A Randomized Control Trial of MuST for Vascular Access Cannulation in Hemodialysis Patients: Contributions for a Safe Nursing Intervention

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Rationale & Objective: Preservation and maintenance of a complication-free arteriovenous fistula (AVF) remains significant challenge. An adequate cannulation technique and successful puncture are critical for preserving AVF and ensuring patient safety. The study investigated whether the multiple single cannulation technique (MuST) leads to improved AVF survival and a lower complication rate than the rope-ladder (RL) technique.

Study Design: The MuST study was a multicenter, prospective, nonblinded, parallel group, randomized controlled trial.

Setting & Participants: A total of 101 patients received hemodialysis in 3 peripheral units; 49 patients were assigned to the MuST group and 52 to the control group.

Intervention: The intervention group received MuST, whereas the control group underwent the RL technique, with both groups followed for period of 12 months.

Outcomes: The primary outcome was to evaluate the AVF survival rate at 12 months, defined as unassisted patency. The secondary outcome included the assessment of assisted primary patency, complication rates, and pain perception.

Results: There were no statistically significant differences between the MuST and RL techniques in unassisted patency (HR, 1.02; 95% CI, 0.38-2.71; $P = 0.98$) or in assisted patency (HR, 0.74; 95% CI, 0.37-1.47; $P = 0.39$). There were no statistically significant differences in the incidence of hematoma or thrombosis, and no infections occurred during the study period. The MuST presented an advantage over the RL technique in the development and formation of new aneurysms. There were no significant differences observed in pain perception between the 2 cannulation techniques.

Limitations: The sample size was smaller than expected due to limitations in the selection of patients during the SARS-CoV-2 pandemic phase.

Conclusions: We could not definitively demonstrate a difference in AVF survival between MuST and RL. The low incidence of AVF thrombosis in both techniques shows that MuST can be a choice for patient safety and well-being when nursing teams decide which cannulation technique to perform.

Trial Registration: Registered at ClinicalTrials.gov with identifier NCT05081648.

Complete author and article information provided before references.

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INTRODUCTION

A functioning vascular access (VA) is essential for the successful treatment and survival of patients undergoing hemodialysis (HD). According to the guidelines of the National Kidney Foundation–Kidney Disease Outcomes Quality Initiative[1] for VA, establishes that "no decision about a single vascular access creation or placement should be made in isolation and independent of each patient's overall ESKD Life-Plan," which is made together by the patient and a coordinated kidney failure management team.

The arteriovenous fistula (AVF) is the most commonly used VA (>70%) in most European dialysis units. Once the early high morbidity associated with maturation failure is overcome, AVFs offer greater primary longevity without the need for intervention and a lower rate of late complications compared to arteriovenous grafts and central venous catheters. Once a patient has a suitable well-matured AVF, the next step is to preserve the patient's lifeline and the selection of the most appropriate cannulation technique. Area cannulation should be avoided whenever feasible due to associated risks. Nevertheless, clinical practice presents a different reality,[2] with this technique remaining the predominant approach in certain European countries.[3] The recommended technique for AVF is rope-ladder (RL),[1,2] and despite standardized protocols, nurses tend to the area cannulation technique in clinical settings.[4] On the other hand, the buttonhole (BH) technique is recommended for patients with short cannulation segments[5] exclusively for AVF and is often selected for patients that self-cannulate.[1] This conservative recommendation is based on the technique-associated increased risks of infection.[6-8] Recently, a new approach to fistula cannulation has been introduced as a safe and easily implementable alternative called the multiple single cannulation technique (MuST).[9-11]

In this study, we aimed to identify whether the MuST allows for greater AVF survival, a lower rate of complications, and lower intensity of pain perception compared with the RL technique.

PLAIN-LANGUAGE SUMMARY

Functioning vascular access (VA) is crucial to patients with chronic kidney disease undergoing hemodialysis. Repeated cannulation of the VA increases the risk of complications, thereby compromising its survival. Although VA is not free of complications, guidelines recommend the rope-ladder (RL) cannulation technique. We conducted a randomized controlled trial of 101 renal patients receiving hemodialysis who required an arteriovenous fistula comparing the multiple single cannulation Technique (MuST) with the RL technique, to assess their survival and complications for 12 months. We found a low incidence in the development of aneurysms in the MuST group, but we were unable to demonstrate a difference in arteriovenous fistula survival between MuST and RL. Further studies are required to determine the benefits and patient safety of MuST.

METHODS

Study Design and Data Collection

This was a multicenter, prospective, nonblinded, parallel group, randomized controlled trial with the intervention group undergoing the MuST procedure and a control group undergoing the RL technique. The protocol was registered on October 18, 2021 at ClinicalTrials.gov (identifier NCT05081648) prior to commencement.

