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A meta-analysis of the impact of initial hemodialysis access type on mortality in elderly incident hemodialysis population

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Abstract

Background Selecting the appropriate vascular access type for elderly patients before initiating hemodialysis presents a challenge, given their limited life expectancy and multiple comorbidities. This systematic review aims to evaluate whether initial arteriovenous access (AVa), including arteriovenous fistulas (AVF) and/or arteriovenous grafts (AVG), offers a benefit in reducing the risk of all-cause mortality compared to central venous catheters (CVC) for patients aged ≥ 65 years.

Methods We conducted searches in PubMed (from 1946 to March 20, 2023), Embase (from 1947 to 20 March 20, 2023), and the Cochrane Library to identify studies comparing the use of CVC with AVa as the initial vascular access in hemodialysis patients aged ≥ 65 years. The primary outcome of interest was all-cause mortality. We pooled the hazard ratio (HR) and 95% confidence intervals (CIs) of the included studies using a random-effect model. The Newcastle–Ottawa Scale was employed to assess the risk of bias for each included study.

Results Ten studies involving over 300,000 patients were included, all of which were retrospective cohort studies. Compared to AVa, the use of CVC as the initial dialysis access is associated with a higher incidence of all-cause mortality in patients aged ≥ 65 years (HR = 1.53, 95%CI = 1.41–1.67, $I^2 = 74.9$).

Conclusion In this analysis, we observed an increased risk of death in elderly patients initiating dialysis with CVC compared to those using AVa. However, the retrospective cohort studies included in this analysis are susceptible to selection bias, indicating that further randomized controlled trials are necessary to confirm these findings.

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Registration The protocol of this systematic review has been registered in the PROSPERO registry (CRD42023435577; https://www.crd.york.ac.uk/prospero).

Keywords Elderly, Hemodialysis, Mortality, Vascular access, Catheter

Introduction

Hemodialysis (HD) is one of the life-sustaining treatment modalities for patients with end-stage renal disease (ESRD) in all age groups. Adequate hemodialysis depends on proper vascular access (VA), which involves arteriovenous fistula (AVF), arteriovenous graft (AVG), and central venous catheter (CVC). Vascular access infection and intervention may be the leading causes of hospitalization

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and mortality in HD patients [1]. Therefore, selecting the optimal vascular access for individuals is crucial.

Data from the United States Renal Data System (USRDS) indicated that incidence of ESRD among individuals aged ≥ 65 years remains the highest in all age stratifications and the mortality increased more rapidly among the elderly HD patients than in younger patients between 2019 and 2020 [2]. A number of retrospective cohort studies have found that catheter use is associated with higher mortality compared with fistula or graft in adult HD patients [3–16]. As a result, arteriovenous access (AVa), which includes AVF and AVG, is currently recommended as the preferred vascular access for the general HD population according to clinical practice guidelines [17, 18]. However, AVa, particularly AVF is more commonly placed in younger patients with fewer comorbidities. This trend indicates that nephrologists are less likely to refer older patients with limited life expectancy and multiple comorbidities for AVF placement [19]. Several studies have demonstrated that elderly patients exhibit a relatively higher risk of failure to maturation or experience longer maturation times of pre-emptively placed AVF compared to their younger counterparts [20–23]. In the case of AVG, their use is limited due to higher intervention rates required to maintain patency [24]. As a consequence, catheters remain the most commonly utilized vascular access method among elderly patients at the initiation of HD [2]. Therefore, we conducted a systematic review and meta-analysis to quantify the risk of all-cause mortality in elderly patients who initiated HD with CVC compared to those who began HD with pre-emptively placed AVa.

Methods

The methodology adhered to the PRISMA guidelines and included the PRISMA flow diagram. Additionally, the protocol has been registered in the PROSPERO registry (CRD42023435577; https://www.crd.york.ac.uk/prospero).

Data sources and search strategies

We conducted searches in PubMed (from 1946 to March 20, 2023), Embase (from 1947 to March 20, 2023) and the Cochrane Library, without imposing any language restrictions, to identify relevant studies. We did not restrict the age of the population in our search strategy, as doing so could potentially exclude studies that included subgroups of the elderly population. The detailed retrieval strategy is outlined in Supplementary Table 1. Concurrently, the reference lists of the included studies were hand-searched at the same time. We conducted a preliminary screening of the titles and abstracts before retrieving the full texts of relevant studies. This retrieval process was carried out independently by two reviewers, and any disagreements were resolved through discussion.

Eligibility criteria and study selection

We defined the elderly as individuals aged ≥ 65 years; however, the definition of elderly varies significantly across studies. Consequently, we included the studies that enrolled elderly population across any age range starting from 65 years, as well as those that comprised subgroups of the elderly. Our objective was to investigate whether incident elderly patients could benefit from preemptively placed arteriovenous access (AVa) compared to central venous catheters (CVC). Therefore, we included studies that compared CVC with either fistulas or grafts, or a combination of the two. We excluded articles that enrolled prevalent patients who had undergone hemodialysis for an extended period, as well as those that analyzed the vascular access used after the initiation of hemodialysis. Longitudinal cohort studies, case–control studies, and controlled clinical trials were all deemed eligible for inclusion. The primary outcome measured was all-cause mortality, while the secondary outcomes were cardiovascular-related mortality and all-cause infection-related mortality. Studies should present estimates of relative risk (RR), hazard ratio (HR), or odds ratio (OR) along with confidence intervals (CIs) or standard errors for the association between the type of initial vascular access and mortality. In cases where relevant studies reported potentially overlapping cohorts, we selected the study with the largest cohort to avoid data duplication.

Data extraction and quality assessment

Two reviewers utilized a standardized form to extract data, including the first author, publication year, study type, region, data source, study period, duration of follow-up, cohort size, mean age, percentage of male participants, eligibility criteria for study entry, definition of the elderly, and adjustments for confounders. In instances where studies employed multiple multivariable adjusted models to assess risk estimates, we selected the estimates from the model that included the most comprehensive set of variables.

Additionally, two reviewers independently evaluated the risk of bias in the eligible studies using the Newcastle–Ottawa Scale (NOS), which is designed to assess the quality of nonrandomized studies [25]. The maximum score was 9 points; studies that achieved 7 points or above were classified as high quality, while those scoring 6 points or below were categorized as low quality [26].

