as diabetes, severe cardiovascular disease (with ejection fraction less than 55%), systemic lupus erythematosus, and malignant diseases, and those with an AVF with known access flow problems, AVF less than 6 months old, patients dialyzed with arteriovenous graft (polytetrafluoroethylene or Goretex graft), those patients on catheter accessed dialysis, those patients who were not on regular hemodialysis, and those patients on once a week and thrice a week hemodialysis including those subjects who would skip their hemodialysis session in the time of conduction of the study. Those new patients on hemodialysis were also excluded because the first several months of dialysis treatment are often the time of multiple changes in dialysis prescription and vascular access.

A signed informed consent was obtained from each subject and their immediate family members before enrollment. After the screening phase and employing the chosen inclusion criteria, out of 39 patients registered in the Dialysis Registry of UCDH-NSI Hemodialysis Center, 20 patients (16 males and 4 females) fulfilled the inclusion criteria for the study. The 20 eligible subjects were equally subdivided into two groups which consist of the intervention group (n = 10) and the control group (n = 10) using an online statistical randomizer.

The researcher determined significant difference in the demographic and hemodialysis characteristics of the subjects in the intervention group and the control group using chi-square for categorical variables (sex, cause of ESRD, and type of AVF) and independent t-test for quantitative variables (age, duration on HD, dry weight, hemoglobin, and albumin) before the finalization of the subjects. There should be no significant difference in sex, cause of ESRD and the type of AVF of the subjects in the intervention group and the control group. There should be no significant difference in age, duration on HD, dry weight, hemoglobin, and albumin levels of the subjects in the intervention group and the control group before the subjects were included in the study.

Intervention

Prior to conduction of the study, all hemodialysis machines were subjected for preventive maintenance procedure according to the manufacturer's instructions to ensure the safety and functionality of hemodialysis machines to be used in the study.

All supplies including AVF kit, fistula needles, saline solutions, bloodlines and dialysate solutions (acid and bicarbonate concentrate) for hemodialysis were procured from Nephro Synergies Inc. Warehouse with the same brand, variety and batch number to maintain consistency of the hemodialysis treatment provided to all subjects of the present study.

The study of Lambie et al. suggested that the variation in hemodialysis adequacy that occurs within dialysis patients is multifactorial [10]. It confirmed the importance of effective vascular access (blood pump speed, needle placement), prescription of and adherence to adequate time on dialysis. To yield accurate results and decrease the possibility of bias and error, the researcher imposed control in this study.

Since dialysis adequacy was affected by different variables, the researcher applied uniformity on hemodialysis prescription of the subjects and as approved by their respective nephrologist in terms of: blood and dialysate flow rate, heparinization, cannulation technique, needle type and size, distance between arterial and venous needle, and needle bevel direction, dialyzer type, size, and reuse, and length of time and frequency of hemodialysis treatment based on the findings and recommendations of published literature and studies.

The ultrafiltration volume and rate was prescribed using estimated dry weight (the amount of body mass (weight) without extra fluid and the lowest weight a patient can tolerate and that will render him edema free at the end of dialysis, without the development of symptoms of hypovolemia (hypotension, cramping, nausea, vomiting). Dry weight was determined by the patient's attending nephrologist and kept constant during study periods. However, for safety and tolerability of patients with hemodialysis, ultrafiltration volume maximum level allowed would be set at four liters per session as approved by their attending nephrologist.

The eligible subjects were randomly assigned into the intervention group where patient's AVF was cannulated in a retrograde manner and the control group where patient's AVF was calculated in an antegrade manner. A total of 6 hemodialysis sessions was performed on each eligible patient. During the study period, each patient received conventional hemodialysis using the same machine with bicarbonate bath and used low-flux polysulfone dialyzer with the same hemodialysis prescription. The length of each dialysis was 4 hours, dialysate flow rate of 500 ml/min and blood flow rate of 300 ml/min. For intervention group, the arterial needle was inserted in the down or against the direction of blood flow or pointing towards the surgical anastomosis (retrograde) with needle bevel up and stayed 2.0 inches away from the anastomosis. On the other hand, for control group, the arterial needle was inserted in up or in the same direction as the blood flow or pointing towards the heart (antegrade) with needle bevel up and stayed away 1.5 inches away from the anastomosis. For intervention group and the control group, the venous needle was inserted in the same direction as the blood flow or pointing towards the heart (antegrade) at 9 cm apart from arterial needle. The rope ladder technique was used as the standard technique for arteriovenous fistula cannulation during the entire study. All cannulation with the same needle size (Gauge 16) and distance between arterial and venous needle in 6 succeeding hemodialysis sessions in new dialyzer up to fifth reuse of dialyzer and blood sampling procedures were done by the nephrology nurse researcher.

The intervention group and the control group underwent blood urea nitrogen determination before hemodialysis, after the first 30 minutes of hemodialysis and after hemodialysis for URR, Kt/V and access recirculation percentage. Blood samples for URR and Kt/V were taken using the fasting technique for pre-HD sample, and slow pump method for post-HD sample, and urea-based, two-needle method for the access recirculation percentage (ARP) was utilized in the first 30 minutes of the hemodialysis session in 6 succeeding hemodialysis sessions.

