De Novo Central Vein Stenosis in Hemodialysis Patients Following Initial Tunneled Central Vein Catheter Placement

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Key Points

- The overall incidence of de novo significant central vein stenosis was 13% in hemodialysis patients after their first tunneled catheter.
- The likelihood of central venous stenosis (CVS) was substantially greater in patients with at least 6 months of central venous catheter (CVC) dependence.
- Our study did not observe a significant association of central venous stenosis with the location of initial tunneled central venous catheter.

Abstract

Background Central vein stenosis (CVS) is a common complication in hemodialysis patients following tunneled central venous catheter (CVC) insertion. Little is known about its incidence, association with patient characteristics, or relationship with duration of CVC placement. We systematically evaluated central vein stenosis in hemodialysis patients receiving their first CVC exchange at a large medical center.

Methods All new hemodialysis patients underwent an ultrasound before their internal jugular tunneled CVC placement, to exclude venous stenosis or thrombosis. After the initial CVC insertion, if the patients were referred for CVC exchange due to dysfunction, a catheterogram/venogram was performed to assess for hemodynamically significant (>50%) central vein stenosis. During a 5-year period (January 2016 to January 2021), we quantified the incidence of CVS in patients undergoing CVC exchange. We also evaluated the association of central vein stenosis with patient demographics, comorbidities, and duration of CVC dependence before exchange.

Results During the study period, 273 patients underwent exchange of a tunneled internal jugular vein CVC preceded by a catheterogram/venogram. Hemodynamically significant CVS was observed in 36 patients (13%). CVS was not associated with patient age, sex, race, diabetes, hypertension, coronary artery disease, peripheral artery disease, or CVC laterality. However, the frequency of CVS was associated with the duration of CVC dependence (26% versus 11% for CVC duration >6 versus <6 months: odds ratio (95% CI), 3.17 (1.45 to 6.97), P=0.003).

Conclusions Among incident hemodialysis patients receiving their first tunneled internal jugular CVC exchange, the overall incidence of de novo hemodynamically significant central vein stenosis was 13%. The likelihood of CVS was substantially greater in patients with at least 6 months of CVC dependence.

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immediate vascular access for dialysis, they are associated with several complications, including infection, thrombosis, and central vein stenosis (CVS) (4–8).

CVS is a common complication in hemodialysis patients following tunneled CVC insertion. It is associated with a lower rate of successful AVF maturation and a delayed time to AVF maturation (9). Relatively little is known about the incidence of CVS, its association with patient characteristics, or its relationship with duration of CVC dependence. The aim of the current study was to evaluate the incidence of CVS after the first tunneled dialysis catheter insertion and its associated risk factors.

Materials and Methods
Study design, data collection, and participants
All patients initiating maintenance hemodialysis at a large academic medical center, without a mature AVF or graft, underwent insertion of a tunneled internal jugular vein CVC, placed by an interventional radiologist or nephrologist under ultrasound and fluoroscopy guidance. As part of the University of Alabama at Birmingham (UAB) protocol, all patients underwent a preliminary ultrasound of the target vein to document its patency and absence of significant stenosis. Moreover, if there was any clinical suspicion of a more proximal venous stenosis raised by difficulty in advancing the guidewire, a venogram was performed to assess the patency of those veins.

If the CVC subsequently developed a persistent dysfunction that precluded adequate delivery of dialysis despite instillation of tissue plasminogen activator, the patient was referred for an exchange of the tunneled catheter for a new one over a guidewire. A catheterogram/venogram was performed routinely before the CVC exchange to assess for the presence of hemodynamically significant (>50%) CVS (Figure 1). In brief, after removal of the sutures securing the catheter to the skin, the catheter was withdrawn to the level of the internal jugular vein insertion. A contrast bolus of 20 ml was instilled through the catheter to obtain a venogram while the patient was holding their breath. If a CVS was visualized, the catheter was exchanged with a sheath, to permit introducing the angioplasty balloon. A follow-up venogram was performed to confirm resolution of the stenosis after the angioplasty.