The participants were recruited in 3 private dialysis clinics operating in different regions of Portugal, reducing possible bias either due to patient characteristics or nursing practices. Patients were randomized to 1 of the 2 cannulation techniques, MuST or RL, and the follow-up period of this study was 12 months. Randomization was performed centrally by the project manager and electronically using a random sequence generator (https://www.random.org/) to create 2 branches (groups). Each group was stratified according to the following criteria: diabetes status and AVF vintage (median <44.80 vs >44.80 months). This stratification was conducted to ensure proper representation of these variables within the sample and to minimize potential bias.

Patients

Adult patients were eligible for inclusion if they were on regular hemodiafiltration program (3 sessions per week), had a native AVF with blood flow (Qa) ≥500 mL/min, and the AVF had been functional for ≥8 weeks without adverse events. The AVF should also consist of segment that allowed cannulation along the vein or 2 distinct areas ≥3 cm long.

Patients were excluded if they undergone angiography or surgical intervention in the last 4 months and had ≥3 interventions. Patients with anesthetic creams use were also excluded (Fig 1).

Interventions

For the study implementation, the senior expert responsible for monitoring and surveillance (key person) for VA and the principal investigator in each clinic were engaged in the process. Initially, study-specific training and awareness raising was conducted for approximately 60 nurses from the clinics. Hence, it was not possible to blind the participants or the nurses who performed the intervention.

At baseline, as well as at 6 months and at the end of the follow-up, photographs of the AV were collected. In addition, the following parameters were assessed: pain intensity, time to hemostasis, peri-needle bleeding, Qa, dialysis dose (single-pool Kt/V) and substitution volume (SV) (Fig 2). Pain was assessed immediately after cannulation of the arterial and venous area according to the visual analog scale.

Patients washed their arms before entering the HD room, and standard disinfection procedures were implemented at the cannulation sites. Sterile sets with the necessary items for AVF cannulation were used. For patients in the MuST group, we selected and identified cannulation sites with a pen until their location was easily visible due to skin depigmentation. Two areas of arterial and venous cannulation were created with 3 cannulation points each ≥1 cm apart. In the RL group, a diagram with the cannulation sites was created for nurses' guidance. Each day, nurses performed a physical examination of the AVF before every HD treatment and recorded their findings using VASACC (vascular access) computer tool and an Excel spreadsheet.

When a critical dysfunction was identified, patients were referred to the Vascular Access Center for angiography or vascular surgery, and after the procedure, records were updated in the Vascular Access OnLine database (AV OnLine). The physicians who performed angioplasty or vascular surgery were blinded to the selected patients for the study.

Patients were monitored until one of the following events occurred: access thrombosis, abandonment due to AVF dysfunction or surgical intervention with anastomosis alteration, patient discontinued the study or transferred to another clinic, hospitalization, death, change of treatment modality, or study end. The data collection took place between January 2022 and April 2023.

Outcome Variables

The primary endpoint was the AVF survival rate at 12 months, defined as unassisted primary patency[12,13] (until the first clinical intervention by angioplasty or vascular surgery). We also defined AVF abandonment as the day on which the access was considered permanently unusable, not suitable for cannulation, or patient's refusal due to pain. Further details have been published elsewhere.[14]

As a secondary outcome (assisted primary patency), we defined the 12 month AVF survival rate as the percentage of fistulas still in use from study initiation until access abandonment due to dysfunction, patient withdrawal, death, treatment modality change, or study

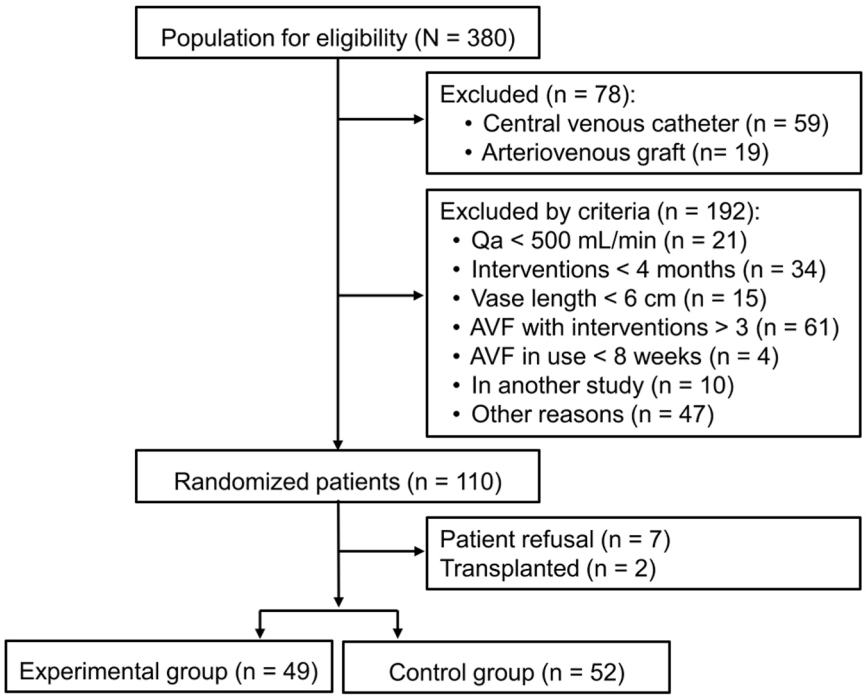

Figure 1. Flowchart of the selection of eligible patients for the study. AVF, arteriovenous fistula; Qa, access blood flow.