Statistical analysis

We pooled the risk estimates and 95% confidence intervals (CIs) of the included studies using the Inverse Variance fixed effect model, unless high heterogeneity was present, in which case we employed the DerSimonian-Laird random effects model. A HR > 1 indicated a higher risk of mortality associated with CVC as initial vascular access. The 95% CI represents the potential range of the pooled HR; if the CI included 1, the result was deemed not statistically significant.

We utilized the Chi-Squared test and I^2 test to evaluate heterogeneity across the included studies. A P-value of less than 0.05 from the chi-squared test indicated significant heterogeneity. The I^2 test was employed to assess the impact of heterogeneity on our analysis with I^2 values categorized as follows: 0–25% indicating low heterogeneity, 25–50% moderate heterogeneity, 50–75% substantial heterogeneity, and 75–100% high heterogeneity. We conducted subgroup analyses based on data source, definition of elderly, region, follow-up duration, and sample size to investigate sources of heterogeneity. A P-value of less than 0.05 for differences between subgroups was considered significant. To explore the association between initial vascular access type and mortality across different age subgroups, we performed additional analyses categorizing patients into the following age groups: 65–74, 75–84, and ≥ 85 years.

To assess the robustness of our results, we conducted a sensitivity analysis by omitting the included studies one at a time. Eight studies reported potentially overlapping cohorts, and we included these studies separately in the sensitivity analyses [27].

To identify potential small-sample effects, we created a funnel plot and tested its asymmetry using Egger test.

We used GRADEpro GDT to create a "Summary of findings" table to report the certainty of evidence (GRADEpro GDT). According to GRADEpro GDT, we assigned four levels of quality of evidence: high, moderate, low, and very low.

Statistical analyses were performed using Stata 14.0 software (STATA Corporation, College Station, TX, USA).

Results

Study selection, characteristics and risk of bias

We identified 6462 citations through electronic searches and an additional 12 citations from reference lists after removing duplicates. The flow of the identification process is illustrated in Fig. 1. 17 studies met our inclusion criteria. Among these, eight studies utilized the same data source (USRDS) and had overlapping study periods [28–35], so we selected the study with the largest cohort to avoid data duplication [29]. Ultimately, we included ten studies in the meta-analysis, which collectively reported data on more than 300,000 patients, all of which were cohort studies [29, 36–44]. The characteristics of the included studies are presented in Table 1.

Five studies were conducted in North America, two in Europe, and two in Asia, while one study included data from North and South America, Asia–Pacific region and Europe. Among these, eight studies were based on the data of elderly subgroup drawn from adult cohorts, whereas two were specifically for elderly population. Sample sizes were reported for all studies except one [42], as we extracted data from a subgroup of an overall cohort consisting of 12,719 participants, and the specific number for the subgroup was not disclosed in that study. All studies reported a HR with 95% CI using multivariable Cox regression analysis.

Table 1 Characteristics of the studies included in the meta-analysis

Study ID	Publication Year	Study Type	Country	Data source	Study period	Mean Follow-up duration (years)	No.of Patients	Mean Age (years)	Male sex (%)	Eligibility criteria	definition of the elderly	Adjustmens		
												Comorbidities	Laboratory data	Predialysis care
Hicks	2015	retrospective cohort study	USA	the United States Renal Data System database (USRDS)	2006-2010	1.57	246380	NR	NR	≥65 years subgroup, no transplant, no death within 3 months of initiating dialysis	≥65 years	≥3	_	√
Kawanishi	2015	retrospective cohort study	Japan	Single hospital center in Japan	2003-2010	NR	130	NR	56	≥80 years subgroup, with fistula or temporary CVC, no graft, no permanent CVC, no CVC that could not be changed to other VA	≥80 years	≥3	serum urea, creatinine, albumin, hemoglobin and CRP	_
Kim	2019	retrospective cohort study	Korea	Single hospital center in Korea	2005-2012	2.9	504	72.4	57.2	≥65 years subgroup, underwent hemodialysis treatment for more than 3 consecutive months, no death within 3 months of initiating dialysis	≥65 years	2	_	_
Ko	2020	retrospective cohort study	USA	Single center in the USA	2007-2011	1.9	3756	85	53.85	≥80 years subgroup, HD for≥60d	≥80 years	≥3	serum albumin	_
Praga	2013	retrospective cohort study	Spain	63 centers in Spain	2007-2011	1.9	1841	79.7	61.6	≥ 75 years subgroup, ESRD≥6 months, HD for more than 3 consecutive months	≥ 75 years	≥3	_	_
Raimann	2017	retrospective cohort study	North- and South America, Asia-Pacific and Europe	multicenter in North- and South America, Asia-Pacific and Europe	2006-2012	1	NR	NR	NR	≥70 years	≥70 years	≥3	_	_
Zhang	2014	retrospective cohort study	Canada	Canadian Organ Replacement Register (CORR) database	2001-2010	3	23066	75.5	58.8	≥65 years subgroup	≥65 years	≥3	serum creatinine, albumin, and hemoglobin	_
Ocak	2011	retrospective cohort study	Netherlands	38 centers in the Netherlands	1997-2004	2	613	73.6	NR	≥65 years subgroup, no previous RRT and survival of the initial 3 months of dialysis	≥65 years	≥3	serum albumin, CRP, eGFR, and cholesterol	√
Xue	2003	retrospective cohort study	USA	US Medicare database	1995-1997	1	44244	74.6	51.2	≥67 years, incident HD patients, no PD, no transplant	≥67 years	1	serum albumin, creatinine and BUN	_
Quinn	2016	retrospective cohort study	Canada	Five medical centers in Canada	2004-2012	1	275	76	62	≥65years subgroup, undergoing predialysis fistula attempt, ESRD, outpatient HD, AKI requiring HD ≥28d, no PD, no transpalnt, no limited liife expectancy due to terminal illness, no AVG	≥65 years	≥3	serum albumin, hemoglobin,eGFR	√

