Center-Effect of Incident Hemodialysis Vascular Access Use: Analysis of a Bi-national Registry

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Key Points

- This study examined patient and center factors associated with arteriovenous fistula/graft access use at hemodialysis commencement.
- Arteriovenous access use at hemodialysis commencement varied four-fold from 15% to 62% (median 39%) across centers.
- There is substantial variability in arteriovenous access use across centers.

Abstract

Background Commencing hemodialysis (HD) with an arteriovenous access is associated with superior patient outcomes compared with a catheter, but the majority of patients in Australia and New Zealand initiate HD with a central venous catheter. This study examined patient and center factors associated with arteriovenous fistula/graft access use at HD commencement.

Methods We included all adult patients starting chronic HD in Australia and New Zealand between 2004 and 2015. Access type at HD initiation was analyzed using logistic regression. Patient-level factors included sex, age, race, body mass index (BMI), smoking status, primary kidney disease, late nephrologist referral, comorbidities, and prior RRT. Center-level factors included size; transplant capability; home HD proportion; incident peritoneal dialysis (average number of patients commencing RRT with peritoneal dialysis per year); mean weekly HD hours; average blood flow; and achievement of phosphate, hemoglobin, and weekly Kt/V targets. The study included 27,123 patients from 61 centers.

Results Arteriovenous access use at HD commencement varied four-fold from 15% to 62% (median 39%) across centers. Incident arteriovenous access use was more likely in patients aged 51–72 years, males, and patients with a BMI of >25 kg/m² and polycystic kidney disease; but use was less likely in patients with a BMI of <18.5 kg/m², late nephrologist referral, diabetes mellitus, cardiovascular disease, chronic lung disease, and prior RRT. Starting HD with an arteriovenous access was less likely in centers with the highest proportion of home HD, and no center factor was associated with higher arteriovenous access use. Adjustment for center-level characteristics resulted in a 25% reduction in observed intercenter variability of arteriovenous access use at HD initiation compared with the model adjusted for only patient-level characteristics.

Conclusions This study identified several patient and center factors associated with incident HD access use, yet these factors did not fully explain the substantial variability in arteriovenous access use across centers.

doi: https://doi.org/10.34067/KID.0005742020

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Introduction
Long-lasting arteriovenous access via a fistula or graft is the preferred mode of hemodialysis (HD) vascular access (1,2). Observational studies have demonstrated that arteriovenous fistulas (AVFs) and arteriovenous grafts (AVGs) are associated with superior patency rates, fewer complications, and lower mortality rates compared with central venous catheters (CVCs) (1,3–6). Furthermore, AVF and AVG incur lower costs (7,8). Despite this evidence, incident AVF and AVG use remains variable, with incident AVF/AVG rates reported to be as high as 84% in Japan and as low as 19% in Gulf Cooperation Council countries (9,10). These large differences in vascular access use persist even after adjustment for patient mix (10).

It was hypothesized that the variability of incident AVF and AVG use involved both patient- and center-level factors. The majority of the current literature on variation in arteriovenous access use focuses on patient-level factors associated with a decreased likelihood of AVF use and includes female sex (11); comorbidities (e.g., peripheral vascular disease and diabetes) (5,12,13); and other factors, such as late presentation to the nephrology service, primary AVF failure, delayed maturation, and central vein stenosis (14,15). There is a paucity of data on AVG creation and risks associated with AVG failure. Many of these reported factors are poorly modifiable. Center-level effects may represent further opportunities for cost-effective and modifiable means to increase the proportion of patients starting HD with an arteriovenous access and for reducing the variability across centers and, potentially, countries. However, little is known about center-level factors that may affect the successful creation and use of AVFs or AVGs at initiation of HD.

The aims of this study were to examine trends in incident HD vascular access use in the Australian and New Zealand dialysis cohort between 2004 and 2015, to determine inter-center variation in incident arteriovenous access use, and to describe the patient- and center-level factors associated with incident arteriovenous access use during this period.

Materials and Methods

Study Design and Population
This study included all incident adult patients commencing HD in Australia and New Zealand between January 1, 2004 and December 31, 2015. Data were provided by the Australia and New Zealand Dialysis and Transplant (ANZDATA) Registry. Patients <18 years of age were excluded. Patients with missing outcome or covariate data and those from centers with less than a mean of ten incident patients on HD per year were excluded. The Strengthening the Reporting of Observational Studies in Epidemiology guidelines were followed (16).

