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Access

Effect of the arterial needle bevel position on puncture pain and postremoval bleeding time in hemodialysis patients: A self-controlled, single-blind study

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Abstract

Aim: This study aimed to investigate the effect of the bevel orientation (facing upwards or downwards towards the skin) of the needle inserted into the arterial limb of the arteriovenous fistula (AVF) on puncture pain and postremoval bleeding time.

Methods: This study, using a single-blind crossover design, was conducted on 35 maintenance hemodialysis patients who had been dialyzed for at least 6 months and in whom blood access was via an AVF. AVF cannulation was performed with the needle bevel pointing upward in the first six sessions and the needle bevel pointing downwards (towards the skin) in the subsequent six sessions. Needles were always inserted in the direction of blood flow. At each dialysis session, cannulation pain was measured using a visual analog scale (VAS), and the bleeding time at the end of dialysis after needle removal was recorded.

Findings: The VAS score and postremoval bleeding time were lower when the needle bevel pointed downwards towards the skin during insertion ($P < 0.05$).

Discussion: Insertion of the needle with the bevel pointed downward decreased puncture pain during cannulation and bleeding time postdialysis on needle removal.

INTRODUCTION

A patient with an arteriovenous fistula (AVF) who receives chronic hemodialysis (HD) treatment is cannulated 312 times a year on average,[1] and 57%–60.9% of the patients report moderate to severe pain.[2,3] Pain may increase nonadherence to the HD regimen, and patients may want to discontinue HD treatment. Nonadherence increases the mortality rate owing to an increase in cardiovascular and respiratory complications.[4]

At the end of HD treatment, arterial and venous needles are withdrawn, and the bleeding is expected to stop within 8–10 min after applying adequate and correct pressure with two fingers.[5] Manual compression stops the bleeding, while the platelet and fibrin mesh help in the formation of blood clots through conventional

pathways. Manual compression is simple, inexpensive, and ideally suited for patients who are compliant and physically capable of applying pressure to their puncture sites. It is critical to ensure bleeding control at the end of the treatment, as AVF-related bleeding that may develop can be fatal due to prolonged bleeding time.[6] In addition, not applying proper pressure to the fistula site can lead to excessive blood loss from the site and loss of the fistula. This increases the nurses' workload,[7,8] and the increase in applied pressure can also result in fistula thrombosis.[9]

The fistula needle causes small punctures at the entrance site that are closed with a thrombus following needle withdrawal. Scar tissue then forms at the entrance site and surrounding skin and can lead to stenosis and aneurysms. Therefore, the needle bevel direction is important in terms of delaying the loss of tissue elasticity and prolonging the use of the access puncture area.[10,11] Very few studies have investigated the effect of the bevel orientation (upward or downwards towards the skin) on puncture pain during cannulation.[11,12] One study reported that a downward orientation of the needle bevel decreased the pain during cannulation, whereas another study found no significant relationship.[11,13] Other studies evaluated puncture pain based on a single cannulation[11] or two cannulation procedures.[13]

Our study aimed to investigate the effect of the orientation of the arterial needle bevel inserted into the AVF on puncture pain and postremoval bleeding time based on results averaged over multiple dialysis sessions.

MATERIALS AND METHODS

Study design and participants

This single-blind study using a crossover design included patients treated at the HD unit of a state hospital between February and May 2021. All cannulations were performed with the arterial needle inserted in the direction of blood flow (antegrade). In six HD sessions, the bevel of the needle faced upwards (away from the skin) and in a subsequent six sessions, the needle bevel faced downwards (towards the skin) during insertion (Figures 1 and 2). All participants were aged ≥18 years, did not have a psychiatric disorder that prevented communication, and volunteered to participate in the study. Exclusions included patients who were known to present difficulties during cannulation, who had a history of hematoma, fistula stenosis or infection, who habitually took painkillers within 3 h of treatment, or who did not want to participate in the study.