completion.[12] For this outcome, the following factors were considered:

- The frequency of interventions, both endovascular and surgical, to maintain functioning access[5];
- Inflammation signs at the AVF cannulation site, which were defined by the presence of one of the following signs: redness, edema, or local exudate[15];
- AVF local infection, defined by the presence of exudate at the cannulation site with a positive bacteriological culture;
- Bacteremia related with AVF and confirmed with a positive blood culture;
- Hematoma or infiltration: an incident that occurs during cannulation that can result in local infiltration, edema, or pain, but recannulation is possible[13];
- Time to hemostasis: time to stop bleeding after needle removal, with up to 10 minutes considered normal;
- Peri-needle bleeding: bleeding from the puncture site during treatment that requires nursing intervention;
- Aneurysm development: segment dilatation of the arterialized vein at 3 times the diameter of the segment considered normal, which means a segment with a width ≥18 mm.[16] The vessel limits at the widest segment were identified by physical examination and measured with a tape, while a photo of the limb was simultaneously collected;
- A development in the existing aneurysm was considered when the vein showed a diameter increase of ≥5 mm;
- Local pain related to cannulation technique;
- Presence of a scab at the cannulation site;
- Easy to identify cannulation site, measured when skin color changes occur at the exact cannulation site.

Sample Size and Power Analysis

A priori power analysis was conducted to estimate the required sample size for detecting significant differences between the 2 independent groups. Assuming a large effect size (Cohen's $d = 0.80$), an alpha level of 0.05, and a statistical power $(1 - \beta)$ of 0.95, and equal group sizes (allocation ratio = 1), the analysis indicated a minimum total sample size of 70 participants (35 per group) was needed to achieve adequate power to detect group differences. The final sample included 101 HD patients, with 49 allocated to the intervention group and 52 to the control group. Given the achieved sample size and balanced group distribution, the actual power was maintained above 0.95.

Statistical Analysis

Data were analyzed according to intention-to-treat.[12] Continuous variables were described using the mean, median, standard deviation, and interquartile range, whereas categorical variables were summarized using absolute and relative frequencies. The median with the 25th and 75th percentiles was used when the variable did not follow a normal distribution. Descriptive analysis were performed for both groups at baseline and at 6 and 12 months. To compare the 2 groups on continuous variables, parametric tests (namely the t test) were used when normality was assumed, and nonparametric tests were applied otherwise.

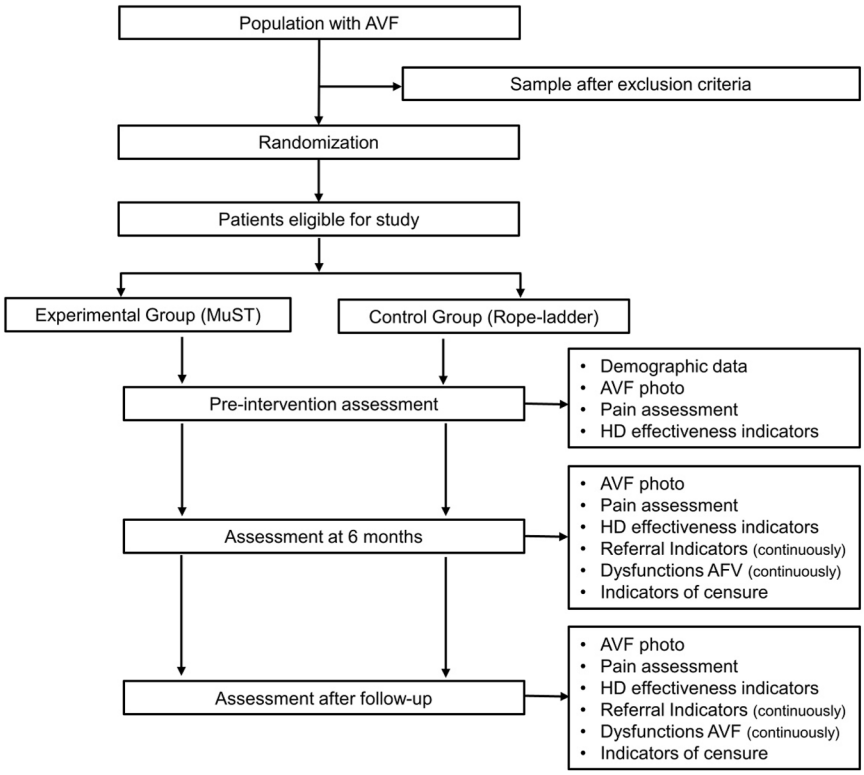

Figure 2. Flowchart of the clinical study design and intervention. AVF, arteriovenous fistula; HD, hemodialysis; MuST, multiple single cannulation technique.

