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Prevalence of Central Venous Stenosis among Black and White ESKD Patients with Dysfunctional Dialysis Access

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Abstract

In the United States, significant racial and ethnic disparities exist in chronic kidney disease (CKD) and its management. Hemodialysis constitutes the main stay of renal replacement therapy for end-stage kidney disease (ESKD), which is initiated using central venous catheters (CVC) in most CKD patients in the United States. Black ESKD patients have higher usage and greater time on CVC for hemodialysis compared to White patients. This trend places Black patients at a potentially higher risk for CVC-related complications such as central venous stenosis (CVS). We posited that Black patients would have a higher prevalence and a greater risk of CVS. A retrospective review was performed of ESKD patients who underwent a fistulogram for dialysis access malfunction. CVS was defined as > 50% stenosis in the central veins. Fistulograms of 428 ESKD patients were adjudicated, and CVS was noted in 167 of these patients. Of the entire cohort, 370 fistulograms belonged to self-reported unique Black and White ESKD patients, of whom 137 patients were noted to have CVS. There was no difference in the of CVS between Black (40%) and White (41%) ESKD patients. However, a higher severity of stenosis (>70%) (P

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= 0.03) was noted in White ESKD patients. An unadjusted model showed a significant association between CVS and cardiovascular disease and the use of CVCs. The risk-adjusted model showed a significant association between diabetes and CVS. Unlike arterial stenotic lesions, this work for the first time demonstrated higher prevalence of severe venous stenotic lesions in White ESKD patients and linked diabetes to stenotic venous disease. This work paves the way for future studies investigating the risk and influence of race and ethnicity on CVS using a larger and diverse data set.

Keywords

CKD; ESKD; hemodialysis; central venous stenosis

INTRODUCTION

Chronic kidney disease (CKD) is a major public health burden and shows an upward trend in prevalence in the United States (*Centers for Disease Control and Prevention. Chronic Kidney Disease in the United States, 2019. Atlanta, GA* 2019; Hill et al., 2016). A disproportionate burden of CKD and end stage kidney disease (ESKD) is observed in racial and ethnic minority populations (*Centers for Disease Control and Prevention. Chronic Kidney Disease in the United States, 2019. Atlanta, GA* 2019). A wealth of studies has clearly demonstrated the Black patients have a higher risk of developing CKD and ESKD (Chu et al., 2021; Hill et al., 2016). Black and Hispanic CKD patients demonstrate a rapid deterioration of renal function by several-fold compared to White patients (Chu et al., 2021). Vascular access is the lifeline of patients with ESKD on hemodialysis and represents a great clinical and economic burden (Saran et al., 2018; Steinman, 2000). Of all the types of vascular accesses, central venous catheters (CVC) are considered an inferior option compared to arteriovenous fistula (AVF), due to greater risk for hospitalization, infectious complications, and mortality associated with CVCs (Al-Balas et al., 2017; Lacson et al., 2009; Solid & Carlin, 2012; Toomay et al., 2016). Despite the Fistula First Breakthrough Initiative in 2005 that improved the prevalence of AVF in ESKD patients in the United States, the prolonged use of CVC for hemodialysis has not decreased (Saran et al., 2018). In the United States in 2015, 80% of incident hemodialysis patients used CVC, which persisted in 68.4% of patients beyond 90 days (Saran et al., 2018). A recent study in 74,194 incident hemodialysis patients on Medicare noted that the mean time on CVC was 220.1 days (Arya et al., 2020).

Racial disparities are observed in several aspects of CVC use. Analysis of 396,075 ESKD patients from the USRDS from 2006 to 2010 showed more White patients with CKD initiated hemodialysis with an AVF than Black CKD patients (Zarkowsky et al., 2015). This difference persisted even after adjusting for age, coronary artery disease, pulmonary disease and other comorbidities or insurance status. This study along with several others (Crews et al., 2013; Harding et al., 2017) indicate greater use of CVC in Black ESKD patients. A recent study showed that compared with Whites, Black ESKD patients spent significantly more days on CVC (Arya et al., 2020). Taken together, these studies suggested higher

exposure of Black ESKD patients to CVC, which can potentially place them at a greater risk of complications related to CVC.

Protracted exposure of CVCs against fragile venous wall results in stenosis of the central veins such as subclavian, brachiocephalic, internal jugular veins and superior vena cava (Adwaney et al., 2019; Agarwal, 2013; Agarwal et al., 2017; Agarwal et al., 2007; Koh et al., 2017; Taal et al., 2004; Toomay et al., 2016). The resultant condition called central venous stenosis (CVS) is a serious complication and can present with a myriad of sequelae primarily stemming from an increase in the venous pressure and decrease in the blood flow from the dialysis access, including arm pain, swelling, and even facial edema or superior vena cava syndrome (Adwaney et al., 2019; Agarwal, 2013; Agarwal et al., 2017; Agarwal et al., 2007; Koh et al., 2017; Taal et al., 2004; Toomay et al., 2016). Reduced blood flow lowers the hemodialysis clearance, increases the risk of prolonged bleeding, and enhances the risk of pseudoaneurysms at the arteriovenous fistula (AVF) or arteriovenous graft (AVG). CVS has the potential to compromise prospects of ever using an arm for an AVF or AVG. In addition to the above morbidity, as a consequence of CVS, ESKD patients need to undergo frequent imaging and interventional procedures adding to the enormous cost of maintaining functional vascular accesses, which has crossed over a billion dollars annually (Steinman, 2000).

CVC is a strong risk factor for CVS. CVS can be asymptomatic (incidental) or symptomatic CVS (Adwaney et al., 2019; Agarwal, 2013; Agarwal et al., 2017; Agarwal et al., 2007; Koh et al., 2017; Taal et al., 2004; Toomay et al., 2016). For example, studies have shown 10–42% prevalence of venous stenotic lesions of different extent in patients undergoing venous mapping or prior to percutaneous tunneled right internal jugular catheters insertion(Taal et al., 2004; Tedla et al., 2018). This prevalence doubled in patients with a history of tunneled internal jugular catheters (Taal et al., 2004). The influence of prior CVCs on CVS was noted in a UK cohort consisting of 2811 ESKD patients (Adwaney et al., 2019). The risk for CVS was 2-fold higher in patients with previous CVCs. In the past, subclavian dialysis catheter usage was common, which was associated with higher prevalence of CVS (Schwab et al., 1988). However, despite avoidance of the subclavian vein for dialysis catheters, CVS remains an important clinical problem affecting approximately one fifth to one-half of hemodialysis patients (Agarwal, 2013; Agarwal et al., 2017; Agarwal et al., 2007; Hernandez et al., 1998; Kovalik et al., 1994; Krishna et al., 2016; MacRae et al., 2005; Shi et al., 2016; Tonelli et al., 2001; Toomay et al., 2016; Trerotola et al., 2015) and has prevalence ranging from 4.3% to 41% depending on the study design (Adwaney et al., 2019; Guo et al., 2017; Lazarides et al., 2007; MacRae et al., 2005). Of the many implicated factors, including cardiac devices (pacemakers), and peripherally inserted central catheters, the highest risk of CVS has been associated with CVC (Adwaney et al., 2019; Guo et al., 2017; Lazarides et al., 2007; MacRae et al., 2005).