Patient- and Center-Level Covariates
The patient-level characteristics examined in this study were patient sex, age at HD initiation, race, body mass index (BMI), primary kidney disease, later referral to nephrologist (defined as <3 months before initiation of RRT), smoking status (current, former, never), chronic lung disease, coronary artery disease, peripheral vascular disease, cerebrovascular disease, cardiovascular disease (defined as coronary artery disease and/or peripheral vascular disease and/or cerebrovascular disease), presence and type of diabetes mellitus, vascular access type at first HD (AVF, AVG, or CVC), presence of prior RRT (pre-emptive transplant or peritoneal dialysis), and duration of prior RRT. BMI was divided into the four categories outlined by the World Health Organization: underweight (BMI <18.5 kg/m²), normal range (BMI 18.5–24.9 kg/m²), overweight (BMI 25–29.9 kg/m²), and obese (BMI ≥30 kg/m²).

The center-level characteristics examined in this study were center size (defined by the average number of incident patients on HD per year); transplanting status (centers performing kidney transplantation); proportion of patients receiving home versus facility-based HD; incident peritoneal dialysis (average number of incident patients on peritoneal dialysis per year); proportion of patients achieving hematologic, biochemical, and dialysis clearance targets, including phosphate levels of 0.8–1.6 mmol/L, hemoglobin levels of 100–115 g/L, and single-pool Kt/V ≥1.4; and dialysis prescription indices, including average dialysis hours per week and average machine blood flow rate during dialysis treatments. All center-level characteristics were recorded on 31 December each year.

Outcomes
Patients were classified according to the access type in use at the first dialysis session (AVF, AVG, and CVC) and categorized as either starting with or without arteriovenous access (i.e., AVF or AVG versus CVC). The primary outcome was commencement of HD with arteriovenous access (AVF or AVG).

The secondary outcomes were the proportion of patients commencing HD with an AVF, AVG, or CVC over time; the variation in arteriovenous access use across centers; and the contribution of patient and center factors to the between-center variation in arteriovenous access use.

Statistical Analyses
Patient- and center-level characteristics are presented as number and percentage for categoric variables, mean with SD for normally distributed continuous variables, and median with interquartile range (IQR) for non-normally distributed continuous variables. Patients were classified according to the access type in use at the first dialysis session (i.e., arteriovenous access [AVF or AVG] versus CVC) for multivariable analyses. Multilevel logistic regression with fixed effects for patient and center factors, and random effects for patient identity and dialysis center identity, were used to identify factors associated with incident arteriovenous access use. Center-level characteristics, except transplanting center status and incident peritoneal dialysis, were divided into quartiles on the basis of the total number of study participants. The second and third quartiles were combined and served as the reference group in analyses. Variations in incident arteriovenous access use across centers was graphically assessed by plotting random center effects as odds ratios (ORs) from three models using multilevel logistic regression with fixed effects for patient and center factors and random effects for patient identity and dialysis center: an intercept-only model without covariates, a model with patient-level covariates, and the final model
with patient- and center-level covariates. The random effects represent each center’s deviation from the overall center average (i.e., reference). The random effects were obtained using a Bayesian approach (17). Percentage reduction in variation in odds for incident arteriovenous access use across centers due to patient-level characteristics was calculated as the ratio of the difference in SDs of center odds from a patient-characteristics model relative to the SD of the center odds of the unadjusted model: (SDUnadjusted−SDpatient)/SDUnadjusted×100. The percentage reduction in variation in odds for incident arteriovenous access use across centers due to center-level characteristics was calculated similarly relative to the patient-level characteristics model: (SDPatient−SDcenter)/SDpatient×100. The SDs were used as a measure of variation in the random center outcome values (log OR) from each multivariate regression model as a descriptive alternative to using the center variance component estimates (random effects) from the statistical models. A P value of <0.05 was considered statistically significant. The analysis was performed using Stata IC software (version 15.1; StataCorp, College Station, TX).

