Evolution of Vascular Access Use among Incident Patients during the First Year on Haemodialysis: A National Cohort Study

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Key Points

- Central venous catheters are the predominant type of vascular access in the Irish dialysis population in the first year of dialysis.
- Substantial centre variation exists which is not explained by patient-related factors alone.
- Evaluation of potential factors is key to inform national policy and guide implementation strategies to improve patient outcomes.

Abstract

**Background:** Although the arteriovenous fistula (AVF) confers superior benefits over central venous catheters (CVC), utilisation rates remain low among prevalent haemodialysis (HD) patients. The goal of this study was to determine the evolution of vascular access type in the first year of dialysis and identify factors associated with conversion from CVC to a functioning AVF.

**Methods:** We studied adult patients (n=610) who began HD between the 01/01/2015 and 31/12/2016 and were treated for at least 90 days using data from the National Kidney Disease Clinical Patient Management System in the Irish Health System. Prevalence of vascular access type was determined at day 90 and 360 following dialysis initiation and at 30-day intervals. Multivariable logistic regression explored factors association with CVC at day 90, and Cox regression evaluated predictors of conversion from CVC to AVF on day 360.

**Results:** CVC use was present in 77% of incident patients at day 90 with significant variation across HD centres (from 63 % to 91%, P<0.001) that persisted following case-mix adjustment. From day 90 to day 360, AVF use increased modestly from 23% to 41%. Conversion from CVC to AVF increased over time but the likelihood was lower for older patients [adjusted hazard ratio (HR) 0.43, 95% CI 0.19-0.96 for age >77yrs vs referent], for patients with lower BMI [HR 0.95, (0.93- 0.98) per unit decrease in BMI], and varied significantly across HD centres [from HR 0.25, (0.08-0.74) to 2.09 (1.04-4.18)].
Conclusion: CVC are the predominant type of vascular access observed during the first year of dialysis with low conversion rates from CVC to AVF. Substantial centre variation exists in the Irish health system that is not explained by patient-related factors alone.
Background

Central venous catheters (CVC) contribute substantially to adverse clinical outcomes including bloodstream infection, infection-related hospitalisation, mortality, and health care costs among patients undergoing haemodialysis (HD) [1-3]. Evidence from international studies has confirmed that CVC are inferior to arteriovenous fistulas (AVF) with regard to major outcomes [1, 3]. A recent systematic review of 62 cohort studies comprising 586,337 patients revealed that patients dialysing with a CVC experienced 25% higher risk of cardiovascular events, 50% higher mortality risks, and double the risk for fatal infections, compared to those who were using a AVF [2]. In contrast, patients dialysing with a functioning AVF have demonstrated substantially lower risks for such negative outcomes [2]. Consequently, international guidelines and professional societies advocate for AVF over CVC as the preferred vascular access type for all patients who require treatment with HD [4].

Although clinical guidelines recommened AVF as the preferred access option for most patients who require HD, the reality is that a substantial number of patients who develop ESKD and require HD begin treatment with a CVC (5). Barriers to AVF creation have hampered efforts at achieving high rates of usable AVF across countries. These include increasingly complex patient phenotypes, high burden of frailty, late referral, insufficient patient education, and lack of standardised care processes that inevitably lead to lower rates of AVF and higher dependency on catheters (6). Increasing the rates of AVF use is a key objective for most national programmes. The development of highly coordinated policies underpinned by strong implementation strategies have yielded benefits for many countries. An excellent example is the Fistula First Policy in the United States where AVF rates have increased steadily from 33% in 2003 to 63% in 2015 among prevalent HD patients (7-8).
However, despite these efforts, the prevalence of functioning AVF at dialysis initiation remain low for many countries and suggests that the appropriate planning, patient engagement and education process prior to dialysis onset fall short of expectations (8-12). It remains unclear to what extent patient-level factors contribute to the high dependency on CVC. It is also uncertain whether rates of AVF placement increase rapidly in the first year of dialysis, at a time when patients are primarily under the supervision of a nephrologist.

To increase our understanding of vascular access provision both prior to and after the initiation of HD, we established an inception cohort of incident HD patients and tracked their progress in the first year of HD in the Irish health system. The primary aim was to describe the patterns of vascular access use during the first year of dialysis among incident patients and determine the extent to which patient-related and centre-related factors influenced access provision. A secondary object was to evaluate conversion rates from CVC to a functioning AVF among those who had started HD with a tunnelled dialysis catheter.
**Methods**

*Data Source*

We utilised the Kidney Disease Clinical Patient Management System (KDCPMS) as the primary data source to examine vascular access use in the Irish health system (12). The KDCPMS is a kidney-specific national information system that tracks patients from late-stage CKD across the transition to end-stage kidney disease (ESKD) in all dialysis centres in Ireland. The system interfaces directly with local hospital information systems to capture real-time data on demographics, laboratory results and core indicators of care for patients under nephrology care. Renal replacement therapies within the Republic of Ireland are provided through primary kidney centres, organised into six hospital groups. Under the supervision of these primary centres, haemodialysis for adult patients is arranged and supervised across 20 dialysis units. Every patient on HD has a “centre of primary medical supervision” at which their care is managed, including arrangements for the provision of vascular access placement. Data such as the primary cause of ESKD, comorbid conditions, and ancillary notes on clinical care delivery are manually entered by users at the site of care. Each renal centre has a local KDCPMS supervisor to support data reporting and data management. Over the last several years, renal centres in the Republic of Ireland were incrementally added on KDCPMS. In 2017, all units were included in the system.

*Study Design*

We established an observational cohort of adult patients who started HD between the 01/01/2015 to the 31/12/2016 and continued to receive renal replacement therapy for at least 90 days post initiation of HD. We excluded patients who had missing data on vascular access recorded at day 90 (Figure 1). Data were captured on demographic characteristics, comorbid conditions, primary cause of ESKD, vascular access type, the location of medical supervision, and a comprehensive list of laboratory values for all patients 90 days following
HD initiation. For each patient, the type of vascular access in use at day 90 of dialysis and at monthly intervals thereafter was recorded. Vascular access assignment was based on the last recorded access in use from the real-time dialysis record. If two access types co-existed, the access type used for the HD treatment was assigned as primary. For this study, patients who were treated with an AVG (n=14) were grouped with those who had an AVF.