Despite the clinical consequences of CVS, none of the previous studies examined the influence of race on CVS. This question is important from both a clinical and a public health perspective considering the evidence that Black patients with ESKD are more likely to have CVC and for a longer time (Arya et al., 2020) thereby placing them at a higher risk of

development of CVS. Therefore, we set out to examine racial disparity in CVS in a cohort of ESKD patients.

METHODS

This study was retrospective in nature involving all the patients with ESKD who presented for a fistulogram for dysfunctional dialysis access at the Boston University Medical Center (BMC) between January 2015 and December 2017. The study was conducted after obtaining approval from the Institutional Review Board of Boston University School of Medicine (H-26367).

BMC is a safety-net hospital in Boston whose patient population is largely comprised of ethnic minorities and non-white patients. Adult ESKD patients with dialysis access malfunctions (poor blood flow, higher arterial or venous dialysis pressure, prolonged bleeding and possibility of access recirculation) are referred from the Boston and southern Massachusetts areas. Patients are referred to vascular surgery or interventional radiology service from the dialysis centers or private nephrologists because of dialysis access malfunction or failure of maturation. ESKD patients on hemodialysis with age >18 irrespective of sex, cause of ESKD and type of access (fistula or graft) or site of access, who underwent fistulogram were included in the study. Those patients who did not undergo a fistulogram were excluded from the study. At the time of fistulogram, images were obtained using iodinated contrast medium.

A list of patients who underwent fistulograms between January 2015 and December 2017 was obtained from Interventional Radiology. This time frame was selected based on availability of previous fistulogram and health records. The electronic health record (EPIC) was accessed to extract demographic information, procedural history, and list of medications such as aspirin, statins, antihypertensives, and anticoagulants. Dialysis-related information including use of dialysis catheter, number and location of catheters, type of vascular accesses- AVF or AVG were recorded. The primary outcome was CVS.

In the core laboratory, fistulograms were interrogated for the target lesion(s) identified visually as the point of greatest diameter reduction. For this analysis, the entire fistulogram study was obtained and adjudicated by a panel of board-certified interventional radiologists or trainee under supervision of interventional radiology faculties (R.V. and M.D, L.C). They were blinded to the findings in the original report. The entire fistulogram was reviewed using GE Centricity® software (Wauwatosa, Wisconsin), and various parameters of CVS – including extent of the lesions, site and length of the lesions – were noted. The severity of the stenosis was determined as the ratio between the minimal lumen diameter compared to reference vein (post-stenotic) diameter. The stenosis was determined by the ratio of luminal diameter at the point to the pre-stenotic reference. Consistent with clinical practice at BMC, the severity of CVS was graded as mild (0–50% stenosis), moderate (50–75% stenosis), severe (>75% stenosis), or completely occluded. Length of the stenotic lesion was grouped into four groups: 0–2cm, 2–4cm, 4–6cm, >6cm. The types of treatments (angioplasty and/or stent) were noted. All data were entered in the Research Electronic Data Capture (REDCap) program hosted by the Clinical and Translational Science Institute

(CTSI) of Boston University School of Medicine. REDCap (Nashville, Tennessee) is a secure, web-based application designed to support data capture for research studies.

Statistical Methods

Summary statistics were computed as mean with standard deviation or median with range for continuous variables and as the frequency with percent for discrete variables. Chi-square and student's t-tests were used to compare White and Black ESKD groups relative to discrete and continuous variables, respectively. Logistic regression was used to perform unadjusted and adjusted analyses to obtain odds ratios and confidence intervals quantifying associations between demographic and medical factors and CVS. CVS was analyzed and reported in the tables (Tables 3–5) as a binary variable irrespective of number of fistulograms and lesions. Univariable logistic regression was used to identify the variables associated with CVS in self-reported Black and White ESKD patients. Variables with a p-value of <0.20 were added to a multivariable logistic regression model and variables were removed until all remaining variables, except for race, had a p-value of <0.10. Analyses were performed using SAS v9.4.

RESULTS

Baseline Characteristics

A total of 428 unique ESKD patients underwent elective fistulograms between 2015–2017. The baseline characteristics of the study population are summarized in Table 1. The mean (± SD) age of the study population was 60.9 ± 13.1 years, 60% of the subjects were male and 71% were black. Diabetes mellitus, hypertension and autoimmune diseases were the causes of ESKD in 49%, 27% and 10% of patients, respectively. Comorbidities included hypertension (94%), diabetes mellitus (62%), congestive heart failure (CHF) (38%), coronary artery disease (CAD) (26%), peripheral artery disease (16%) and stroke (14%). Viral infections (HIV, Hepatitis C) were noted in 18% of patients, while venous thromboembolism was noted in 8% of patients. As shown in Table 1, patients were on either anti-platelet or anticoagulation agents for various reasons including atrial fibrillation. Patients on aspirin accounted for 55% of the study population, while warfarin was used in 13% of ESKD patients. Other oral anticoagulants were used in <1% of patients. Most patients had a history of CVC use (76%) while the duration of exposure to the CVC ranged between 7 and 842 days. A vast majority of study subjects (88.5%) had an AVF as their hemodialysis access at the time of fistulogram.

Central Venous Stenosis

In our cohort, CVS was noted in 167 patients (39%) (Figure 1A) and involved predominantly the left side. The subclavian and brachiocephalic vein involvements were reported in 38% and 24%, respectively. The right brachiocephalic vein (23%) was less frequently involved. Less than 2% of patients had superior vena cava stenosis (Figure 1). The majority of patients had a stenosis of 71–80% (31% of patients with CVS) and 50–70% (25% of patients with CVS), while 11% of patients had a complete occlusion (Figure 1B).