Two full-time access coordinators scheduled all vascular access procedures performed by the surgeons, radiologists, and nephrologists, and maintained a prospective, computerized database of these procedures (10). We extracted from this database the subset of patients undergoing their first tunneled CVC placement over a 5-year period (January 2016 to January 2021). We then queried the database to identify the subset of patients who underwent a subsequent exchange of their initial CVC. Our Institutional Review Board approved retrospective review of the electronic medical records for research and provided a waiver of informed consent. In addition, each patient’s electronic medical record was reviewed to extract demographic and clinical information.

The goal of the current study was to quantify the proportion of patients with de novo CVS observed during their first CVC exchange, and to determine its association with clinical characteristics.

Statistical Analyses
We ascertained the proportion of patients with hemodynamically significant CVS detected during their first CVC exchange. We then compared the demographic, clinical, and vascular properties of patients with and without de novo CVS. Baseline features of the patients were compared by chi-squared test for categorical variables and by t tests for continuous variables. P < 0.05 was considered statistically significant. Statistical analysis was performed with SAS Statistics for Windows, version 9.4.

Results
During the 5-year study period, 1289 tunneled hemodialysis catheters were placed. Of this total, we identified 273 incident hemodialysis patients who underwent insertion of an initial tunneled CVC insertion followed by a subsequent CVC exchange. Of these 273 patients, 36 (or 13%) were found to have hemodynamically significant CVS observed at the time of the first CVC exchange. The presence of de novo CVS was not associated with patient age, sex, race, diabetes, hypertension, coronary artery disease, or peripheral artery disease (Table 1). The tunneled CVC was placed

Figure 1. | A case of central vein stenosis during tunneled catheter exchange. (A) Left tunneled internal jugular hemodialysis catheter in a 42-year-old female, which has poor flows despite appropriate positioning in the right atrium. (B) Catheterogram during CVC exchange showing complete occlusion at the level of the left brachiocephalic vein confluence with mediastinal collaterals. (C) Angioplasty of the brachiocephalic vein stenosis using a 12-mm-diameter balloon. (D) Venogram showing interval resolution of the stenosis and decompression of the collaterals. CVC, central venous catheter.
Discussion

CVS is a common complication in hemodialysis patients following tunneled CVC insertion, but its pathogenesis remains poorly understood. Several factors may potentially contribute to its development, including repetitive trauma related to catheter movement against the vein wall, as well as thrombosis and inflammatory changes secondary to a foreign body reaction (11–13). Several prior studies have identified younger age, presence of a cardiac rhythm device, previous history of an AVF or graft, and greater number of catheter exchanges as risk factors for CVS (9,14,15).

The frequency of CVS varies substantially among published studies (15,16). Similar to the present study, the prevalence of CVS in the range of 9%–12% has been reported in patients with high-flow AVFs in the absence of a prior CVC (16–18). However, a higher frequency of CVS was reported (27%–51%) in association with dysfunctional fistulas or grafts and prior catheterization of the left internal jugular vein or the subclavian vein (14,17–19).

A notable finding in the current study is the strong association of CVS with the duration of tunneled CVC dependence. This finding highlights the importance of timely access planning to shorten the duration of tunneled CVC exposure. In contrast to some studies, our study did not observe a significant association of CVS with the location of the CVC. This discrepancy may be a reflection of the relatively small number of CVCs placed in the left internal jugular vein in the current study, precluding the showing of a statistically significant difference.

Our study has several strengths. First, unlike many previous studies, we focused on patients undergoing insertion of their first tunneled CVC. Second, we were able to document de novo CVS related to tunneled CVC in patients with no previous vascular access or CVC exposure, as documented by central vein imaging (catheterogram/venogram) performed with full-strength contrast using digital subtraction angiography. Third, we used a multidisciplinary approach designed to standardize our processes of care for CVC placement and dysfunction. Fourth, we relied on a small number of highly experienced interventional nephrologists and radiologists. Finally, the use of a prospective, computerized database ensured capture of all patients fulfilling the enrollment criteria.