NR: not reported

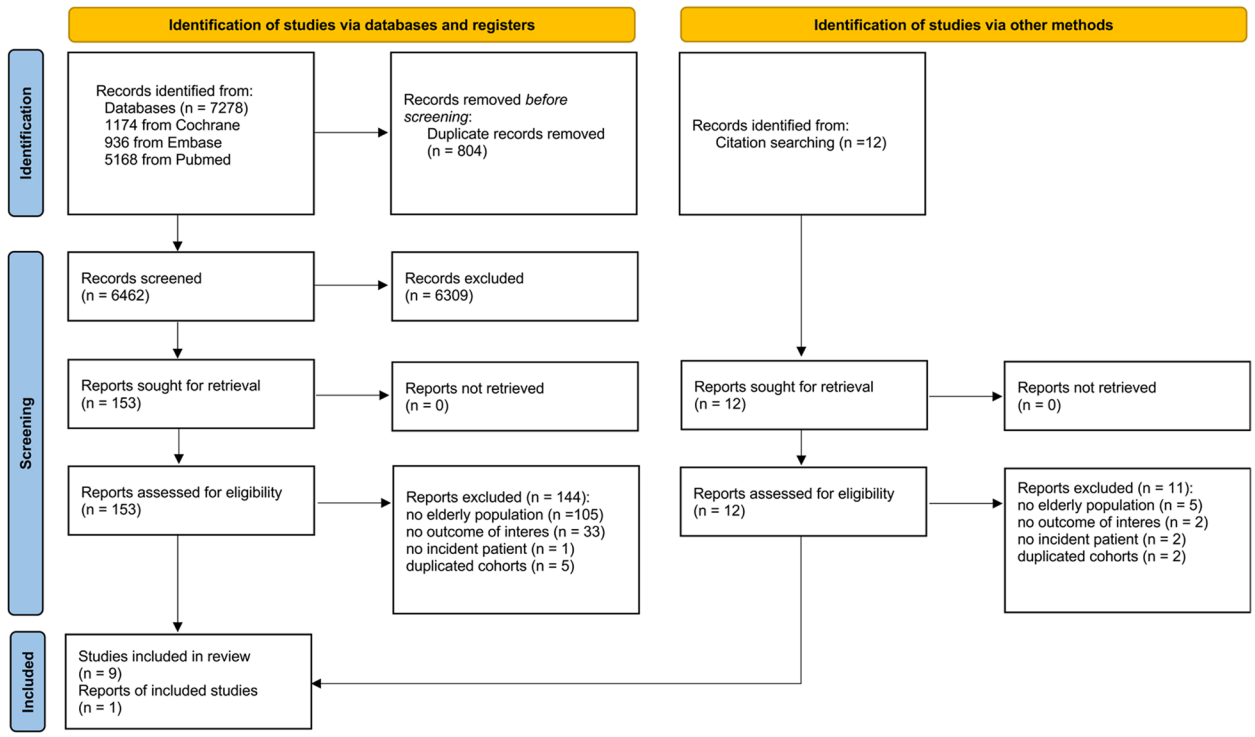


Fig. 1 Flow diagram of identification process

According to the NOS score, only one study was classified as high-quality (NOS score ≥ 7), while the remaining nine studies were deemed low-quality (NOS score < 7) (Supplementary Table 2). The distribution of bias domains according to the NOS in our analysis is presented in Table 2. Selection bias was evident in 90% of the studies, as all included studies were retrospective. The choice of vascular access type was not determined by randomized grouping but was instead influenced by patients' health status and vascular conditions. The

Table 2 Distribution of bias domains of NOS for each included study

Component	Studies, No.(%)
Selection	
Representativeness of the exposed cohort	
(whether the study takes measures to reduce the selection bias)	
Yes	1 (10%)
No or not reported	9 (90%)
Selection of the non-exposed cohort	
(whether the non-exposed cohort is derived from the same population as the exposed)	
Yes	1 (10%)
No or not reported	9 (90%)
Ascertainment of exposure	
Yes	7 (70%)
No or not reported	3 (30%)
Demonstration that outcome of interest was not present at start of study	
Yes	10 (100%)
No or not reported	0
Cohort comparability	
Studies controlled for possible confounders in analysis	
Controlled for age, sex, comorbidities and laboratory data	6 (60%)
Controlled for age, sex and comorbidities	4 (40%)
No or not reported	0
Outcome	
Asessment of outcome	
Adequate(government or hospital death records)	5 (50%)
Inadequate or not reported	5 (50%)
The length of follow-up enough for outcome to occur	
⩽1 year	3 (30%)
>1 year	7 (70%)
Adequacy of follow-up of cohorts	
Adequate (losses to follow-up reported and proportion of losses to follow-up ⩽10%)	1 (10%)
Inadequate (losses to follow-up not reported or proportion of losses to follow-up >10%	9 (90%)

cohorts receiving CVC tended to have poorer physical conditions and limited life expectancies. Although each study adjusted for confounders to varying extents, the potential for selection bias persisted. Notably, Quinn et al. [41] restricted the patient population to those who underwent a fistula attempt, thereby ensuring that the baseline health statuses of the two groups were comparable [41].

Whole group outcomes

All-cause mortality was reported in ten articles. Compared to patients who initiated HD with pre-emptively established AVa, those who began HD with CVC exhibited a 53% increased risk of all-cause mortality (HR = 1.53, 95%CI = 1.41–1.67, I^2 = 74.9, Fig. 2). Only two studies reported cardiovascular-related mortality and infection-related mortality respectively [28, 39]. The pooled estimates indicated that CVC was also associated with a higher risk of both cardiovascular-related mortality (HR = 2.13, 95%CI = 1.37–3.29) and infection-related mortality (HR = 2.57, 95%CI = 1.61–4.12) compared to AVa (Supplementary Fig. 1, Fig. 2). However, the limited number of included cohorts precludes drawing a credible conclusion.

Subgroup analysis

We conducted subgroup analyses to explore the sources of heterogeneity in the analysis of all-cause mortality (I2 = 74.9%) using predefined characteristics of eligible studies, including data source, definition of elderly, region, follow-up duration, and sample size (Supplementary Figs. 3–7). However, the I^2 remained high within the subgroups and the heterogeneity remained unexplained (Table 3).

The choice of vascular access type was not determined by randomized grouping; rather, it was influenced by patients' health status and vascular conditions. Clinical experience indicates that patients with poorer physical conditions and multiple comorbidities are more likely to be recommended for treatment with CVC. To mitigate selection bias, each study included in our analysis was adjusted for various confounding factors including sex, age, comorbidities, laboratory indicators, and medications to varying degrees; however, the specific items included in these adjustments varied significantly (Supplementary Table 4). This variation may partly account for the heterogeneity observed among the different studies. To further investigate this heterogeneity, we conducted post-hoc subgroup analyses based on three criteria: (1) whether the number of adjusted comorbidities was ≥ 3, (2) whether laboratory indicators were adjusted, and (3) whether pre-dialysis care was adjusted, as listed in Table 1. The results of these subgroup analyses indicated that none of these factors could sufficiently explain the observed heterogeneity among the studies (Supplementary Fig. 8–10). Given that it is common for patients to experience conversions of their VA type, particularly during the