Comparison of Black and White ESKD patients

Of the full cohort, 370 patients consisted of self-reported Black (305) and White (65) patients with ESKD. There was a trend toward male predominance in both the White and Black patients with ESKD (Table 2). Other than diabetes (p = 0.05) and hypertension (p = 0.05), both Black and White patients with ESKD had similar comorbidities including CAD, chronic obstructive pulmonary disease (COPD) and peripheral artery disease. The causes of CKD were comparable between both groups. The number of all catheters (dialysis CVC – tunneled and non-tunneled Quinton catheters and triple lumen catheters) did not differ between two groups, nor did the duration of dialysis via CVC. Of these 370 patients, 137 patients were detected to have CVS. There was no difference in the incidence of CVS between Black (40%) and White (41%) ESKD patients (P =0.90). Interestingly, significantly higher severe stenotic lesions (>75%) were noted in White patients with ESKD in left brachiocephalic vein (P = 0.02) and in superior vena cava (P = 0.03). Close to 60% of patients were on antithrombotic or antiplatelet medications (Table 3).

Association of CVS

Initially, unadjusted analyses were conducted on Black and White patients only. As shown in Table 4, age is significantly associated with CVS (OR = 1.02, 95% CI: 1.00–1.04, p-value = 0.019). Diabetes is also associated with CVS with an odds ratio of 1.59 (95% CI: 1.01–2.49, p-value = 0.045) when comparing patients with diabetes to patients without diabetes. Intriguingly, history of GI bleeding was also associated with CVS (OR = 3.25 with 95% CI, 1.47 to 6.18; p-value = 0.0036).

The multivariable model for the association between race and CVS also adjusts for sex, age, diabetes, GI bleed, and history of renal transplant (Table 5). After adjusting for these parameters, there was no significant association of race with the development of CVS [OR 0.81, 95% CI 0.45 – 1.48, p = 0.50] (Table 4). When reducing the model further so that all variables, except for race, had a p-value of <0.05, only age and GI bleeding remained in the model. This final model has an odds ratio for race of 0.94 (95% CI: 0.51–1.66, p = 0.79) when comparing Black patients to White patients. The odds ratio for age is 1.02 (95% CI: 1.00 – 1.04, p-value = 0.024) and the odds ratio for GI bleed is 3.19 (95% CI: 1.43 – 7.11, p-value = 7.106) for the risk of CVS.

DISCUSSION

This retrospective analysis of ESKD patients with CVS using adjudicated fistulograms showed that with equal exposure of CVCs, Black and White ESKD had no difference in the prevalence of CVS. Intriguingly, White ESKD patient had higher severity of CVS compared to Black patients with ESKD.

The present study addresses an important knowledge gap in the CVS field. While the previous studies had delineated various factors associated with CVS (Adwaney et al., 2019; Agarwal, 2013; Agarwal et al., 2017; Agarwal et al., 2007; Koh et al., 2017; Taal et al., 2004; Toomay et al., 2016), none examined the effect of racial disparity in CVS. Our study is timely since a recent analysis of the USRDS database indicated a significant racial

disparity in the use CVCs and their length of exposure. A greater number of Black patients with ESKD were initiated on hemodialysis through CVCs and spent approximately 40 more days on CVCs compared to White patients with ESKD (Arya et al., 2020). This difference persisted despite adjustments in sex, age and functional status etc (Arya et al., 2020). Therefore, it stands to reason that prolonged exposure to CVC in Black patients with ESKD is likely to increase the CVC-related complications, which was probed in this work.

Bias and generalizability of the findings

In contrast to a previous report (Arya et al., 2020), we did not observe increased use of CVC in Black patients with ESKD. This result may reflect the practice of a single center in contrast to the study by Arya et al., which included the USRDS database and reflected a national trend in the use of CVCs. Despite this difference, our cohort is suitable to probe the question related to racial disparities since it involved a diverse group of ESKD patients consisting predominantly of non-White patients with ESKD.

This case mix of higher Black compared to White ESKD patient is consistent with similar national and regional trend (Albertus et al., 2016; ESRD, 2017; “U.S. Renal Data System, USRDS 2013 Annual Report: Atlas of Chronic Kidney Disease and Diabetes and Digestive and Kidney Diseases, Bethesda, MD.,” 2011). Nationally, ESKD prevalence has increased between 2000 and 2020 for all race/ethnicity groups, the highest prevalence is noted in Black patients (NIDDK, 2022). The prevalence of ESRD in Black patients is 4 times higher than that of White patients with ESKD (ESRD, 2017; “U.S. Renal Data System, USRDS 2013 Annual Report: Atlas of Chronic Kidney Disease and Diabetes and Digestive and Kidney Diseases, Bethesda, MD.,” 2011). A study focusing on analyzing the prevalence of ESKD in the Southern US Community Cohort found that the rate of ESKD in Black was 285/100000 person years as compared to 79/100000 persons-years in White patients (Albertus et al., 2016). Taken together, these data suggest that ESKD case mix in this study is representative of the US ESKD patients and population from other centers. Despite this point, cautious interpretation is warranted as the current data is from a single center. Also, we acknowledge selection bias in our design. As the inclusion criteria consisted of patients undergoing a fistulogram to evaluate dialysis access dysfunction, this design did not include asymptomatic or mildly symptomatic CVS lesions.

Race as a risk factors of CVS

Racial factors are examined in the pathogenesis of atherothrombotic processes contributing to cardiovascular and peripheral arterial diseases (Arya et al., 2018; Chen et al., 2011; Mochari-Greenberger & Mosca, 2015). Also, racial factors have been implicated in dialysis access stenosis, intimal hyperplasia and fistula maturation (Lilly et al., 2012; Lok et al., 2006). Even after adjusting for other confounders between racial groups, the current study did not show any increase in the prevalence of CVS in Black patients with ESKD. This result may point to the fundamental differences in racial predilection in arterial and venous stenotic pathologies. The severity of arterial stenotic lesions such as coronary artery is lower in Black compared to White patients in the general population (Liao et al., 2001; Whittle et al., 2002). On the other hand, a study from Al Sheek et al (Alsheekh et al., 2017) noted no racial differences in the iliac vein stenosis following iliac vein stenting (Alsheekh et al.,

2017). Of note, race has been implicated as a risk factor in non-stenotic venous diseases such as deep vein thrombosis and venous thromboembolism in the general population and in specific circumstances (Addo-Tabiri et al., 2020; White & Keenan, 2009).

