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Authors

Woo, Karen
Ulloa, Jesus
Allon, Michael
et al.

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Establishing patient-specific criteria for selecting the optimal upper extremity vascular access procedure

Karen Woo, MD[a], **Jesus Ulloa, MD**[b], **Michael Allon, MD**[c], **Christopher G. Carsten III, MD**[d], **Eric S. Chemla, MD**[e], **Mitchell L. Henry, MD**[f], **Thomas S. Huber, MD**[g], **Jeffrey H. Lawson, MD**[h], **Charmaine E. Lok, MD**[i], **Eric K. Peden, MD**[j], **Larry Scher, MD**[k], **Anton Sidawy, MD**[l], **Melinda Maggard-Gibbons, MD**[m], and **David Cull, MD**[d]

[a]Division of Vascular Surgery, David Geffen School of Medicine, University of California, Los Angeles

[b]Department of Surgery, UCSF School of Medicine, University of California, San Francisco

[c]Division of Nephrology, University of Alabama School of Medicine, University of Alabama, Birmingham

[d]Division of Vascular Surgery, University of South Carolina School of Medicine, University of South Carolina, Greenville

[e]St. George's University Hospitals NHS Foundation Trust Vascular Institute, St. George's University, London

[f]Division of Transplantation Surgery, The Ohio State University College of Medicine, The Ohio State University, Columbus

[g]Division of Vascular Surgery, University of Florida College of Medicine, University of Florida, Gainesvil-le

[h]Division of Vascular Surgery, Duke University School of Medicine, Duke University, Durham

[i]Department of Medicine, Faculty of Medicine, University of Toronto, Toronto

[j]Department of Cardiovascular Surgery, Houston Methodist Hospital, Houston

Correspondence: Karen Woo, MD, 200 UCLA Medical Plaza, Ste 526, Los Angeles, CA 90095 (kwoo@mednet.ucla.edu).

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Overall responsibility: KW

[k]Department of Cardiothoracic and Vascular Surgery, Albert Einstein College of Medicine, Bronx

[l]Division of Vascular Surgery, George Washington School of Medicine and Health Sciences, George Washington University, Washington, D.C

[m]Department of Surgery, David Geffen School of Medicine, University of California, Los Angeles

Abstract

Objective—The Kidney Disease Outcome Quality Initiative and Fistula First Breakthrough Initiative call for the indiscriminate creation of arteriovenous fistulas (AVFs) over arteriovenous grafts (AVGs) without providing patient-specific criteria for vascular access selection. Although the U.S. AVF rate has increased dramatically, several reports have found that this singular focus on increasing AVFs has resulted in increased AVF nonmaturation/early failure and a high prevalence of catheter dependence. The objective of this study was to determine the appropriateness of vascular access procedures in clinical scenarios constructed with combinations of relevant factors potentially influencing outcomes.

Methods—The RAND/UCLA Appropriateness Method was used. Accordingly, a comprehensive literature search was performed and a synthesis of results compiled. The RAND/UCLA Appropriateness Method was applied to 2088 AVF and 1728 AVG clinical scenarios with varying patient characteristics. Eleven international vascular access experts rated the appropriateness of each scenario in two rounds. On the basis of the distribution of the panelists' scores, each scenario was determined to be appropriate, inappropriate, or indeterminate.

Results—Panelists achieved agreement in 2964 (77.7%) scenarios; 860 (41%) AVF and 588 (34%) AVG scenarios were scored appropriate, 686 (33%) AVF and 480 (28%) AVG scenarios were scored inappropriate, and 542 (26%) AVF and 660 (38%) AVG scenarios were indeterminate. Younger age, larger outflow vein diameter, normal or obese body mass index (vs morbidly obese), larger inflow artery diameter, and higher patient functional status were associated with appropriateness of AVF creation. Older age, dialysis dependence, and smaller vein size were associated with appropriateness of AVG creation. Gender, diabetes, and coronary artery disease were not associated with AVF or AVG appropriateness. Dialysis status was not associated with AVF appropriateness. Body mass index and functional status were not associated with AVG appropriateness. To simulate the surgeon's decision-making, scenarios were combined to create situations with the same patient characteristics and both AVF and AVG options for access. Of these 864 clinical situations, 311 (36%) were rated appropriate for AVG but inappropriate or indeterminate for AVF.

Conclusions—The results of this study indicate that patient-specific situations exist wherein AVG is as appropriate as or more appropriate than AVF. These results provide patient-specific recommendations for clinicians to optimize vascular access selection criteria, to standardize care, and to inform payers and policy. Indeterminate scenarios will guide future research.

More than 400,000 patients in the United States with end-stage kidney disease (ESKD) were hemodialysis dependent in 2013.[1] The financial impact of ESKD and hemodialysis on the U.S. health care system is enormous. Medicare costs for ESKD were $30.9 billion in 2013 with an annual per-person expenditure of $84,550 in the hemodialysis population.[1]

The Fistula First Breakthrough Initiative (FFBI) introduced by the Centers for Medicare and Medicaid Services in 2004 initially established a target of 40% arteriovenous fistula (AVF) utilization among the prevalent hemodialysis population and subsequently raised the target to 66%.[2] Since the implementation of the FFBI, the percentage of prevalent hemodialysis patients using an AVF has increased from 37.6% in 2004 to 62.5% in 2013.[1] Graft placement decreased significantly, and although still too high, total catheter rates decreased modestly, with catheters >90 days present in <10% of prevalent dialysis patients.[1] With this increase in prevalence of AVF, a debate has emerged regarding the role of arteriovenous grafts (AVGs) and the potential for further reduction in catheter exposure.[3] The FFBI itself recently clarified its message that "fistula first" does not mean "fistula only."[4] However, it remains unclear how to identify those patients in whom an AVF may not be appropriate.

Although clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access exist, they offer general recommendations that are often not actionable on an individual patient level.[5,6] A multitude of patient characteristics may influence the outcome of a hemodialysis access procedure, including sex, race, age, comorbidities such as diabetes and hypertension, vascular anatomy, obesity, and socioeconomic issues. The results of the Hemodialysis Fistula Maturation study, a prospective National Institutes of Health-funded observational study of AVF maturation, will help elucidate factors that influence AVF maturation.[7] Nevertheless, the results will likely not be able to address difficult access decisions that must often be made in complicated hemodialysis access patients. Ideally, an evidence-based approach would be applied to each hemodialysis patient. However, the available evidence is based on population-level data rather than on patient-level data. Furthermore, the necessary individualized nature of hemodialysis vascular access selection and care renders classic study methods, such as randomized controlled trials and case-controlled studies, for every possible clinical scenario not feasible.