### Table 1. Comparison of patients with or without central vein stenosis at the time of tunneled dialysis catheter exchange (n=273)

| Variables                      | Absence of Central Vein Stenosis (n=237) | Presence of Central Vein Stenosis (n=36) | P Value |
|-------------------------------|------------------------------------------|------------------------------------------|---------|
| Age, yr                       | 59±14                                    | 55±17                                    | 0.15    |
| Gender, n (%)                 |                                          |                                          |         |
| Female                        | 119 (50)                                 | 20 (56)                                  | 0.55    |
| Male                          | 118 (50)                                 | 16 (44)                                  |         |
| Race, n (%)                   |                                          |                                          |         |
| Non-Hispanic White            | 38 (16)                                  | 8 (22)                                   | 0.17    |
| Black                         | 178 (76)                                 | 28 (78)                                  |         |
| Othera                        | 19 (8)                                   | 0 (0)                                    |         |
| Comorbidities, n (%)          |                                          |                                          |         |
| DM                            | 131 (55)                                 | 18 (50)                                  | 0.55    |
| HTN                           | 230 (97)                                 | 35 (97)                                  | 0.95    |
| PVD                           | 29 (8)                                   | 2 (6)                                    | 0.61    |
| CAD                           | 51 (22)                                  | 7 (19)                                   | 0.77    |
| Site of tunneled catheter, n (%)|                                         |                                          |         |
| Right IJ                      | 187 (79)                                 | 29 (81)                                  | 0.82    |
| Left IJ                       | 50 (21)                                  | 7 (19)                                   |         |

None of the patients had a history of a percutaneously inserted central catheter, central line, port, or cardiac device inserted ipsilateral to the dialysis CVC. DM, diabetes; HTN, hypertension; PVD, peripheral vascular disease; CAD, coronary artery disease; IJ internal jugular.

*Other includes Asian (12 patients) and Hispanic (seven patients).
Our study also has some limitations. First, the patients were derived from a single large dialysis center, and the results may not generalize to some dialysis centers. Second, a venogram was obtained only in those patients undergoing CVC exchange. Thus, it is possible that we have underestimated the incidence of de novo CVS among patients with CVC dependence. It is also possible that some of the patients had a preexisting CVS that antedated insertion of the initial CVC. However, this seems unlikely, given that none of the study patients had a prior device or catheter placed ipsilateral to the dialysis CVC, as well as the standardized evaluation process of the central veins before placement of the initial CVC. Finally, some of the catheter dysfunctions may have been due to a fibrin sheath, rather than CVS. Unfortunately, the presence of fibrin sheaths was not routinely addressed in the procedure notes, so we are unable to quantify this possibility in our retrospective study.

Among incident hemodialysis patients receiving their first tunneled internal jugular CVC, the overall incidence of hemodynamically significant CVS was 13%. The likelihood of CVS was substantially higher among patients with greater than 6 months of CVC dependence. Efforts to establish a permanent vascular access in a timely fashion in order to decrease the duration of CVC exposure may decrease the incidence of CVS.

Disclosures
M. Allon has a consultancy agreement with CorMedix and is a member of the Kidney360 Editorial Board as Editor-in-Chief. R. Varma has been a speaker for Becton, Dickinson and Company. The remaining authors have nothing to disclose.

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Author Contributions
Ammar Almehmi conceptualized the study; Rakesh Varma was responsible for data curation; Hassan Al-Balas was responsible for formal analysis; Alian Al-Balas, Hassan Al-Balas, and Rakesh Varma were responsible for methodology; Alian Al-Balas was responsible for investigation and wrote the original draft; Michael Allon was responsible for funding acquisition, resources and validation; Michael Allon, Hassan Al-Balas, Ammar Almehmi, and Rakesh Varma reviewed and edited the manuscript.

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