Racial disparities are also driven by a multitude of factors such as social and environmental conditions contributing to a clinical phenotype. The influence of these factors remain an area of active research and is captured by the comment "*the genetic research that the zip code is more important than a genetic code*" (Graham, 2016). This point underscores the notion that race is not a mere biological construct but should be evaluated comprehensively along with socioeconomic and other factors (Yudell et al., 2016).

Other Risk Factors and Mechanism of CVS

Our current analysis did include general cardiovascular factors such as hypertension, CAD, heart failure, cardiovascular disease and these were not different between White and Black patients with ESKD. In our risk-adjusted model, age and GI bleeding emerged as independent risk factors for CVS, which were not demonstrated in the previous studies. As such, gastrointestinal bleeding may reflect frequent use of central venous lines in these patients, which can contribute to CVS development. It is also likely that the conditions that predispose to a need for anticoagulation/antiplatelet therapy (atrial fibrillation, coronary artery disease or auto-immune disease, etc.) might lower the risk of CVS. On the other hand, conditions such as GI bleeding might increase the risk of CVS due to stopping anticoagulation. In our cohort, 65% of patients were on anticoagulants or antiplatelet agents and their use did not significantly increase the risk for CVS. Other factors such as HCV could be potential risk modifiers as it's been linked to vascular events/thrombosis in other populations (Wang et al., 2015). Age as a risk factor for CVS is intriguing. One possibility is that the higher age may reflect a greater likelihood of exposure to CVCs and a higher risk for CVS. Also, it is conceivable that aging may augment the processes driving venous stenosis upon exposure to CVCs. This notion is supported by the observations that injured coronary arteries following stent placement showed greater stenosis in older compared to younger patients (Eghbalieh et al., 2012; Han et al., 2015).

That White ESKD patients showed a greater number of severe stenotic lesions compared to Black ESKD patients is an intriguing observation. This result is especially important since both racial groups had comparable exposure to CVCs. This finding points to potential racial/genetic factors that influence the remodeling processes exacerbating the severity of stenotic lesions. The exact nature of such factors and signaling cascades remain elusive. Diabetes is a well-established risk factor for atherothrombotic arterial diseases (Chalakova et al., 2020; Collins et al., 2020). It is also linked to venous thromboembolism (Chung et al., 2015; Yang et al., 2015). This is the first report associating diabetes with the risk of CVS. This observation warrants examination of other general cardiovascular risk factors, such as smoking and hypercholesteremia in CVS in larger studies. All these studies underscore the need for investigating the mechanism of CVS and the effect of race of severity of stenosis.

In addition to systemic factors such as diabetes, many other factors, such as anatomy and collateral circulation status, contribute to CVS (Shi et al., 2016). Our study showed CVS predominantly on the left side, involving the subclavian and brachiocephalic veins. Others

have also noted a higher prevalence of CVS on the left subclavian and brachiocephalic veins compared to the right side (Shi et al., 2016). This increase can be ascribed due to greater angulation of left brachiocephalic vein compared to the right brachiocephalic vein resulting in more damage to the vessel wall from CVC inserted from the left internal jugular vein. Superimposed on this issue is the increase flow from the presence of ipsilateral vascular access, which will further augment turbulence at the stenotic lesion.

Limitations

Like any retrospective analysis, this study has limitations. This study is based on a single center experience and included patients with symptomatic CVS. Hispanic, Asian, American Native constituted 7%, 2% and 0.2%, respectively, in our cohort. These groups were small and hence were not included in the analysis. Lastly, self-reported race was used rather than genetic ancestry and smoking status was not available for all the patients. A future larger study with patients from different centers and diverse racial mix along with the information on other comorbidities is warranted to address these limitations.

CONCLUSIONS

In conclusion, this study demonstrates no racial predilection in the prevalence of CVS. However, race does influence the severity of CVS lesions. We anticipate these results to seed future large-scale studies probing CVS and factors influencing the prevalence and extent of CVS.

REFERENCES

Addo-Tabiri NO, Chudasama R, Vasudeva R, Leiva O, Garcia B, Ravid JD, Bunze T, Rosen L, Belghasem M, Francis J, Brophy M, Johnson B, Ferguson R, Weinberg J, & Chitalia VC (2020, Feb). Black Patients Experience Highest Rates of Cancer-associated Venous Thromboembolism. Am J Clin Oncol, 43(2), 94–100. 10.1097/COC.0000000000000639 [PubMed: 31809329]

Adwaney A, Lim C, Blakey S, Duncan N, & Ashby DR (2019, Mar 7). Central Venous Stenosis, Access Outcome and Survival in Patients undergoing Maintenance Hemodialysis. Clin J Am Soc Nephrol, 14(3), 378–384. 10.2215/CJN.07010618 [PubMed: 30765534]

Agarwal AK (2013, Jun). Central vein stenosis. Am J Kidney Dis, 61(6), 1001–1015. 10.1053/j.ajkd.2012.10.024 [PubMed: 23291234]

Agarwal AK, Khabiri H, & Haddad NJ (2017, Feb). Complications of Vascular Access: Superior Vena Cava Syndrome. Am J Kidney Dis, 69(2), 309–313. 10.1053/j.ajkd.2016.08.040 [PubMed: 27866966]

Agarwal AK, Patel BM, & Haddad NJ (2007, Jan–Feb). Central vein stenosis: a nephrologist's perspective. Semin Dial, 20(1), 53–62. 10.1111/j.1525-139X.2007.00242.x [PubMed: 17244123]

Al-Balas A, Lee T, Young CJ, Kepes JA, Barker-Finkel J, & Allon M (2017, Dec). The Clinical and Economic Effect of Vascular Access Selection in Patients Initiating Hemodialysis with a Catheter. J Am Soc Nephrol, 28(12), 3679–3687. 10.1681/ASN.2016060707 [PubMed: 28710090]

Albertus P, Morgenstern H, Robinson B, & Saran R (2016, Dec). Risk of ESRD in the United States. Am J Kidney Dis, 68(6), 862–872. 10.1053/j.ajkd.2016.05.030 [PubMed: 27578184]

Alsheekh A, Hingorani A, Ferm S, Kibrik P, Aurshina A, Marks N, & Ascher E (2017, Oct). Is there an effect of race/ethnicity on early complications of iliac vein stenting? Vascular, 25(5), 549–552. 10.1177/1708538117699335 [PubMed: 28330434]