In this situation, the RAND/UCLA Appropriateness Method (RAM) can be applied to determine appropriateness criteria for hemodialysis patients. The RAM was developed in the mid-1980s by the RAND Corporation and the University of California-Los Angeles as a tool to "measure the appropriateness of care."[8] In the RAM, an appropriate procedure is "one in which the expected health benefit exceeds the expected negative consequences by a sufficiently wide margin that the procedure is worth doing."[8] When the RAM is applied as described, it combines the best available scientific evidence with the collective judgment of experts to produce a statement that addresses appropriateness of a procedure at patient-specific levels, taking into account relevant factors that may influence outcome. The RAM has been extensively validated and used in numerous medical procedures, including coronary angiography, coronary artery bypass graft surgery, carotid endarterectomy, abdominal aortic aneurysm surgery, and bariatric surgery.[9–14] The purpose of this study was to develop appropriateness criteria to help select the most appropriate type of hemodialysis vascular access creation for individual patients.

METHODS

The RAM starts with an extensive literature review and meta-analysis studying the risks and benefits of the procedure in question. A set of clinical scenarios for the procedure are then developed with specific definitions for any terms that could be ambiguous. The expert panel then rates all scenarios in two rounds. The ratings are analyzed using a validated mathematical formula designated by the RAM to determine appropriateness. All results are based on expert rating of hypothetical scenarios, with no involvement of actual patients or patient data.

Systematic review

A systematic review and meta-analysis of factors influencing hemodialysis vascular access outcomes were performed by the Mayo Clinic Knowledge and Evaluation Research Unit in conjunction with the principal investigators (D.C., K.W.). The results were distributed to the panelists for reference in conjunction with the scenarios so that the panelists could use the results in considering their ratings. The results of the systematic review and meta-analysis have been published under separate cover.[15]

Panel selection

The panel was composed of 11 physicians (2 nephrologists, 1 transplant surgeon, and 8 vascular surgeons; Table I). The panelists were selected on the basis of peer recommendations as dialysis vascular access experts who had clinical or research expertise in the construction and management of dialysis vascular access. In selecting panelists, we attempted to be inclusive of panelists from countries other than the United States as well as a range of medical specialties. Whereas panelists did not represent any professional organizations, they are leaders in the respective organizations in which they are involved. All invitees agreed to participate.

Scenarios

Based on the literature review, 3816 clinical scenarios for upper extremity AVF and AVG were developed to make the scenarios applicable to a majority of the hemodialysis population. The scenarios were developed by the primary investigators (K.W., D.C.) under advisement by an expert RAM investigator (M.M.G.). Every scenario included details of the patient's age, dialysis status, relevant vein diameter, and specific vascular access operation. The operations included radial-cephalic fistula (n = 504), forearm basilic vein transposition (n = 504), forearm loop graft (n = 864), brachial-cephalic fistula (n = 432), upper arm basilic vein transposition (n = 432), brachial-brachial transposition (n = 216), and upper arm graft (n = 864; Table II). Each scenario also included details about one of the following characteristics: sex, diabetes, coronary artery disease, body mass index, inflow artery diameter (for access based on a wrist artery only), or patient functional status. Each data point was defined in instructions sent to the panelists (Table II). Of note, because the diameter cutoff in the literature for a vein that is more likely to result in a successful fistula is unclear, we did not attempt to define these numbers. Although we did use specific diameters in the scenarios, the panelists were instructed to regard these as "small, medium, and large," according to their own practices (Table II). Similarly, although we used defined

age categories (<60, 60–75, and >75 years) for ease of scenario writing, panelists were instructed to view the categories as "young, older, and elderly."

The factors chosen for the scenarios were determined from the literature review to be factors that had been previously studied by multiple investigators and therefore assumed to be factors widely considered to be associated with vascular access outcomes. Other factors that were originally considered for inclusion in scenarios were years on dialysis (dialysis vintage), history of failed accesses, history of hypotension with dialysis, history of access infections, and inflow artery calcification. However, the association of many of these factors with vascular access outcomes is poorly studied in the literature. Therefore, it was determined by the primary investigators that because of limited evidence and the recommendation by RAND that the upper limit of scenarios be 2000, some factors that were originally considered were not ultimately included in the scenarios.

Rating

All panelists rated every scenario twice. Ratings were performed in two rounds. In the first round, the rating sheets (Fig) were sent to the panelists together with instructions and a summary of the results of the literature review and meta-analysis. Panelists were instructed to rate the appropriateness level of each scenario on a 1- to 9-point scale (1, risks clearly exceed the benefits by a wide margin, suggesting that the indicator is very inappropriate; and 9, benefits clearly exceed the risks by a wide margin, suggesting that the indicator is very appropriate). A score of 5 means that the scenario is of uncertain or equivocal appropriateness. Panelists performed the ratings independently and returned the rating sheets.

In the second round of rating, panelists convened in person during 1 day to discuss the scenarios. Two panelists were unable to attend and participated by conference call. During the second round of rating, each panelist was supplied with a new set of rating sheets that included information on (1) what his or her first round rating was for each scenario and (2) the distribution of ratings derived from all of the panelists for each scenario. The scenarios were discussed for clarification and the panelists re-rated each scenario after the discussion. The goals of the second meeting were (1) to ensure that the expert panelists all had the same understanding of each clinical scenario and (2) to allow discussion of the clinical decision-making process surrounding each scenario. In accordance with the RAM, there was no effort to reach a panel consensus. During the second round of rating, the RAM allows the panelists to create additional scenarios as they see fit. The panelists did not recommend addition of scenarios but did request elimination of some scenarios, which were not included in the final results presented here.

Clinical situations

To simulate the surgeon's or clinician's decision-making, scenarios were combined to create situations with the same patient characteristics and both AVF and AVG options for vascular access. For example, one clinical situation is, "In a male patient who is age >75 years, is dialysis dependent, and has a >2.4-mm cephalic vein throughout the upper extremity, how appropriate is it to perform a radial-cephalic fistula, a forearm loop graft, a brachial cephalic

fistula, or an upper arm AVG?" In this example of a clinical situation, each vascular access type constitutes one scenario for a total of four scenarios with the same patient characteristics.

Classifying appropriateness

According to the RAM, scenarios were classified into three levels of appropriateness: (1) appropriate: panel median of 7 to 9 without disagreement; (2) indeterminate: panel median of 4 to 6 or any median with disagreement; and (3) inappropriate: panel median of 1 to 3 without disagreement. Only ratings from the second round were used in the final classification of appropriateness. First-round ratings were used only to inform the second round and were not used in the final classification of appropriateness. In the RAM, disagreement is a binary outcome— either there is disagreement or there is not. The presence of disagreement was determined using the Inter-percentile Range Adjusted for Symmetry, as defined by the RAM.[8] The Interpercentile Range Adjusted for Symmetry is a mathematical function that takes into account the distribution of the individual panelists' scores to determine whether the amount of dispersion represents disagreement (Appendix 1, online only).