The primary cause of kidney disease and comorbid diagnoses were collapsed into categories and classified as per the US Renal Data System (10). A patient was considered to have hypertension or diabetes if these conditions were listed among the comorbid conditions or if diabetes or hypertension was among the causes of kidney disease. Laboratory variables were recorded at day 90, or the nearest session within 7 days of day 90. The time-weighted median value for each test type was determined and included in the final dataset. Patient assignment to a specific dialysis centre was based on the last “location of primary medical supervision” on day 90 following dialysis initiation. Ethical approval was not sought as this study formed part of a national quality improvement initiative and satisfied the ethical and information governance for analysis of secondary health data for improvement in population health in Ireland (11).

**Outcomes**

The evolution of vascular access was assessed at monthly intervals from day 90 to day 360 of dialysis and the conversion rate from CVC to AVF were determined.

**Statistical Analyses**

Baseline characteristics were described for the whole population at day 90 by access type and by HD centre. The number of patients in each centre was suppressed to maintain centre anonymity. Continuous variables are presented as mean ±standard deviation (SD) or median and interquartile range (IQR), as appropriate, while categorical variables are expressed as
percentages. Group comparisons for continuous variables were performed using the Kruskal–Wallis test while group comparisons were performed with the chi-squared test.

Multivariable logistic regression was used to explore factors associated with CVC use versus AVF at day 90 following initiation. Explanatory variables were classified as demographic, the primary cause of ESKD, comorbid medical conditions, laboratory indicators of health, and dialysis centre. BMI was modelled as a categorical variable as, its continuous form was not linearly related to the log odds. Model building progressed manually based on univariate associations, clinical reasoning and previously published literature. A final model was constructed to explore the relative contribution of all explanatory factors with catheter use at day 90. The associations of explanatory factors with catheter presence were represented by adjusted odds ratios (AOR) and 95% CI. For each model, the C-statistic was calculated to assess the model performance.

Cox proportional hazards regression was used to evaluate the rate of conversion from CVC use at day 90 to AVF use at day 360. Unadjusted and sequentially adjusted models were constructed to identify factors associated with conversion to AVF expressed as hazard ratios (HRs) and 95% confidence intervals (95%CI). HRs were first adjusted for demographic variables, then for cause of ESKD and finally for clinical variables (comorbidities and laboratory variables). The proportional hazard assumption was assessed by plotting scaled Schoenfeld residuals versus rank time. Two-sided significance tests were used and P-values <0.05 were considered significant. A sensitivity analysis was conducted to further explore centre variation. Effect/ deviation coding was used for centre-based comparisons in the logistic and cox regression models. Effect coding provides estimates which are deviations from a grand mean or in this case a national average (referent). All analyses were performed using R statistical software [14].
Results

Baseline characteristics

Table 1 summarises patient characteristics on day 90 following dialysis initiation according to the vascular access type. Overall, 610 participants met the inclusion criteria and were included in the final analysis. The mean age of patients was 59.7 years in the CVC group and 63.7 years in the AVF group. Male participants represented 65.1% of the total cohort (62.4% in the CVC group and 73.9% in the AVF group). Diabetic nephropathy and glomerulonephritis were the leading causes of ESKD. In general, baseline characteristics were similar between access groups although patients with a CVC were on average 4 kilograms heavier, and had significantly higher baseline values for serum albumin, urea and serum creatinine concentrations compared to the AVF group. The study cohort was distributed across six hospital groups with ten centres of primary medical supervision. The distribution of patients by centre of primary medical supervision and by vascular access type is shown in Table 2. CVC was the predominant access type at day 90 ESKD and varied significantly from 63.3% in Centre 8 to 90.9% in Centre 6. Centre 1 had the largest proportion of patients overall and therefore was chosen as a referent for centre-based comparisons.

Patient and facility-level characteristics associated with CVC use at day 90

By day 90 of dialysis treatment, the proportion of patients that utilised a CVC as primary vascular access was substantial (77%) as illustrated in Figure 2. Factors associated with CVC use at day 90 are shown in Table 3. With adjustment for demographics and clinical factors, patients dialysed with a CVC at day 90 were more often women (AOR: 1.73, CI: 1.01-3.12) Patients with congestive heart failure were less likely to dialyse with a catheter (AOR: 0.50, CI: 0.26-0.97). Similarly, higher serum albumin concentrations were significantly associated with lower odds of CVC (AOR: 0.88, CI: 0.82-0.95 per 1 g/L increase). Significant variation
in CVC use was observed across different centres of primary medical supervision, with use ranging from 63% to 91%, P-value <0.001 (Figure 3). Patients undergoing dialysis at centres 3 and 9 were significantly less likely to use a CVC than AVF as their primary access (AOR: 0.41, CI: 0.17-0.96, p-value < 0.05 and AOR: 0.25, CI: 0.09-0.67, p-value <0.05, respectively). This variation persisted when the national average (gran mean) was used as the referent group. In this analysis patients from centre 9 were significantly less likely to use a CVC than AVF [AOR: 0.37 (0.17-0.79)], while, patients from centre 4 had significantly greater utilisation of CVC than AVF compared to the national average [AOR: 2.76 (1.29-6.59)]. (Supplementary Table 1)

**Factors associated with conversion of CVC to AVF**

The evolution of permanent vascular access in the first year of haemodialysis is shown in Figures 2 and 3. The overall percentage of patients with a CVC decreased significantly from 77% at day 90 to 59% by day 360 with a corresponding rise in AVF use from 23% to 41%. After adjustment for patient and facility-level characteristics, significant inter-centre variation was observed at the end of follow-up. Compared to the reference group (Centre 1), patients from centre 3 were more than 2-fold more likely to convert to an AVF whereas patients in Centre 4 were 75% less likely to use an AVF at the end of the first year of dialysis (Centre 3: HR, 2.09 (1.04-4.18) and Centre 4: HR: 0.25, (0.08-0.74) as shown in Table 4 and Figure 4. This centre variation persisted when the national average (grand mean) was used as referent, (Suppmentary Table 2). The assumption of constant relative risk over time was assessed by Schoenfeld residual analysis. The sex term was found to violate the proportional hazard assumption (p<0.001). Consequently the Cox model was refit stratified by the sex term. The same inter-centre variation was confirmed and the factors associated with conversion to AVF remain unchanged. The Cumulative incidences of vascular access conversion in the overall sample stratified by sex is described in Figure 5. From this it was apparent that conversion
rates from CVC to AVF increased over time for both men and women. However, conversion rates were higher for women than men prior to day 240, while thereafter the rates of conversion were higher for men than for women. In our analysis, older patients were less likely to convert from CVC to AVF during follow-up, HR 0.43, (0.19-0.96) for age > 77 years vs < 60 years (referent). Additionally, rates of conversion were significantly higher in CVC patients with elevated BMI following adjustment, HR 1.05 (1.02-1.08) per 1 kg/m² higher BMI.