Arya S, Binney Z, Khakharia A, Brewster LP, Goodney P, Patzer R, Hockenberry J, & Wilson PWF (2018, Jan 12). Race and Socioeconomic Status Independently Affect Risk of Major Amputation in Peripheral Artery Disease. J Am Heart Assoc, 7(2). 10.1161/JAHA.117.007425

Arya S, Melanson TA, George EL, Rothenberg KA, Kurella Tamura M, Patzer RE, & Hockenberry JM (2020, Mar). Racial and Sex Disparities in Catheter Use and Dialysis Access in the United States Medicare Population. J Am Soc Nephrol, 31(3), 625–636. 10.1681/ASN.2019030274 [PubMed: 31941721]

Centers for Disease Control and Prevention. Chronic Kidney Disease in the United States, 2019. Atlanta, GA (2019). https://www.cdc.gov/kidneydisease/pdf/2019_National-Chronic-Kidney-Disease-Fact-Sheet.pdf

Chalakova T, Yotov Y, Tzotchev K, Galcheva S, Balev B, Bocheva Y, Usheva N, & Iotova V (2020, May 10). Type 1 Diabetes Mellitus - Risk Factor for Cardiovascular Disease Morbidity and Mortality. Curr Diabetes Rev. 10.2174/1573399816666200511004205

Chen LQ, Rohatgi A, Ayers CR, Das SR, Khera A, Berry JD, McGuire DK, & de Lemos JA (2011, Dec). Race-specific associations of myeloperoxidase with atherosclerosis in a population-based sample: the Dallas Heart Study. Atherosclerosis, 219(2), 833–838. 10.1016/j.atherosclerosis.2011.08.029 [PubMed: 21917261]

Chu CD, Powe NR, McCulloch CE, Crews DC, Han Y, Bragg-Gresham JL, Saran R, Koyama A, Burrows NR, Tuot DS, Centers for Disease C, & Prevention Chronic Kidney Disease Surveillance, T. (2021, Sep 1). Trends in Chronic Kidney Disease Care in the US by Race and Ethnicity, 2012–2019. JAMA Netw Open, 4(9), e2127014. 10.1001/jamanetworkopen.2021.27014 [PubMed: 34570204]

Chung WS, Lin CL, & Kao CH (2015, Oct). Diabetes increases the risk of deep-vein thrombosis and pulmonary embolism. A population-based cohort study. Thromb Haemost, 114(4), 812–818. 10.1160/TH14-10-0868 [PubMed: 26271946]

Collins SE, Lethebe BC, Williamson T, & McAlister FA (2020, Apr). Cardiovascular risk factor control in British adults with diabetes mellitus: Retrospective cohort study. Endocrinol Diabetes Metab, 3(2), e00114. 10.1002/edm2.114 [PubMed: 32318632]

Crews DC, Pfaff T, & Powe NR (2013, Sep). Socioeconomic factors and racial disparities in kidney disease outcomes. Semin Nephrol, 33(5), 468–475. 10.1016/j.semnephrol.2013.07.008 [PubMed: 24119852]

Eghbalieh SD, Chowdhary P, Muto A, Ziegler KR, Kudo FA, Pimiento JM, Mirmehdi I, Model LS, Kondo Y, Nishibe T, & Dardik A (2012, Feb). Age-related neointimal hyperplasia is associated with monocyte infiltration after balloon angioplasty. J Gerontol A Biol Sci Med Sci, 67(2), 109–117. 10.1093/gerona/glr190 [PubMed: 22016364]

ESRD, U. S. R. D. S. M. e. f. p. w. (2017). 2017 USRDS Annual Data Report: Epidemiology of Kidney Disease in the United States, Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases. USRD, February 8.

Graham GN (2016, Oct). Why Your ZIP Code Matters More Than Your Genetic Code: Promoting Healthy Outcomes from Mother to Child. Breastfeed Med, 11, 396–397. 10.1089/bfm.2016.0113 [PubMed: 27513279]

Guo X, Shi Y, Xie H, Zhang L, Xue G, Gu L, Hao C, Yang S, & Kan K (2017, Jan 23). Left innominate vein stenosis in an asymptomatic population: a retrospective analysis of 212 cases. Eur J Med Res, 22(1), 3. 10.1186/s40001-017-0243-3 [PubMed: 28115002]

Han Z, Feng L, Du H, Sun Z, Hu S, Dai J, Sun M, Xing L, Hou J, Zhang S, & Yu B (2015, Dec). Impact of Age on Stent Strut Coverage and Neointimal Remodeling as Assessed by Optical Coherence Tomography. Medicine (Baltimore), 94(50), e2246. 10.1097/MD.0000000000002246 [PubMed: 26683940]

Harding K, Mersha TB, Webb FA, Vassalotti JA, & Nicholas SB (2017). Current State and Future Trends to Optimize the Care of African Americans with End-Stage Renal Disease. Am J Nephrol, 46(2), 156–164. 10.1159/000479479 [PubMed: 28787724]

Hernandez D, Diaz F, Rufino M, Lorenzo V, Perez T, Rodriguez A, De Bonis E, Losada M, Gonzalez-Posada JM, & Torres A (1998, Aug). Subclavian vascular access stenosis in dialysis patients: natural history and risk factors. J Am Soc Nephrol, 9(8), 1507–1510. https://www.ncbi.nlm.nih.gov/pubmed/9697674 [PubMed: 9697674]

Hill NR, Fatoba ST, Oke JL, Hirst JA, O'Callaghan CA, Lasserson DS, & Hobbs FDR (2016). Global Prevalence of Chronic Kidney Disease - A Systematic Review and Meta-Analysis. PLoS One, 11(7), e0158765–e0158765. 10.1371/journal.pone.0158765 [PubMed: 27383068]

Koh K, Koh YX, Choke ET, Wang JC, & Kian CJ (2017, Jan). Alternative Strategies for Central Venous Stenosis and Occlusion in Patients Requiring Haemodialysis Access. Ann Acad Med Singapore, 46(1), 39–41. https://www.ncbi.nlm.nih.gov/pubmed/28182818 [PubMed: 28182818]

Kovalik EC, Newman GE, Suhocki P, Knelson M, & Schwab SJ (1994, Apr). Correction of central venous stenoses: use of angioplasty and vascular Wallstents. Kidney Int, 45(4), 1177–1181. https://www.ncbi.nlm.nih.gov/pubmed/8007589 [PubMed: 8007589]

Krishna VN, Eason JB, & Allon M (2016, Nov). Central Venous Occlusion in the Hemodialysis Patient. Am J Kidney Dis, 68(5), 803–807. 10.1053/j.ajkd.2016.05.017 [PubMed: 27492146]

