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Effect of needle bevel position in arteriovenous fistula cannulation and bleeding during hemodialysis

Ustun Yilmaz, Aysun Unal, Esref Ertan Cicek, Ayca Inci, Semih Gul, Gulay Demirtaş, Muammer Avci, Metin Sarikaya

Antalya Training and Research Hospital, Department of Nephrology, Antalya, Turkey

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Abstract

This study investigated the effect of needle bevel position during arteriovenous fistula cannulation on bleeding stop time in patients with chronic hemodialysis. An arteriovenous fistula puncture was performed on patients using the needle bevel up and down and the bleeding stop time was recorded in minutes. The outcomes of the two techniques were compared. The anticoagulant type used did not affect the bleeding stop time in the 55 patients with hemodialysis included in this study. On separately considering puncture outcomes and anticoagulant type used, the bleeding stop time in both arterial and venous needle bevel down punctures was found to be significantly lower compared with the bevel up puncture ($p<0.05$). The bleeding stop time was found to be shorter in bevel down arteriovenous fistula puncture.

Keywords: Hemodialysis, arteriovenous fistula, needle, puncture, cannulation, bevel position

Introduction

In hemodialysis (HD) treatment, access to the vessel is provided by HD catheter, arteriovenous graft and arteriovenous fistula (AVF). Arteriovenous graft and AVF are permanent vascular access routes. AVF is the opening/connection between the artery and vein. AVF cannulation is one of the gold standard methods used for providing vascular access in a patient with end-stage renal disease (ESRD) receiving HD treatment [1,2]. Since HD is usually performed three times a week (4–8 hours), a fistula or graft for treating HD must be punctured approximately 300 times a year using 2 needles (arterial and venous) during each dialysis treatment [3]. Hence, the AVF puncture must be performed by a safe route and the right technique for performing HD sufficient times.

Due to the anatomical location of the needles used for cannulation, the direction of entry, the width, whether the needle has a posterior eye or not, the inclination direction/angle, and cannulation methods have not been discussed widely in the medical literature. This lack of information leads to cannulation failures increasing morbidity and mortality accompanying dialysis [4].

One of the issues affecting safe cannulation is the bevel position of the needle used during AVF puncture. During the cannulation process puncture can be achieved in two ways, bevel down (BD) with the needle face downwards and bevel up (BU) with the needle face oriented upwards. (Figure 1). International guidelines do not give clear recommendations on the bevel position of the needles during cannulation. The National Kidney Foundation (KDOQI), in its clinical practice guideline for vascular access in 2006, recommended that the AVF be cannulated with a 25° puncture angle and bevel-up needle position [5]. BD or BU types of needle puncture methods, used during cannulation, vary in different HD centers [6-9]. Additionally, the literature indicates that many centers frequently use the AVF puncture method with needle bevel-up position [6-9]. However, few reports have compared AVF cannulation methods (bevel-up or bevel-down punctures) with various clinical aspects. Additionally to the fact that many HD centers prefer BU puncture in AVF cannulation, few studies have investigated whether BD puncture has an advantage concerning clinical aspects over the BU puncture [6-11]. We examined some of these reports. A study comprising of 48 patients, which evaluated the degree of pain and skin damage

*Corresponding Author: Ustun Yilmaz, Antalya Training and Research Hospital, Department of Nephrology, Antalya, Turkey
E-mail:ustunfy@gmail.com

reported that higher pain intensity and a larger hole in the skin were associated with the BU puncture [10]. In a study conducted on 17 patients, visual observations after the total puncture count revealed that less bleeding occurred in patients who underwent BD puncture for AVF cannulation compared to the BU puncture method [11]. However, the time required for the bleeding to stop was not measured in this study.

Anemia may occur because of frequent bleeding and blood loss after punctures. It is known that anemia increases the rate of hospitalization, decreases the quality of life, and most importantly increases the probability of death in patients with ESRD [12-14]. Since blood loss is harmful to patients with HD, it is important to examine the puncture techniques to identify the least destructive/aggressive ones.

Since the literature about the bevel position of the needles in AVF cannulation is not explicit, the anemia that develops after continuous excessive bleeding is an important issue in patients with HD. The needle bevel position should be investigated concerning its effect on bleeding caused during AVF cannulation. Therefore, the current study aims to determine the effect of the needle face positions BD or BU, used during the AVF cannulation procedure, on the time required for the bleeding to cease.