The blood specimens were centrifuged and blood serum was saved. It was transported to UCDH-Laboratory daily and was frozen until the time of processing. All blood samples were processed and analyzed using Erba Mannheim XL-100 blood chemistry machine (Erba, Germany) by UV Kinetic, enzymatic method with the same equipment throughout the duration of the study on a daily basis. All measurements were performed by same laboratory personnel.

All dialyzer used in the study were reprocessed manually for reuse by the in-house reuse technician using Renalin 3.5% sterilant solution based on the unit's policy. All dialyzer should pass both residual and total cell volume (TCV) test. The dialyzer should pass the residual test to ensure that all disinfectant had been washed out with reverse osmosis water during rinsing. The total cell volume (TCV) or fiber bundle volume of dialyzer was measured by purging the filled blood compartment with air and measuring the volume of obtained fluid. The change in total cell volume of dialyzer was recorded after each use. The TCV should meet the standard recommended by the Association of Advanced Medical Instrumentation (AAMI) which states that each dialyzer should have at least 80% of its original priming volume/fiber bundle volume to ensure that hollow fibers of dialyzer were sufficient for clearance of urea and other toxins.

To ensure the safety of subjects and compliance on hemodialysis prescription during the course of the study, the researcher utilized hemodialysis monitoring flow sheet. During hemodialysis, the clinical signs and hemodynamic status (temperature, pulse rate, respiratory rate, and blood pressure) of the subjects were monitored and controlled appropriately. Subjects were also monitored for any intradialytic signs and symptoms (fever, sweating, cramps, nausea, vomiting, chest pain, hypotension and hypertension) during the dialysis session.

Cannulation-related complications may occur anytime during the course of the study. These include infiltration (occurs when the needle tip goes into the vein and out the other side), hematoma (blood leaks into the tissue around the blood vessel) and access failure. In case of these cannulation-related complications, there would be immediate treatment which was available free of charge in the hemodialysis center. It would also involve referral to a vascular surgeon for further evaluation and management. The researcher would provide reimbursement or payment for the treatment and other expenses incurred because of the adverse event.

Outcome

Dialysis adequacy was assessed using urea reduction ratio (URR) and Kt/V as primary outcome measure, and access recirculation percentage (ARP) as secondary outcome measure. The URR values were categorized as inadequate (less than 65%), near to optimal (65% to 79%) and optimal level (80 to 100%). The Kt/V values were categorized as inadequate (less than 1.20), near to optimal (1.20 to 1.79), and optimal level (1.80 to 2.30). The ARP values were categorized as above acceptable limit (more than 10%), within acceptable limit (1 to 10%), and most-well functioning fistula (0 to 0.99%).

Statistical method

The data collected from laboratory results were calculated using a computer assisted program (Nephrology Calculator) for urea reduction ratio (URR), Kt/V, and access recirculation percentage. URR was calculated according to the formula: URR = (predialysis urea – postdialysis urea) / predialysis urea x 100.

The single pool Kt/V was resolved from the predialysis to postdialysis urea ratio (R), the ultrafiltration volume in liters (UF), the length of a dialysis session in hours (t), and post dialysis weight in kilogram (W) using the equation: $Kt/V = -\ln(R - 0.008 \times t) + (4 - 3.5 \times R) \times UF/W$. Access recirculation percentage (ARP) was computed using the formula: $ARP = (S - A) / (S-V) \times 100$, where S, A, and V refer to the urea concentrations in the systemic blood, pre-dialyzer arterial line, and post dialyzer venous circuit, respectively.

URR, Kt/V, and ARP values calculated in each subject in the intervention and control group were compared. The mean URR, Kt/V and ARP were compared using independent t-test.

All statistical analyses were conducted using Simplified Statistics for Beginners (SSB) for the average mean, chi-square, analysis of variance (ANOVA), and t-test for independent variables.

Ethical Considerations

This single-center study was reviewed and approved by the ethics committee of United Candelaria Doctors Hospital to ensure the protection and safety of patients under study would be observed.

Results

Study Population

A total of 20 adult hemodialysis patients were included, consisting of 16 males (80%) and 4 females (20%). The mean age of the patients was 49.95 years old. The underlying cause of End Stage Renal Disease reported as hypertensive nephropathy (30%), chronic glomerulonephritis (40%), obstructive nephropathy (10%), NSAID nephropathy (5%), chronic tubulo-interstitial nephritis (5%), urate nephropathy (5%) and IgA nephropathy (5%). The mean duration of patients on hemodialysis was 2.53 years. The type of AVF was radiocephalic (40%) and brachiocephalic (60%). The mean dry weight of the patients was 52.78kg, the mean hemoglobin was 10.58 mg/dl, and the mean albumin was 4.08 g/dl. Baseline demographic and hemodialysis characteristics of the subjects in intervention group and control group were similar as shown in Table 1.