Lacson E Jr., Wang W, Lazarus JM, & Hakim RM (2009, Nov). Change in vascular access and mortality in maintenance hemodialysis patients. Am J Kidney Dis, 54(5), 912–921. 10.1053/j.ajkd.2009.07.008 [PubMed: 19748717]

Lazarides MK, Georgiadis GS, Antoniou GA, & Staramos DN (2007, Feb). A meta-analysis of dialysis access outcome in elderly patients. J Vasc Surg, 45(2), 420–426. 10.1016/j.jvs.2006.10.035 [PubMed: 17264030]

Liao Y, Ghali JK, Berzins L, & Cooper RS (2001, Dec). Coronary angiographic findings in African-American and white patients from a single institution. J Natl Med Assoc, 93(12), 465–474. https://www.ncbi.nlm.nih.gov/pubmed/11800275 [PubMed: 11800275]

Lilly MP, Lynch JR, Wish JB, Huff ED, Chen SC, Armistead NC, & McClellan WM (2012, Apr). Prevalence of arteriovenous fistulas in incident hemodialysis patients: correlation with patient factors that may be associated with maturation failure. Am J Kidney Dis, 59(4), 541–549. 10.1053/j.ajkd.2011.11.038 [PubMed: 22342212]

Lok CE, Allon M, Moist L, Oliver MJ, Shah H, & Zimmerman D (2006, Nov). Risk equation determining unsuccessful cannulation events and failure to maturation in arteriovenous fistulas (REDUCE FTM I). J Am Soc Nephrol, 17(11), 3204–3212. 10.1681/ASN.2006030190 [PubMed: 16988062]

MacRae JM, Ahmed A, Johnson N, Levin A, & Kiaii M (2005, Jan-Feb). Central vein stenosis: a common problem in patients on hemodialysis. ASAIO J, 51(1), 77–81. https://www.ncbi.nlm.nih.gov/pubmed/15745139 [PubMed: 15745139]

Mochari-Greenberger H, & Mosca L (2015, May). Differential Outcomes by Race and Ethnicity in Patients with Coronary Heart Disease: A Contemporary Review. Curr Cardiovasc Risk Rep, 9(5). 10.1007/s12170-015-0447-4

NIDDK U (2022). Annual Data Report: CKD and ESKD trrends. NIDDK.NIH.gov.

Saran R, Robinson B, Abbott KC, Agodoa LYC, Bhave N, Bragg-Gresham J, Balkrishnan R, Dietrich X, Eckard A, Eggers PW, Gaipov A, Gillen D, Gipson D, Hailpern SM, Hall YN, Han Y, He K, Herman W, Heung M, Hirth RA, Hutton D, Jacobsen SJ, Jin Y, Kalantar-Zadeh K, Kapke A, Kovesdy CP, Lavallee D, Leslie J, McCullough K, Modi Z, Molnar MZ, Montez-Rath M, Moradi H, Morgenstern H, Mukhopadhyay P, Nallamothu B, Nguyen DV, Norris KC, O'Hare AM, Obi Y, Park C, Pearson J, Pisoni R, Potukuchi PK, Rao P, Repeck K, Rhee CM, Schrager J, Schaubel DE, Selewski DT, Shaw SF, Shi JM, Shieu M, Sim JJ, Soohoo M, Steffick D, Streja E, Sumida K, Tamura MK, Tilea A, Tong L, Wang D, Wang M, Woodside KJ, Xin X, Yin M, You AS, Zhou H, & Shahinian V (2018, Mar). US Renal Data System 2017 Annual Data Report: Epidemiology of Kidney Disease in the United States. Am J Kidney Dis, 71(3 Suppl 1), A7. 10.1053/j.ajkd.2018.01.002 [PubMed: 29477157]

Schwab SJ, Quarles LD, Middleton JP, Cohan RH, Saeed M, & Dennis VW (1988, Jun). Hemodialysis-associated subclavian vein stenosis. Kidney Int, 33(6), 1156–1159. 10.1038/ki.1988.124 [PubMed: 2969991]

Shi Y, Zhu M, Cheng J, Zhang J, & Ni Z (2016, Feb). Venous stenosis in chronic dialysis patients with a well-functioning arteriovenous fistula. Vascular, 24(1), 25–30. 10.1177/1708538115575649 [PubMed: 25725216]

Solid CA, & Carlin C (2012). Timing of arteriovenous fistula placement and Medicare costs during dialysis initiation. Am J Nephrol, 35(6), 498–508. 10.1159/000338518 [PubMed: 22584153]

Steinman T (2000). Economc Issues in Dilaysis: Influence of Dialysis-Related Complications in the Managed-Care Era. Marcel Dekker Inc.

Taal MW, Chesterton LJ, & McIntyre CW (2004, Jun). Venography at insertion of tunnelled internal jugular vein dialysis catheters reveals significant occult stenosis. Nephrol Dial Transplant, 19(6), 1542–1545. 10.1093/ndt/gfh216 [PubMed: 15034155]

Tedla FM, Clerger G, Distant D, & Salifu M (2018, Jul 6). Prevalence of Central Vein Stenosis in Patients Referred for Vein Mapping. Clin J Am Soc Nephrol, 13(7), 1063–1068. 10.2215/CJN.14001217 [PubMed: 29739749]

Tonelli M, Jindal K, Hirsch D, Taylor S, Kane C, & Henbrey S (2001, Aug). Screening for subclinical stenosis in native vessel arteriovenous fistulae. J Am Soc Nephrol, 12(8), 1729–1733. https://www.ncbi.nlm.nih.gov/pubmed/11461946 [PubMed: 11461946]

Toomay S, Rectenwald J, & Vazquez MA (2016, May). How Can the Complications of Central Vein Catheters Be Reduced?: Central Venous Stenosis in Hemodialysis Patients. Semin Dial, 29(3), 201–203. 10.1111/sdi.12478 [PubMed: 26926841]

Trerotola SO, Kothari S, Sammarco TE, & Chittams JL (2015, Feb). Central venous stenosis is more often symptomatic in hemodialysis patients with grafts compared with fistulas. J Vasc Interv Radiol, 26(2), 240–246. 10.1016/j.jvir.2014.10.048 [PubMed: 25534637]

U.S. Renal Data System, USRDS 2013 Annual Report: Atlas of Chronic Kidney Disease and Diabetes and Digestive and Kidney Diseases, Bethesda, MD. (2011). 2(11), 326–328.