Material and Methods

Study design

This is a single-center, observational study. The study protocol was approved by the ethics committee of the Antalya Training and Research Hospital (Approval number: 10/11) and was conducted in accordance with the ethical standards defined in the 1964 Declaration of Helsinki. During the execution of the study, the patients were informed about the study, and their written consent was obtained.

Patients

A total of 55 patients (26 women and 29 men) who were treated for HD via AVF in the HD unit of Antalya Training and Research Hospital were included in the study, of these 19 patients had AVF in the forearm and 36 patients had AVF in the upper arm. Initially, the BD puncture was performed in 55 patients using low-molecular-weight heparin (LMWH), and the bleeding stopping times were determined. In the same patient group using LMWH, the AVF needle puncture was applied in different HD sessions in the form of a BU, and the corresponding bleeding stopping times were determined. Once again, in the same patient group, these procedures were repeated with unfractionated heparin (UFH) in different HD sessions, and the bleeding stopping times were determined. The inclusion criteria were patients receiving HD treatment for at least 3 months due to the ESRD diagnosis, with AVF that has been in use for at least 1 month and were aged >18 years. Patients with acute renal failure, those using drugs that may prolong the bleeding time, those with hereditary or acquired coagulation disorders, patients with low platelet count, patients with HD of age <18 years, and under HD treatment via an HD catheter or arteriovenous graft were not included in this study.

Cannulation technique and data collection

In each patient, the AVF puncture was performed by a dialysis technician at a 25° angle using a standard 15-G lumen needle using the rope ladder technique, 3–4cm from the arteriovenous anastomosis line and 5cm between them. Both the arterial and venous needle AVF punctures were performed using the needle BD, and the stopping time of the bleeding started at the puncture site was recorded in minutes. The bevel-up AVF puncture was performed on the same patient by the same dialysis technician in another HD session, and the duration of bleeding that started at the puncture site was recorded in minutes. After the data were recorded in different sessions, considering the type of anticoagulation used, and the bleeding stopping times of arterial needles according to the needle bevel position were compared among themselves, and the venous needle bleeding stop times were compared among themselves.

Anticoagulation dose and the bleeding stop time measurement

Each participant was provided a certain dose of anticoagulation for HD treatment.

After the AVF needle punctured the BD, the bleeding stop time was measured. In a different HD session, the same dose of anticoagulation was applied to the same patient, and the bleeding stopping time after the bevel-up puncture was measured.

After the puncture needles were removed at the end of the HD session, compression with a tampon was applied to prevent massive bleeding from the AVF. After 8 min of compression, the tampon was removed and checked to assess whether the bleeding stopped. Next, by counting down from 8 for 1 min (7,6,5,4,3…), the tampon was removed every minute and the last value at which there was no bleeding was recorded as the bleeding stop time in minutes. Owing to the bleeding tendency in patients with chronic kidney disease and the risk of massive bleeding due to the special vascular structure of the AVF, the bleeding stopping time was not measured in seconds, considering that the continuous removal of the compression pad may lead to continued bleeding or massive bleeding.

Statistical analyses

Categorical variables were presented as n(%), and continuous variables were presented as mean (standard deviation), median (interquartile range [IQR]: 25th–75th percentile). The chi-square test or Fisher's exact test was used for statistical comparisons of categorical variables between the two groups. Wilcoxon Signed rank test was applied for statistical comparisons of dependent variables between the two groups, and Mann–Whitney U-test was performed for statistical comparisons of independent variables between the two groups. For statistical significance, $p<0.05$ was accepted. Statistical analysis was performed using the Statistical Package for Social Sciences for Windows version 23.

Results

Total 55 patients (26 [47.3%] female and 29 [52.7%] male) diagnosed with ESRD who underwent HD with AVF were included in this study. The mean age and duration of HD treatment in these patients were 50±18 years and 88±52 months, respectively. The mean height, weight, and body mass index were 163±10cm, 58.2±12.8kg, and 21.8±4.4kg/m², respectively. Basal laboratory parameters of these patients were analyzed and were found to be as, mean BUN (blood urea nitrogen) 68.52±18.48mg/dl, creatinine

7.2±3.05mg/dl, phosphorus 5.2±1.5mg/dl, calcium 8.6±2.84mg/dl, parathyroid hormone 465±335 pg/ml, hemoglobin 10.4±1.35g/dl, hematocrit 31.7±3.9%, ferritin 466.43±255.47ng/ml and albumin 3.8±0.44g/dl. The average doses of anticoagulants used were, LMWH 0.4±0.1 IU (international unit) and UFH 3500±1000 IU (Table 1).