Sample size

Thirty-eight patients were selected for the study. Sampling calculations were performed using the G*Power program based on analysis of a pilot study done in four patients, in whom pain severity was evaluated using a numerical scale between 0 and 10. In this pilot group,

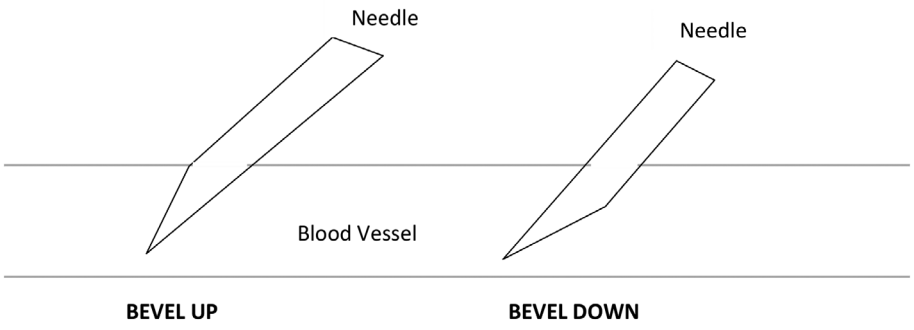

FIGURE 1 Bevel position of the needle.

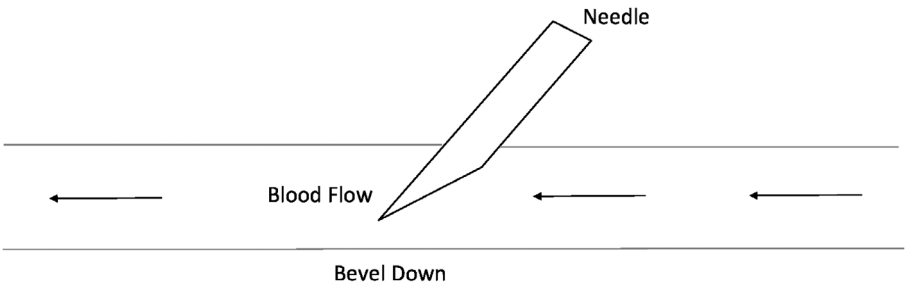

FIGURE 2 Antegrade insertion: Direction of blood flow.

pain severity was 3.25 ± 0.50 with upward orientation of the needle bevel, and 2.75 ± 0.95 with downward orientation. Sample size calculations suggested that 31 participants would be sufficient to detect a pain difference of 0.60 at a confidence interval of 95%, with a power of 80%. Thirty-five patients completed the study; 3 patients were excluded, 1 due to communication difficulties, and 2 because they refused to participate.

Intervention

All cannulations were performed with the arterial needle inserted in an antegrade direction (in the direction of blood flow). Twelve sessions were analyzed; in the first 6 sessions the arterial needle bevel was oriented upwards (away from the skin), and in the second 6 sessions the needle bevel was oriented downwards (towards the skin). The same nurse performed all cannulations for a given patient.

Once the cannulation site was cleaned with an appropriate antiseptic solution, it was allowed to dry for at least 30 s. The arterial needle was inserted at an angle of 30°–45° to the skin surface, at least 5 cm away from the fistula anastomosis.[14] Following needle insertion, the patient's pain was evaluated by a nurse who was not associated with the study. The venous needle was always inserted after the arterial needle.

Compression application

At the end of the HD treatment, after the fistula needle was withdrawn, moderate compression was applied over a gauze pad using two fingers. Guidelines advise removing first the venous needle and then the arterial needle.[5,14] The patients were not allowed to apply compression themselves. After compression had been applied for 3 min, half of the gauze was lifted to check whether the bleeding had stopped. If it had not stopped, compression was continued for another 3 min, and half of the gauze was lifted again to check whether the bleeding had stopped.

Data collection

Patient descriptive characteristics

A semi-structured form was developed by the researchers after reviewing the related literature[1,4,7,9,11,14] which contained 11 questions about sociodemographic and medical data.