Variable	Subjects (N=20)	Intervention Group (n=10)	Control Group (n=10)	Value
Age (in years), mean[a]	49.95	50.8	49.1	0.27
Sex[b]				
Male	16 (80%)	8 (80%)	8 (80%)	0.00
Female	4 (20%)	2 (20%)	2 (20%)	
Cause of ESRD[b]				
Hypertensive Nephropathy	6 (30%)	4 (40%)	2 (20%)	5.17
Chronic Glomerulonephritis	8 (40%)	3 (30%)	5 (50%)	
Obstructive Nephropathy	2 (10%)	1 (10%)	1 (10%)	
Urate Nephropathy	1 (5%)	0	1 (10%)	
IgA Nephropathy	1 (5%)	1 (10%)	0	
NSAID Nephropathy	1 (5%)	0	1 (10%)	
Chronic Tubulo-Interstitial Nephritis	1 (5%)	1 (10%)	0	
Duration on HD (in years), mean[a]	2.53	2.2	2.85	1.17
Type of AVF[b]				
Radiocephalic	8 (40%)	3 (30%)	5 (50%)	0.83
Brachiocephalic	12 (60%)	7 (70%)	5 (50%)	
Dry Weight (in kg)[a]	52.78	53.35	52.2	0.26
Hemoglobin (in mg/dl), mean[a]	10.58	10.59	10.57	0.11
Albumin (in g/dl), mean[a]	4.08	4.10	4.06	0.35

Table 1: Demographic and Hemodialysis Characteristics of Study Population. [a]independent t-test was used, $\alpha = 0.05$; [b]chi-square was used, $\alpha = 0.05$.

INTERVENTION GROUP					CONTROL GROUP				
RETROGRADE					ANTEGRADE				
Subject No.	URR		Kt/V		Subject No.	URR		Kt/V	
	Value	Verbal Description	Value	Verbal Description		Value	Verbal Description	Value	Verbal Description
1	71.03	NTO	1.37	NTO	1	73.20	NTO	1.68	NTO
2	68.46	NTO	1.47	NTO	2	76.98	NTO	1.95	O
3	67.74	NTO	1.38	NTO	3	78.34	NTO	1.93	O
4	70.75	NTO	1.56	NTO	4	75.18	NTO	1.71	NTO
5	69.17	NTO	1.49	NTO	5	75.03	NTO	1.70	NTO
6	69.32	NTO	1.57	NTO	6	70.73	NTO	1.43	NTO
7	68.84	NTO	1.32	NTO	7	71.55	NTO	1.56	NTO
8	69.04	NTO	1.46	NTO	8	79.66	NTO	1.80	O
9	69.47	NTO	1.39	NTO	9	71.88	NTO	1.54	NTO
10	69.67	NTO	1.53	NTO	10	73.98	NTO	1.74	NTO
TOTAL	**69.35**	**NTO**	**1.45**	**NTO**	**TOTAL**	**74.65**	**NTO**	**1.70**	**NTO**
SUMMARY	**URR**	**Percentage**	**Verbal Description**		SUMMARY	**URR**	**Percentage**	**Verbal Description**	
	80 to 100%	-	Optimal			80 to 100%	-	Optimal	
	65 to 79%	100% (10)	Near to optimal			65 to 79%	100% (10)	Near to optimal	
	Less than 65%	-	Inadequate			Less than 65%	-	Inadequate	
	Kt/V	**Percentage**	**Verbal Description**			**Kt/V**	**Percentage**	**Verbal Description**	
	1.80 to 2.30	-	Optimal			1.80 to 2.30	30% (3)	Optimal	
	1.20 to 1.79	100% (10)	Near to optimal			1.20 to 1.79	70% (7)	Near to optimal	
	Less than 1.20	-	Inadequate			Less than 1.20	-	Inadequate	
LEGEND	**URR** 80 to 100% - Optimal (O) dialysis 65 to 79% - Near to optimal (NTO) dialysis Less than 65% - Inadequate (I) dialysis				LEGEND	**Kt/V** 1.80 to 2.30 - Optimal (O) dialysis 1.20 to 1.79 - Near to optimal (NTO) dialysis Less than 1.20 – Inadequate (I) dialysis			

Table 2: Mean URR and Kt/V of the Subjects.

The mean urea reduction ratio (URR) and Kt/V of the subjects is shown in Table 2. The mean URR and Kt/V of subjects cannulated in a retrograde manner (intervention group) and antegrade manner (control group) were 69.35% and 1.45, and 74.65% and 1.70, respectively. The results showed that both retrograde and antegrade arterial needle placement delivered near to optimal dialysis.

Based on the summary in Table 2, it can be noted that the URR of 65 to 79% and Kt/V of 1.20 to 1.79 which reflects near to optimal dialysis was observed in 100% of the subjects in the intervention group or subjects cannulated in a retrograde manner. Meanwhile, 100% of the subjects in the control group or patients cannulated in an antegrade manner obtained near to optimal dialysis as reflected in the URR values. Based on the Kt/V values of the subjects on control group, 30% of them obtained optimal dialysis (1.80 to 2.30) and the remaining 70% fall to near to optimal dialysis (1.20 to 1.79). These findings indicate a substantial adequate hemodialysis treatment was provided in the subjects under study.