To analyze relationships between categorical variables, the χ^2 test was conducted. To assess primary assisted and unassisted fistula patency, Kaplan–Meier survival curves were generated. For secondary factors, such as the frequency of hematoma, signs of infection, local infection or bacteremia, and thrombosis, the number of episodes per 1,000 days of AVF was calculated.[13] Results were considered significant when $P < 0.05$. Statistical analysis were performed using SPSS (version 29; IBM).

Ethical Considerations

This study was approved by the Fresenius Medical Care, Portugal, ethical committee on March 26, 2021, no. 03/2021, in accordance with national requirements and the Declaration of Helsinki. All patients signed an informed consent form and were permitted to withdraw from the study at any time. Thus, the patients who provided informed consent and met the inclusion and exclusion criteria were randomized into 2 groups.

RESULTS

Description of the Participants

One hundred one HD patients were included in the MuST study, 49 in the interventional group and 52 in the controlled group. Table 1 shows patient demographics and clinical characteristics, kidney failure etiology, comorbid conditions, laboratory parameters, previous VA, and medication in both groups. The data were evenly distributed across the study groups, and no significant differences were observed in the baseline characteristics. Age ranged from 25 to 93 years, with a mean ± standard deviation of 68.8 ± 14.2 years. Approximately 22% were in the fourth quartile, aged 78 years or older. Most participants were men (n = 68, 67.3%). Around 30% of patients had a high or very high 1-year mortality risk according to the Charlson comorbidity index. Approximately half of the patients had VA prior to the fistula in use (n = 49, 48.5%) and had a central venous catheter (n = 43, 42.6%). Regarding the AVF used, patients who had previously undergone angiographic or surgical intervention (n = 37, 36.6%) were identified. Additionally, 44.1% created the AVF before starting HD and 51.5% still had their first fistula in use. The lower percentage of diabetic patients in the control group was due to a higher number of patients refusing to take part in the study.

Primary Outcome (Unassisted Patency)

The median AVF survival follow-up was 12.0 months (25th percentile = 7.0 and 75th percentile = 12.0 months) in MuST and 12.0 months (25th percentile = 5.4 months and 75th percentile = 12.0 months) for RL. During the follow-up period, 6 patients were referred to angiography and 4 patients for surgery (Table 2).

Among the 3 MuST patients referred for angiography, 2 were diagnosed with cephalic arch stenosis and 1 with intra-access stenosis. After the intervention, AVF patency

Table 1. Patient Baseline Characteristics According to Cannulation Technique

Variables	MuST (n = 49)	Rope-Ladder (n = 52)	*P*
Demographics			
Age (y)	67.7 ± 12.8	69.8 ± 15.4	0.46[a]
Men	32 (65.3%)	36 (69.2%)	0.67[b]
Dry weight (kg)	73.2 ± 15.9	70.7 ± 14.1	0.40[a]
Clinical characteristics			
AVF vintage (mo)	51.6 (28.0-86.6)	49.2 (26.7-81.6)	0.33[a]
Dialysis vintage (mo)	52.0 (30.0-90.0)	58.0 (27.0-76.0)	0.24[a]
Qa_BTM (mL/min)	1,402 ± 541	1,395 ± 606	0.95[a]
Total anticoagulant (IU/kg)	61.30 ± 16.3	66.3 ± 16.5	0.13[a]
Charlson comorbidity index	4.7 ± 2.3	4.4 ± 2.2	0.64[a]
Cause of kidney failure, n (%)			
Diabetes mellitus	14 (28.6%)	9 (17.3%)	0.18[b]
Hypertension	7 (14.3%)	9 (17.3%)	0.79[b]
Glomerulonephritis	9 (18.4%)	7 (13.5%)	0.50[b]
Cause unknown	11 (22.5%)	7 (13.5%)	0.24[b]
Polycystic kidney disease	3 (6.1%)	5 (9.6%)	0.52[b]
Other known cause	5 (10.2%)	15 (28.8%)	0.02[b]
Comorbid conditions			
Diabetes mellitus	16 (32.7%)	12 (23.1%)	0.36[b]
Hypertension and heart disease	13 (26.5%)	20 (38.5%)	0.20[b]
Peripheral vascular disease	6 (12.2%)	6 (11.5%)	0.91[b]
Digestive tract disease	1 (2.0%)	2 (3.8%)	
Oncological disease	3 (6.1%)	4 (7.7%)	
Other	1 (2.0%)	2 (3.8%)	
Not specified	9 (18.4%)	6 (11.5%)	
Laboratory values			
Hematocrit (%)	34.2 ± 4.7	34.2 ± 3.2	0.95[a]
Hemoglobin (mg/dL)	11.4 ± 1.5	11.4 ± 1.0	0.90[a]
Albumin (g/dL)	4.0 ± 0.3	4.1 ± 0.3	0.66[a]
Previous vascular accesses			
Previously constructed vascular access (yes)	20 (40.8%)	29 (55.8%)	0.13[b]
CVC previously implanted (yes)	17 (34.7%)	26 (50.0%)	0.12[b]
Current AVF previously interventional (yes)	18 (36.7%)	19 (36.5%)	0.98[b]
Previous aneurysm (yes)	37 (75.5%)	34 (65.4%)	0.23[b]
Medication			
Use of antithrombotic agents (yes)	30 (61.2%)	22 (42.3%)	0.06[b]
Use of antibiotics	0 (0%)	0 (0%)	