TABLE 1 Descriptive characteristics of the subjects ($n = 35$)

	n	%
Age, years	62 (49–71)	
HD treatment duration, months	79 (34–120)	
Fistula age, months	59 (23–83)	
Sex		
Female	14	40
Male	21	60
Educational status		
Not literate	6	17.1
Literate	5	14.3
Secondary school	17	48.6
High school and over	7	20
Income status		
Income less than expense	9	25.7
Income equal to expense	26	74.3
Presence of chronic disease		
Yes	27	77.1
No	8	22.9
Presence of diabetes mellitus		
Yes	7	20
No	28	80
Presence of hypertension		
Yes	22	62.9
No	13	37.1
Presence of heart failure		
Yes	10	28.6
No	25	71.4
Current fistula		
First fistula	9	25.7
Second fistula	16	45.7
Third fistula	10	28.6
AVF location		
Brachiocephalic	9	25.7
Radiochephalic	26	74.3
Cannulation method		
Rope ladder	8	22.8
Area puncture	10	48.6
Button hole	17	28.6
Anticoagulant use		
Yes	22	62.9
No	13	37.1

Note: Data were presented as *n* (%) or median (IQR).
Abbreviations: AVF, arteriovenous fistula; HD, hemodialysis.

TABLE 2 Comparison of the pain and postremoval bleeding time according to bevel positions

	VAS							Bleeding time						
	First	Second	Third	Fourth	Fifth	Sixth	*P* value[a]	First	Second	Third	Fourth	Fifth	Sixth	*P* value[a]
Up	1 (1–2)	1 (1–3)	1 (1–2)	1 (1–2)	2 (1–3)	2 (1–3)	0.058	5 (5–7)	5 (4–7)	5 (5–8)	6 (5–7)	5 (5–7)	6 (5–7)	1.879; 0.866
Down	1 (1–2)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	1 (1–1)	0.288	5 (4–5)	5 (4–6)	5 (4–6)	5 (4–5)	4 (4–5)	4 (4–5)	4.955; 0.421
P value[b]	0.01	0.001	0.008	0.006	<0.001	<0.001		0.003	0.015	<0.001	0.002	<0.001	<0.001	

Note: Data were presented as median (IQR).
Abbreviation: VAS, visual analog scale.
[a]Friedman test.
[b]Wilcoxon signed test.

Primary outcomes

Visual analog scale for pain

This scale, developed by Price et al.[15] has been used in a number of studies to evaluate the severity of perceived pain and was found to be reliable and valid. Eti Aslan[16] conducted a Turkish validity and reliability study using the VAS to evaluate postoperative pain. Permission to use the scale was obtained from Eti Aslan[16] via e-mail. The patients were asked to grade their pain from "0 = not at all" to "10 = prominent" after fistula cannulation. The VAS was evaluated after puncture of the fistula by a HD nurse who worked at the HD unit and was blinded to the study. A total of 12 HD sessions and 12 punctures were evaluated.

Postremoval bleeding time

The duration (minutes) from when pressure was applied once the fistula needle was withdrawn until the moment the bleeding was determined to have stopped was calculated as the bleeding time.

Ethical consideration

This study was conducted in accordance with the principles of the Declaration of Helsinki. Local ethics committee approval (meeting date: 01/04/2021, decision no: 2021.48) and the required institutional permissions were obtained to conduct the study, together with written consent from the participants. The trial was registered on the ClinicalTrials.gov website as a National Clinical Trial (NCT05115448).

Statistical analysis

Data were analyzed using IBM SPSS Statistics for Windows, version 22.0 (SPSS; IBM Corp., Armonk, NY). The compliance of the measurement values with a normal distribution was investigated using the "Shapiro–Wilk test." The mean ± standard deviation, median, and interquartile range (IQR) were used to present the descriptive statistics of continuous numerical variables, and numbers (*n*) and percentages (%) were used to present categorical variables. Variables were analyzed by standard statistics using the paired sample test, Friedman test, and Wilcoxon signed-rank test. A *P*-value <0.05 was considered to be statistically significant.