In subgroup analysis, the intervention group showed no significant difference in URR (F-value: 2.372) and Kt/V (F-value: 1.235) of the subjects in 6 succeeding hemodialysis sessions as compared to a critical value of 2.39. Similarly, the control group showed no significant difference in URR (F-value: 0.697) and Kt/V (F-value: 0.710) of the subjects in 6 succeeding hemodialysis sessions as compared to a critical value of 2.39. There was a significant difference on URR (t-value: 5.35) and Kt/V (t-value: 4.25) of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions as compared to a critical value of 2.101.

Subject No.	INTERVENTION GROUP			Subject No.	CONTROL GROUP		
	RETROGRADE				ANTEGRADE		
	Access Recirculation Percentage (ARP)				Access Recirculation Percentage (ARP)		
	Value	Verbal Description			Value	Verbal Description	
1	8.92	Within Acceptable Limit		1	4.64	Within Acceptable Limit	
2	4.13	Within Acceptable Limit		2	2.10	Within Acceptable Limit	
3	8.50	Within Acceptable Limit		3	3.20	Within Acceptable Limit	
4	2.51	Within Acceptable Limit		4	4.52	Within Acceptable Limit	
5	4.70	Within Acceptable Limit		5	1.42	Within Acceptable Limit	
6	5.19	Within Acceptable Limit		6	3.03	Within Acceptable Limit	
7	6.49	Within Acceptable Limit		7	2.63	Within Acceptable Limit	
8	1.90	Within Acceptable Limit		8	2.85	Within Acceptable Limit	
9	1.91	Within Acceptable Limit		9	3.67	Within Acceptable Limit	
10	2.20	Within Acceptable Limit		10	2.12	Within Acceptable Limit	
TOTAL	**4.65**	**Within Acceptable Limit**		**TOTAL**	**3.02**	**Within Acceptable Limit**	
SUMMARY	ARP	Percentage	Verbal Description	SUMMARY	ARP	Percentage	Verbal Description
	0 to 0.99%	-	Most Well-Functioning Fistula		0 to 0.99%	-	Most Well-Functioning Fistula
	1 to 10%	100% (10)	Within Acceptable Limit		1 to 10%	100% (10)	Within Acceptable Limit
	More than 10%	-	Above acceptable limit		More than 10%	-	Above acceptable limit
LEGEND	**ARP Values** 0 to 0.99% - Most Well-Functioning Fistula 1 to 10% - Within Acceptable Limit More than 10% - Above acceptable limit, requires further investigation						

Table 3: Mean ARP of the Subjects.

The mean access recirculation percentage of the subjects is shown in Table 3. The mean access recirculation percentage of the subjects was 4.65% in the intervention group (retrograde) and 3.02% in the control group (antegrade). The results showed that both retrograde and antegrade arterial needle placement have an access recirculation percentage within acceptable limits.

Based on the summary in Table 3, it can be noted that the ARP of 1 to 10% was observed in 100% of the subjects in the intervention group or subjects cannulated in a retrograde manner and the subjects in the control group or subjects cannulated in an antegrade manner. The results showed that most (100%) of the patients have access recirculation percentage within acceptable limits.

In subgroup analysis, the intervention group showed no significant difference in access recirculation percentage of the subjects in 6 succeeding hemodialysis sessions with computed F-value of 0.479 as compared to a critical value of 2.39. The control group showed no significant difference in access recirculation percentage of the subjects in 6 succeeding hemodialysis sessions with computed F-value of 0.408 as compared to a critical value of 2.39. There was no significant difference on access recirculation of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions with computed t-value of 1.81 as compared to a critical value of 2.101.

During the course of the study, no patient dropped out of the study. There were no incidences of cannulation-related complications. However, there were two patients experienced hypertension during hemodialysis sessions which was managed and controlled appropriately.

Discussion

Dialysis adequacy is a challenge for nephrologist. An adequate delivery of hemodialysis dose is an essential task of the dialysis nurse. In this single-center, randomized controlled trial involving 20 End-Stage Renal Disease patients undergoing maintenance hemodialysis, the researcher was able to show that antegrade arterial needle placement is more beneficial to use in arteriovenous fistula cannulation than retrograde arterial needle placement in terms of dialysis adequacy.

The results showed that the mean URR and Kt/V of patients cannulated in an antegrade manner was higher than those patients cannulated in a retrograde manner (URR 74.65%; vs. 69.35%; Kt/V 1.70 vs. 1.45). The results of this study are congruent with the findings of Marita et al. showing the mean Kt/V of subjects was 1.70 in an antegrade manner, and 1.55 in retrograde manners [11]. Conversely, the findings of Dias, Neto, and da Costa, Cicek et al., Kim et al., Ozmen et al. and Kang, Song, and Min showed that Kt/V of patients cannulated in retrograde manner was higher than those patients cannulated in an antegrade manner (1.71 vs 1.16; 1.44 vs 1.42; 1.46 vs 1.43; 1.75 vs. 1.74; 1.46 vs 1.43, respectively) [12-16]. In addition, Ozmen et al. showed that the URR of patients cannulated in a retrograde manner was higher than those patients cannulated in an ante grade manner (74.2% vs 73.0%, respectively) [15].