Statistical analysis

Univariate analysis was performed to determine the association of scenario characteristics with level of appropriateness. Multivariable analysis was not performed because of lack of uniformity in the characteristics specified across scenarios. Analysis was performed using SAS 9.4 software (SAS Institute, Cary, NC).

RESULTS

There were a total of 3816 scenarios. Panelists achieved agreement in 2964 (77.7%) scenarios; 860 (41%) AVF and 588 (34%) AVG scenarios were scored appropriate, 686 (33%) AVF and 480 (28%) AVG scenarios were scored inappropriate, and 542 (26%) AVF and 660 (38%) AVG scenarios were indeterminate (Appendix 2, online only).

Overall, younger age, larger outflow vein diameter, normal or obese body mass index (vs morbidly obese), larger inflow artery diameter, and higher patient functional status were associated with appropriateness of AVF creation. Dialysis status, gender, diabetes, and coronary artery disease were not associated with appropriateness of AVF creation. Older age, dialysis dependence, and smaller vein size were associated with appropriateness of AVG creation. Gender, diabetes, coronary artery disease, body mass index, and functional status were not associated with graft appropriateness. Factors associated with a vascular access type's being appropriate varied by the vascular access type (Table III).

Radial-cephalic fistula

Panelists were significantly less likely to find radial-cephalic fistula appropriate for elderly patients or patients who were dependent and living in a facility (Table IV). Panelists did not find radial-cephalic fistulas appropriate in any patients with small cephalic vein or radial

artery diameter <2 mm. There was no association between dialysis status, sex, diabetes, coronary artery disease, or body mass index and appropriateness of radial-cephalic fistulas.

Forearm basilic vein transposition

Panelists were less likely to find forearm basilic vein transposition appropriate in elderly patients (Table V). Forearm basilic vein transposition was not found to be appropriate in any patients with small vein, in patients with arterial diameter <2 mm, or in patients who were dependent and living in a facility. There was no association between dialysis status, sex, diabetes, coronary artery disease, or body mass index and appropriateness of forearm basilic vein transposition.

Brachial-cephalic fistula

Panelists were less likely to find brachial-cephalic fistula appropriate in elderly patients, patients who were morbidly obese, patients who were dialysis dependent, and those who were dependent and living in a facility (Table VI). Scenarios in which the patient was dialysis dependent and had a medium-diameter vein were more likely to be rated indeterminate than scenarios in which the patient was predialysis with a medium-diameter vein. Brachial-cephalic fistulas were inappropriate in all patients with small vein. There was no association between sex, diabetes, or coronary artery disease and appropriateness of brachial-cephalic fistula.

Upper arm basilic vein transposition

Panelists were less likely to find upper arm basilic vein transposition appropriate in elderly patients, patients who were morbidly obese, and those who were dependent and living in a facility (Table VII). Basilic vein transpositions were inappropriate in all patients with small vein. There was no association between dialysis status, sex, diabetes, or coronary artery disease and appropriateness of upper arm basilic vein transposition.

Brachial-brachial transposition

Brachial-brachial transposition was found to be inappropriate or indeterminate in all scenarios, with no scenarios rated appropriate (Table VIII). Brachial-brachial transposition was more likely to be inappropriate (vs indeterminate) in the elderly patient and patients who were dependent and living in a facility. Brachial-brachial transposition was inappropriate in all patients with small- or medium-diameter vein and those who were morbidly obese.

Forearm loop graft

Panelists were more likely to find forearm loop graft appropriate in elderly patients and those who were dialysis dependent (Table IX). Forearm loop graft was more likely to be inappropriate in patients with large veins. There was no association between sex, diabetes, coronary artery disease, body mass index, or functional status and appropriateness of forearm loop graft.

Upper arm graft

Upper arm graft was more likely to be appropriate in elderly patients, dialysis-dependent patients, and those with small veins (Table X). There was no association between sex, diabetes, coronary artery disease, body mass index, or functional status and appropriateness of upper arm graft.

Clinical situations

A total of 864 clinical situations were created in which the patient's characteristics were held the same and the options for operation were varied to include both AVF and AVG. Of the 864 clinical situations, 216 (25%) were rated appropriate for AVG but inappropriate for AVF, 45 (5.2%) were rated appropriate for both AVG and AVF, and 95 (11%) were rated appropriate for AVG but indeterminate for AVF (Appendix 3, online only).

DISCUSSION

The growing debate regarding fistula vs graft for hemodialysis vascular access has manifested itself in the literature with such titles as "When should a patient receive an arteriovenous graft rather than a fistula?"[16] and "Comparison of arteriovenous fistulas and arteriovenous grafts in patients with favorable vascular anatomy and equivalent access to health care: is a reappraisal of the Fistula First initiative indicated?"[17] Formal debates have been published, most recently in the *Journal of Vascular Surgery* regarding "The optimal initial choice for permanent arteriovenous hemodialysis access."[18] Ultimately, both sides of the debate concluded that it is "imperative that each individual patient be critically analyzed before any vascular access procedure" and that "surgical vascular access planning and postoperative maintenance are tied to each individual patient's unique status and circumstance." A key point in both arguments was that dialysis access patients often have complicated medical and anatomic issues that must be addressed on an individual basis. A parallel debate was published in the *Journal of the American Society of Nephrology*, entitled "Resolved: fistulas are preferred to grafts as initial vascular access for dialysis: pro and con," with a similar conclusion, with both sides agreeing that critical areas in which to improve care are decreasing catheter placement and duration.[19,20]

Factors that may be associated with vascular access outcomes

Our results suggest that age, functional status, outflow vein diameter, inflow artery diameter (for forearm access), body mass index, and dialysis dependence were significant factors in the decision-making process regarding the appropriateness of type of vascular access creation. Factors that were not significant in any scenarios were gender, diabetes, and coronary artery disease.

There is an increasing body of literature demonstrating inferior maturation rates and patency of AVF in the elderly compared with younger patients.[21,22] These potentially worse outcomes have to be balanced with markedly reduced life expectancy among aging ESKD patients.[1,23–25] In addition, age is a complex issue that is linked to many factors, including functional status. The presence of frailty is a marker for decreased survival, a factor that must be considered in determining the optimal vascular access for a patient.[23,26] These

considerations are reflected in the ratings of the panelists, with elderly, dependent functional status, and living in a facility resulting in significant proportions of inappropriate and indeterminate cases for all types of AVF studied.