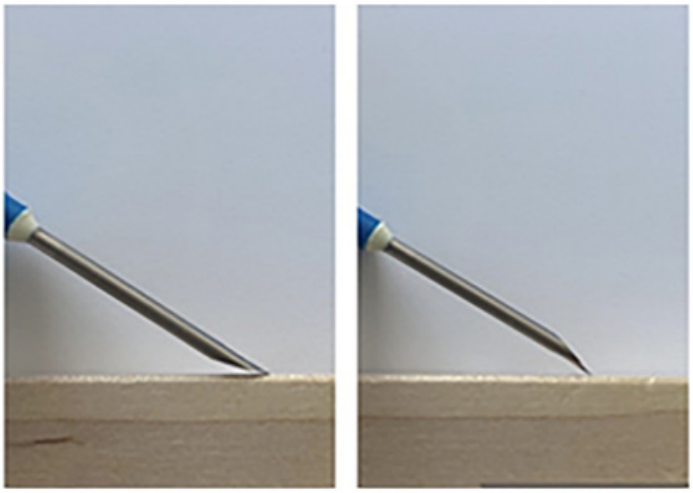
Table 1. Sociodemographic characteristics and laboratory parameters of patients on hemodialysis

Age (years)	**50±18**
Sex	
Female	26(47.3%)
Male	29(52.7%)
Hemodialysis duration (months)	88±52
Height (cm)	163±10
Weight (kg)	58.2±12.8
Body mass index (kg/m²)	21.8±4.4
BUN (mg/dl)	68.52±18.48
Creatinine (mg/dl)	7.25±3.05
Phosphorus (mg/dl)	5.2±1.5
Calcium (mg/dl)	8.6±2.84
Parathyroid hormone (pg/ml)	465±335
Hemoglobin (g /dl)	10.4±1.35
Hematocrit (%)	31.7±3.9
Ferritin (ng/ml)	466.43±255.47
Albumin (g /dl)	3.8±0.44
Heparin dose	
LMWH (IU)	0.4±0.1
UFH (IU)	3500±1000

LMWH: low-molecular-weight heparin, UFH: unfractionated heparin, BUN: blood urea nitrogen

The effects of bevel position in arterial and venous needle puncture on the median time required for the bleeding to stop was compared in the case of different coagulants applied. The median time required for the bleeding to stop in the BD needle artery intervention was 3min (IQR 25th–75th percentile 3–3min) with the use of LMWH and was 3min (IQR 25th–75th percentile 3–3min) with the use of UFH (p=0.09). In BD venous needle puncture, it was 3min (IQR 25th–75th percentile 2–3min) with the use of LMWH, while it was 3min (IQR 25th–75th percentile 2–3min) with the use of UFH (p=0.17). It was found to be 6 min (IQR 25th–75th percentile 6–6min) in BU artery needle puncture with LMWH use, and 6 min (IQR 25th–75th percentile 4–6min) in UFH use (p=0.47). It was found to be 6min (IQR 25th–75th percentile 6–6min) in BU venous needle puncture with LMWH use, and 6min (IQR 25th–75th percentile 6–6min) with UF use (p=0.77) (Table 2).

The effect of different coagulants in patients was analyzed separately. Bleeding cessation times were compared based on arterial and venous AVF puncture bevel positions. In the use of LMWH, the median bleeding cessation time after BD artery puncture was 3min (IQR 25th–75th percentile 3–3min), while it was 6min (IQR 25th–75th percentile 6–6min) in BU artery puncture (p<0.001). While the median bleeding cessation time was 3 min (IQR 25th–75th percentile 2–3min) in BD venous puncture and it was 6min (IQR 25th–75th percentile 6–6min) in BU venous puncture (p<0.001). With UFH use, the median bleeding cessation time after BD artery puncture was 3 min (IQR 25th–75th percentile 3–3 min) while it was 6min (IQR 25th–75th percentile 4–6min) in BU artery puncture (p<0.001). While the median bleeding cessation time was 3min (IQR 25th–75th percentile 2–3min) in BD venous puncture, it was 6 min (IQR 25th–75th percentile 6–6 min) in BU venous puncture (p<0.001) (Table 3).