This study revealed a significant difference on URR and Kt/V of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions. The mean URR and Kt/V of subjects delivered via antegrade arterial needle placement was higher than those subjects cannulated in a retrograde manner in 6 succeeding hemodialysis sessions which makes antegrade more beneficial than retrograde arterial needle placement. The results of this study confirm the claims of Shariati et al. that there was a statistically significant correlation between Kt/V and arterial needle direction [17].

Conversely, the findings of this study disagree with the conclusion made by previous studies stating that there was no significant difference in dialysis adequacy parameters between antegrade and retrograde arterial needle placement [11,13-16,18]. Furthermore, the findings of this study are incongruent with the conclusions drawn from previous study that revealed that the retrograde placement of the arterial needle had a significantly higher probability to attain Kt/V of 1.20 and that retrograde with a needle distance of 10 cm or more presented the best Kt/V values [12,19]. In addition, English reported a small advantage to retrograde insertion showed that the retrograde direction of placement of the arterial needle was proposed to improve dialysis adequacy and recommended to be used more frequently in the dialysis setting [20]. Similarly, a very little difference in outcomes dependent upon direction of the cannulated needle was reported as a personal experience [21,22].

Based on the findings of the study, the 0.25 difference in Kt/V and 5.30% difference in URR between subjects cannulated in the retrograde manner (intervention group) and the antegrade manner (control group) (Kt/V 1.48 versus 1.78; URR 70.01% versus 76.09%, respectively) that was observed may have considerable clinical significance.

According to published literature and studies, there was a decrease in mortality noted at around 5 to 7% and reduced risk of cardiovascular disease and infections associated with an increase of 0.1 unit in Kt/V and for every 0.5% increase in URR to 65%, mortality rate decreases to 11% [23-25]. Conversely, there was an increase in the relative risk of death at around 7% and 11% increase in the annual rates of hospitalization; increase in hospital days at around 12% and a significant increase in the cost of inpatient care associated with 0.1 decrease in Kt/V [26,27].

The occurrence of recirculation has two major implications for hemodialysis. Recirculation significantly impairs the efficiency of the hemodialysis treatment. It can also be a sign of a pending problem that indicates impaired access blood flow putting the access at high risk of failing because of thrombosis [28].

This study revealed that mean access recirculation percentage of the subjects was 4.65% in the intervention group (retrograde) and 3.02% in the control group (antegrade). The results showed that both retrograde and antegrade arterial needle placement have an access recirculation percentage within acceptable limits. It can be noted that the mean ARP of subjects delivered via antegrade arterial needle placement was lower than those subjects cannulated in a retrograde manner in 6 succeeding hemodialysis sessions. The results of the present study confirm the claim of Dias, Neto, and da Costa which revealed that the correlation between access recirculation and Kt/V seems to reveal a tendency to impairment of the efficiency of dialysis with higher access recirculation rate [12].

The results of the present study coincide with the findings of Cicek et al. showing that the mean access recirculation percentage was 8.94% in antegrade and 9.23% in retrograde [13]. On the other hand, Marita et al. revealed that in five of ten patients, the recirculation value was 9.62% with antegrade and 7.5% with retrograde arterial needle placement [11]. In three patients, the recirculation values were 10.5% with both insertion techniques and in two patients, the recirculation value was 5.5% with antegrade and 8.6% with retrograde arterial needle placement.

This study showed no significant difference on access recirculation percentage of the subjects using retrograde and antegrade arterial needle placement in 6 succeeding hemodialysis sessions. This was supported by the conclusion made by previous studies stating that there was no significant difference in access recirculation percentage between antegrade and retrograde arterial needle placement [11,13].

Furthermore, the results of the present study agree with the findings of Sochi et al. that revealed that access recirculation did not depend on puncture direction [29]. Furthermore, Schoch, Wilson, and Agar, Kang, Song, and Min and Kim et al., found that there was no recirculation observed during either antegrade or retrograde cannulations [14,16,30]. On the other hand, Molaei et al. revealed that the recirculation rate had a significant relationship with the direction of needle placement and the space between two arteriovenous fistula needles [31]. As supported by the claim of Gauly et al. that enlarging the distance between bevels of the arterial and venous needles decreases access recirculation [19].