Numerous authors have demonstrated the association between larger outflow vein diameter and improved maturation and patency.[27,28] However, the diameter cutoff used in the literature between fistula failure and success ranges anywhere from 1.6 to 4 mm.[29–31] Furthermore, during the discussion that occurred as part of the second round of rating, it was clear that the cutoff vein diameter varied widely among the surgeons in the room. This supported our decision not to use firm vein diameter cutoffs in the definitions of the scenarios. Nevertheless, the panelists' ratings are consistent with these findings, with larger veins being found to be more likely to be appropriate for fistula. Determination of a consensus vein cutoff diameter for success was outside the scope of this study but is another subject that could be addressed in the future using the RAND process. The artery diameter was defined in our scenarios for only forearm fistulas with a cutoff of 2 mm because of more agreement in the literature about the minimum required arterial inflow diameter.[31,32] Again, the panelists' ratings were consistent with the findings in the literature.

All types of fistula operations were more likely to be either inappropriate or indeterminate in patients who were morbidly obese. Obesity is often associated with the superficial veins being deep and requiring an additional procedure to superficialize the vein. Although more technically complex, these well-established operations are an important consideration that must be balanced with other patient factors and are reflected in the ratings of the panelists.

Dialysis dependence was associated with increased likelihood of an AVG operation's being appropriate. In dialysis-dependent patients, the potential benefits of an AVF must be weighed against the potential complications associated with dialysis through a central venous catheter, including bacteremia and central vein stenosis. An AVG may allow a dialysis-dependent patient to have the catheter removed as soon as 48 hours after the operation, depending on the type of graft used.[33] Although not widely used yet, immediate cannulation grafts appear to have similar outcomes to other grafts and may play a significant role in the overall goal of catheter reduction in the future.

Numerous studies evaluating gender, diabetes, and coronary artery disease have arrived at conflicting findings about their associations with vascular access maturation and patency. Some studies have suggested that female sex is associated with AVF nonmaturation and reduced patency, whereas others have shown no association.[29,34–37] Similarly, studies have demonstrated longer maturation times, increased risk of nonmaturation, and decreased patency in diabetics, whereas other studies have demonstrated no association.[26,29–31,36–39] It is likely for this reason that there was no association between these factors and appropriateness ratings for any AVF or AVG procedure.

The strengths of the current study include the basis of independently and systematically searched evidence, the exhaustive consideration of numerous patient scenarios, the two-stage process to ascertain clarity in decision-making and rating by the vascular access experts, and the use of a previously validated tool to assess the appropriateness of various vascular access

types and their respective creations. The major limitation is that we have not yet confirmed that adherence to the appropriateness ratings results in better outcomes of vascular access operations. Our next step will be to validate the results using retrospective and prospective studies. Another limitation of the current study is that it evaluated only upper extremity vascular accesses and did not assess the appropriateness of various vascular access types created or placed elsewhere in the body. Patients with challenging vascular access issues may be well served by vascular accesses created in alternative sites other than the upper extremity. Although we would have liked to have more international experts, particularly from Europe, because of limitations in funding, we were able to have only one expert from Canada and one expert from the United Kingdom. As such, the differences in practice patterns and preferences in non-U.S. countries were likely not adequately represented. There are a number of factors that were not included in the scenarios that may influence outcomes of vascular access because of a need to limit the scenarios to a reasonable number as well as factors, such as the physician's training and experience, that have little or no evidence in the literature but are suspected of having an association with outcomes. Finally, although it would have been ideal to include scenarios that were representative of all possible combinations of all factors, this would have created an excessive number of scenarios that would have made the study not feasible.

Future directions

Scenarios that were found to be indeterminate provide guidance for areas of dialysis access that require further investigation. The factors that were most associated with indeterminate scenarios were elderly age, dependent functional status living in a facility, and morbid obesity. These populations are certainly vulnerable populations in any disease process but perhaps particularly so in ESKD, given that life expectancy can be <5 years for these patients.[1] Quality of life, a factor that is often overlooked by physicians in planning the optimal vascular access for a patient, should ultimately be taken into consideration in balancing the risks of failed and multiple procedures against life expectancy.

In 2014, the Centers for Medicare and Medicaid Services adopted a measure in their End-Stage Renal Disease Quality Incentive Program that imposes a financial penalty on dialysis centers with lower rates of patients undergoing dialysis with a fistula and those with higher rates of catheter use.[40] These penalties are not risk adjusted according to the patient's characteristics. Likewise, the Kidney Disease Outcome Quality Initiative guidelines on vascular access, which have not been revised since 2006, and the FFBI both call for creation of fistula over graft without consideration of individual patient factors.[5] There were numerous clinical situations in this study in which the panelists found AVG to be more appropriate than AVF or equally appropriate as well as situations wherein AVG was thought to be appropriate and AVF was indeterminate. Consequently, it is imperative that guidelines and policy be amended to encourage and allow a thoughtful ESKD life plan that takes into account the multitude of patient factors that must be considered in determining the optimal vascular access for an individual patient.[41]

Using the results of this study, we are creating a mobile phone application and online application that allows users to input a patient's characteristics and generate our study

ratings. The application will also include video content demonstrating various vascular access procedures and provide a forum for discussion of challenging vascular access cases. The application is currently being beta tested at various sites.

An important next step is to apply the results of the study to patients to determine if patients who are treated in accordance with the panelists' ratings have better outcomes than patients who are not treated in accordance with the ratings. We plan to apply the study results retrospectively and prospectively to determine the influence of the vascular access outcomes.

CONCLUSIONS

This study combines literature and expert opinion to provide expert panel ratings for the most beneficial vascular access in a majority of hemodialysis-dependent patients. The variation in results by patient characteristics underlines the importance of developing an individualized plan for optimal vascular access in each patient. This study indicates that vascular access selection should be dictated by patient-specific characteristics, including vascular anatomy, age, and functional status, rather than by a universal guideline such as Fistula First. The results of this study also identify factors that providers do not consider to be influential in deciding what the optimal vascular access is for a patient, including diabetes and coronary artery disease. Criteria that were associated with indeterminate appropriateness, including elderly age, poor functional status, and morbid obesity, should be the focus for future vascular access investigation. Finally, national and international guidelines and policy must be amended to reflect the factors that panelists determined to be influential in determining optimal vascular access type and a personalized approach to hemodialysis vascular access planning.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

1. United States Renal Data System. Epidemiology of kidney disease in the United States. Bethesda, Md: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases; 2015. 2015 USRDS annual data report.
2. Neumann ME. "Fistula first" initiative pushes for new standards in access care. Nephrol News Issues. 2004; 18:43.
3. Lok CE. Fistula first initiative: advantages and pitfalls. Clin J Am Soc Nephrol. 2007; 2:1043–53. [PubMed: 17702726]