Results

Patient and Center Characteristics

Between January 1, 2004 and December 31, 2015, a total of 29,163 incident patients commenced HD in 88 centers across Australia and New Zealand. After excluding 27 small centers (1045 patients) with less than ten patients initiating HD per year and 1445 patients with incomplete data on baseline characteristics or outcomes, 27,123 incident patients on HD from 61 centers were included in the final analysis (Figure 1). Of these, 10,414 (38%) patients commenced HD with an AVF or AVG and 16,709 (62%) commenced dialysis with a CVC. Baseline patient characteristics are shown in Table 1. Most patients commenced HD at a hospital-based facility (92%), 7% of patients commenced HD in a satellite dialysis unit, and 0.7% commenced home HD. A minority of patients (16%) had previously been treated with RRT (either peritoneal dialysis or preemptive kidney transplant) for a median duration of 1.7 years (IQR, 0.7–3.5 years).

Center characteristics are displayed in Table 2. There were 61 HD centers involved, with the number of incident patients on HD each year per center ranging from ten to 124 (median, 31; IQR, 19–50). A total of 25 (41%) centers were identified as transplanting centers (i.e., where transplant surgery was performed). The median proportion of patients on home HD was 10% (IQR, 5–16%). The mean number of patients starting peritoneal dialysis at the included centers was 8.4 (IQR, 4.1–16.3). The median hours of dialysis per week was 14.1 hours (IQR, 13.4–14.7 hours), 99% (IQR 87–100) of patients achieved the target of single pool Kt/V of ≥1.4, 38% (IQR, 35–41) had a hemoglobin level within the target range (100–115 g/L), and 47% (IQR, 43–52) reached the target phosphorus range of 0.8–1.6 mmol/L. The median percentage of patients achieving a machine blood flow rate of 300 ml/min was 83% (IQR, 65–89%). On average, 10% of patients received hemodialfiltration during the study period.

Vascular Access Use Variability across Centers and Time

The proportion of patients commencing HD with an arteriovenous HD access varied from 15% to 61% across centers (median, 39%; Figure 2).

Between 2004 and 2015, the number of incident patients on HD and the proportions of patients starting dialysis with an AVF or AVG remained relatively stable, as shown in Figure 3 and Supplemental Table 1. There was a small increase in odds of starting HD with AVF or AVG over time (OR, 1.00003 per year; 95% CI, 1.000007 to 1.000054; P=0.10). This is shown in Supplemental Table 2.

Patient Factors Associated with Incident Arteriovenous Access Use

The multivariable analyses, including patient- and center-level factors to predict arteriovenous access use, are presented in Table 3. Factors associated with an increased likelihood of starting dialysis with an arteriovenous access included being aged between 51 and 72 years compared with the reference age of 18–51 (OR for age quartile 51–62 years, 1.27; 95% CI, 1.18 to 1.38; OR for age quartile 62–72 years, 1.15; 95% CI, 1.06 to 1.25), overweight and obesity (BMI of 25–29.9 kg/m², OR, 1.20; 95% CI, 1.12 to 1.29; BMI of ≥30 kg/m², OR, 1.53; 95% CI, 1.42 to 1.64), and polycystic kidney disease as primary kidney disease with diabetes as reference (OR, 2.21; 95% CI, 1.91 to 2.56). Factors associated with lower odds of incident AVF or AVG use included female sex (OR, 0.71; 95% CI, 0.67 to 0.75), Maori or Pacific

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Figure 1. Study patient and center flow diagram. HD, hemodialysis.
Islander race compared with White (OR, 0.87; 95% CI, 0.77 to 0.98), coronary artery disease (OR, 0.82; 95% CI, 0.77 to 0.87), peripheral vascular disease (OR, 0.88; 95% CI, 0.82 to 0.94), diabetes mellitus (OR, 0.83; 95% CI, 0.76 to 0.92), and chronic lung disease (OR, 0.91; 95% CI, 0.84 to 0.98). Late referral to a nephrology service (OR, 0.13; 95% CI, 0.12 to 0.14) or prior RRT (kidney transplant or peritoneal dialysis) were also predictive of lower odds of starting dialysis with