In contrast, the findings of the present study disagree with the conclusion made by previous study stating that antegrade cannulation can result in recirculation than on retrograde cannulation [20]. On the other hand, Harman found no significant increase in recirculation by cannulating in the direction of flow (antegrade) [22]. In addition, it denies the claim of Basile et al. that access recirculation was absent when calculated in a retrograde manner [32]. Furthermore, the results of the present study argue with the claims of Dias, Neto, and da Costa that the distance between needles and their direction when different from a retrograde technique are directly related to recirculation that reduces the efficiency of dialysis and that the access recirculation percentage was higher in antegrade than in a retrograde manner [12]. It showed that the mean access recirculation percentage of subjects cannulated in an antegrade manner was 20.68% as compared with subjects cannulated in a retrograde manner, the mean access recirculation percentage was 8.51%. On the other hand, Wiggins, Agar, and Somerville pointed out that recirculation if or when it occurs is not the result of the direction either antegrade or retrograde in which the needle is inserted, but is a reflection of a mechanical failure in the AVF [18]. Furthermore, the results of the present study confirm the claim of Wiggins, Agar, and Somerville that the routine use of retrograde arterial needle cannulation to avert recirculation had no scientific basis, but rather, grew out of the historical practices of the early shunt days where the arterial limb of the shunt had to be faced in the flow-direction of blood [18]. But when the AVF took over as the preferred access, a similar 'into-the-flow-of-blood' or antegrade arterial insertion practice continued.

There was a variation observed in the access recirculation percentage values obtained of the subjects in the intervention group of the present study. It was noted that the access recirculation percentage in intervention group (retrograde) was higher than the subjects in the control group (antegrade). According to Zeraati, Beladi Mousavi, Beladi Mousavi it is well-established that access recirculation in an arteriovenous fistula among hemodialysis patients markedly decreases efficiency of dialysis that can lead to significant inadequate dialysis and contributes to lower survival of HD patients [33]. Therefore, periodic assessment of dialysis access recirculation has important diagnostic implications and should be standard. Access recirculation has profound clinical significance that any access recirculation among HD patients should be considered abnormal.

Several authors cited factors responsible for access recirculation which includes low blood flow through the fistula, low left ventricular ejection fraction, stenosis in the blood vessels especially in new vascular accesses due to the staff nurses' lack of familiarity with the access anatomy, and improper or misdirection of arterial and venous needle placement and close proximity between needles by HD staff during HD [31,33-37].

Since arteriovenous fistula recirculation is a common occurrence in HD patients and the most common factors of recirculation are misplacement and close proximity of needles, therefore emphasis should be given on education and training of HD staffs [35]. Therefore, knowledge about the technique of cannulation specifically arterial needle placement is necessary in order to prevent complications of the vascular access, which, when present, can compromise the blood flow of the access, resulting in high access recirculation percentage. The nursing team should use this knowledge in doing cannulation procedures, which guarantees greater durability of access and a better quality of dialysis. Therefore, by detecting the amount and causes of recirculation, hemodialysis nurses can improve the quality of dialysis delivery to patients.

Based on the previous studies, antegrade placement is easier and safer to puncture for the nurses and for the patients for self-puncturing, and may be fistula protective if both needles were in antegrade placement [11,38]. In addition, Cicek et al. showed that arteriovenous fistula cannulation with the arterial needle in an antegrade direction seems to reduce injury of vein, with an easy and safe fixation of bloodlines, and improvement of patient comfort during dialysis [13]. At the same way, antegrade cannulation has a longer segment for cannulation and was more comfortable and less painful, compared to retrograde cannulation [16]. Furthermore, Harman added that antegrade cannulation is much easier to recannulate if there are problems such as infiltrations and clotted needle [22]. Xie et al. noted that antegrade cannulation can reduce incident rates of complication and it can be used to keep long time of service of AV fistula in patients on hemodialysis [39]. In addition, antegrade cannulation can be used to cannulate near the arterial anastomosis of an access without the needles entering the anastomosis site. It is reported to be particularly helpful in newly created arteriovenous fistulas that are not fully matured, as the antegrade cannulation can sometimes provide a higher blood flow with less bloodline collapse or line sucking, and a better pre-pump arterial pressure [40].

Adequate hemodialysis is of importance and directly related to a better health condition as it is the cornerstone for the well-being of each patient, and to lower morbidity and mortality rates for hemodialysis patients [12,26,41]. Several studies showed that there was a positive correlation of dialysis adequacy with all the four domains of Kidney Disease Quality of Life (physical health, mental health, kidney disease problems, patient satisfaction) [42,43]. Delivering adequate hemodialysis minimizes disease complications and hospitalization, improves the quality of life, decrease healthcare costs and the survival of the patient. The nursing team plays a fundamental role in terms of delivering adequate dialysis doses by avoiding the use of inadequate techniques of AVF cannulation [12]. The results of the present study imply that successful vascular access cannulation requires a high level of awareness and skills of the dialysis nurse, frequent monitoring, and evaluation of the cannulation technique are mandatory to guarantee that dialysis patients will receive the high quality of care. Therefore, the mentioned evidence calls for attention of dialysis practitioners and health authorities to consider the extent use of antegrade arterial needle placement in arteriovenous fistula cannulation to improve outcomes for hemodialysis patients.

Limitations

The present study presented a number of considerable limitations. First and most importantly, the research design used in this study did not establish a clear-cut causal relationship among different confounding variables of the subjects which include: demographic and hemodialysis characteristics such as age, sex, cause of ESRD, location and type of arteriovenous fistula, duration of patient on hemodialysis therapy and patient's compliance with diet therapy. Second, based on the type of intervention, blinding was not feasible to the study groups. Lastly, the researcher conducted this study at one hemodialysis center and in short duration, therefore a limited number of hemodialysis patients were available and the sample size was small for a definite conclusion. Any factors not included in this study would be the basis for further research.