Wang CC, Chang CT, Lin CL, Lin IC, & Kao CH (2015, Sep). Hepatitis C Virus Infection Associated With an Increased Risk of Deep Vein Thrombosis: A Population-Based Cohort Study. Medicine (Baltimore), 94(38), e1585. 10.1097/MD.0000000000001585 [PubMed: 26402820]

White RH, & Keenan CR (2009). Effects of race and ethnicity on the incidence of venous thromboembolism. Thromb Res, 123 Suppl 4, S11–17. https://doi.org/S0049-3848(09)70136-7 [pii]10.1016/S0049-3848(09)70136-7 [PubMed: 19303496]

Whittle J, Conigliaro J, Good CB, Hanusa BH, & Macpherson DS (2002, Nov). Black-white differences in severity of coronary artery disease among individuals with acute coronary syndromes. J Gen Intern Med, 17(11), 867–873. 10.1046/j.1525-1497.2002.20335.x [PubMed: 12406359]

Yang G, Meng F, Liu Y, Kong L, & Shen Y (2015). Diabetes mellitus and risk of deep vein thrombosis after total knee replacement: a meta-analysis of cohort studies. Int J Clin Exp Med, 8(6), 9086–9092. https://www.ncbi.nlm.nih.gov/pubmed/26309562 [PubMed: 26309562]

Yudell M, Roberts D, DeSalle R, & Tishkoff S (2016, Feb 5). SCIENCE AND SOCIETY. Taking race out of human genetics. Science, 351(6273), 564–565. 10.1126/science.aac4951 [PubMed: 26912690]

Zarkowsky DS, Arhuidese IJ, Hicks CW, Canner JK, Qazi U, Obeid T, Schneider E, Abularrage CJ, Freischlag JA, & Malas MB (2015, Jun). Racial/Ethnic Disparities Associated With Initial Hemodialysis Access. JAMA Surg, 150(6), 529–536. 10.1001/jamasurg.2015.0287 [PubMed: 25923973]

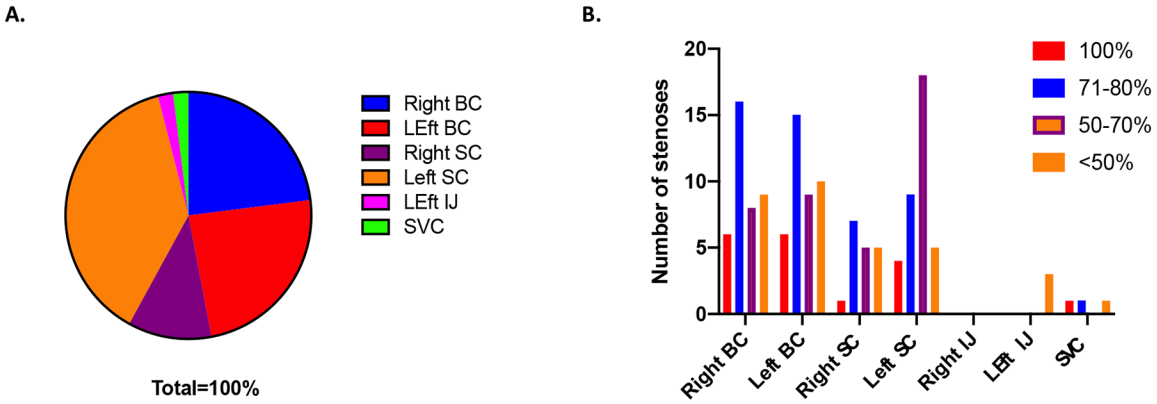

Figure 1.

(A). Central venous stenotic lesions in different central veins presented as percentages. The highest number of CVS lesions were noted in left subclavian vein. BC = brachiocephalic vein, SC= subclavian vein, IJ= internal jugular vein, SVC= Superior vena cava.

(B). Distribution of severity of stenosis in different central veins.

Table 1.

Baseline characteristics of the cohort (n = 428)

Demographics	**Variable**	**n**	**%**
Sex			
	Male	256	60
	Female	172	40
Median age			
		62 (range, 18–91)	
Race			
	White	65	15
	Black	305	71
	Hispanic	29	7
	Asian	10	2
	American Native	1	0.2
	Unknown	18	4
Comorbidities			
	Diabetes	264	62
	CAD	111	26
	COPD	40	9
	Hypertension	401	94
	GI Bleed	39	9
	Heart Failure	162	38
	PVD	68	16
	Stroke	60	14
	HIV	22	5
	Hepatitis C	55	13
	Cancer	60	14
	Autoimmune *	22	5
	Hyperlipidemia	166	39
	Renal Transplant	39	9
	Valvular Heart Disease	32	8
	Atrial Fibrillation	54	13
	DVT/PE	32	8
	Other	239	56
Cause of CKD			
	Diabetes	123	29
	Hypertension	90	21
	Lupus Nephritis	9	2
	Glomerulonephritis	4	1

Demographics	Variable	n	%
	Polycystic kidney disease	14	3
	Chronic Heart Failure	3	0.7
	Chronic Liver Disease	1	0.3
	Other [#]	136	32
	Unknown	48	11
Non-TLC central catheters			
	Porta cath	4	0.9
	PICC Line	47	11
	Pacemakers	24	6
	Other Central Catheters	2	0.5
	No Central Catheter Reported	348	81
	Tunneled CVC lines	299	70
Median duration of tunneled CVC (days)		184 (range 0 – 1210)	
Median number of tunneled CVC per patient		1 (range 0–14)	

[#]Other: Obstructive Nephropathy, AKI related CKD, Medication induced CKD

[*]Autoimmune: SLE

CVC: Central venous catheters, PICC: Peripherally inserted central catheter, CAD: coronary artery disease, COPD: Chronic obstructive pulmonary disease, HIV: human immunodeficiency virus, DVT/PE: Deep vein thrombosis/pulmonary embolism

Table 2.