Bevel down Bevel up

Figure 1. Arteriovenous fistula needle puncture bevel down and bevel up cannulation methods, respectively, according to the bevel positions

Table 2. Comparison of the effects of arterial and venous needle puncture bevel positions on the bleeding stop time according to the applied anticoagulation method

	LMWH (IU) (n: 55)				UFH (IU) (n:55)				p* value
	Mea±stand-art deviation	Median	Percentile 25	Percentile 75	Mean±stand-artdeviation	Median	Percentile 25	Percentile 75	
BD artery needle intervention bleeding stop time (min)	3±1	3	3	3	3 ±0	3	3	3	0.09
BD venous needle intervention bleeding stop time (min)	3±1	3	2	3	3±1	3	2	3	0.17
BU artery needle intervention bleeding stop time (min)	6±1	6	6	6	5±1	6	4	6	0.47
BU venous needle puncture bleeding stop time (min)	6±1	6	6	6	6±1	6	6	6	0.77

LMWH: low-molecular-weight heparin, UFH: unfractionated heparin, IU: international unit, BD: bevel down, BU: bevel up, min: minute * Mann–Whitney U-test

Table 3. Comparison of the patients using low-molecular-weight heparin or unfractionated heparin according to the effect of arterial and venous needle puncture bevel position on the bleeding stop time

	Bevel down	Mea±standart deviation	Median	Percentile 25	Percentile 75	Bevel up	Mean±standat-deviation	Median	Percentile 25	Percentile 75	p* value
LMWH (n: 55)	BD artery needle puncture bleeding stop time (min)	3 ± 1	3	3	3	BU artery needle puncture bleeding stop time (min)	6±1	6	6	6	<0.001
	BD venous needle puncture bleeding stop time (min)	3 ± 1	3	2	3	BU venous needle puncture bleeding stop time (min)	6±1	6	6	6	<0.001
	Bevel down	**Mean±standard deviation**	**Median**	**Percentile 25**	**Percentile 75**	**Bevel up**	**Mean±standart deviation**	**Median**	**Percentile 25**	**Percentile 75**	
UFH (n: 55)	BD artery needle puncture bleeding stop time (min)	3 ± 0	3	3	3	BU artery needle puncture bleeding stop time (min)	5±1	6	4	6	<0.001
	BD venous needle puncture bleeding stop time (min)	3 ± 1	3	2	3	BU venous needle puncture bleeding stop time (min)	6±1	6	6	6	<0.001

LMWH: low-molecular-weight heparin, UFH: unfractionated heparin, BD: bevel down, BU: bevel up, min: minute *Wilcoxon Signed Ranked Test

Discussion

AVF puncture failures and technical errors may result in the patient not receiving satisfactory HD therapy. In this context, problems related to AVF puncture may indirectly increase morbidity and mortality. Therefore, it is important to place the needles used for AVF puncture correctly during the HD session. The ideal technique for AVF cannulation is not well-defined/established. Different cannulation techniques are applied by different dialysis centers. During AVF needle puncture, issues such as needle entry direction, needle size, back eye, and needle type have been discussed in earlier studies [7,15,16]. Another concern in HD cannulation is the bevel position of the needles used during AVF puncture, which is seldom discussed in the literature but is crucial as it might affect the treatment. Also, previous studies are mostly focused on the evaluation of pain after needle puncture [10,17]. There are a limited number of studies examining bleeding at the puncture site and the problems it may cause. To our knowledge, there is only one study in the literature that directly compares bleeding after BD and BU-type needle punctures in AVF cannulation. However, this study was conducted with a limited number of subjects (17 patients), and the bleeding cessation time was not measured [11]. Considering that the decrease in hemoglobin caused by chronic blood loss in patients with HD leads to inefficient HD treatment, it is important to apply a puncturing method causing minimal bleeding. Therefore, in our study, it was hypothesized that when the AVF needle puncture is inclined in a BD position, the bleeding stops sooner than that in the BU position hence resulting in lesser blood loss. Additionally, to the detailed study about the bleeding time, the relationship between the anticoagulant used and the needle bevel position was also examined.

In a meta-analysis study conducted in patients with HD, it was reported that the use of LMWH or UFH did not differ in terms of bleeding risk [18]. However, bevel position during needle puncture was not mentioned in these studies. In the present study, patients with HD were divided into two groups according to the use of LMWH or UFH. When arterial and venous needle punctures were performed as BD and BU, no difference was found between bleeding cessation times depending on the anticoagulant used.