| Table 1. Patient characteristics of the study population |
| Characteristic | Descriptive Statistics |
|----------------|-----------------------|
| | All (n=27,123) | AVF (n=9881) | AVG (n=533) | CVC (n=16,709) |
| Female sex, n (%) | 10,447 (39) | 3291 (33) | 289 (54) | 6867 (41) |
| Age (yr), mean (SD) | 60.4 (15.1) | 60.6 (14.2) | 62.1 (14.6) | 60.3 (15.7) |
| Race, n (%) | | | | |
| White | 18,734 (69) | 7204 (73) | 433 (81) | 11,097 (66) |
| Asian | 2101 (8) | 725 (7) | 24 (5) | 1352 (8) |
| ATSI | 2523 (9) | 925 (9) | 31 (6) | 1567 (9) |
| Maori/Pacific Islanders | 3229 (12) | 827 (8) | 42 (8) | 2360 (14) |
| Other | 536 (2) | 200 (2) | 3 (0.6) | 333 (2) |
| BMI (kg/m²), n (%) | | | | |
| <18.5 | 839 (3) | 205 (2) | 15 (3) | 619 (4) |
| 18.5–24.9 | 8166 (30) | 2640 (27) | 158 (30) | 5638 (32) |
| 25–29.9 | 8445 (31) | 3144 (32) | 143 (27) | 5158 (31) |
| ≥30 | 9673 (36) | 3892 (39) | 217 (41) | 5564 (33) |
| Smoking status, n (%) | 3689 (14) | 1227 (12) | 63 (12) | 2399 (14) |
| Current | 11,281 (42) | 4229 (43) | 203 (38) | 6849 (41) |
| Former | 12,153 (45) | 4425 (45) | 267 (50) | 7461 (45) |
| Comorbid conditions, n (%) | | | | |
| Diabetes mellitus | 13,402 (49) | 4672 (47) | 253 (48) | 8477 (50) |
| Peripheral vascular disease | 6861 (25) | 2810 (22) | 169 (32) | 4512 (27) |
| Coronary artery disease | 11,209 (41) | 3763 (38) | 235 (44) | 7211 (43) |
| Cerebrovascular disease | 4114 (15) | 1317 (13) | 100 (19) | 2697 (16) |
| Chronic lung disease | 4851 (18) | 1550 (16) | 98 (18) | 3203 (19) |
| Primary kidney disease, n (%) | | | | |
| Diabetic nephropathy | 10,475 (39) | 3639 (37) | 194 (36) | 6642 (40) |
| GN | 5908 (22) | 2307 (23) | 81 (15) | 3520 (21) |
| Renovascular/hypertension | 3659 (14) | 1301 (13) | 85 (16) | 2273 (14) |
| Polycystic kidney disease | 1595 (6) | 932 (9) | 53 (10) | 610 (4) |
| Other | 5486 (20) | 1702 (17) | 53 (10) | 3664 (22) |
| Previous kidney replacement therapy, n (%) | 4239 (16) | 1353 (14) | 86 (16) | 2800 (17) |
| Duration of RRT (yr), median (IQR) | 1.7 (0.7–3.5) | 2.0 (0.8–3.7) | 2.3 (0.9–4.6) | 1.6 (0.6–3.3) |
| HD modality at initiation, n (%) | | | | |
| Home-based HD | 182 (0.7) | 160 (2) | 5 (0.9) | 17 (0.1) |
| Hospital-based HD | 25,024 (92) | 8447 (86) | 448 (84) | 16,129 (97) |
| Satellite-based HD | 1917 (7) | 1274 (13) | 80 (15) | 563 (3) |

AVF, arteriovenous fistula; AVG, arteriovenous graft; CVC, central venous catheter; ATSI, Aboriginal and Torres Strait Islander; BMI, body mass index; IQR, interquartile range; HD, hemodialysis.

*For patients who had RRT (pre-emptive kidney transplant or peritoneal dialysis) before HD initiation (n=4239).

Islander race compared with White (OR, 0.87; 95% CI, 0.77 to 0.98), coronary artery disease (OR, 0.82; 95% CI, 0.77 to 0.87), peripheral vascular disease (OR, 0.88; 95% CI, 0.82 to 0.94), diabetes mellitus (OR, 0.83; 95% CI, 0.76 to 0.92), and chronic lung disease (OR, 0.91; 95% CI, 0.84 to 0.98). Late referral to a nephrology service (OR, 0.13; 95% CI, 0.12 to 0.14) or prior RRT (kidney transplant or peritoneal dialysis) were also predictive of lower odds of starting dialysis with

| Table 2. Center characteristics of the study population |
| Center Characteristic (n=61) | Descriptive Statistics |
| Center size: average number of incident patients on HD per year | 31 (19–50) |
| Centers with transplantation facility | 25 (41) |
| Home hemodialysis, % of patients per center | 10 (5–16) |
| Peritoneal dialysis: average number of incident patients on PD per year | 8.4 (4.1–16.3) |
| Weekly number of HD hours | 14.1 (13.4–14.7) |
| Blood flow rate ≥300 ml/min, % of patients per center | 83 (65–89) |
| Phosphate target (0.8–1.6 mmol/L), % of patients per center | 47 (43–52) |
| Hemoglobin target (100–115 g/L), % of patients per center | 38 (35–41) |
| Weekly Kt/V target (≥1.4), % of patients per center | 99 (87–100) |