4. Sales CM, Schmidt RJ. FFBI Clinical Practice Workgroup. Fistula First clarifies its message. J Vasc Surg. 2010; 52:1699. [PubMed: 21146752]
5. NKF-K/DOQI clinical practice guidelines for vascular access: update 2006. Am J Kidney Dis. 2001; 37:S137–81. [PubMed: 11229969]
6. Sidawy AN, Spergel LM, Besarab A, Allon M, Jennings WC, Padberg FT, et al. The Society for Vascular Surgery: clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access. J Vasc Surg. 2008; 48:2S–25S. [PubMed: 19000589]
7. Dember LM, Imrey PB, Beck GJ, Cheung AK, Himmelfarb J, Huber TS, et al. Objectives and design of the hemodialysis fistula maturation study. Am J Kidney Dis. 2014; 63:104–12. [PubMed: 23992885]
8. Fitch, K., Bernstein, SJ., Aguilar, MD., Burnand, B., LaCalle, JR., Lazaro, P., et al. The RAND/UCLA appropriateness method user's manual. Santa Monica, Calif: RAND Corporation; 2001.
9. Lawson EH, Gibbons MM, Ko CY, Shekelle PG. The appropriateness method has acceptable reliability and validity for assessing overuse and underuse of surgical procedures. J Clin Epidemiol. 2012; 65:1133–43. [PubMed: 23017632]
10. Bernstein SJ, Brorsson B, Aberg T, Emanuelsson H, Brook RH, Werko L. Appropriateness of referral of coronary angiography patients in Sweden. Heart. 1999; 81:470–7. [PubMed: 10212163]
11. Hemingway H, Crook AM, Dawson JR, Edelman J, Edmonson S, Feder G, et al. Rating the appropriateness of coronary angiography, coronary angioplasty and coronary artery bypass grafting: the ACRE study. J Public Health Med. 1999; 21:421–9. [PubMed: 11469365]
12. Merrick NJ, Fink A, Park RE, Brook RH, Kosecoff J, Chassin MR, et al. Derivation of clinical indications for carotid endarterectomy by an expert panel. Am J Public Health. 1987; 77:187–90. [PubMed: 3799858]
13. Yermilov I, McGory ML, Shekelle PW, Ko CY, Maggard MA. Appropriateness criteria for bariatric surgery: beyond the NIH guidelines. Obesity. 2009; 17:1521–7. [PubMed: 19343019]
14. Ballard, DJ., Etchason, JA., Hillborne, LH., Campion, ME., Kamberg, C., Solomon, D., et al. A literature review and ratings of appropriateness and necessity. Santa Monica, Calif: RAND Corporation; 1992. Abdominal aortic aneurysm surgery.
15. Almasri J, Alsawas M, Mainou M, Mustafa RA, Wang Z, Woo K, et al. Outcomes of vascular access for hemodialysis: a systematic review and meta-analysis. J Vasc Surg. 2016; 64:236–43. [PubMed: 27345510]
16. Lee HW, Allon M. When should a patient receive an arteriovenous graft rather than a fistula? Semin Dial. 2013; 26:6–10. [PubMed: 23173947]
17. Disbrow DE, Cull DL, Carsten CG, Yang SK, Johnson BL, Keahey GP. Comparison of arteriovenous fistulas and arteriovenous grafts in patients with favorable vascular anatomy and equivalent access to health care: is a reappraisal of the Fistula First initiative indicated? J Am Coll Surg. 2013; 216:679–86. [PubMed: 23395157]
18. Sgroi MD, Patel MS, Wilson SE, Jennings WC, Blebea J, Huber TS. The optimal initial choice for permanent arteriovenous hemodialysis access. J Vasc Surg. 2013; 58:539–48. [PubMed: 23890446]
19. Allon M, Robbin ML. Resolved: fistulas are preferred to grafts as initial vascular access for dialysis: con. J Am Soc Nephrol. 2008; 19:1632–3. [PubMed: 18754117]
20. Besarab A. Resolved: fistulas are preferred to grafts as initial vascular access for dialysis: pro. J Am Soc Nephrol. 2008; 19:1629–31. [PubMed: 18508963]
21. 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; 67:2462–9. [PubMed: 15882293]
22. Lazarides MK, Georgiadis GS, Antoniou GA, Staramos DN. A meta-analysis of dialysis access outcome in elderly patients. J Vasc Surg. 2007; 45:420–6. [PubMed: 17264030]
23. Tamura MK, Tan JC, O'Hare AM. Optimizing renal replacement therapy in older adults: a framework for making individualized decisions. Kidney Int. 2012; 82:261–9. [PubMed: 22089945]
24. O'Hare AM. Vascular access for hemodialysis in older adults: a "patient first" approach. J Am Soc Nephrol. 2013; 24:1187–90. [PubMed: 23813217]

25. O'Hare AM, Bertenthal D, Walter LC, Garg AX, Covinsky K, Kaufman JS, et al. When to refer patients with chronic kidney disease for vascular access surgery: should age be a consideration? Kidney Int. 2007; 71:555–61. [PubMed: 17245396]
26. Johansen KL, Chertow GM, Jin C, Kutner NG. Significance of frailty among dialysis patients. J Am Soc Nephrol. 2007; 18:2960–7. [PubMed: 17942958]
27. Dageforde LA, Harms KA, Feurer ID, Shaffer D. Increased minimum vein diameter on preoperative mapping with duplex ultrasound is associated with arteriovenous fistula maturation and secondary patency. J Vasc Surg. 2015; 61:170–6. [PubMed: 25065580]
28. Farber A, Imrey PB, Huber TS, Kaufman JM, Kraiss LW, Larive B, et al. Multiple preoperative and intraoperative factors predict early fistula thrombosis in the Hemodialysis Fistula Maturation Study. J Vasc Surg. 2016; 63:163–70. [PubMed: 26718822]
29. Patel ST, Hughes J, Mills JL Sr. Failure of arteriovenous fistula maturation: an unintended consequence of exceeding Dialysis Outcome Quality Initiative guidelines for hemodialysis access. J Vasc Surg. 2003; 38:439–45. discussion: 445. [PubMed: 12947249]
30. Dunn J, Herscu G, Woo K. Factors influencing maturation time of native arteriovenous fistulas. Ann Vasc Surg. 2015; 29:704–7. [PubMed: 25728334]
31. 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; 60:2013–20. [PubMed: 11703621]
32. Korten E, Toonder IM, Schrama YC, Hop WC, van der Ham AC, Wittens CH. Dialysis fistulae patency and preoperative diameter ultrasound measurements. Eur J Vasc Endovasc Surg. 2007; 33:467–71. [PubMed: 17196852]
33. Al Shakarchi J, Houston G, Inston N. Early cannulation grafts for haemodialysis: a systematic review. J Vasc Access. 2015; 16:493–7. [PubMed: 26070093]
34. Ernandez T, Saudan P, Berney T, Merminod T, Bednarkiewicz M, Martin PY. Risk factors for early failure of native arteriovenous fistulas. Nephron. 2005; 101:c39–44. [PubMed: 15886495]
35. Maya ID, O'Neal JC, Young CJ, Barker-Finkel J, Allon M. Outcomes of brachiocephalic fistulas, transposed brachiobasilic fistulas, and upper arm grafts. Clin J Am Soc Nephrol. 2009; 4:86–92. [PubMed: 18945990]
36. Fitzgerald JT, Schanzer A, Chin AI, McVicar JP, Perez RV, Troppmann C. Outcomes of upper arm arteriovenous fistulas for maintenance hemodialysis access. Arch Surg. 2004; 139:201–8. [PubMed: 14769581]
37. Diehm N, van den Berg JC, Schnyder V, Buhler J, Willenberg T, Widmer M, et al. Determinants of haemodialysis access survival. Vasa. 2010; 39:133–9. [PubMed: 20464668]
38. Lee T, Ullah A, Allon M, Succop P, El-Khatib M, Munda R, et al. Decreased cumulative access survival in arteriovenous fistulas requiring interventions to promote maturation. Clin J Am Soc Nephrol. 2011; 6:575–81. [PubMed: 21088288]
39. Lauvao LS, Ihnat DM, Goshima KR, Chavez L, Gruessner AC, Mills JL Sr. Vein diameter is the major predictor of fistula maturation. J Vasc Surg. 2009; 49:1499–504. [PubMed: 19497513]
40. Fishbane S, Miller I, Wagner JD, Masani NN. Changes to the endstage renal disease quality incentive program. Kidney Int. 2012; 81:1167–71. [PubMed: 22534963]
41. Lok CE, Davidson I. Optimal choice of dialysis access for chronic kidney disease patients: developing a life plan for dialysis access. Semin Nephrol. 2012; 32:530–7. [PubMed: 23217332]