TABLE 3 Comparison of the average of six HD seasons of pain and bleeding time according to bevel positions

	Bevel up	Bevel down	*P* value
VAS	1.66 (1.66–2.33)	1.16 (1–1.33)	<0.001[a]
Postremoval bleeding time (min)	5.89 ± 1.43	4.76 ± 0.98	<0.001[b]

Note: Data were presented as the median (IQR) and mean ± standard deviation.
Abbreviation: VAS, visual analog scale.
[a]Wilcoxon signed test.
[b]Paired-samples *t* test.

RESULTS

Thirty-five patients participated in this study; 60% were males, and 77.1% had an additional chronic disorder. The median (IQR) length of time on HD was 79 (34–120) months. A total of 62.9% of the patients used anticoagulant drugs (Table 1).

The VAS value was higher in the bevel up group in terms of the first ($P = 0.01$), second ($P = 0.001$), third ($P = 0.008$), fourth ($P = 0.006$), fifth ($P < 0.001$), and sixth ($p < 0.001$) month. The bleeding time was lover in the bevel down group in terms of the first ($P = 0.003$), second ($P = 0.001$), third ($P = 0.008$), fourth ($P = 0.006$), fifth ($P < 0.001$), and sixth ($p < 0.001$) month (Table 2).

The median VAS score (IQR) was 1.66 (1.66–2.33) when the needle bevel pointed upward during cannulation and 1.16 (1–1.33) when the bevel pointed downward. The mean postremoval bleeding time was 5.89 ± 1.43 min when the needle bevel pointed upward during cannulation and 4.76 ± 0.98 min when the needle bevel pointed downward (Table 3).

DISCUSSION

In this study, we found that the puncture pain score was significantly lower in patients in whom the needle was inserted with the bevel pointed downwards facing the skin. Our results were different from those of Akyol Durmaz[13] who studied 32 patients using a crossover design, and found no statistically significant difference in terms of the pain scores between bevel-upward and bevel-downward needle insertions. Our results do agree with those of Crespo Montero et al.[11] who found that the pain score related to needle insertion was lower when the needle bevel pointed downwards during insertion. One possible explanation for this is the observation that a puncture with the bevel facing downward produces a shorter transversal cut than when the skin puncture is made that with the needle bevel facing upward.[12,17] The needle inserted with the bevel pointed downward was determined to cause smaller skin tears and cuts in the study by Crespo Montero et al.[11]

Seventeen patients were followed up for 3 months by Gaspar et al.[18] where fistula needles were first inserted with the bevel pointed upward and then with the bevel pointed downward. Hemorrhage occurred in 0.26% of patients after insertion with the bevel pointed downward versus in 6.9% of the patients after insertion with the bevel pointed upward. Lim et al.[19] compared hematoma formation following catheter insertion into the jugular vein with the needle direction as upward or downward in 338 patients, with 169 patients in each group, and proved with ultrasound images that the incidence of postinsertion hematomas was lower in the bevel facing downward group. The postremoval bleeding time was also shorter with the needle inserted with the bevel pointed downward in that study. Similar to the study by Crespo Montero et al.[11] the reason could be a shortened bleeding time as a result of the smaller cuts created by the needle inserted in the bevel-down direction. In addition, the scar tissue created by the needle inserted in the bevel down direction during each application in the six HD sessions could have decreased the bleeding time in this study.

It was noted from our review of the literature that nurses often direct the needle bevel downward by rotating the needle after first inserting the arterial needle with the bevel up. This might increase the risk of postremoval bleeding by causing trauma to the endothelial layer. The current study shows that bevel-down use of the arterial needle does not require needle rotation, and the trauma that may occur in the endothelial layer can thus be eliminated.

Our study had some limitations. The findings were from a single HD center, and further multicenter studies are needed. This was a single-blind study because the researchers who collected the data during the application were aware of the bevel direction used during cannulation. The order of treatments (upwards vs. downwards bevel orientation) should optimally have been balanced, with half of the initial group of treatments being upwards insertion and half being downwards insertion; there may have been a time-effect related to the order of treatments.

In conclusion, our study results suggest that insertion of the arteriovenous fistula needles with the bevel pointed downward decreases the level of pain experienced during

cannulation and shortens the duration of postremoval bleeding.

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CONFLICT OF INTEREST

No conflict of interest has been declared by the authors.

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