Discussion
In this nationally representative study, we observed high rates of CVC utilisation (77%) and correspondingly low rates of AVF use (33%) among new patients treated with haemodialysis in the Irish health system. We furthermore revealed relatively low conversion rates from CVC to AVF with only 41% of all patients achieving a functioning AVF at the end of the first year of dialysis. Our analysis also uncovered considerable variation in CVC use across centres (from 63% to 91% at day 90) and in the subsequent rates of CVC conversion to AVF during the follow-up period, which was not explained by measured patient-related characteristics. Collectively, these findings indicate that factors operating outside the patient domain (i.e. facility-level characteristics and organisational factors) may be responsible for the low rates of AVF in the first year and also account for the substantial differences that exist across centres in the Irish health system. These results highlight that Ireland lags behind international best practice in achievement of recommended AVF rates, findings that have important implications for strategic planning and actionable initiatives.

The most striking finding from this national study is the high prevalence of CVC use within 3 months of dialysis initiation and its relative persistence throughout the first year of dialysis. Optimum pre-dialysis care involves aligning the right vascular access with the right patient at
the right moment in time in the right circumstance (15). Such alignment is challenging and may hindered by a complex interplay of individual patient characteristics and centre-based practices [16]. Historically, it has been argued that delayed patient referral to nephrologists is the major contributor to increased catheter use due to inadequate pre-dialysis preparation time [16–20]. More recent evidence, however, suggests a more complex set of reasons given that programmes with early referral pathways continue to have high rates of CVC use [21].

We highlight substantial variation in AVF use across dialysis facilities in the Irish health system, that was not explained by patient-level factors. Percentage rates for AVF at day 90 following HD initiation were remarkably low and varied from 9.1 % to 36.7 % suggesting that factors operating in the pre-dialysis period were accountable. Although our research did not specifically examine patient-specific factors such as preference or expected survival that may influence the type of vascular access, our results are broadly consistent with published data highlighting the substantial role of facility-related factors in driving practice patterns [22–25]. Although international differences exist with regard to vascular access practices; our observations suggest that care delivery in Ireland lags behind that of other industrialised countries. Data from the international DOPPS study found that AVF use at day 60 post dialysis initiation was 56% in Germany and 53% in the UK, substantially higher than the 23% rate in our Irish study (25). It is our view that such international comparisons serve to support changes in national policy and in strategic planning in order to promote a coordinated vascular access programme. An excellent example of such landmark initiatives aiming to tackle facility-related hindrances is the ‘’Fistula First Breakthrough Initiative’’ implemented in the United States in 2003. This highly effective and goal-directed quality improvement project resulted in doubling the prevalence of AVF use from 33% to 63% a decade later [7-8, 26]. Similarly, to improve vascular access practice, focused strategic policies and effective
pre-dialysis care is an essential requirement needed to address health care provider processes in the Irish healthcare system.

The adverse influence of age was again evident from this analysis with older patients less likely to convert from a CVC at day 90 to a functioning AVF at the end of the first year. High prevalence of multimorbidity, shortened life expectancies and high rates of non-functioning AVF compared to younger patients may have influenced clinical practice in an Irish context. Equally noteworthy, was the finding of higher rates of conversion from CVC to AVF with increasing BMI values. Although, higher BMI is associated with fistula failure, the conversion rate from CVC at day 90 to an AVF at day 360 AVF was significantly higher for patients with larger rather than smaller body size. Our findings further support the observations of de Pinho et al from the REIN registry (27) where patients with higher BMI were more likely to convert to a functional AV access.

Our research has some limitations worth mentioning. Given the retrospective nature of the study, we accept that unmeasured and residual confounding is an inherent shortcoming. We also acknowledge that other important factors such as patient preference and AVF failure rates were not available in our dataset and consequently were not included in the final analysis. We did observe missing data on selected demographic and comorbid indicators but in general the rates were low (< 10%), and our observed rates for primary causes of ESKD and comorbid conditions were similar to those from other European countries [28,29]. Despite these shortcomings, our study had several important strengths. First, the study was nationally representative and provided the first detailed description of vascular access practices among incident HD patients in the Irish health system. Second, the availability of longitudinal data within the first year of dialysis provided new insights into the evolution of vascular access and its determinants. Third, our analysis captured a comprehensive set of patient-level characteristics including comorbid conditions and labaratory indicators of health.
and allowed us to adjust for several potential confounders. Fourth, there was virtually complete follow-up on all patients with very few lost to follow-up. As a consequence, our results are broadly generalisable and highlight the substantial variability in vascular access provision in the Irish health system.

We conclude that CVCs are the predominant type of vascular access in the Irish dialysis population which are highly prevalent in the first year of dialysis. Substantial centre variation exists which was not explained by patient-related factors alone. Potential explanatory reasons include: access to nephrology care, poor vascular access planning, patient motivation for access placement, variation in surgical expertise, and difficulty with AV fistula maturation in high-risk groups. Rigorous evaluation of these potential factors is key to inform national policy and guide implementation strategies so that we can improve patient outcomes.

Disclosures

L. Plant reports the following: Honoraria: A.Menarini, NovoNordisk, Novartis, Servier, MSD, AstraZeneca. A. Stack reports the following: Consultancy Agreements: AstraZeneca, Vifor Pharma, Astellas; Research Funding: Educational Grant Vifor Pharma; Honoraria: Vifor, Menarini, AstraZeneca; Scientific Advisor or Membership: Editorial Board BMC Nephrology; Speakers Bureau: Vifor. The remaining authors have nothing to disclose.