Note: The percentages are relative to the frequencies evaluated within the respective class of cannulation techniques. For continuous variables, the mean ± standard deviation are presented. For categorical variables, the frequency and percentage are reported. Median (25th-75th percentiles) are reported for variables with a nonnormal distribution.

Abbreviations: AVF, arteriovenous fistula; MuST, Multiple Single Cannulation Technique; Qa_BTM, access blood flow from Blood Temperature Monitor.

[a]*t* test for 2 independent groups.

[b]χ^2 test for categorical variables.

was successfully maintained in these patients. The intervention group experienced 2 cases of thrombosis, one of which was recovered after thrombectomy. The incidence of thrombosis in our study was 0.0083 episodes/1,000 AVF days. In addition, 6 patients in total were censored. Two were censored due to pain and 2 due to difficulty in maintaining the RL group. In the MuST group, 1 patient was censored due to desquamated skin erythema and 1 due to increased hemostasis time.

Unassisted patency at 12 months was similar between groups, with 83.7% in the MuST group and 84.6% in the RL group. The survival curve estimates are presented in Fig 3. No significant differences in unassisted primary patency were found between the 2 groups (log-rank < 0.01, P = 0.98). The Cox proportional hazards model also did not identify MuST as a risk predictor compared with RL (hazard ratio, 1.02; 95% confidence interval, 0.38-2.71; P = 0.97).

Secondary Outcome (Assisted Patency)

At 12 months, AVF assisted patency was 71.4% in the MuST group compared with 63.5% in the RL group. The median follow-up time for patients in the MuST group was 12.0 months (25th percentile = 8.8 months and 75th percentile = 12.0 months) versus 9.5 months (25th

Table 2. Frequency of Referring to Angiography and Surgery Between the 2 Groups

Referral Factors	MuST (n = 49)	Rope-Ladder (n = 52)
Referral to angiography (right censored)	46 (93.9%)	49 (94.2%)
Physical examination	0 (0%)	2 (3.8%)
Decreased AVF blood flow	0 (0%)	1 (1.9%)
Increased hemostasis time	3 (6.1%)	0 (0%)
Decreased dialysis efficacy	0 (0%)	0 (0%)
Others	0 (0%)	0 (0%)
Referral to surgery (right censored)	46 (93.9%)	51 (98.1%)
AVF thrombosis	2 (4.1%)	1 (1.9%)
Aneurysm development	0 (0%)	0 (0%)
Poor distal perfusion	0 (0%)	0 (0%)
Acute bleeding	0 (0%)	0 (0%)
AVF local infection	0 (0%)	0 (0%)
Others	1 (2%)	0 (0%)

Note: Data are reported as n (%).
Abbreviations: AVF, arteriovenous fistula; MuST, multiple single cannulation technique.

Table 3. Frequency of Censoring Factors in Arteriovenous Fistula Assisted Patency

Factors for Abandonment	MuST (n = 49)	Rope-Ladder (n = 52)
Patients right censored	35 (71.4%)	33 (63.5%)
Thrombosis	1 (2%)	1 (1.9%)
Dysfunctional AVF/abandonment	1 (2%)	2 (3.8%)
Transfer/hospitalization	4 (8.2%)	6 (11.5%)
Patient refusal/abandonment	0 (0%)	2 (3.8%)
Death	2 (4.1%)	4 (7.7%)
Transplant	1 (2%)	4 (7.7%)
Others	5 (10.2%)	0 (0%)

Note: Data are reported as n (%).
Abbreviations: AVF, arteriovenous fistula; MuST, multiple single cannulation technique.

percentile = 6.3 months and 75th percentile = 12.0 months) in the RL group. According to intention-to-treat analysis, 68 (67.3%) patients were right-censored, with no event and 33 events occurred, 14 in MuST and 19 in the RL group. Censure factors are described in Table 3.

Throughout the study follow-up, AVF survival was compared between the 2 groups, as illustrated in Fig 4.

Although a tendency toward low risk was observed with MuST, Cox regression analysis did not identify a significant difference (hazard ratio, 0.74; 95% confidence interval, 0.37-1.47; P = 0.39). Similarly, the log-rank test indicated no significant differences between survival curves (log-rank = 0.75, P = 0.39).