Comparison between Black and White ESKD patients

Demographics		**White patients (N= 65)**		**Black patients (N= 305)**		**P value**
	Variable	**n**	**%**	**N**	**%**	
Sex						0.085
	Male	45	69.23	176	57.70	
Median age (years)						0.66
		66 (range, 18–84)		61 (range, 28–91)		
Comorbidities						
	Diabetes	32	49.23	190	62.3	0.05
	CAD	20	30.77	70	22.95	0.18
	COPD	6	9.23	31	10.16	0.81
	Hypertension	57	87.69	288	94.43	0.05
	GI Bleed	4	6.15	29	9.51	0.38
	Heart Failure	23	35.38	118	38.69	0.61
	Cardiovascular Disease	8	12.31	32	10.49	0.67
	Peripheral Arterial Disease	10	15.38	45	14.75	0.90
	Stroke	5	7.69	47	15.41	0.10
	HIV	1	1.54	20	6.56	0.11
	Hepatitis C	6	9.23	45	14.75	0.24
	Cancer	9	13.85	44	14.43	0.90
	Autoimmune *	5	7.69	14	4.59	0.30
	Hyperlipidemia	25	38.46	111	36.39	0.75
	Renal Transplant	4	6.15	29	9.51	0.38
	Valvular Heart Disease	5	7.69	20	6.56	0.74
	Atrial Fibrillation	12	18.46	35	11.48	0.12
	PE or DVT	6	9.23	22	7.38	0.61
	Other #	41	63.08	164	53.77	0.17
Cause of CKD						
	Diabetes	16	26.67	88	29.43	0.49
	Hypertension	11	18.33	66	22.07	0.40
	Lupus Nephritis	0	0	9	3.01	0.16
	Glomerulonephritis	1	1.67	3	1	0.69
	PKD	3	5	10	3.34	0.60
	Chronic Heart Failure	0	0	3	1	0.42
	Chronic Liver Disease	0	0	1	0.3	0.64
	Other ##	23	38.33	93	31.1	0.44
	Unknown	6	10	26	8.7	0.85
Central catheters						

Demographics		White patients (N= 65)		Black patients (N= 305)		P value
	Variable	**n**	**%**	**N**	**%**	
	All central catheters (non-tunneled and tunneled dialysis CVC)	46	71	224	73	0.66
	Pacemaker	5	7.69	17	5.57	0.51
Median duration of tunneled line (days)		195 (range, 0–951)		187 (range, 0–1210)		0.69
Median number of tunneled lines per patient		1 (range, 1–10)		2 (range, 1–14)		0.35
CVS						0.90
	No	34	59	166	60	
	Yes	24	41	113	40	
Location						
Right brachiocephalic vein						
	50–75% (Moderate)	1	4	5	4	0.95
	>75% (Severe)	2	8	11	10	0.83
	Occluded	2	8	3	3	0.18
Left brachiocephalic vein						
	50–75% (Moderate)	0	0	8	7	0.18
	>75% (Severe)	5	21	7	6	0.02
	Occluded	1	4	4	4	0.88
Right subclavian vein						
	50–75% (Moderate)	0	0	5	4	0.30
	>75% (Severe)	1	4	6	5	0.82
	Occluded	0	0	1	0.9	0.64
Left subclavian vein						
	50–75% (Moderate)	2	8	15	13	0.51
	>75% (Severe)	2	8	6	5	0.57
	Occluded	0	0	4	4	0.35
Superior Vena Cava						
	>75% (Severe)	1	4	0	0	0.03

*Systemic Lupus Erythematosus, Rheumatoid Arthritis, Inflammatory Bowel Disease, Psoriasis

#Benign Prostatic Hyperplasia, Obesity, Hypothyroidism, Depression

##Drug Toxicity, Renal Artery Stenosis, Obstructive Nephropathy

Table 3.

Use of antithrombotic and antiplatelet medications

Anticoagulant	n	%
None	148	35
Warfarin	55	13
Clopidogrel	44	10
Aspirin 325 mg	13	3
Aspirin 81mg	221	52
Rivaroxaban	0	0.0
Apixaban	3	0.7
Dabigatran	0	0.0

Table 4.

Univariate analysis of factors associated with CVS in Black and White ESKD patients

Variable	Odds Ratio	95% CI		p-value
Sex (female vs. male)	1.44	0.92	2.24	0.11
Race (Black vs. White)	0.96	0.54	1.71	0.90
Ethnicity (Hispanic vs. non-Hispanic)	0.49	0.19	1.28	0.15
Age (years)	1.02	1.00	1.04	0.019
Diabetes (yes vs. no)	1.59	1.01	2.49	0.045
CVD (yes vs. no)	1.32	0.85	2.07	0.22
COPD (yes vs. no)	1.00	0.48	2.10	1.00
GI Bleed (yes vs. no)	3.25	1.47	7.18	0.0036
Heart Failure (yes vs. no)	0.89	0.57	1.40	0.61
Stroke (yes vs. no)	0.91	0.49	1.70	0.77
Other Comorbidities (yes vs. no)	0.92	0.60	1.43	0.72
Viral Diseases (yes vs. no)	0.95	0.53	1.70	0.87
Cancer (yes vs. no)	1.44	0.61	2.14	0.67
Hyperlipidemia (yes vs. no)	1.26	0.81	1.98	0.31
Renal Transplant (yes vs. no)	1.63	0.78	3.42	0.20
Valvular Disease (yes vs. no)	1.01	0.42	2.44	0.98
Atrial Fibrillation (yes. vs. no)	1.04	0.54	2.02	0.91
PE or DVT (yes vs. no)	1.78	0.80	3.98	0.16
Anticoagulants (yes vs. no)	1.28	0.81	2.02	0.29
Cause of CKD (hypertension vs. diabetes)	0.98	0.53	1.83	0.96
Cause of CKD (other vs. diabetes)	0.71	0.42	1.21	0.21
History of catheter (any vs. none)	1.72	0.96	3.09	0.070
History of catheter (PICC vs. none)	1.60	0.80	3.20	0.19
History of catheter (not PICC vs. none)	2.00	0.76	5.21	0.16
Previously Tunneled Lines (yes vs. no)	1.44	0.88	2.34	0.15
Duration Tunneled Lines (days)	1.00	0.999	1.002	0.41

CVD- cardiovascular disease, GI bleed- gastrointestinal bleed, COPD- chronic obstructive pulmonary disease, PE- pulmonary embolism, DVT- deep vein thrombosis

Table 5.

Adjusted analysis for factors associated with CVS in Black and White ESKD patients.

Variable	OR	95% CI		p-value
Race (Black vs. White)	0.81	0.45	1.48	0.50
Sex (female vs. male)	1.51	0.95	2.39	0.079
Age	1.02	1.00	1.04	0.055
Diabetes (yes vs. no)	1.54	2.94	2.52	0.084
GI Bleed (yes vs. no)	3.22	1.43	7.24	0.0048
Renal transplant (yes vs. no)	2.04	0.93	4.46	0.075

GI- Gastrointestinal bleed.