Conclusions

Antegrade arterial needle placement provides more adequate hemodialysis than retrograde arterial needle placement in terms of URR and Kt/V among non-diabetic, non-cardiac patients undergoing maintenance hemodialysis in 6 succeeding hemodialysis sessions. The directions of the arterial needle either retrograde and antegrade did not have significant effects on access recirculation.

Recommendations

A further study on comparison of the effect of antegrade and retrograde arterial needle placement on dialysis adequacy be performed larger, multicenter study, and longer periods that would strengthen the evidence obtained in the present study. To conduct another study focusing on the effect of arterial needle placement on dialysis adequacy using other vascular access type such as arteriovenous graft, on the diabetic patients, and patients on thrice a week HD session. To conduct further study to evaluate the effect of arterial needle placement in the arteriovenous fistula on dialysis adequacy using online clearance monitor (OCM), or using other blood sampling methods such as stop-pump method for post-HD sample for URR and Kt/V determination and non-urea based techniques for access recirculation such as ultrasound dilution technique, conductivity, or potassium-based dilution method. To conduct a further study to evaluate the effect of the arterial needle placement considering patient comfort or perception of pain, arterial and venous pressure, rate of hematoma and infiltration, and symptoms of uremia resolution.

References

1. Borromeo AR, Lewis SL, Dirksen SL, Heitkemper MM, Bucher L, et al. (2014) Lewis's medical-surgical nursing: an assessment and management of clinical problems. (8th edn.) China: Elsevier Mosby.
2. Smeltzer SC, Bare BG, Hinkle JL, Cheever KH (2010) Brunner &Suddarth's textbook of medical-surgical nursing (12th edn.). Philadelphia: Lippincott Williams & Wilkins.
3. Dela Cruz R (2014) Kidney disease PH's 7th leading cause of death. The Manila Times.
4. Philippine News Agency (2012) Rise in kidney failure cases alarm health experts. Interaksyon.
5. Philippine Renal Disease Registry [PRDR] (2014) Incidence of hemodialysis patients.
6. Daugirdas JT (2011) Handbook of chronic kidney disease management. Philadelphia: Lippincott Williams & Wilkins.
7. Cruz N (2010) Sad plight of patients with kidney failure. Philippine Daily Inquirer.
8. National Kidney Foundation – Kidney Disease Outcome Quality Initiative [NKF-KDOQI] (2006) K/DOQI clinical practice guidelines and clinical practice recommendations for 2006 updates: Hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. American Journal of Kidney Disease 48: S31.
9. Berkoben M, Blankestijn PJ (2011) Arteriovenous fistula recirculation in hemodialysis. Nephro-Urology Monthly 19: 1312-1338.
10. Lambie SH, Taal MW, Fluck RJ, McIntyre CW (2004) Analysis of factors associated with variability in haemodialysis adequacy. Nephrol Dial Transplant 19: 406-412.
11. Marita M, Preda M, Miriunis C, Parisotto MT (2014) Influence of antegrade vs. retrograde arterial needle placement on dialysis efficiency. Poster presentation at the EDTNA/ERCA 43rd International Conference, Riga, Latvia.
12. Dias TS, Neto MM, da Costa JAC (2008) Arteriovenous fistula puncture: An essential factor for hemodialysis efficiency. Renal Failure 30: 870-876.
13. Cicek S, Haydanli L, Kinay B, Unal E, Karadakovan A, et al. (2010) Influence of needle orientation in arteriovenous fistula on dialysis adequacy. Poster presentation at the EDTNA/ERCA 39th International Conference, Dublin, Ireland.
14. Kim SK, Kim HK, Lee JY, Kim YS, Yoon SA, et al. (2009) Comparison of recirculation and dialysis adequacy between antegrade and retrograde cannulations for hemodialysis. Blood Purification 28: 275-292.
15. Ozmen S, Kadiroglu AK, Ozmen CA, Danis R, Sit D, et al. (2008) Does the direction of arterial needle in AV fistula cannulation affect dialysis adequacy? Clin Nephrol 70: 229-232.