Other Secondary Outcomes Associated With Cannulation Techniques

The rate of the fistula complications of hematoma/infiltration was 15 episodes (0.04/1,000 AVF-days) in both groups combined (7 for MuST, 8 for RL). Hematomas associated with the use of the RL technique most frequently occurred at the last cannulation spot (step).

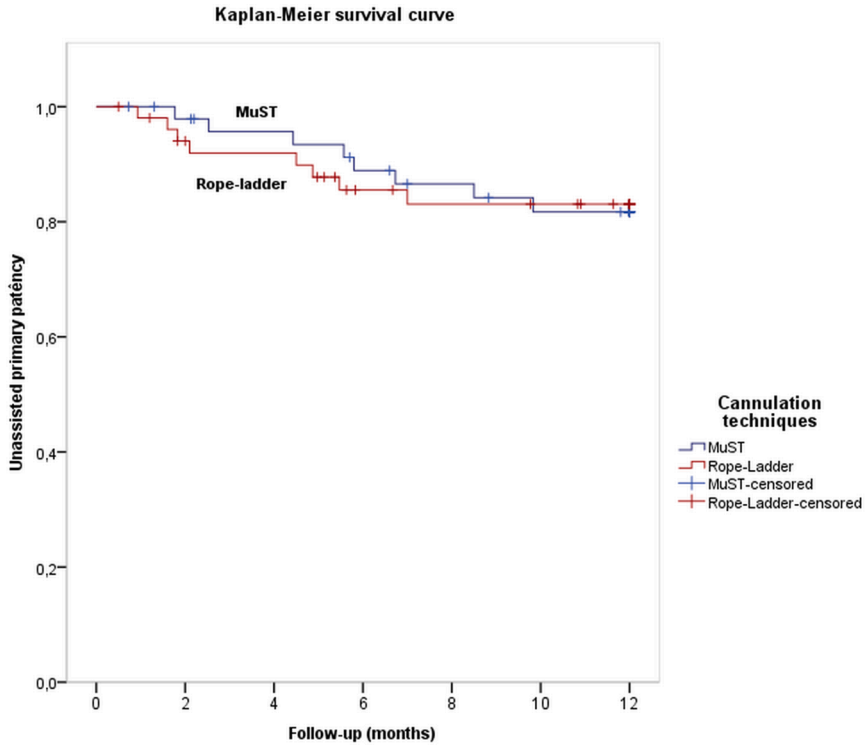

Figure 3. Arteriovenous fistula unassisted patency curve comparing the 2 groups of cannulation techniques. MuST, multiple single cannulation technique.

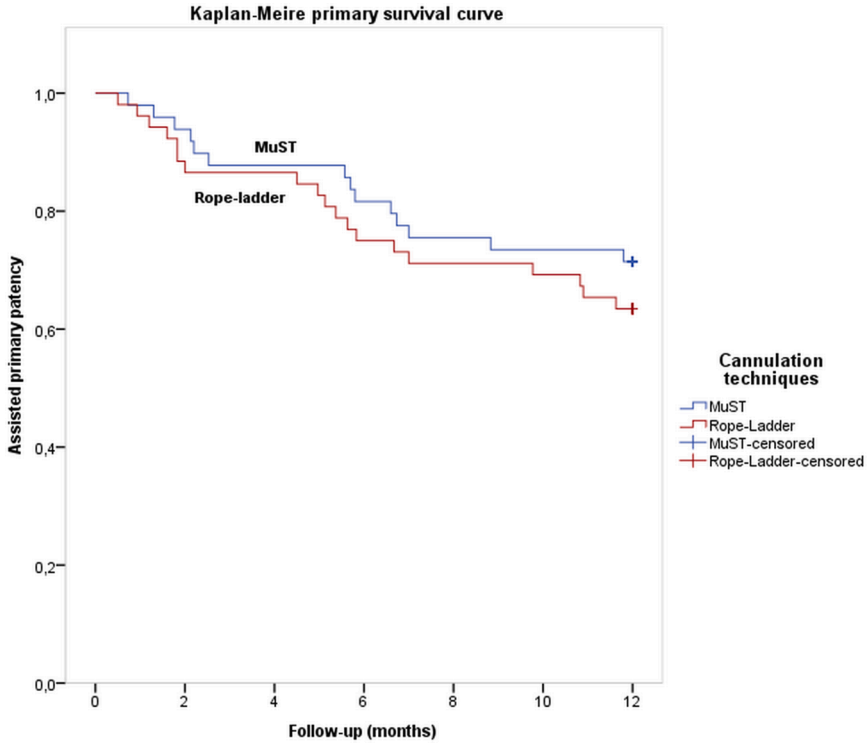

Figure 4. Arteriovenous fistula assisted patency curve comparing the 2 groups of cannulation techniques. MuST, multiple single cannulation technique.

A high rate of aneurysms was observed among the selected patients (n = 71, 70.3%); 17 continued to progress and 4 patients developed new aneurysms. A higher rate of both pre-existing and newly developed aneurysms was associated with RL group (Table 4).