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Authors’ Contributions

W Hussein: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing - original draft

G Ahmed: Data curation; Writing - original draft

L Browne: Data curation; Formal analysis; Funding acquisition; Methodology; Validation; Visualization; Writing - review and editing

W Plant: Investigation; Supervision; Writing - review and editing

A Stack: Data curation; Funding acquisition; Methodology; Project administration; Resources; Supervision; Writing - original draft; Writing - review and editing

All authors contributed to the development of the manuscript, and approved the final version.

Supplemental Material

Supplementary table 1: Patient and centre characteristics associated CVC use (versus AVF) access at 90 days following haemodialysis initiation.

Supplementary Table 2 Patient and centre characteristics associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days following haemodialysis initiation.
References


13. Ressearch Ethics Committees:
https://www.hse.ie/eng/services/list/5/publichealth/publichealthdepts/research/rec.html
. accessed 16/11/2019

14. R Core Team. R: A Language and Environment for Statistical Computing [Internet]. 2016; 0.


17. Lorenzo V, Martín M, Rufino M, Hernandez D, Torres A, Ayus JC. Predialysis


### Tables

**Table 1.** Patient characteristics by vascular access type at 90 days following haemodialysis initiation

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>CVC</th>
<th>AVF</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>610</td>
<td>468 (76.7)</td>
<td>142 (23.3)</td>
<td></td>
</tr>
<tr>
<td><strong>Sex (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>397</td>
<td>292 (73.6)</td>
<td>105 (26.4)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>213</td>
<td>176 (82.6)</td>
<td>37 (17.4)</td>
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</tr>
<tr>
<td><strong>Mean Age in years (±SD)</strong></td>
<td>610</td>
<td>59.7(15.8)</td>
<td>63.7(15.3)</td>
<td>0.008</td>
</tr>
<tr>
<td><strong>Age Group</strong></td>
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<td></td>
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<tr>
<td>&lt;60</td>
<td>232</td>
<td>169 (72.8)</td>
<td>63 (27.2)</td>
<td></td>
</tr>
<tr>
<td>60-77</td>
<td>260</td>
<td>200 (76.9)</td>
<td>60 (23.1)</td>
<td></td>
</tr>
<tr>
<td>78+</td>
<td>118</td>
<td>99 (83.9)</td>
<td>19 (16.1)</td>
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<td><strong>Primary Cause of ESKD (%)</strong></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Polycystic kidney Disease</td>
<td>40</td>
<td>22 (55.0)</td>
<td>18 (45.0)</td>
<td></td>
</tr>
<tr>
<td>Diabetic nephropathy</td>
<td>111</td>
<td>80 (72.1)</td>
<td>31 (27.9)</td>
<td></td>
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<tr>
<td>Glomerulonephritis</td>
<td>112</td>
<td>81 (72.3)</td>
<td>31 (27.7)</td>
<td></td>
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<tr>
<td>Hypertension</td>
<td>33</td>
<td>26 (78.8)</td>
<td>7 (21.2)</td>
<td></td>
</tr>
<tr>
<td>Other cause</td>
<td>56</td>
<td>48 (85.7)</td>
<td>8 (14.3)</td>
<td></td>
</tr>
<tr>
<td>Other urologic</td>
<td>38</td>
<td>25 (65.8)</td>
<td>13 (34.2)</td>
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<tr>
<td>Unknown/missing</td>
<td>220</td>
<td>186 (84.5)</td>
<td>34 (15.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Comorbidities n(%)</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Atherosclerotic heart disease</td>
<td>97</td>
<td>75 (77.3)</td>
<td>22 (22.7)</td>
<td>0.898</td>
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<tr>
<td>Cerebrovascular Disease</td>
<td>28</td>
<td>24 (85.7)</td>
<td>4 (14.3)</td>
<td>0.266</td>
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<td>Congestive Heart Failure</td>
<td>98</td>
<td>71 (72.4)</td>
<td>27 (27.6)</td>
<td>0.300</td>
</tr>
<tr>
<td>Other Cardiac Disease</td>
<td>98</td>
<td>71 (72.4)</td>
<td>27 (27.6)</td>
<td>0.303</td>
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<td>Peripheral Vascular Disease</td>
<td>25</td>
<td>19 (76.0)</td>
<td>6 (24.0)</td>
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<tr>