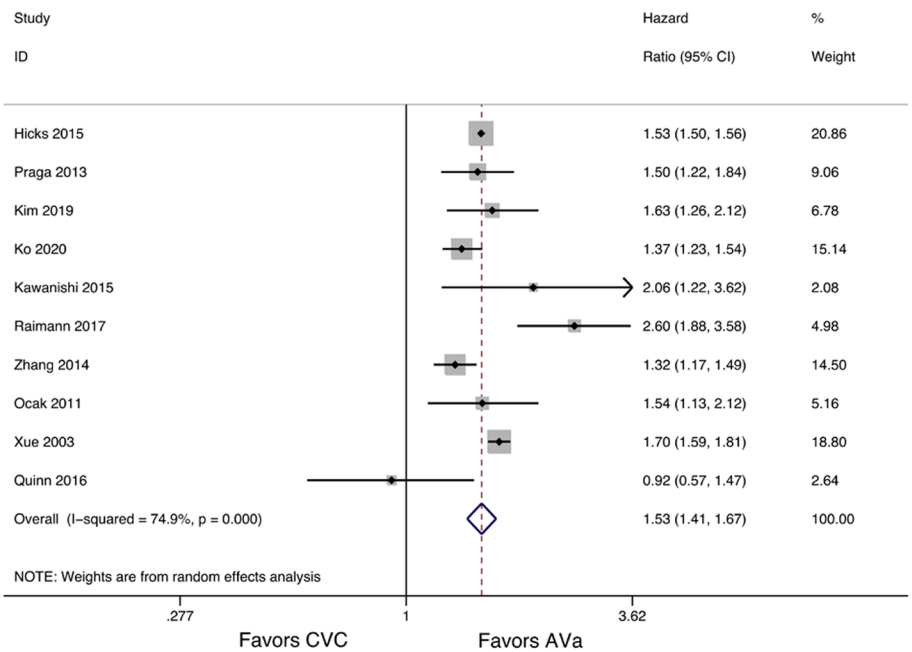
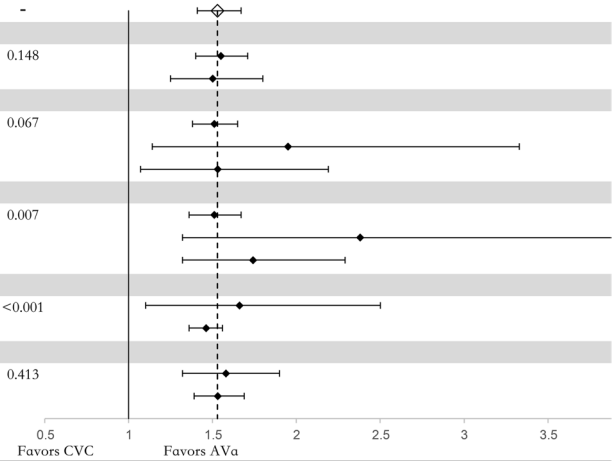


Fig. 2 Forest plot for risk of all-cause mortality for the use of central venous catheter vs. arteriovenous access at the initiation of hemodialysis in the elderly

Table 3 Subgroup analyses of the association between all-cause mortality and the use of central venous catheter vs. arteriovenous access according to study characteristics

Study characteristics	No. of studies	HR (95% CI)	P	Heterogeneity ($I2; \tau^2$)	P for between subgroups
All studies	10	1.53 (1.41, 1.67)	<0.001	75%, <0.001	-
Data source					
multi-center	7	1.55 (1.40, 1.71)	<0.001	80%, 0.010	0.148
single-center	3	1.50 (1.25, 1.80)	0.196	39%, 0.011	
Definition of elderly (years)					
⩾65 or ⩾67	6	1.51 (1.38,1.65)	<0.001	76%, 0.006	0.067
⩾70 or ⩾75	2	1.95 (1.14,3.33)	0.005	87%, 0.132	
⩾80	2	1.53 (1.07,2.19)	0.15	52%, 0.043	
Region					
North America	6[a]	1.51 (1.36,1.67)	<0.001	85%, 0.010	0.007
Asia	3[a]	2.38 (1.32,4.30)	0.003	83%, 0.224	
Europe	3[a]	1.74 (1.32,2.29)	0.024	73%, 0.043	
Follow-up duration					
⩽1	3	1.66 (1.10,2.50)	0.001	85%, 0.107	<0.001
>1	6	1.46 (1.36,1.56)	<0.001	46%, 0.003	
Sample size					
⩽5000	7	1.58 (1.32,1.90)	0.003	69%, 0.037	0.413
>5000	3	1.53 (1.39,1.69)	<0.001	87%, 0.006	



[a] Raimann et al. (2017) [42] comprised pre-set region groups of North America, Asia and Europe, and we separately included them into our subgroup analyses

first year after initiating dialysis, the varying proportions of VA type conversions may also contribute to the observed heterogeneity.

Subgroup analyses were subsequently conducted based on different age categories. The results indicated that patients with CVC as their initial dialysis access experienced higher mortality rates compared to those who initially used AVa in the age subgroups of 65–74, 75–84, and over 85 years (HR=1.53, 95% CI=1.32–1.76; HR=1.38, 95% CI=1.22–1.57; and HR=1.48, 95% CI=1.40–1.56, respectively) (Fig. 3).