In a 53-year-old male patient, remodeling of the fistula vessel was observed, along with regression of the existing aneurysm. All AVF patency indicators and treatment efficacy outcomes remained stable compared with the beginning of the study (Fig 5).

An increased time to develop hemostasis was observed in 5 patients in the MuST group. Among these, 2 patients were diagnosed with stenosis in the cephalic arch, and 1 patient exhibited stenosis between cannulation sites. Only 1 patient dropped out of the study due to angioplasty recurrence. Remarkably, all patients in this group had a hypertensive etiology.

MuST was associated with peri-needle bleeding in 5 patients; however, other factors were also associated with this complication, such as AVF and HD vintage and higher Qa than the other patients (Table S1).

The presence of scabs at cannulation sites was observed in 38.8% of the patients after 3 months of using MuST and in 48.9% at 12 months (Table S2). The cannulation sites were easily identifiable at 3 months in 77.6% of patients, and in only 1 patient, the cannulation site was not identifiable at 6 months.

In both groups, no local inflammatory infectious signs or bacteremia were identified.

The mean ± standard deviation pain perception score at the end of the study was 3.67 ± 1.59 in the MuST group and 3.52 ± 2.05 in the RL group. Pain scores decreased over the course of the study in both groups. Although the reduction in the MuST group approached significance (t_{35} = 1.93, P = 0.06), it did not meet the conventional threshold. No significant change was observed in the RL group (t_{32} = 1.04; P = 0.31) (Table S3). Similarly, no significant difference between groups was observed at the end of the study (P = 0.73). Nonetheless, it is important to note that 2 patients discontinued the RL technique due to cannulation-related pain.

No significant differences were detected in single-pool Kt/V or substitution volume from the beginning to the end of the study (P > 0.05).

Table 4. Frequency of Secondary Outcomes Between the 2 Groups

Secondary Outcomes	MuST (n = 49)	Rope-Ladder (n = 52)
Hematomas/infiltrations	7 (14.3%)	8 (15.4%)
Development of previous aneurysms	5 (10.2%)	12 (23.1%)
New aneurysms	0 (0%)	4 (7.7%)
Time to hemostasis >10 min	5 (10.2%)	1 (1.9%)
Peri-needle bleeding	5 (10.2%)	0 (0%)
Local signs of infection	0 (0%)	0 (0%)
Bacteremia	0 (0%)	0 (0%)

Note: Data are reported as n (%).
Abbreviation: MuST, multiple single cannulation technique.

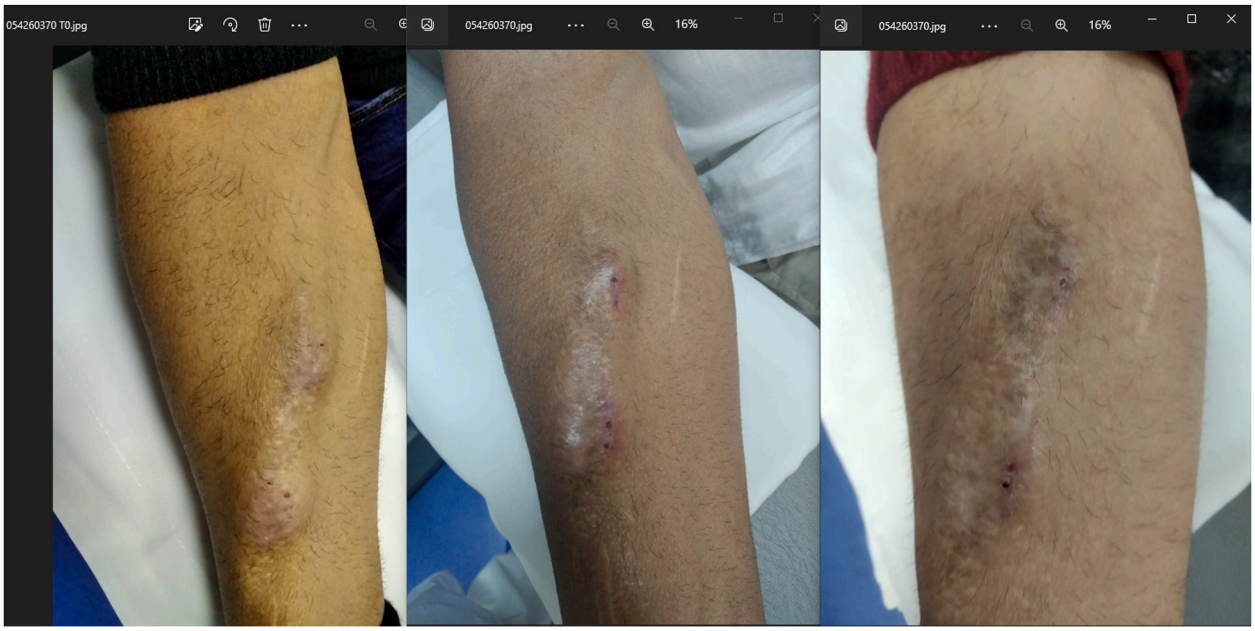

Figure 5. Patient using standard cannulation technique, then switched to the multiple single cannulation technique (MuST). At the end of 12 months, regression of previously existing aneurysm was observed.