ARTICLE HIGHLIGHTS

- **Type of Research:** Data of a systematic review and meta-analysis were used and the RAND/UCLA Appropriateness Method was applied to clinical scenarios.
- **Take Home Message:** The review of multiple extremity access scenarios by subject experts indicates that there are patient-specific situations in which access grafts may be as appropriate as or more appropriate than autogenous fistulas.
- **Recommendation:** The authors recommend that these data create a case for revising existing access guidelines to account for situations in which access grafts may be as appropriate as or more appropriate than autogenous fistulas.

How appropriate is it to perform each of the listed operations on a patient who is **age <60, pre-dialysis** and has a **≥2.5 mm cephalic vein** throughout the upper extremity?					
	Radial-cephalic fistula	Forearm Loop Graft	Brachial-cephalic fistula	Upper Arm AV Graft	
Gender					
i. Male	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. Female	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
Diabetes					
i. Yes	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. No	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
Coronary artery disease					
i. Yes	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. No	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
BMI					
i. normal	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. obese	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
iii. morbidly obese	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
Inflow artery diameter					
i. <2mm	1 2 3 4 5 6 7 8 9				
ii. >2 mm	1 2 3 4 5 6 7 8 9				
Functional status					
i. independent	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. dependent, lives at home	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	
ii. dependent, lives in a facility	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	

Fig.

Example of a rating sheet. *AV*, Arteriovenous.

Table I

Panelists

Name	Specialty	Country	Affiliation
Michael Allon	Nephrology	United States	University of Alabama at Birmingham
Christopher Carsten	Vascular surgery	United States	University of South Carolina, Greenville
Eric Chemla	Vascular surgery	United Kingdom	University of London, St. George's Medical School
Mitchell Henry	Transplant surgery	United States	Ohio State University
Thomas Huber	Vascular surgery	United States	University of Florida
William Jennings	Vascular surgery	United States	University of Oklahoma
Jeffrey Lawson	Vascular surgery	United States	Duke University
Charmaine Lok	Nephrology	Canada	University of Toronto
Eric Peden	Vascular surgery	United States	Methodist Hospital, Houston
Larry Scher	Vascular surgery	United States	Albert Einstein/Montefiore
Anton Sidawy	Vascular surgery	United States	George Washington University

Table II

Operation and variable definitions

Operation	Definition	
Radial-cephalic fistula	Forearm fistula constructed between the distal radial artery and the cephalic vein	
Forearm loop graft	Prosthetic loop graft located in the forearm using an inflow artery and outflow vein in the antecubital area Assume that the graft used is your preferred graft material/configuration/manufacturer.	
Brachial-cephalic fistula	Upper arm cephalic vein fistula with inflow from the brachial artery or proximal radial artery, if that is your practice	
Upper arm AVG	Prosthetic graft located in the upper arm using inflow from the brachial artery and outflow into the axillary vein Assume that the graft used is your preferred graft material/configuration/manufacturer.	
Forearm basilic vein transposition	Basilic vein fistula located in the forearm using either the distal radial or distal ulnar artery as inflow, per your preference	
Upper arm basilic vein transposition	Basilic vein fistula located in the upper arm using the brachial artery or proximal radial artery as inflow; performed in one or two stages, per your preference	
Brachial-brachial transposition	Brachial vein fistula located in the upper arm using the brachial artery or proximal radial artery as inflow; performed in one or two stages, per your preference	
Variable	**Categories**	**Definition**
Age	<60 years	Equate this with what you would normally consider to be a young patient.
	60–75 years	Equate this with what you would normally consider to be an older patient.
	>75 years	Equate this with what you would normally consider to be an elderly patient.
Dialysis status	Predialysis	Assume that the patient has been referred for vascular access creation in a timely fashion that would allow maturation of a fistula if indicated.
	Dialysis dependent	Patient currently requires regular hemodialysis and requires permanent vascular access.
Vein size (measured by the modality you normally consider to be reliable)	<2.0 mm	Equate this with what you would normally consider to be a small-diameter vein that you think would have a low likelihood of developing into a mature fistula.
	2.0–2.5 mm	Equate this with what you would normally consider to be a marginal-diameter vein that you think would have a moderate likelihood of developing into a mature fistula.
	>2.5 mm	Equate this with what you would normally consider to be a large-diameter vein that you think has a high likelihood of developing into a mature fistula.
Diabetes	Yes	Controlled by diet, oral hypoglycemic, or insulin
	No	No known history of diabetes of any type
Coronary artery disease	Yes	History of myocardial infarction, angina, coronary artery bypass graft, or percutaneous coronary intervention
	No	No known history of coronary artery disease of any type
Body mass index	Normal	<25
	Obese	30–40
	Morbidly obese	>40 and assume vein is difficult to cannulate in unelevated position
Inflow artery diameter(measured by the modality you consider to be reliable)	<2 mm >2 mm	
Functional status	Independent	Able to perform all activities of daily living without assistance

Operation	Definition	
	Dependent, lives at home	Requires assistance to perform most activities of daily living but is still able to live outside of a facility
	Dependent, lives in a facility	Requires assistance to perform nearly all activities of daily living and requires 24-hour care in a facility (ie, nursing home)

AVG, Arteriovenous graft.