Values for categoric variables are given as number (%); values for continuous variables are given as median (interquartile range). HD, hemodialysis; PD, peritoneal dialysis.
an AVF or AVG (OR, 0.65; 95% CI, 0.60 to 0.70). The variation in odds of incident arteriovenous access use across centers increased by 8% after adjustment for patient-level characteristics (Figure 4).

Center Factors Associated with Incident Arteriovenous Access Use

The use of an AVF or AVG at dialysis initiation was not significantly associated with the size of the center; availability of a transplant service; average number of patients starting peritoneal dialysis per year; average weekly dialysis hours; or achievement of performance targets, including minimum machine blood flow rate and weekly Kt/V, phosphate, or hemoglobin levels (Table 3). Centers with a high proportion of patients on home HD (≥16%) were associated with lower odds of incident arteriovenous access use (OR, 0.70; 95% CI, 0.53 to 0.94), although the overall group P value did not reach statistical significance (P=0.06 for home HD categories).

Adjustment for these center characteristics accounted for a 25% reduction in the observed intercenter variability of arteriovenous access use at HD initiation (Figure 4).

**Discussion**

This study found that incident arteriovenous access use varied four-fold across HD centers in Australia and New Zealand, and the percentage of incident arteriovenous access did not change substantially between 2004 and 2015. Patient-level factors associated with greater arteriovenous access use included age ranging between 51 and 72 years; overweight and obesity; polycystic kidney disease as primary kidney disease; male sex; early referral to a nephrology service; no prior RRT; White race compared with Maori or Pacific Islander race; and absence of peripheral vascular disease, diabetes mellitus, and chronic lung disease. Although none of the center-level characteristics were predictive of increased arteriovenous access use, centers with the highest proportion of patients on home HD had a lower likelihood of starting patients on dialysis with an AVF or AVG. The variation of arteriovenous access use across centers was increased by 8% after adjusting for patient-level characteristics, but reduced by 25% after additional adjustment for center-level characteristics. These findings suggest that variation in arteriovenous access use across centers may be more strongly related to center-level effects.
Table 3. Multivariable logistic regression of arteriovenous access (arteriovenous fistula or graft compared with central venous catheter) use at hemodialysis initiation, adjusted for patient- and center-level characteristics