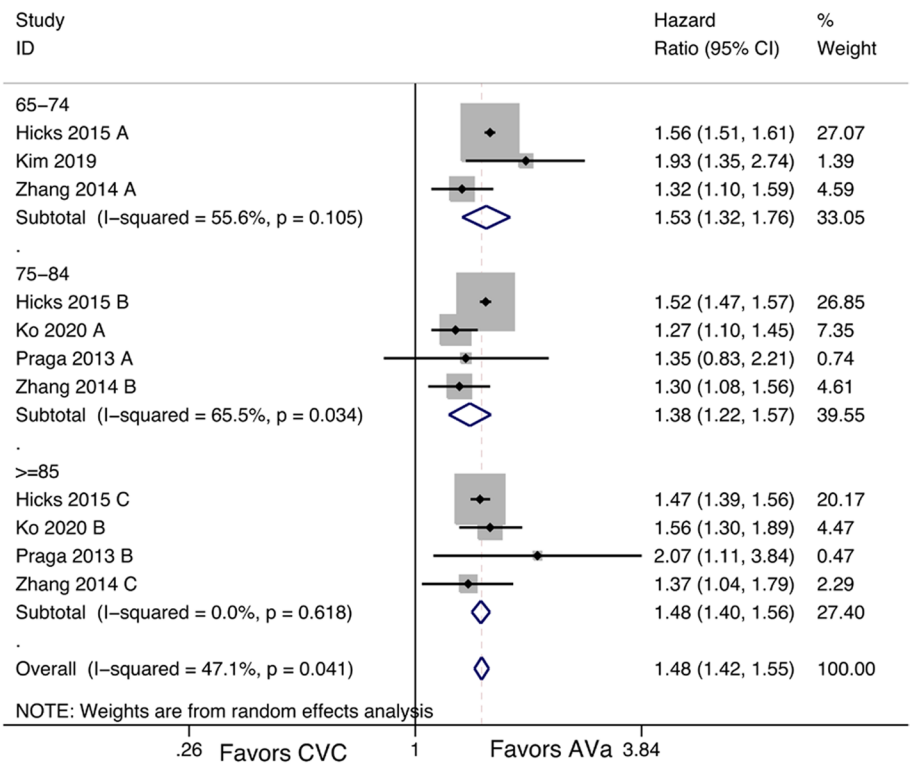


Fig. 3 Subgroup analyses of the association between all-cause mortality and the use of central venous catheter vs. arteriovenous access according to different age category

Sensitivity analysis and small-sample effect

The superior survival rate in patients utilizing AVa as initial dialysis access compared to those using CVC remained consistent in sensitivity analyses that excluded eligible studies one at a time (Supplementary Fig. 11). We also incorporated the other seven duplicated cohorts into our analysis, and the results remained robust [28, 30–35] (Supplementary Table 4).

Although the funnel plot displayed some asymmetry (Supplementary Fig. 12), we performed the Egger test to assess this asymmetry. The results indicated no evidence of a small-sample effect ($P=0.907$).

Certainty of evidence

Based on the evaluation conducted using GRADEpro, the level of evidence for this finding is assessed to be very low (Supplementary Table 5). The primary limitations arise from the study design, which presents a serious risk of bias, as well as inconsistencies in the research findings.

Discussion

Advanced age is recognized as an independent risk factor for maturation failure of arteriovenous fistula [21, 45] and inferior patency rates [21]. Elderly patients face a dilemma when selecting vascular access for hemodialysis, as both patients and physicians often prefer catheters due to the limited life expectancy and presence of comorbidities. However, the findings of this systematic review and meta-analysis provide evidence that the use of CVC at the initiation of hemodialysis is associated with a higher risk of mortality compared to preemptively placed AVa. In terms of type-specific cardiovascular-related mortality and infection-related mortality, two cohort studies indicate that CVC as initial HD access is associated with lower survival rate compared to AVa, which is consistent with findings from studies involving adult HD patients [3–16].

According to the cause-specific mortality data for hemodialysis patients reported in the annual report of USRDS, over half of the deaths with a known cause were attributed to cardiovascular disease, followed by all-cause infection accounting for 16.7% [2]. The distribution of causes of death among elderly patients exhibits a similar pattern [46]. In our review, we identified two studies indicating that elderly patients who initiated HD with a catheter had a higher risk of both cardiovascular-related and infection-related mortality compared to those who began HD with an AVa. This finding may contribute to the increased all-cause mortality observed in patients who initiated HD with a catheter; however, the limited number of included cohorts prevents us from drawing a definitive conclusion.

The following mechanism may account for the increased mortality observed in patients with CVC. The insertion of a catheter creates a foreign surface that facilitates bacteria colonization and the formation of biofilm, which can induce antimicrobial resistance. In the context of the compromised immune system present in patients with ESRD, catheter is associated with a higher risk of infection and mortality [47].

In addition, several studies have suggested that inflammation status, as indicated by the marker C-reactive protein (CRP), predict all-cause and cardiovascular mortality in hemodialysis patients by mediating endothelial dysfunction and accelerating atherosclerosis [48–50]. A subsequent study revealed that CRP levels in patients receiving dialysis through a non-infected catheter were higher compared to those receiving dialysis via a fistula [51]. This inflammation status, independent of infection in patients utilizing CVC, may contribute to the observed increase in mortality.

However, Ravani et al. [52] found that the associations between access type and all-cause mortality were nearly identical in models that excluded and included access complications. The hazard ratios were 2.00 (95% confidence interval, 1.55 to 2.58) for CVC compared to AVF when access complications were excluded, and 2.01 (95% confidence interval, 1.56 to 2.59) when access complications were included [52]. Another study by Quinn et al. [41] reported that among incident HD patients who had undergone a pre-dialysis fistula attempt, the inferior survival rate in patients treated with CVC was not related to complications of vascular access when compared to those using fistula as their vascular access [41]. It is likely that the association between VA type and all-cause mortality was influenced by factors independent of VA complications.

This study has strengths. It presents a quantitative analysis of the relationship between vascular access and outcomes in incident elderly HD patients, which to our knowledge, was conducted by few researchers. Our research findings indicate that AVa provides a significant survival advantage as the initial dialysis access for elderly patients, which has important implications for clinical practice. It has been reported that nearly 40% of patients begin dialysis late due to delayed referral to nephrologists, and such late referral (defined as less than three months prior to the initiation of dialysis) are associated with increased mortality during the first year of treatment [53]. These patients often experience emergencies, primarily acute pulmonary edema or hyperkalemia, and consequently start dialysis using CVCs during hospitalization; this group is referred to as "crashlander".The

emergent initiation of dialysis via CVC is linked to high rates of mortality and hospitalization [54]. Therefore, timely referrals and early access planning are essential for improving patient outcomes. Early planning facilitates adequate pre-dialysis preparation and ensures the selection of the most appropriate access type. Preoperative vascular assessment is critical in determining the feasibility and success rates of AVF or AVG creation. Routine preoperative vascular imaging has been shown to significantly enhance the placement of AVF and improve the adequacy of forearm fistulas for dialysis [55]. Furthermore, vascular assessment can help identify patients who are unsuitable for AVF, thereby avoiding unnecessary surgeries and associated complications.