Table III

Factors associated with a vascular access type's being rated appropriate

	Vascular access type						
	Radial-cephalic fistula	**Forearm basilic vein transposition**	**Forearm graft**	**Brachial-cephalic fistula**	**Upper arm basilic vein transposition**	**Brachial-brachial transposition[a]**	**Upper arm graft**
Age, years	<75	<75	>75	<75	<75	—	>75
Sex[b]	—	—	—	—	—	—	—
Dialysis status	—	—	Dependent	—	—	—	Dependent
Diabetes[c]	—	—	—	—	—	—	—
Coronary artery disease[d]	—	—	—	—	—	—	—
Body mass index	—	—	—	Normal or obese	Normal or obese	—	—
Functional =status	Independent or dependent, living at home	Independent or dependent, living at home	—	Independent or dependent, living at home	Independent or dependent, living at home	—	—
Vein diameter	Larger	Larger	Smaller	Larger	Larger	—	Smaller
Inflow artery diameter[e]	>2 mm	>2 mm	—	—	—	—	—

[a] No factors were associated with appropriateness of brachial-brachial transposition.

[b] There was no association between sex and appropriateness of any vascular access type.

[c] There was no association between diabetes and appropriateness of any vascular access type.

[d] There was no association between coronary artery disease and appropriateness of any vascular access type.

[e] Inflow artery diameter was assessed only for forearm arteriovenous fistula (AVF).

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Table IV

Radial-cephalic fistula scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	15 (8.9)	119 (70.8)	34 (20.2)	<.001
60–75	28 (16.7)	119 (70.8)	21 (12.5)	
>75	33 (19.6)	31 (18.5)	104 (61.9)	
Dialysis status				
Predialysis	41 (16.3)	140 (55.6)	71 (28.2)	.25
Dialysis dependent	35 (13.9)	129 (51.2)	88 (34.9)	
Vein diameter				
Small	71 (84.5)	0	13 (15.5)	<.001
Medium	5 (1.5)	199 (59.2)	132 (39.3)	
Large	0	70 (83.3)	14 (16.7)	
Sex				
Male	4 (11.1)	23 (63.9)	9 (25.0)	1
Female	4 (11.0)	23 (63.9)	9 (25.0)	
Diabetes				
Yes	5 (13.9)	23 (63.0)	8 (22.2)	.96
No	5 (13.9)	22 (61.1)	9 (25.0)	
Coronary artery disease				
Yes	5 (13.9)	24 (66.7)	7 (19.4)	.96
No	5 (13.9)	23 (63.9)	8 (22.2)	
Body mass index				
Normal	5 (13.9)	23 (63.9)	8 (22.2)	.42
Obese	6 (16.7)	22 (61.1)	8 (22.2)	
Morbidly obese	6 (16.7)	16 (44.4)	14 (38.9)	
Artery diameter				
<2 mm	10 (27.8)	0	26 (72.2)	<.001
>2 mm	4 (11.1)	23 (63.9)	9 (25.0)	
Functional status				
Independent	5 (13.9)	23 (63.9)	8 (22.2)	<.001
Dependent, living at home	5 (13.9)	22 (61.1)	9 (25.0)	
Dependent, living in facility	7 (19.4)	2 (5.6)	27 (75.0)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table V

Forearm basilic vein transposition scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	64 (38.1)	54 (32.1)	50 (29.8)	<.001
60–75	63 (37.5)	51 (30.4)	54 (32.1)	
>75	96 (57.1)	21 (12.5)	51 (30.4)	
Dialysis status				
Predialysis	111 (44.1)	68 (27.0)	73 (29.0)	.52
Dialysis dependent	112 (44.5)	58 (23.0)	82 (32.5)	
Vein diameter				
Small	168 (100)	0	0	<.001
Medium	48 (28.6)	13 (7.7)	107 (63.7)	
Large	7 (4.2)	113 (67.3)	48 (28.6)	
Sex				
Male	14 (38.9)	11 (30.6)	11 (30.6)	1
Female	14 (38.9)	11 (30.6)	11 (30.6)	
Diabetes				
Yes	14 (38.9)	11 (30.6)	11 (30.6)	.96
No	14 (38.9)	11 (30.6)	11 (30.6)	
Coronary artery disease				
Yes	14 (38.9)	12 (33.3)	10 (27.8)	.96
No	14 (38.9)	12 (33.3)	10 (27.8)	
Body mass index				
Normal	14 (38.9)	12 (33.3)	10 (27.8)	.37
Obese	14 (38.9)	9 (25.0)	13 (36.1)	
Morbidly obese	19 (52.8)	5 (13.9)	12 (33.3)	
Artery diameter				
<2 mm	27 (75.0)	0	9 (25.0)	<.001
>2 mm	13 (36.1)	12 (33.3)	11 (30.6)	
Functional status				
Independent	14 (38.9)	12 (33.3)	10 (27.8)	.006
Dependent, living at home	15 (41.7)	9 (25.0)	12 (33.3)	
Dependent, living in facility	23 (63.9)	0	13 (36.1)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table VI

Brachial-cephalic fistula scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	24 (16.7)	107 (74.3)	13 (9.0)	<.001
60–75	24 (16.7)	107 (74.3)	13 (9.0)	
>75	24 (16.7)	72 (50.0)	48 (33.3)	
Dialysis status				
Predialysis	36 (16.7)	154 (71.3)	26 (12.0)	.02
Dialysis dependent	36 (16.7)	132 (61.1)	48 (22.2)	
Vein diameter				
Small	72 (100)	0	0	<.001
Medium	0	221 (76.7)	67 (23.3)	
Large	0	65 (90.3)	7 (9.7)	
Sex				
Male	6 (16.7)	28 (77.8)	2 (5.6)	1
Female	6 (16.7)	28 (77.8)	2 (5.6)	
Diabetes				
Yes	6 (16.7)	28 (77.8)	2 (5.6)	1
No	6 (16.7)	28 (77.8)	2 (5.6)	
Coronary artery disease				
Yes	6 (16.7)	28 (77.8)	2 (5.6)	1
No	6 (16.7)	28 (77.8)	2 (5.6)	
Body mass index				
Normal	6 (16.7)	28 (77.8)	2 (5.6)	<.001
Obese	6 (16.7)	25 (69.4)	5 (13.9)	
Morbidly obese	6 (16.7)	12 (33.3)	18 (50.0)	
Functional status				
Independent	6 (16.7)	27 (75.0)	3 (8.3)	<.001
Dependent, living at home	6 (16.7)	24 (66.7)	6 (16.7)	
Dependent, living in facility	6 (16.7)	2 (5.6)	28 (77.8)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table VII