| Characteristic | OR (95% CI) | P Value |
|----------------|-------------|---------|
| **Patient characteristics (n=27,123)** | | |
| Female sex | 0.71 (0.67 to 0.75) | <0.001 |
| **Age** | | <0.001 |
| 18–51 yr | 1.00 (reference) | |
| 51–62 yr | 1.27 (1.18 to 1.38) | <0.001 |
| 62–72 yr | 1.15 (1.06 to 1.25) | 0.001 |
| >72 yr | 1.02 (0.94 to 1.12) | 0.58 |
| **Race** | | 0.14 |
| White | 1.00 (reference) | |
| Asian | 1.02 (0.92 to 1.14) | 0.72 |
| ATSI | 0.93 (0.82 to 1.06) | 0.28 |
| Maori/Pacific Islanders | 0.87 (0.77 to 0.98) | 0.02 |
| Other | 0.96 (0.79 to 1.17) | 0.66 |
| **BMI** | | <0.001 |
| <18.5 kg/m² | 0.73 (0.62 to 0.87) | <0.001 |
| 18.5–24.9 kg/m² | 1.00 (reference) | |
| 25–29.9 kg/m² | 1.20 (1.12 to 1.29) | <0.001 |
| ≥30 kg/m² | 1.53 (1.42 to 1.64) | <0.001 |
| **Smoking status** | | 0.57 |
| Never | 1.00 (reference) | |
| Former | 1.00 (0.95 to 1.07) | 0.88 |
| Current | 0.96 (0.88 to 1.05) | 0.53 |
| **Comorbid conditions** | | |
| Diabetes mellitus | 0.83 (0.76 to 0.92) | <0.001 |
| Peripheral vascular disease | 0.88 (0.82 to 0.94) | <0.001 |
| Coronary artery disease | 0.82 (0.77 to 0.87) | <0.001 |
| Cerebrovascular disease | 0.93 (0.86 to 1.01) | 0.08 |
| Chronic lung disease | 0.91 (0.84 to 0.98) | 0.01 |
| **Primary kidney disease** | | <0.001 |
| Diabetic nephropathy | 1.00 (reference) | |
| GN | 1.08 (0.97 to 1.20) | 0.17 |
| Renovascular/hypertension | 1.04 (0.93 to 1.17) | 0.49 |
| Polycystic kidney disease | 2.21 (1.91 to 2.56) | <0.001 |
| Other | 0.90 (0.81 to 1.01) | 0.06 |
| **Late nephrology referral** | | 0.13 (0.12 to 0.14) | <0.001 |
| **Previous RRT** | | 0.65 (0.60 to 0.70) | <0.001 |
| **Center characteristics (n=61)** | | |
| Center size; average no. of incident patients on HD per year | | 0.85 |
| 10–34 | 1.00 (0.75 to 1.32) | 0.98 |
| 34–89 | 1.00 (reference) | |
| ≥90 | 1.13 (0.74 to 1.74) | 0.57 |
| Center with transplantation facility | 1.25 (0.95 to 1.64) | 0.11 |
| Peritoneal dialysis, average no. of incident patients on PD per year | 0.99 (0.97 to 1.00) | 0.08 |
| Home hemodialysis, % of patients per center | | 0.05 |
| 0–4% | 1.02 (0.76 to 1.38) | 0.88 |
| 5–15% | 1.00 (reference) | |
| ≥16% | 0.70 (0.53 to 0.94) | 0.02 |
| Weekly number of HD hours | | 0.74 |
| 11.5–13 | 0.95 (0.68 to 1.32) | 0.75 |
| 13.1–14.7 | 1.00 (reference) | |
| ≥14.8 | 1.11 (0.83 to 1.50) | 0.48 |
| Blood flow rate ≥300 ml/min, % of patients per center | | 0.30 |
| 3–9% | 0.88 (0.67 to 1.13) | 0.51 |
| 70–88% | 1.00 (reference) | |
| >88% | 1.11 (0.86 to 1.44) | 0.41 |
| Phosphate target (0.8–1.6 mmol/L), % of patients per center | | 0.16 |
| 28–42% | 0.77 (0.58 to 1.03) | 0.08 |
| 42–52% | 1.00 (reference) | |
| >52% | 1.01 (0.78 to 1.31) | 0.96 |
| Hemoglobin target (100–115 g/L), % of patients per center | | 0.42 |
| 29–35% | 1.02 (0.79 to 1.32) | 0.86 |
| 36–40% | 1.00 (reference) | |
| ≥41% | 0.87 (0.67 to 1.12) | 0.27 |
| Weekly Kt/V target (≥1.4), % of patients per center | | 0.36 |
| 33–87% | 0.83 (0.63 to 1.08) | 0.17 |
This observed variability in arteriovenous access use across centers is consistent with previously published literature demonstrating significant variation in incident vascular access use internationally and across centers within single countries (9,10,18–20). An international comparison made on the basis of data from the Dialysis Outcomes and Practice Patterns Studies (DOPPS) demonstrated a 3.4-fold variation in incident arteriovenous access use across 12 countries in Europe, North America, and Asia (9).