We acknowledge that our analysis has some limitations. First, the studies included in our analysis may exhibit potential selection bias. In current clinical practice, maintenance hemodialysis patients are still advised to select an AVF as the preferred method of vascular access. However, this recommendation introduces inherent selection bias, as patients utilizing CVC often present with poorer health conditions. Several studies have identified common reasons for the use of CVCs, including inadequate pre-dialysis care, lack of surgical referral, failure to recover from acute kidney injury, an unexpectedly rapid decline in kidney function, transitions in dialysis modalities due to complications related to peritoneal dialysis, or changes in the decision regarding the initial dialysis method [56, 57]. Patients who initiate dialysis urgently are considered to be at a higher risk of mortality. To mitigate selection bias, each study included in our analysis was adjusted for various confounders. Moreover, one study excluded CVC that could not be converted to alternative vascular access [36], while three studies excluded deaths occurring within three months of initiating dialysis to eliminate fatalities attributable to pre-existing health conditions [29, 37, 39]. It is reported that, among patients aged ≥ 70 years, the use of CVCs has a more pronounced effect on outcomes than urgent initiation [58]. Large cohort studies can also help mitigate selection bias to some extent. Consequently, it remains unclear whether the selection bias is substantial enough to reverse the results, and the limitation does not preclude the utility of analyzing results from retrospective cohort studies. Notably, Quinn et al. [41] reported that in patients aged ≥ 65 years who underwent a predialysis fistula attempt, there was no significant difference in mortality between the CVC and AVF groups. They limited the patient population to individuals who had undergone a predialysis fistula attempt, ensuring that the baseline health status of the two groups was as comparable as possible [41]. This result is contrary to the findings from other studies included in our analysis, which did not limit the population to individuals who had previously attempted arteriovenous access before initiating dialysis. One possible explanation is that, as previously mentioned, individuals who start dialysis urgently are treated preferentially with CVC in the unrestricted elderly population and may exhibit poorer health status. However, it is important to note that the population who has attempted AVF creation before initiating dialysis exhibits notable differences in medical interventions, including dialysis protocols and the quality of care, compared to those who have not. These differences may also influence patient survival rates, potentially obscuring the survival benefits associated with AVF. In this context, only double-blind randomized controlled trials can effectively minimize this selection bias. Nevertheless, our literature search indicates that no randomized controlled studies have been conducted to randomly assign patients based on their initial choice of vascular access. Achieving such randomization is challenging, as variations in vascular conditions, comorbidities, life expectancy and urgency of the condition among patients can significantly influence the decision to utilize either an AVa or a CVC. Second, preoperative vessel assessment is crucial for determining the appropriate type of vascular access. Unfortunately, none of the ten included studies addressed whether a vascular assessment was conducted prior to establishing vascular access, nor did they specify the method of vascular evaluation performed. This omission raises concerns regarding potential confounding factors. To address this gap, it is recommended that future studies systematically document vascular status and preoperative vessel assessment methods before the establishment of access. Third, our analysis was based on the type of vascular access at the point of dialysis initiation. However, it is common for patients to experience conversions of their VA type, particularly during the first year after initiating dialysis. Given that AVF maturation can take 3–12 months [59], patients who require the initiation of hemodialysis via a CVC in emergency situations may be advised to establish an AVF or AVG once their health has stabilized, contingent upon the suitability of their vascular conditions. Furthermore, AVF or AVG may be abandoned due to complications such as maturation failure, thrombosis, or stenosis, which can impede adequate patency [60]. This variability may lead to misclassification of the VA type, potentially affecting the observed association between VA type and mortality [61]. Several studies subdivide VA types into different groups, including CVC only, AVF/ AVG only, placement of AVF/AVG from CVC and placement of CVC from failed AVF/

AVG, and conduct pairwise comparisons. However, the majority of these studies have been primarily focused on adult populations, which highlights a significant gap in the evidence concerning elderly patients. Lastly, the heterogeneity in our analysis were substantial and the prespecified subgroup analysis cannot identify the potential source of the heterogeneity. We speculate that the heterogeneity arises from residual selection bias and variation in proportion of conversion of VA type subsequently. Given the above bias of observational studies, future randomized controlled trials are necessary.

Conclusions

In the elderly population undergoing hemodialysis population, the use of CVC as the initial vascular access is associated with higher mortality compared to AVa. This association remains significant in the subgroup of very elderly patients (those over 85 years of age). However, the strength of the available evidence is limited by potential selection bias inherent in cohort studies; therefore, randomized controlled trials should be prioritized.

Abbreviations

HD	Hemodialysis
AVa	Arteriovenous access
VA	Vascular access
CVC	Central venous catheter
AVF	Arteriovenous fistula
AVG	Arteriovenous graft
ESRD	End-stage renal disease
RR	Relative risk
HR	Hazard ratio
OR	Odds ratio
Cis	Confidence intervals
NOS	Newcastle–Ottawa Scale
USRDS	The United States Renal Data System
CRP	C-reactive protein

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions

Conceptualization: YC; Methodology: XT, YC; Data curation: XT, NH; Formal analysis: XT, NH; Data interpretation: XT, NH, DS, LL, YC; Writing-original draft: XT, YC; Writing-review and editing: XT, NH, DS, LL, YC; Supervision: YC; All authors have made an intellectual contribution to the manuscript and approved the submission. All authors have made an intellectual contribution to the manuscript and approved the submission.