<td>Diabetes</td>
<td>209</td>
<td>162 (77.5)</td>
<td>47 (22.5)</td>
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<td>Hypertension</td>
<td>339</td>
<td>250 (73.7)</td>
<td>89 (26.3)</td>
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</tr>
<tr>
<td><strong>Physical Measurements (mean ± SD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Dialysis Systolic Blood Pressure (mmHg)</td>
<td>610</td>
<td>141.9(19.1)</td>
<td>144.7(21.8)</td>
<td>0.236</td>
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<tr>
<td>Pre-Dialysis Diastolic Blood Pressure (mmHg)</td>
<td>610</td>
<td>73.5(13.6)</td>
<td>76.6(14.0)</td>
<td>0.022</td>
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<td>Variable</td>
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<td>AVF</td>
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<td>--------------------------------</td>
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<td>---------</td>
</tr>
<tr>
<td>Post Systolic Blood Pressure(mmHg)</td>
<td>610</td>
<td>138.1 (19.2)</td>
<td>140.5 (19.2)</td>
<td>0.181</td>
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<tr>
<td>Post Diastolic Blood Pressure(mmHg)</td>
<td>610</td>
<td>74.9 (12.3)</td>
<td>76.5 (12.3)</td>
<td>0.125</td>
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<td><strong>Anthropometric Measures</strong></td>
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<tr>
<td>Pre-Dialysis weight (Kg)</td>
<td>609</td>
<td>81.9 (18.2)</td>
<td>77.6 (18.9)</td>
<td>0.008</td>
</tr>
<tr>
<td>Mean BMI (kg/m²)</td>
<td>510</td>
<td>28.1 (6.5)</td>
<td>27.3 (6.5)</td>
<td>0.178</td>
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<tr>
<td><strong>BMI Category n(%)</strong></td>
<td></td>
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<tr>
<td>18.5-25.0</td>
<td>178</td>
<td>142 (79.8)</td>
<td>36 (20.2)</td>
<td></td>
</tr>
<tr>
<td>&lt;18.5</td>
<td>20</td>
<td>17 (85.0)</td>
<td>3 (15.0)</td>
<td></td>
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<tr>
<td>25.0-30.0</td>
<td>165</td>
<td>125 (75.8)</td>
<td>40 (24.2)</td>
<td></td>
</tr>
<tr>
<td>&gt;30.0</td>
<td>147</td>
<td>106 (72.1)</td>
<td>41 (27.9)</td>
<td>0.326</td>
</tr>
<tr>
<td><strong>Laboratory Measures (mean ± SD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>569</td>
<td>37.1 (4.4)</td>
<td>34.9 (5.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Calcium (mmol/L)</td>
<td>569</td>
<td>2.3 (0.1)</td>
<td>2.2 (0.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Phosphate mmol/L</td>
<td>475</td>
<td>1.5 (0.3)</td>
<td>1.5 (0.4)</td>
<td>0.656</td>
</tr>
<tr>
<td>Haemoglobin (g/dL)</td>
<td>570</td>
<td>10.5 (1.2)</td>
<td>10.3 (1.2)</td>
<td>0.108</td>
</tr>
<tr>
<td>Ferritin (ng/L) Median(IQR)</td>
<td>443</td>
<td>346.0 (313.2)</td>
<td>415.0 (449.5)</td>
<td>0.064</td>
</tr>
<tr>
<td>PTH (pg/ml) Median(IQR)</td>
<td>468</td>
<td>220.5 (220.6)</td>
<td>224.3 (291.7)</td>
<td>0.910</td>
</tr>
<tr>
<td>Pre-Dialysis Creatinine (umol/L)</td>
<td>500</td>
<td>602.9 (202.2)</td>
<td>547.9 (210.0)</td>
<td>0.004</td>
</tr>
<tr>
<td>Pre-Dialysis eGFR (ml/min/1.73 m²)</td>
<td>500</td>
<td>8.5(3.5)</td>
<td>9.4(4.3)</td>
<td>0.042</td>
</tr>
<tr>
<td>Pre-Dialysis Urea (mmol/L)</td>
<td>486</td>
<td>21.6(5.6)</td>
<td>19.8(5.7)</td>
<td>0.007</td>
</tr>
<tr>
<td>Pre-Dialysis Potassium (mmol/L)</td>
<td>477</td>
<td>4.5 (0.5)</td>
<td>4.5 (0.5)</td>
<td>0.573</td>
</tr>
<tr>
<td>Pre-Dialysis Bicarbonate (mmol/L)</td>
<td>452</td>
<td>22.5 (2.2)</td>
<td>23.8 (2.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Post-Dialysis Creatinine (umol/L)</td>
<td>430</td>
<td>257.6 (102.5)</td>
<td>243.9 (109.0)</td>
<td>0.119</td>
</tr>
<tr>
<td>Post-Dialysis eGFR (ml/min/1.73 m²)</td>
<td>430</td>
<td>24.0 (9.5)</td>
<td>26.3 (12.5)</td>
<td>0.286</td>
</tr>
<tr>
<td>Post-Dialysis Urea (mmol/L)</td>
<td>486</td>
<td>21.6 (5.6)</td>
<td>19.8 (5.7)</td>
<td>0.007</td>
</tr>
<tr>
<td>Post-Dialysis Potassium (mmol/L)</td>
<td>424</td>
<td>3.6 (0.4)</td>
<td>3.6 (0.4)</td>
<td>0.705</td>
</tr>
<tr>
<td>Post-Dialysis Bicarbonate</td>
<td>180</td>
<td>27.7 (2.6)</td>
<td>27.7 (2.6)</td>
<td>0.598</td>
</tr>
</tbody>
</table>