This indicates that the use of either type of anticoagulant does not increase the bleeding after AVF puncture.

In order to minimize bleeding and to cannulate without damaging the vessel wall, studies on needle bevel position have been carried out in patient groups with nonHD. In one of these studies, the patient group undergoing BD puncture of the internal jugular vein was compared with the patient group undergoing BU puncture. Posterior venous wall injury and hematoma were reported to be less common in the BD puncture group [19].

Although needle bevel direction varies between centers during AVF puncture in patients with HD, BU puncture method is generally preferred. In a multicenter study with 171 HD centers by Gauly et al., it was reported that AVF punctures were performed in the BU and BD positions in 72.3% and 27% of the patients, respectively [9]. The National Kidney Foundation (KDOQI) reported in 2006 that the AVF should be cannulated with a 25° puncture angle in BU position [5]. Castro et al. reported that 100% of AVF needle punctures were performed in their center in the BU position [6].

However, some cannulation prefer needle BD position, probably to reduce pain and the risk of vascular posterior wall injury [20]. However, the relationship between needle bevel position and bleeding cessation time has not been investigated in these studies.

In a study by Sallee et al., it was reported that 56% of the patients had AVF BU needle punctures and 48% of the patients had bled at the puncture sites for more than 10 minutes, however, the relationship between bleeding time and needle bevel position was not discussed [21]. In the previously mentioned study by Gaspar et al., 17 patients were recruited, and it was reported that bleeding was detected in only 27 (3.6%) punctures after a total of 748 punctures. It has been reported that 26 (6.9%) of these occurred

after BU AVF puncture and 1 (0.26%) was seen after BD puncture [11]. However, the time required for the bleeding to stop was not recorded in this study, and bleeding was monitored visually.

Additionally to the fact that blood loss after AVF needle puncture is an important problem in patients with HD, excessive compression methods used to stop bleeding and their constant repetition may cause thrombosis in the region of AVF [22,23]. In this context, lesser bleeding and shorter duration will ensure avoidance of compression.

This shows that minimizing blood loss is also important for preventing thrombosis.

When different types of anticoagulants were evaluated separately in the present study, the bleeding cessation time in both arterial and venous needle BD AVF puncture after LMWH or UFH was found to be significantly lower than that of the BU AVF puncture. This shows that irrespective of the anticoagulant used, BD AVF puncture causes lesser bleeding than the BU AVF puncture.

To address whether BD or BU should be preferred in AVF cannulation, an aspect less discussed in the literature, we performed the aforementioned study. To the best of our knowledge, this is the only study in which the effect of AVF needle puncture bevel position on bleeding cessation time was evaluated and whether this duration changed according to the type of anticoagulant used was examined. Since blood loss will be minimized due to the shorter bleeding time after AVF BD puncture, we propose that mortality and morbidity in patients will also be reduced indirectly. Therefore, we recommend using this method in AVF cannulation. Our study presents optimal guidelines for AVF cannulation. Also, our study will encourage more comprehensive studies to evaluate the pain, bleeding cessation time, and risk of vascular posterior wall damage with respect to the AVF needle puncture bevel position.

The present study has some limitations. It was performed in a single dialysis center, the number of patients was small, the levels of pain and vessel wall damage corresponding to the AVF puncture bevel position were not evaluated. Additionally, hemorrhage-related decrease in hemoglobin and mortality between the two puncture techniques were not compared.

Conclusion

When AVF needle puncture was performed using the same bevel position for HD treatment, there was no difference between the bleeding cessation times depending on the LMWH or UFH use. Therefore, it was found that there was no difference between anticoagulants in terms of bleeding risk. In all patients who underwent LMWH or UFH, bleeding cessation time was found to be significantly lower in BD AVF in both arterial and venous modes compared to BU position. In conclusion, in line with the results obtained in this study, BD needle puncture can be recommended for AVF cannulation during HD treatment in patient groups where blood loss can cause important clinical problems. However, comprehensive studies in the future with a larger number of participants are needed to support these findings.

Conflict of interests
The authors declare that there is no conflict of interest in the study.

Financial Disclosure
The authors declare that they have received no financial support for the study.

Ethical approval
This study was approved by the Ethics Committee of the Scientific Research Ethics Committee of Antalya Training and Research Hospital (Approval number: 10/11) and was conducted in accordance with the ethical standards defined in the 1964 Helsinki Declaration. During the study execution, the patients were informed about the study, and their written consent was obtained.

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