Data availability

All data generated or analysed during this study are included in this published article and its supplementary information files.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Lok CE, Foley R. Vascular Access Morbidity and Mortality: Trends of the Last Decade. Clin J Am Soc Nephrol. 2013;8(7):1213–9.
2. United States Renal Data System Annual Data Report 2022 [May 20, 2023]; Available from: https://usrds-adr.niddk.nih.gov.
3. Yap HY, Pang SC, Tan CS, Tan YL, Goh N, Achudan S, et al. Catheter-related complications and survival among incident hemodialysis patients in Singapore. J Vasc Access. 2018;19(6):602–8.
4. Taylor G, Gravel D, Johnston L, Embil J, Holton D, Paton S. Prospective surveillance for primary bloodstream infections occurring in Canadian hemodialysis units. Infect Control Hosp Epidemiol. 2002;23(12):716–20.
5. Stevenson KB, Hannah EL, Lowder CA, Adcox MJ, Davidson RL, Mallea MC, et al. Epidemiology of hemodialysis vascular access infections from longitudinal infection surveillance data: predicting the impact of NKF-DOQI clinical practice guidelines for vascular access. Am J Kidney Dis. 2002;39(3):549–55.
6. Soleymanian T, Sheikh V, Tareh F, Argani H, Ossareh S. Hemodialysis vascular access and clinical outcomes: an observational multicenter study. J Vasc Access. 2017;18(1):35–42.
7. Rivara MB, Soohoo M, Streja E, Molnar MZ, Rhee CM, Cheung AK, et al. Association of Vascular Access Type with Mortality, Hospitalization, and Transfer to In-Center Hemodialysis in Patients Undergoing Home Hemodialysis. Clin J Am Soc Nephrol. 2016;11(2):298–307.
8. Perl J, Nessim SJ, Moist LM, Wald R, Na Y, Tennankore KK, et al. Vascular Access Type and Patient and Technique Survival in Home Hemodialysis Patients: The Canadian Organ Replacement Register. Am J Kidney Dis. 2016;67(2):251–9.
9. Pastan S, Soucie JM, McClellan WM. Vascular access and increased risk of death among hemodialysis patients. Kidney Int. 2002;62(2):620–6.
10. Ozeki T, Shimizu H, Fujita Y, Inaguma D, Maruyama S, Ohyama Y, et al. The Type of Vascular Access and the Incidence of Mortality in Japanese Dialysis Patients. Intern Med. 2017;56(5):481–5.
11. Murakami M, Fujii N, Kanda E, Kikuchi K, Wada A, Hamano T, et al. Association of four types of vascular access including arterial superficialization with mortality in maintenance hemodialysis patients: a nationwide cohort study in Japan. Am J Nephrol. 2023;54(3-4):83–94.
12. Malas MB, Canner JK, Hicks CW, Arhuidese IJ, Zarkowsky DS, Qazi U, et al. Trends in incident hemodialysis access and mortality. JAMA Surg. 2015;150(5):441–8.
13. Lugon JR, Neves P, Pio-Abreu A, do Nascimento MM, Sesso R. Evaluation of central venous catheter and other risk factors for mortality in chronic hemodialysis patients with COVID-19 in Brazil. Int Urol Nephrol. 2022;54(1):193–9.
14. Lorenzo V, Martn M, Rufino M, Hernández D, Torres A, Ayus JC. Predialysis nephrologic care and a functioning arteriovenous fistula at entry are associated with better survival in incident hemodialysis patients: an observational cohort study. Am J Kidney Dis. 2004;43(6):999–1007.
15. Hamadneh SA, Nueirat SA, Qadoomi J, Shurrab M, Qunibi WY, Hamdan Z. Vascular access mortality and hospitalization among hemodialysis