BMI; Body Mass Index.
PTH; Parathyroid hormone.
eGFR; Estimated glomerular filtration rate (ml/min per 1.73 m²), Pre-Dialysis and Post-Dialysis eGFR were calculated using the Chronic Kidney Disease Epidemiology Collaboration (CKD-EPI) equation.
Table 2. Patient distribution by access type at 90 days from haemodialysis initiation for each centre of primary medical supervision

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>CVC (%)</th>
<th>AVF (%)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>610</td>
<td>76.7</td>
<td>23.3</td>
<td></td>
</tr>
<tr>
<td>Primary Centre of Supervision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre 1</td>
<td>120</td>
<td>82.5</td>
<td>17.5</td>
<td></td>
</tr>
<tr>
<td>Centre 2</td>
<td>27</td>
<td>74.1</td>
<td>25.9</td>
<td></td>
</tr>
<tr>
<td>Centre 3</td>
<td>106</td>
<td>64.2</td>
<td>35.8</td>
<td></td>
</tr>
<tr>
<td>Centre 4</td>
<td>73</td>
<td>86.3</td>
<td>13.7</td>
<td></td>
</tr>
<tr>
<td>Centre 5</td>
<td>45</td>
<td>84.4</td>
<td>15.6</td>
<td></td>
</tr>
<tr>
<td>Centre 6</td>
<td>44</td>
<td>90.9</td>
<td>9.1</td>
<td></td>
</tr>
<tr>
<td>Centre 7</td>
<td>39</td>
<td>79.5</td>
<td>20.5</td>
<td></td>
</tr>
<tr>
<td>Centre 8</td>
<td>49</td>
<td>63.3</td>
<td>36.7</td>
<td></td>
</tr>
<tr>
<td>Centre 9</td>
<td>50</td>
<td>68</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Centre 10</td>
<td>57</td>
<td>77.2</td>
<td>22.8</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Table 3: Patient and centre characteristics associated CVC use (versus AVF) access at 90 days following haemodialysis initiation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>AOR</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.76 (1.01-3.12)</td>
<td>0.048</td>
</tr>
<tr>
<td>Age per 1 year increase</td>
<td>1.01 (0.99-1.02)</td>
<td>0.441</td>
</tr>
<tr>
<td><strong>Primary cause of ESKD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetic Nephropathy (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Polycystic kidney Disease</td>
<td>0.62 (0.20-1.94)</td>
<td>0.403</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>1.08 (0.39-3.06)</td>
<td>0.879</td>
</tr>
<tr>
<td>Hypertension</td>
<td>3.21 (0.77-15.75)</td>
<td>0.124</td>
</tr>
<tr>
<td>Urologic</td>
<td>0.52 (0.15-1.78)</td>
<td>0.287</td>
</tr>
<tr>
<td>Other</td>
<td>2.96 (0.93-10.63)</td>
<td>0.078</td>
</tr>
<tr>
<td>Unknown/missing</td>
<td>2.00 (0.80-5.22)</td>
<td>0.146</td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.83 (0.49-1.39)</td>
<td>0.480</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.68 (0.77-3.88)</td>
<td>0.204</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>2.8 (0.83-13.21)</td>
<td>0.133</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>0.5 (0.26-0.97)</td>
<td>0.038</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>1.69 (0.49-7.94)</td>
<td>0.446</td>
</tr>
<tr>
<td>Atherosclerotic heart disease</td>
<td>0.92 (0.45-1.92)</td>
<td>0.819</td>
</tr>
<tr>
<td><strong>BMI Category</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;18.5</td>
<td>0.90 (0.23-4.70)</td>
<td>0.894</td>
</tr>
<tr>
<td>18.5-25.0 (Ref)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>25.0-30.0</td>
<td>0.85 (0.46-1.54)</td>
<td>0.585</td>
</tr>
<tr>
<td>&gt;30.0</td>
<td>0.64 (0.34-1.19)</td>
<td>0.158</td>
</tr>
</tbody>
</table>
### Laboratory measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Odds Ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin per 1 g/l increase</td>
<td>0.88 (0.82-0.95)</td>
<td>0.001</td>
</tr>
<tr>
<td>Haemoglobin per 1 g/dl increase</td>
<td>0.36 (0.07-1.89)</td>
<td>0.227</td>
</tr>
<tr>
<td>Calcium per 1 mmol/L increase</td>
<td>0.97 (0.78-1.21)</td>
<td>0.799</td>
</tr>
</tbody>
</table>

### Centre of supervision

<table>
<thead>
<tr>
<th>Centre</th>
<th>Odds Ratio (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre 1 (Reference)</td>
<td>1.00 (Reference)</td>
<td>0.000</td>
</tr>
<tr>
<td>Centre 2</td>
<td>0.55 (0.19-1.70)</td>
<td>0.281</td>
</tr>
<tr>
<td>Centre 3</td>
<td>0.41 (0.17-0.96)</td>
<td>0.041</td>
</tr>
<tr>
<td>Centre 4</td>
<td>1.88 (0.69-5.46)</td>
<td>0.228</td>
</tr>
<tr>
<td>Centre 5</td>
<td>0.86 (0.31-2.63)</td>
<td>0.788</td>
</tr>
<tr>
<td>Centre 6</td>
<td>1.46 (0.33-10.35)</td>
<td>0.652</td>
</tr>
<tr>
<td>Centre 7</td>
<td>0.43 (0.13-1.47)</td>
<td>0.163</td>
</tr>
<tr>
<td>Centre 8</td>
<td>0.46 (0.19-1.11)</td>
<td>0.084</td>
</tr>
<tr>
<td>Centre 9</td>
<td>0.25 (0.09-0.67)</td>
<td>0.006</td>
</tr>
<tr>
<td>Centre 10</td>
<td>0.79 (0.31-2.07)</td>
<td>0.620</td>
</tr>
</tbody>
</table>

\(^1\) Adjusted Odds Ratio from Logistic Regression Model adjusted for dialysis centre, demographic and lifestyle characteristics (sex, age and BMI group), comorbid conditions, and primary cause of kidney disease and laboratory indicators. Area under the curve = 0.77.
Table 4. Patient and centre characterises associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days following haemodialysis initiation.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>HR (95% CI)</th>
<th>P-value</th>
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<tbody>
<tr>
<td><strong>Primary Centre of Supervision</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre 1 (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Centre 2</td>
<td>0.27 (0.06-1.18)</td>
<td>0.081</td>
</tr>
<tr>
<td>Centre 3</td>
<td>2.09 (1.04-4.18)</td>
<td>0.038</td>
</tr>
<tr>
<td>Centre 4</td>
<td>0.25 (0.08-0.74)</td>
<td>0.012</td>
</tr>
<tr>
<td>Centre 5</td>
<td>0.96 (0.4-2.28)</td>
<td>0.920</td>
</tr>
<tr>
<td>Centre 6</td>
<td>0.49 (0.14-1.76)</td>
<td>0.275</td>
</tr>
<tr>
<td>Centre 7</td>
<td>1.08 (0.38-3.06)</td>
<td>0.890</td>
</tr>
<tr>
<td>Centre 8</td>
<td>0.91 (0.36-2.29)</td>
<td>0.836</td>
</tr>
<tr>
<td>Centre 9</td>
<td>1.22 (0.5-2.94)</td>
<td>0.665</td>
</tr>
<tr>
<td>Centre 10</td>
<td>0.73 (0.3-1.74)</td>
<td>0.473</td>
</tr>
<tr>
<td><strong>Age Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;60 (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>60-77</td>
<td>0.78 (0.49-1.26)</td>
<td>0.314</td>
</tr>
<tr>
<td>&gt;77</td>
<td>0.43 (0.19-0.96)</td>
<td>0.040</td>
</tr>
<tr>
<td><strong>Primary cause of ESKD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetic Nephropathy (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td>2.11 (0.77-5.77)</td>
<td>0.146</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>0.97 (0.38-2.43)</td>
<td>0.939</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.27 (0.05-1.38)</td>
<td>0.115</td>
</tr>
<tr>
<td>Other</td>
<td>0.53 (0.17-1.59)</td>
<td>0.253</td>
</tr>
<tr>
<td>Urologic</td>
<td>1.16 (0.32-4.15)</td>
<td>0.823</td>
</tr>
<tr>
<td>Comorbidities</td>
<td>Hazard Ratio</td>
<td>p-Value</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Unknown/missing</td>
<td>0.67 (0.3-1.48)</td>
<td>0.323</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.31 (0.79-2.16)</td>
<td>0.292</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.21 (0.61-2.39)</td>
<td>0.589</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>0.79 (0.3-2.07)</td>
<td>0.625</td>
</tr>
<tr>
<td>Congestive cardiac failure</td>
<td>1.01 (0.5-2.02)</td>
<td>0.984</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>0.55 (0.16-1.88)</td>
<td>0.339</td>
</tr>
<tr>
<td>Atherosclerotic cardiac disease</td>
<td>0.73 (0.37-1.44)</td>
<td>0.361</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropometric measures</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI per 1 kg/m$^2$ increase</td>
<td>1.05 (1.02-1.08)</td>
<td>0.002</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Laboratory measures</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumin per 1 g/l increase</td>
<td>1.04 (0.98-1.1)</td>
<td>0.226</td>
</tr>
<tr>
<td>Haemoglobin per 1 g/dl increase</td>
<td>1.16 (0.96-1.39)</td>
<td>0.125</td>
</tr>
<tr>
<td>Calcium per 1 mmol/L increase</td>
<td>1.17 (0.3-4.54)</td>
<td>0.823</td>
</tr>
</tbody>
</table>