DISCUSSION

The study results showed no significant differences between the 2 groups in demographic variables, which minimized the risk of bias in patients with previously used AVF. The majority of participants were older, reflecting the aging population commonly among HD patients. This trend is consistent with findings across many European countries, where treatment of end-stage renal disease is frequently administered to individuals aged 75 years and older.[17] Unassisted patency at 12 months in the MuST group was higher than that reported in the MuST I study,[9] in which the survival rates were 76.3%, 59.6%, and 76.8% in the MuST, BH, and RL groups, respectively. The results of this study also compare favorably with those from other studies,[18,19] in which the 12-month unassisted patency rates were 57.0% and 62.0%. Although no significant difference was observed between MuST and RL in the current analysis, the consistently better outcomes observed in MuST may suggest a potential clinical benefit that warrants further research. The main causes of referral to the Vascular Access Center were changes in the AVF as identified by physical examination, increased hemostasis time related to stenoses, and thrombosis.

Thrombosis is the most common cause of AVF failure, and in 75% of cases, it is associated with critical stenosis.[20] In this study, 3 AVF thromboses occurred; however, the incidence appears to be low compared to a systematic review[21] that showed a median of 0.24 events per 1,000 days/patient. The aging of the HD population is a recognized predictor of AVF failure.[22] However, the low incidence of thrombosis in our study may be associated with the implementation of surveillance and assessment protocols for AVF dysfunction, along with early referral to Vascular Access Center . Another factor that may have positively influenced our results is related to the exclusion criteria for patients with new AVFs or those with >3 revisions.

Assisted patency over the 12-month follow-up was slightly higher in the MuST group. Although this suggests a favorable trend, no significant differences were observed between the 2 groups.

A very low hematoma rate was observed in our study than in another study,[23] which reported 19 hematomas associated with BH, 7 during tunnel creation, and 27 in RL, over a 6 month follow-up period. Other studies have also concluded that hematoma formation and infiltration are reduced in patients using BH,[4,15] likely due to the presence of the tunnel and the use of blunt needles. In this study, some patients continued to develop aneurysms, and new aneurysms associated with RL were observed. This dysfunction may also be related to other factors such as individual disposition, intra-access blood pressure, or Qa.[24] In contrast, tissue remodeling with regression of an aneurysm was observed in the MuST group. This unexpected finding suggests a potential advantage of MuST over RL in the development and formation of new aneurysms.

Prolonged time to hemostasis was identified as a complication associated with MuST, typically emerging within the first months of the study period. However, this event appears to be related to stenosis in the draining vein[20,25] and elevated intra-access pressure due to arterial hypertension in these patients, rather than being attributed to tissue fragility and repeated punctures in the same places.

Peri-needle bleeding occurred in the MuST group in patients with previous aneurysms and other factors already reported, which may have contributed to the occurrence of this event. The fact that MuST cannulates at exactly the same point

leads to the formation of fibrotic tissue, which can lead to loss of tissue elasticity with poor adjustment to the needle diameter and probably bleeding. The cannulation points were modified, thereby overcoming the limitation. Peri-needle bleeding was also reported in a previous study,[23] appearing in 11 episodes in BH and 17 associated with the traditional cannulation method. We have noticed that in most patients, the identification of the cannulation sites was possible after the second month, which facilitated the application of this cannulation technique. The absence of infections may be related to the disinfection procedures implemented before cannulation, patient adherence, and the widely used sets of sterile items. On the other hand, the 12-month follow-up may be a limitation, given the average time for infections to appear is between 11 months and 3 years.[8,19]

Pain perception decreased more significantly in the MuST group, and no patients discontinued the treatment due to pain. However, the study did not support significant differences in pain perception between MuST and RL. Cannulation pain remains the most common discomfort reported by patients when undergoing puncture with the RL method using beveled needles.[26]

The sample size was smaller than expected due to limitations in the selection of patients during the SARS-CoV-2 pandemic phase, which may have influenced the release of other conclusions related to the reduced number of events.

In conclusion, this study did not provide evidence to support significant differences in AVF survival between the MuST and RL techniques. Similarly, no significant differences were observed in complication rate or pain perception. However, the findings suggest a possible advantage of MuST regarding the development and formation of new aneurysms, which may indicate enhanced safety in nursing care delivery. Given the patient population vulnerability, any small improvements can be meaningful. Patient-centered care, combined with support, comfort, and trust during critical moments, has the potential to positively influence outcomes.

SUPPLEMENTARY MATERIAL

Supplementary File (PDF)

Table S1. Factors that may be associates with peri-needle bleeding at MuST.

Table S2. Presence of scab and easily identifiable of the cannulation site in MuST.

Table S3. Pain intensity between the two cannulation techniques.

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