Upper arm basilic vein transposition scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	49 (34.0)	80 (55.6)	15 (10.4)	<.001
60–75	49 (34.0)	72 (50.0)	23 (16.0)	
>75	52 (36.1)	27 (18.8)	65 (45.1)	
Dialysis status				
Predialysis	75 (34.7)	89 (41.2)	52 (24.1)	.99
Dialysis dependent	75 (34.7)	90 (41.7)	51 (23.6)	
Vein diameter				
Small	144 (100)	0	0	<.001
Medium	6 (4.2)	66 (45.8)	72 (50.0)	
Large	0	113 (78.5)	31 (21.5)	
Sex				
Male	12 (33.3)	18 (50.0)	6 (16.7)	1
Female	12 (33.3)	18 (50.0)	6 (16.7)	
Diabetes				
Yes	12 (33.3)	18 (50.0)	6 (16.7)	1
No	12 (33.3)	18 (50.0)	6 (16.7)	
Coronary artery disease				
Yes	12 (33.3)	18 (50.0)	6 (16.7)	1
No	12 (33.3)	18 (50.0)	6 (16.7)	
Body mass index				
Normal	12 (33.3)	18 (50.0)	6 (16.7)	<.001
Obese	13 (36.1)	13 (36.1)	10 (27.8)	
Morbidly obese	14 (38.9)	5 (13.9)	17 (47.2)	
Functional status				
Independent	12 (33.3)	18 (50.0)	6 (16.7)	<.001
Dependent, living at home	12 (33.3)	16 (44.4)	8 (22.2)	
Dependent, living in facility	15 (41.7)	1 (2.8)	20 (55.6)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table VIII

Brachial-brachial transposition scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	51 (70.8)	0	21 (29.2)	.05
60–75	51 (70.8)	0	21 (29.2)	
>75	62 (86.1)	0	10 (13.9)	
Dialysis status				
Predialysis	78 (72.2)	0	30 (27.8)	.2
Dialysis dependent	86 (79.6)	0	22 (20.4)	
Vein diameter				
Small	72 (100)	0	0	<.001
Medium	72 (100)	0	0	
Large	20 (27.8)	0	52 (72.2)	
Sex				
Male	13 (72.2)	0	5 (27.8)	1
Female	13 (72.2)	0	5 (27.8)	
Diabetes				
Yes	13 (72.2)	0	5 (27.8)	1
No	13 (72.2)	0	5 (27.8)	
Coronary artery disease				
Yes	13 (72.2)	0	5 (27.8)	1
No	13 (72.2)	0	5 (27.8)	
Body mass index				
Normal	13 (72.2)	0	5 (27.8)	.05
Obese	13 (72.2)	0	5 (27.8)	
Morbidly obese	18 (100)	0	0	
Functional status				
Independent	13 (72.2)	0	5 (27.8)	<.001
Dependent, living at home	13 (72.2)	0	5 (27.8)	
Dependent, living in facility	16 (88.9)	0	2 (11.1)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table IX

Forearm loop graft scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	102 (35.4)	72 (25.0)	114 (39.6)	.05
60–75	101 (35.1)	62 (21.5)	125 (43.4)	
>75	10 (3.5)	127 (44.1)	151 (52.4)	
Dialysis status				
Predialysis	173 (40.1)	24 (5.6)	235 (54.4)	<.001
Dialysis dependent	40 (9.3)	237 (54.9)	155 (35.9)	
Vein diameter				
Small	0 (0)	72 (33.3)	144 (66.7)	<.001
Medium	91 (25.3)	110 (30.6)	159 (44.2)	
Large	122 (42.4)	79 (27.4)	87 (30.2)	
Sex				
Male	19 (26.4)	21 (29.2)	32 (44.4)	1
Female	19 (26.4)	22 (30.6)	31 (43.1)	
Diabetes				
Yes	19 (26.4)	21 (29.2)	32 (44.4)	1
No	19 (26.4)	22 (30.6)	31 (43.1)	
Coronary artery disease				
Yes	19 (26.4)	21 (29.2)	32 (44.4)	1
No	19 (26.4)	22 (30.6)	31 (43.1)	
Body mass index				
Normal	19 (26.4)	21 (29.2)	32 (44.4)	.75
Obese	19 (26.4)	22 (30.6)	31 (43.1)	
Morbidly obese	13 (18.1)	23 (31.9)	36 (50.0)	
Functional status				
Independent	19 (26.4)	21 (29.2)	32 (44.4)	.53
Dependent, living at home	18 (25.0)	22 (30.6)	32 (44.4)	
Dependent, living in facility	11 (15.3)	23 (31.9)	38 (52.8)	

Data are presented as No. (%) of scenarios with each characteristic that were rated appropriate, inappropriate, and indeterminate by the panelists.

Table X

Upper arm graft scenarios by appropriateness

Characteristic	Appropriateness			*P* value
	Inappropriate	Appropriate	Indeterminate	
Age, years				
<60	135 (46.9)	95 (33.0)	58 (20.1)	<.001
60–75	111 (38.5)	73 (25.4)	104 (36.1)	
>75	21 (7.3)	158 (54.9)	109 (37.8)	
Dialysis status				
Predialysis	184 (42.6)	82 (19.0)	166 (38.4)	<.001
Dialysis dependent	83 (19.2)	244 (56.5)	105 (24.3)	
Vein diameter				
Small	0 (0)	143 (66.2)	73 (33.8)	<.001
Medium	113 (31.4)	108 (30)	139 (38.6)	
Large	154 (53.5)	75 (26)	59 (20.5)	
Sex				
Male	24 (33.3)	26 (36.1)	22 (30.6)	1
Female	24 (33.3)	27 (37.5)	21 (29.2)	
Diabetes				
Yes	24 (33.3)	27 (37.5)	21 (29.2)	1
No	24 (33.3)	27 (37.5)	21 (29.2)	
Coronary artery disease				
Yes	24 (33.3)	27 (37.5)	21 (29.2)	1
No	24 (33.3)	27 (37.5)	21 (29.2)	
Body mass index				
Normal	24 (33.3)	27 (37.5)	21 (29.2)	.33
Obese	24 (33.3)	26 (36.1)	22 (30.6)	
Morbidly obese	15 (20.8)	27 (37.5)	30 (41.7)	
Functional status				
Independent	24 (33.3)	27 (37.5)	21 (29.2)	.38
Dependent, living at home	22 (30.6)	28 (38.9)	22 (30.6)	
Dependent, living in facility	14 (19.4)	30 (41.7)	28 (38.9)	

Data are presented as No. (%) of scenarios that were rated appropriate, inappropriate, and indeterminate by the panelists.