1 Hazard Ratio from sex stratified cox model, adjustments were made for dialysis centre, demographic and lifestyle characteristics (age group and body mass index), comorbid conditions, and primary cause of kidney disease and laboratory indicators. Body mass index was modelled as a linear variable, there was no evidence of conversion from CVC to AVF in this cohort for underweight participants.
Figure Legends

Figure 1. A flow diagram illustrating cohort construction. KDCPMS refers to Kidney Disease Clinical Patient Management System.

Figure 2. The evolution of vascular access in the Irish health system during the first year of dialysis among incident patients in 2015 & 2016. Data is extracted from the Kidney Disease Clinical Patient Management System (KDCPMS).

Figure 3. The evolution of vascular access in the Irish healthcare system during the first year of dialysis among incident patients in 2015 & 2016 stratified by centre of primary medical supervision.

Figure 4. Hazard Ratio for conversion of VA access from a CVC in place at 90 days to a functional AVF at 360 days by Primary Centre of supervision, for incident haemodialysis patients in 2015 & 2016 from the Kidney Disease Clinical Patient Management System (KDCPMS).

Figure 5. Cumulative event function for conversion of a CVC from day 90 to an AVF by day 360 versus time from haemodialysis initiation stratified by sex. Adjustments include age, primary kidney disease, comorbidities, laboratory variables and centre of medical supervision.
Haemodialysis initiation between 01/01/2015 and 31/12/2016
N = 669

EXCLUDED
Unspecified access type by day 90: N = 59

INCLUDED
N = 610

AVF as Primary Access at session 90 days from 1st dialysis session
N = 142
(AVF = 128, AVG = 14)

CVC as Primary Access at session 90 days from 1st dialysis session
N = 468
Figure 2

Vascular Access
- AVF
- CVC

Percentage (%) vs Days

Days: 90, 120, 150, 180, 210, 240, 270, 300, 330, 360

- AVF
- CVC

Percentage: 23, 25, 27, 29, 31, 34, 35, 36, 40, 41
Figure 4

Hazard Ratio (95% CI)

Primary Centre of Supervision

Centre 4  Centre 2  Centre 6  Centre 10  Centre 8  Centre 5  Centre 1  Centre 7  Centre 9  Centre 3

(Referent)
Figure 5

- Male
- Female

Cumulative event

Time (Days)
Evolution of Vascular Access Use among Incident Patients during the First Year on Haemodialysis: A National Cohort Study


Supplementary Material

Supplementary table 1: Patient and centre characteristics associated CVC use (versus AVF) access at 90 days following haemodialysis initiation.

Supplementary Table 2 Patient and centre characteristics associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days following haemodialysis initiation.
Supplementary table 1: Patient and centre characteristics associated CVC use (versus AVF) access at 90 days following haemodialysis initiation.

<table>
<thead>
<tr>
<th>Variable</th>
<th>AOR1 (95% CI)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centre (Reference: National Average)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre 1</td>
<td>1.47 (0.83-2.70)</td>
<td>0.197</td>
</tr>
<tr>
<td>Centre 2</td>
<td>0.81 (0.34-2.07)</td>
<td>0.642</td>
</tr>
<tr>
<td>Centre 3</td>
<td>0.61 (0.33-1.13)</td>
<td>0.110</td>
</tr>
<tr>
<td>Centre 4</td>
<td>2.76 (1.29-6.59)</td>
<td>0.014</td>
</tr>
<tr>
<td>Centre 5</td>
<td>1.27 (0.56-3.19)</td>
<td>0.582</td>
</tr>
<tr>
<td>Centre 6</td>
<td>2.15 (0.63-11.9)</td>
<td>0.283</td>
</tr>
<tr>
<td>Centre 7</td>
<td>0.63 (0.25-1.78)</td>
<td>0.360</td>
</tr>
<tr>
<td>Centre 8</td>
<td>0.67 (0.35-1.33)</td>
<td>0.244</td>
</tr>
<tr>
<td>Centre 9</td>
<td>0.37 (0.17-0.79)</td>
<td>0.009</td>
</tr>
<tr>
<td>Centre 10</td>
<td>1.16 (0.57-2.49)</td>
<td>0.695</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1.76 (1.01-3.12)</td>
<td>0.048</td>
</tr>
<tr>
<td>Age per 1-year increase</td>
<td>1.01 (0.99-1.02)</td>
<td>0.441</td>
</tr>
<tr>
<td><strong>Primary Kidney Disease</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetic nephropathy (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td>0.62 (0.20-1.94)</td>
<td>0.403</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>1.08 (0.39-3.06)</td>
<td>0.879</td>
</tr>
<tr>
<td>Hypertension</td>
<td>3.21 (0.77-15.75)</td>
<td>0.124</td>
</tr>
<tr>
<td>Other cause</td>
<td>2.96 (0.93-10.63)</td>
<td>0.078</td>
</tr>
<tr>
<td>Other urologic</td>
<td>0.52 (0.15-1.78)</td>
<td>0.287</td>
</tr>
<tr>
<td>Unknown/missing</td>
<td>2.00 (0.80-5.22)</td>
<td>0.146</td>
</tr>
<tr>
<td><strong>Comorbidities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.83 (0.49-1.39)</td>
<td>0.480</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.68 (0.77-3.88)</td>
<td>0.204</td>
</tr>
</tbody>
</table>
Cerebrovascular Disease 2.80 (0.83-13.21) 0.133
Congestive Heart Failure 0.50 (0.26-0.97) 0.038
Peripheral Vascular Disease 1.69 (0.49-7.94) 0.446
Atherosclerotic heart disease 0.92 (0.45-1.92) 0.819