patients in Palestine. Saudi journal of kidney diseases and transplantation : an official publication of the Saudi Center for Organ Transplantation, Saudi Arabia. 2018;29(1):120–6.
16. Chiu CH, Wang CY, Moi SH, Wu CH, Yang CH, Chen JB. Comparison of tunneled central venous catheters and native arteriovenous fistulae by evaluating the mortality and morbidity of patients with prevalent hemodialysis. J Formos Med Assoc. 2019;118(4):807–14.
17. Schmidli J, Widmer MK, Basile C, de Donato G, Gallieni M, Gibbons CP, et al. Editor's Choice - Vascular Access: 2018 Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). Eur J Vasc Endovasc Surg. 2018;55(6):757–818.
18. Lok CE, Huber TS, Lee T, Shenoy S, Yevzlin AS, Abreo K, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. Am J Kidney Dis. 2020;75(4, Supplement 2):S1-S164.
19. Xi W, MacNab J, Lok CE, Lee TC, Maya ID, Mokrzycki MH, et al. Who should be referred for a fistula? A survey of nephrologists. Nephrol Dial Transplant. 2010;25(8):2644–51.
20. Lok CE, Oliver MJ, Su J, Bhola C, Hannigan N, Jassal SV. Arteriovenous fistula outcomes in the era of the elderly dialysis population. Kidney Int. 2005;67(6):2462–9.
21. Lazarides MK, Georgiadis GS, Antoniou GA, Staramos DN. A meta-analysis of dialysis access outcome in elderly patients. J Vasc Surg. 2007;45(2):420–6.
22. Hod T, DeSilva RN, Patibandla BK, Vin Y, Brown RS, Goldfarb-Rumyantzev AS. Factors predicting failure of AV "fistula first" policy in the elderly. Hemodial Int. 2014;18(2):507–15.
23. Hayden JA, Côté P, Bombardier C. Evaluation of the quality of prognosis studies in systematic reviews. Ann Intern Med. 2006;144(6):427–37.
24. Woodside KJ, Repeck KJ, Mukhopadhyay P, Schaubel DE, Shahinian VB, Saran R, et al. Arteriovenous Vascular Access-Related Procedural Burden Among Incident Hemodialysis Patients in the United States. Am J Kidney Dis. 2021;78(3):369-79.e1.
25. Wells G SB, O'Connell D, Peterson J, Welch V, Losos M. The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses.; Available from: https://www.ohri.ca/programs/clinical_epidemiology/oxford.asp.
26. Kim HS, Kim TH, Chung HH, Song YS. Risk and prognosis of ovarian cancer in women with endometriosis: a meta-analysis. Br J Cancer. 2014;110(7):1878–90.
27. Ravani P, Palmer SC, Oliver MJ, Quinn RR, MacRae JM, Tai DJ, et al. Associations between hemodialysis access type and clinical outcomes: a systematic review. J Am Soc Nephrol. 2013;24(3):465–73.
28. Saleh T, Sumida K, Molnar MZ, Potukuchi PK, Thomas F, Lu JL, et al. Effect of Age on the Association of Vascular Access Type with Mortality in a Cohort of Incident End-Stage Renal Disease Patients. Nephron. 2017;137(1):57–63.
29. Hicks CW, Canner JK, Arhuidese I, Zarkowsky DS, Qazi U, Reifsnyder T, et al. Mortality benefits of different hemodialysis access types are age dependent. J Vasc Surg. 2015;61(2):449–56.
30. Grubbs V, Wasse H, Vittinghoff E, Grimes BA, Johansen KL. Health status as a potential mediator of the association between hemodialysis vascular access and mortality. Nephrol Dial Transplant. 2014;29(4):892–8.
31. Foley RN, Chen SC, Collins AJ. Hemodialysis access at initiation in the United States, 2005 to 2007: still "catheter first." Hemodial Int. 2009;13(4):533–42.
32. DeSilva RN, Sandhu GS, Garg J, Goldfarb-Rumyantzev AS. Association between initial type of hemodialysis access used in the elderly and mortality. Hemodial Int. 2012;16(2):233–41.
33. DeSilva RN, Patibandla BK, Vin Y, Narra A, Chawla V, Brown RS, et al. Fistula first is not always the best strategy for the elderly. J Am Soc Nephrol. 2013;24(8):1297–304.
34. Brown RS, Patibandla BK, Goldfarb-Rumyantzev AS. The Survival Benefit of "Fistula First, Catheter Last" in Hemodialysis Is Primarily Due to Patient Factors. J Am Soc Nephrol. 2017;28(2):645–52.
35. Arhuidese IJ, Cooper MA, Rizwan M, Nejim B, Malas MB. Vascular access for hemodialysis in the elderly. J Vasc Surg. 2019;69(2):517-25.e1.
36. Kawanishi H, Shintaku S, Moriishi M. Vascular access in super-aged patients. J Vasc Access. 2015;16(Suppl 10):S22–7.
37. Kim HY, Bae EH, Ma SK, Kim SW. Association between initial vascular access and survival in hemodialysis according to age. Korean J Intern Med. 2019;34(4):867–76.
38. Ko GJ, Rhee CM, Obi Y, Chang TI, Soohoo M, Kim TW, et al. Vascular access placement and mortality in elderly incident hemodialysis patients. Nephrol Dial Transplant. 2020;35(3):503–11.
39. Ocak G, Halbesma N, Le Cessie S, Hoogeveen EK, Van Dijk S, Kooman J, et al. Haemodialysis catheters increase mortality as compared to arteriovenous accesses especially in elderly patients. Nephrol Dial Transplant. 2011;26(8):2611–7.
40. Praga M, Merello JI, Palomares I, Bayh I, Marcelli D, Aljama P, et al. Type of vascular access and survival among very elderly hemodialysis patients. Nephron Clin Pract. 2013;124(1–2):47–53.
41. Quinn RR, Oliver MJ, Devoe D, Poinen K, Kabani R, Kamar F, et al. The Effect of Predialysis Fistula Attempt on Risk of All-Cause and Access-Related Death. J Am Soc Nephrol. 2017;28(2):613–20.
42. Raimann JG, Barth C, Usvyat LA, Preciado P, Canaud B, Etter M, et al. Dialysis Access as an Area of Improvement in Elderly Incident Hemodialysis Patients: Results from a Cohort Study from the International Monitoring Dialysis Outcomes Initiative. Am J Nephrol. 2017;45(6):486–96.
43. Xue JL, Dahl D, Ebben JP, Collins AJ. The association of initial hemodialysis access type with mortality outcomes in elderly Medicare ESRD patients. Am J Kidney Dis. 2003;42(5):1013–9.
44. Zhang JC, Al-Jaishi AA, Na Y, de Sa E, Moist LM. Association between vascular access type and patient mortality among elderly patients on hemodialysis in Canada. Hemodial Int. 2014;18(3):616–24.
45. Feldman HI, Joffe M, Rosas SE, Burns JE, Knauss J, Brayman K. Predictors of successful arteriovenous fistula maturation. Am J Kidney Dis. 2003;42(5):1000–12.
46. Foote C, Ninomiya T, Gallagher M, Perkovic V, Cass A, McDonald SP, et al. Survival of elderly dialysis patients is predicted by both patient and practice characteristics. Nephrol Dial Transplant. 2012;27(9):3581–7.
47. Wang L, Jia L, Jiang A. Pathology of catheter-related complications: what we need to know and what should be discovered. J Int Med Res. 2022;50(10):3000605221127890.
48. Zimmermann J, Herrlinger S, Pruy A, Metzger T, Wanner C. Inflammation enhances cardiovascular risk and mortality in hemodialysis patients. Kidney Int. 1999;55(2):648–58.
49. Yeun JY, Levine RA, Mantadilok V, Kaysen GA. C-Reactive protein predicts all-cause and cardiovascular mortality in hemodialysis patients. Am J Kidney Dis. 2000;35(3):469–76.
50. Arici M, Walls J. End-stage renal disease, atherosclerosis, and cardiovascular mortality: is C-reactive protein the missing link? Kidney Int. 2001;59(2):407–14.
51. Goldstein SL, Ikizler TA, Zappitelli M, Silverstein DM, Ayus JC. Non-infected hemodialysis catheters are associated with increased inflammation compared to arteriovenous fistulas. Kidney Int. 2009;76(10):1063–9.
52. Ravani P, Quinn R, Oliver M, Robinson B, Pisoni R, Pannu N, et al. Examining the Association between Hemodialysis Access Type and Mortality: The Role of Access Complications. Clin J Am Soc Nephrol. 2017;12(6):955–64.
53. de Jager DJ, Voormolen N, Krediet RT, Dekker FW, Boeschoten EW, Grootendorst DC, et al. Association between time of referral and survival in the first year of dialysis in diabetics and the elderly. Nephrol Dial Transplant. 2010;26(2):652–8.
54. Shimizu Y, Nakata J, Yanagisawa N, Shirotani Y, Fukuzaki H, Nohara N, et al. Emergent initiation of dialysis is related to an increase in both mortality and medical costs. Sci Rep. 2020;10(1):19638.
55. Allon M, Lockhart ME, Lilly RZ, Gallichio MH, Young CJ, Barker J, et al. Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. Kidney Int. 2001;60(5):2013–20.
56. Steinberg AG, Mount PF, Branagan M, Toussaint ND. Tunnelled central venous catheters for incident haemodialysis patients: a Victorian survey exploring reasons for use. Intern Med J. 2023;53(11):2079–84.
57. Lenz O, Sadhu S, Fornoni A, Asif A. Overutilization of Central Venous Catheters in Incident Hemodialysis Patients: Reasons and Potential Resolution Strategies. Semin Dial. 2006;19(6):543–50.
58. Alizada U, Sauleau E-A, Krummel T, Moranne O, Kazes I, Couchoud C, et al. Effect of emergency start and central venous catheter on outcomes in incident hemodialysis patients: a prospective observational cohort. J Nephrol. 2022;35(3):977–88.
59. Huber TS, Berceli SA, Scali ST, Neal D, Anderson EM, Allon M, et al. Arteriovenous Fistula Maturation, Functional Patency, and Intervention Rates. JAMA Surg. 2021;156(12):1111–8.

60. Bylsma LC, Gage SM, Reichert H, Dahl SLM, Lawson JH. Arteriovenous Fistulae for Haemodialysis: A Systematic Review and Meta-analysis of Efficacy and Safety Outcomes. Eur J Vasc Endovasc Surg. 2017;54(4):513–22.
61. Astor BC, Eustace JA, Powe NR, Klag MJ, Fink NE, Coresh J. Type of vascular access and survival among incident hemodialysis patients: The choices for healthy outcomes in caring for ESRD (CHOICE) study. J Am Soc Nephrol. 2005;16(5):1449–55.

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