In keeping with the findings of previous studies (3,12), this investigation identified several patient-level factors that were associated with a decreased likelihood of starting HD via an AVF or AVG, including the presence of diabetes mellitus, peripheral vascular disease, coronary artery disease, and chronic lung disease and late referral to a nephrologist. Additionally, prior kidney transplantation or peritoneal dialysis was found to be associated with lower odds of starting dialysis with an arteriovenous access. This finding is supported by previous studies in kidney transplant recipients, suggesting that patients returning to dialysis after kidney allograft failure are less likely to start dialysis with an arteriovenous access (21,22). The authors suggested this may have been due to psychologic “denial” of transplant failure by patients or nephrologists, lack of access to predialysis planning and education, unpredictability of the trajectory of declining graft function, or unexpected graft failure (22). In the absence of a “backup” fistula or graft, these patients are likely to initiate HD via a CVC (6). Furthermore, in this study, patients who were overweight or obese were more likely to start dialysis with an arteriovenous access compared with patients of normal weight. Previous studies have reported variable associations between BMI and arteriovenous access use, ranging from no association (23,24), to lower likelihood of AVF placement but higher likelihood of AVG placement (11), to increased likelihood of arteriovenous access creation (14). The apparent disparity in these findings is likely explained by variations in study design (e.g., prospective versus retrospective data collection, single-center versus registry-based data), size, statistical analyses, and differences in the case mix of study populations.

Table 3. (Continued)

| Characteristic | OR (95% CI)       | P Value |
|---------------|-------------------|---------|
| 88%–99.6%     | 1.00 (reference)  | 0.98    |
| 99.7%–100%    | 0.98 (0.75 to 1.27) | 0.87    |

OR, odds ratio; ATSI, Aboriginal and Torres Strait Islander; BMI, body mass index; HD, hemodialysis; PD, peritoneal dialysis. *Reference category refers to second and third quartile (merged) in all center-level variables except for center with transplantation facility.

Figure 4. Variation of incident AVF/AVG use across 61 centers during the period 2004–2015 in unadjusted (triangle), patient level–adjusted (square), and multilevel–adjusted (patient and center; circle) models.
Although none of the center-level characteristics captured in the ANZDATA Registry was predictive of increased arteriovenous access use, centers with the highest proportion of patients on home HD demonstrated a lower likelihood of starting patients on dialysis with an AVF or AVG. It may be speculated that differences in the time point at which different centers coded their patients as being established on home dialysis may account for this finding. However, because the overall group comparison did not reach statistical significance, this association most likely represents a statistical type 1 error.

Investigations of center characteristics associated with arteriovenous access use have been sparse. Most recently, Dahlerus et al. (25) examined intercenter variability in AVF use in a prevalent HD population by categorizing facilities according to their overall level of patient comorbidity burden. This study showed that comorbidity levels accounted for <1% of variation in AVF access use in the majority of centers, with the exception of facilities with a very low or very high level of comorbidity burden, where AVF use was greater or smaller, respectively. This study emphasizes that, even in the prevalent HD population, there may be important, modifiable, center-level characteristics that affect successful arteriovenous access use. Furthermore, a study of 1183 incident and 949 prevalent patients on HD from 498 dialysis facilities participating in DOPPS between 2002 and 2007 found that centers with higher median blood flow rates had higher odds of AVF failure (OR, 1.21; 95% CI, 1.05 to 1.39) (19). The authors suggested that higher blood flow rates may have led to disturbances in laminar flow in the HD circuit that, in turn, increased the risks of platelet aggregation and thrombosis. Interestingly, the observed relationship between blood flow and AVF failure was weaker in Australia and New Zealand than in North America (19). This regional variability may have accounted for the lack of association between blood flow rate and incident arteriovenous access use in this analysis. In 2004, a study of 10,112 patients on chronic HD from 173 dialysis facilities, from a single provider in the United States, investigated the effect of case mix and center characteristics—including size, staffing ratio, transplant activity, and socioeconomic data (employment and median household income)—on prevalent AVF use. Higher proportions of prevalent AVF use were observed in larger facilities and those with a higher median household income, but this association was lost in multivariate analysis of patient and center characteristics (26). Similarly to our study, adjustment for center characteristics decreased the unexplained between-facility variation in AVF use only to a limited degree (reduction in between-facility variance from 7% to 6%) (26). In addition, several surgeon characteristics have been identified as important contributors to the variability in AVF creation and maturation success including recency in medical qualification and general surgical specialization (27). Other surgeon related factors identified include the volume of created AVF as predictor of AVF maturation success (27,28), and the surgeon’s intraoperative level of frustration and concern about maturation success as a predictor of early AVF thrombosis (29). Previous studies have suggested that processes of care, particularly those focused on predialysis care such as vascular access coordinators (30,31), patient education programs (32–34), and factors related to medical and surgical expertise (35,36), may hold greater promise to enhance arteriovenous access use. Collection of more granular information on these potentially modifiable factors in patient registries may help to inform which strategies could increase the use of AVF and AVG in incident and prevalent patients on dialysis.