16. Kang SM, Song WJ, Min KH (2007) Comparison of recirculation and dialysis adequacy between antegrade and retrograde cannulations for hemodialysis. Clinical Nursing Research 13: 159-168.
17. Shariati AR, Asayesh H, Nasiri H, Tajbakhsh R, Hesam M, et al. (2012) Comparison of dialysis adequacy in patients that referred to Golestan province hemodialysis centers. Journal of Health Promotion Management 1: 55-63.
18. Wiggins KJ, Agar JWM, Somerville CA (2003) A controlled study of the impact of arterial needle direction on dialysis adequacy in patients undergoing hemodialysis through radiocephalic arteriovenous fistula. Nephrology 8: A70.
19. Gauly A, Parisotto MT, Skinder A, Schoder V, Furlan A, et al. (2011) Vascular access cannulation in hemodialysis patients - a survey of current practice and its relation to dialysis dose. J Vasc Access 12: 358-364.
20. English DJ (2005) Retrograde arterial needle placement improves dialysis adequacy. Nephrol Nurs J 32: 224.
21. Brouwer D (2005) Needle placement is paramount to achieving effective dialysis and preserving vascular accesses. Nephrol Nurs J 32: 225-227.
22. Harman E (2005) The arterial needle can be placed in the direction of flow to achieve effective treatment. Nephrol Nurs J 32: 224-225.
23. Bethesda MD (2008) USRDS 2008 annual data report: Atlas of chronic kidney disease and end-stage renal disease in the United States.
24. Henning MR (2007) Affecting Kt/V: An analysis of staff interventions. Dialysis & Transplantation 36: 548-601.
25. Zeraati AA, Naghibi M, Jabbari Noghabi H (2008) Assessment of factors affecting adequacy of dialysis in hemodialysis patients. Medical Journal of Mashhad University of Medical Sciences 51: 45-52.
26. Amini M, Aghighi M, Masoudkabir F, Zamyadi M, Norouzi S, et al. (2011) Hemodialysis adequacy and treatment in Iranian patients: a national multicenter study. Iran J Kidney Dis 5: 103-109.
27. Nilsson LG, Bosch JP, Alquist M (2011) Quality control in hemodialysis adequacy. European Nephrology 5: 132-37.
28. Ronco C, Levin NW (2009) Hemodialysis and peritoneal dialysis access. Switzerland: Karger.
29. Sochi K, Shinnou S, Nakamura M, Minakuchi J, Kawashima S (2008) Correlation between vascular access and recirculation rate. Journal of Japanese Society for Dialysis Therapy 41: 245-249.
30. Schoch M, Wilson S, Agar JWM (2008) Variations in vascular access flow in haemodialysis can depend on arterial needle orientation. Renal Society of Australiasia Journal 4: 45-50.
31. Molaei E, Aghakhani MJ, Abdollahi AA, Shariati A, Bakhsh RT (2010) Arteriovenous fistula recirculation and its relationship with some factors in hemodialysis patients. Journal of Gorgan Bouyeh Faculty of Nursing & Midwifery 7: 15-22.
32. Basile C, Ruggieri G, Vernaglione L, Montanaro A, Giordano R (2003) A comparison of methods for the measurement of hemodialysis access recirculation. J Nephrol 16: 908-913.
33. Zeraati A, Beladi Mousavi SS, Beladi Mousavi M (2013) A review article: Access recirculation among end stage renal disease patients undergoing maintenance hemodialysis. Nephro-Urology Monthly 5: 728-732.
34. Beladi Mousavi SS, Tavazoe M, Hayati F, Sametzadeh M (2010) Arteriovenous fistula recirculation in hemodialysis: Causes and prevalences. Shiraz E-Medical Journal 11: 219-224.
35. Mahbub T, Chowdhury MNU, Jahan F, Islam MN, Khan FM, et al. (2013) Factors responsible for increased percent recirculation in arteriovenous fistula among hemodialysis patients. Bangladesh Medical Research Council Bulletin 39: 28-33.
36. Gilbert SJ, Weiner DE, Gipson DS, Perazella MA, Tonelli M (2014) National Kidney Foundation's primer on kidney diseases. Philadelphia: Elsevier Saunders.
37. Salimi J, Razeghi E, Karjalian H, Meysamie A, Dahhaz M, et al. (2008) Predicting hemodialysis access failure with measurement of dialysis access recirculation. Saudi Journal of Kidney Dialysis Transplantation 19: 781-784.
38. Parisotto MT, Schoder VU, Miriunis C, Grassmann AH, Scatizzi LP, et al. (2014) Cannulation technique influences arteriovenous fistula and graft survival. Kidney International 86: 790-797.
39. XieY, Huang X, Hong D, Chen W, Huang L, et al. (2010) The study on improved puncture to the time of service of internal arteriovenous fistula in patients with hemodialysis. Journal of Practical Nursing 19.
40. Brouwer DJ (2011) Cannulation camp: Basic needle cannulation training for dialysis staff. Dialysis & Transplantation 40: 434-439.
41. Hassell DR, van der Sande FM, Kooman JP, Tordoir JP, Leunissen KM (2001) Optimizing dialysis dose by increasing blood flow rate in patients with reduced vascular-access flow rate. Am J Kidney Dis 38: 948-955.
42. Murali R, Sathyanarayana D, Muthusethupathy MA (2015) Assessment of quality of life in chronic kidney disease patients using the kidney disease quality of life-short form questionnaire in Indian population: A community based study. Asian Journal of Pharmaceutical and Clinical Research 8: 71-74.
43. Shrestha S, Ghotekar LR, Sharma SK, Shangwa PM, Karki P (2008) Assessment of quality of life in patients of end stage renal disease on different modality of treatment. Journal of Nepal Medical Association 41: 1-6.