**BMI Category**

<18.5 0.90 (0.23-4.70) 0.894
18.5-25.0 (Reference) 1.00
25.0-30.0 0.85 (0.46-1.54) 0.585
>30.0 0.64 (0.34-1.19) 0.158

**Laboratory Variables**

Serum Albumin per 1 g/l increase 0.88 (0.82-0.95) 0.001
Haemoglobin per 1 g/dl increase 0.36 (0.07-1.89) 0.227
Calcium per 1 mmol/L increase 0.97 (0.78-1.21) 0.799

1 Adjusted Odds Ratio from Logistic Regression Model adjusted for dialysis centre, demographic and lifestyle characteristics (sex, age and BMI group), comorbid conditions, and primary cause of kidney disease and laboratory indicators. For primary centre the grand mean of all centres was sued as the referent.
**Supplementary Table 2** Patient and centre characterises associated with conversion from a CVC in place at 90 days to a functional AVF at 360 days following haemodialysis initiation.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>HR (95% CI) ¹</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Centre (Reference: National Average)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre 1</td>
<td>1.29 (0.78-2.14)</td>
<td>0.320</td>
</tr>
<tr>
<td>Centre 2</td>
<td>0.36 (0.1-1.31)</td>
<td>0.121</td>
</tr>
<tr>
<td>Centre 3</td>
<td>2.82 (1.67-4.75)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Centre 4</td>
<td>0.34 (0.14-0.86)</td>
<td>0.023</td>
</tr>
<tr>
<td>Centre 5</td>
<td>1.23 (0.59-2.53)</td>
<td>0.582</td>
</tr>
<tr>
<td>Centre 6</td>
<td>0.65 (0.22-1.91)</td>
<td>0.429</td>
</tr>
<tr>
<td>Centre 7</td>
<td>1.58 (0.65-3.85)</td>
<td>0.319</td>
</tr>
<tr>
<td>Centre 8</td>
<td>1.18 (0.55-2.52)</td>
<td>0.676</td>
</tr>
<tr>
<td>Centre 9</td>
<td>1.64 (0.8-3.32)</td>
<td>0.175</td>
</tr>
<tr>
<td>Centre 10</td>
<td>1.39 (0.59-3.32)</td>
<td>0.454</td>
</tr>
<tr>
<td><strong>Age Group</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;60 (Reference)</td>
<td>1.00</td>
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</tr>
<tr>
<td>60-77</td>
<td>0.78 (0.49-1.25)</td>
<td>0.308</td>
</tr>
<tr>
<td>&gt;77</td>
<td>0.43 (0.19-0.95)</td>
<td>0.037</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.74 (0.44-1.23)</td>
<td>0.245</td>
</tr>
<tr>
<td><strong>Primary cause of ESKD</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diabetic nephropathy (Reference)</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Polycystic kidney disease</td>
<td>2.00 (0.74-5.40)</td>
<td>0.174</td>
</tr>
<tr>
<td>Glomerulonephritis</td>
<td>0.93 (0.37-2.35)</td>
<td>0.881</td>
</tr>
<tr>
<td>Characteristics</td>
<td>HR (95% CI) $^1$</td>
<td>p-value</td>
</tr>
<tr>
<td>---------------------------</td>
<td>-----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Hypertension</td>
<td>0.26 (0.05-1.36)</td>
<td>0.112</td>
</tr>
<tr>
<td>Other cause</td>
<td>0.51 (0.17-1.52)</td>
<td>0.226</td>
</tr>
<tr>
<td>Other urologic</td>
<td>1.10 (0.31-3.97)</td>
<td>0.880</td>
</tr>
<tr>
<td>Unknown/missing</td>
<td>0.65 (0.30-1.44)</td>
<td>0.288</td>
</tr>
</tbody>
</table>

**Comorbidities**

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>HR (95% CI) $^1$</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension</td>
<td>1.35 (0.82-2.22)</td>
<td>0.242</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.18 (0.60-2.34)</td>
<td>0.633</td>
</tr>
<tr>
<td>Cerebrovascular Disease</td>
<td>0.82 (0.31-2.14)</td>
<td>0.680</td>
</tr>
<tr>
<td>Congestive Heart Failure</td>
<td>0.99 (0.49-1.99)</td>
<td>0.976</td>
</tr>
<tr>
<td>Peripheral Vascular Disease</td>
<td>0.57 (0.17-1.95)</td>
<td>0.368</td>
</tr>
<tr>
<td>Atherosclerotic heart disease</td>
<td>0.73 (0.37-1.44)</td>
<td>0.366</td>
</tr>
<tr>
<td>BMI per 1 kg/m$^2$ increase</td>
<td>1.05 (1.02-1.08)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Serum Albumin per 1 g/l increase</td>
<td>1.04 (0.98-1.10)</td>
<td>0.216</td>
</tr>
<tr>
<td>Haemoglobin per 1 g/dl increase</td>
<td>1.15 (0.96-1.38)</td>
<td>0.140</td>
</tr>
<tr>
<td>Calcium per 1 mmol/L increase</td>
<td>1.16 (0.30-4.40)</td>
<td>0.832</td>
</tr>
</tbody>
</table>

$^1$ Hazard Ratio adjustments were made for dialysis centre, demographic and lifestyle characteristics (age group and body mass index), comorbid conditions, and primary cause of kidney disease and laboratory indicators. Body mass index was modelled as a linear variable, there was no evidence of conversion from CVC to AVF in this cohort for underweight participants. For primary centre the grand mean of all centres was used as the referent.