The strengths of this binational registry study include the large sample size from comprehensive data capture of all patients initiating HD in 61 centers across Australia and New Zealand over a 12 year period. Robust statistical analyses, including multivariable adjustment of patient- and center-related factors, were used to mitigate the risk of confounding. However, these strengths should be balanced against the limitations of this study which include the retrospective study design. The limited depth and granularity of the data collected in the registry may have contributed to the observed intercenter variation in vascular access use. Potentially modifiable practice patterns, including variation in timeliness of HD access referral and access creation, were not captured in the ANZDATA Registry and may have accounted for some of the intercenter variability in incident access type. Furthermore, temporal trends of access type in use at later time points were not available to assess changes in use of arteriovenous access after HD initiation. Additionally, the study excluded patients with missing information and centers of very small size, which potentially introduced selection bias. The possibility of reporting and coding/classification bias cannot be excluded because ANZDATA is a voluntary registry and there is no external audit of data accuracy. Residual confounding may persist despite robust statistical analyses. Finally, the results of this study are based on the Australian and New Zealand population and may not be generalizable to other countries.

There is substantial, four-fold variability in incident arteriovenous access use across centers in Australia and New Zealand. This study identified several patient and center factors associated with incident HD access use, yet these factors did not fully explain the substantial variability in arteriovenous access use across centers. Further work is needed to explore the complexities of timely arteriovenous access creation and to examine clinician and patient attitudes toward vascular access creation. Identification and implementation of favorable and modifiable process-of-care factors to ensure timely referral, creation, and follow-up may help increase the proportion of patients starting dialysis with a fistula or graft and mitigate the large disparities between centers.

Disclosures
D.W. Johnson has previously received consultancy fees, research grants, speaker’s honoraria, and travel sponsorships from Baxter Healthcare and Fresenius Medical Care. He is also a current recipient of an Australian National Health and Medical Research Council Practitioner Fellowship. C.M. Hawley has received research support from Baxter Healthcare and Fresenius Medical Care. S. McDonald has received research support from Baxter Healthcare. All remaining authors have nothing to disclose.

Funding
None.
Acknowledgments

The authors gratefully acknowledge the substantial contribution of the entire Australia and New Zealand nephrology community (physicians, surgeons, database managers, nurses, renal operators, and patients) in providing information for and maintaining the ANZDATA Registry database. The ANZDATA Registry is funded by the Australian Organ Transplantation Authority, the New Zealand Ministry of Health, and Kidney Health Australia. Astellas Pharmaceuticals provided nondirected contributions, and the National Health and Medical Research Council and Kidney Health Australia provided research support.

The data reported here have been supplied by the ANZDATA Registry.

The interpretation and reporting of these data are the responsibility of the authors and in no way should be seen as an official policy or interpretation of the ANZDATA Registry.

Author Contributions

P.A. Clayton, C.M. Hawley, A.B. Irish, D.W. Johnson, S. McDonald, S. Ng, K.R. Polkinghorne, K.S. Rabindranath, M.A. Roberts, and A.K. Viccelli reviewed and edited the manuscript; P.A. Clayton, C.M. Hawley, S. Ng, E.M. Pascoe, and A.K. Viccelli were responsible for formal analysis; C.M. Hawley and D.W. Johnson were responsible for methodology; C.M. Hawley, D.W. Johnson, S. Ng, M.A. Roberts, and A.K. Viccelli wrote the original draft; C.M. Hawley, S. Ng, E.M. Pascoe, and A.K. Viccelli were responsible for data curation; C.M. Hawley and A.K. Viccelli conceptualized the study; D.W. Johnson, S. Ng, and A.K. Viccelli provided supervision; and S. Ng and A.K. Viccelli were responsible for investigation.

Supplemental Material

This article contains the following supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0005742020/-/DCSupplemental.

Supplemental Table 1. Longitudinal trend in hemodialysis access use at dialysis commencement in Australia and New Zealand 2004–2015.

Supplemental Table 2. Multivariable logistic regression of arteriovenous access (arteriovenous fistula or graft) use compared to central venous access use at hemodialysis initiation adjusted for patient characteristics including year of HD commencement.

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Received: September 23, 2020 Accepted: January 27, 2021