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New frontiers in vascular access practice: from standardized to patient-tailored care and shared decision making

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Abstract

Vascular access planning is critical in the management of patients with advanced kidney disease who elect hemodialysis for kidney replacement therapy. Policies put in place more than two decades ago attempted to standardize vascular access care around the model of optimal—i.e, arteriovenous fistula—and least preferred—i.e., central venous catheter—type of access. This homogenized approach to vascular access care emerged ineffective in the ever increasingly heterogeneous and complex dialysis population. The most recent vascular access guidelines acknowledge limitations of standardized care and encourage tailoring vascular access care based on patient and disease characteristics. In this article we discuss available literature in support of patient-tailored access care based on differences in vascular access outcomes by biologic and social factors—age, sex and race. Further, we draw attention to the overlooked dimension of patient-reported preferences and shared decision making in the practice of vascular access planning. We discuss milestones to overcome as requisite steps to implement effective shared decision making in vascular access care. Finally, we take into consideration local practice co-factors as major players in vascular access fate. We conclude that a personalized approach to hemodialysis vascular access will require dynamic care specifically relevant to the individual based on biological factors, fluctuating clinical needs, values and preferences.

Introduction

Creation and preservation of a vascular access is at the core of hemodialysis (HD), the most frequently used form of kidney replacement therapy in the US. Decades of scientific evolution materialized into three types of vascular access: arteriovenous fistula (AVF), arteriovenous graft (AVG), and central venous catheter (CVC). At the inception of the kidney replacement therapy era, creation of *any* form of vascular access was a blissful achievement. Subsequently, vascular access care was funneled to a *one* access type approach—i.e., AVF. Landmark studies executed in the 1990s and decades of guidelines that dominated clinical practice between 1997-2019 generated a legacy of AVF-centered practice which upheld AVF as the primary vascular access objective in all HD-dependent patients[1]. At last, the mainstream approach in vascular access practice is starting to develop fundamental shifts.

A growing number of studies have pointed to differing vascular access outcomes, particular AVF outcomes, between different patient groups[2-11]. With increasing observation that AVF-prioritized care is particularly ineffective in certain patients groups, the latest vascular access guidelines shifted recommendations from a standardized approach to a customized approach, recommending placement of the "right access, in the right patient, at the right time, for the right reasons"[12]. The new guidelines encourage consideration of individual patient variables and preference-sensitive decision making in line with the principles of patient-centered medicine. However, effective implementation of shared decision making (SDM) in vascular access care remains elusive given the complexities involved in the decision-making process. Below we discuss the available knowledge as it pertains to vascular access outcomes which can be used as an initial step to tailor access care to each individual (**Figure 1a**). Knowledge gaps and complexities involved in what is a multifaceted approach to vascular access care are presented (**Table 1**). Closure of these gaps is a prerequisite to implement effective SDM into routine care are presented (**Figure 1b**). Thus, we draw a distinction between *patient-tailored* access care that could be adopted based on current data; and *SDM* access care as a key area for future work.

Patient-tailored Vascular Access Care

Drawing from large epidemiologic studies and in the context of varied biologic phenotypes (age, sex) and social factors (race), we analyze how vascular access customization can be developed and managed. Using the evidence-practice model for customized vascular access care (**Figure 1a**), the dialysis access can be strategized based on individual-level risk for AV access failure and trade-offs between short-term and long-term access outcomes, using available knowledge.

Age and vascular access outcomes

Many studies have attested to the challenging task of achieving a functioning AVF in older patients. A meta-analysis of 13 studies concluded that older patients have 50-65% higher risk of primary AVF failure and 80% higher risk of secondary AVF failure compared with younger patients[13]. Vascular access interventions in older patients to maintain a patent AV access are required nearly 60% more often with an AVF than an AVG[9].

Based on inferior AVF outcomes in older patients and patient-specific factors impacting clinical outcomes, it is not surprising that recent reports indicate that older patients starting HD with a CVC and who underwent placement of AVG as first AV access for HD placed either before or after dialysis initiation had fewer catheter-dependent days and similar survival as those who had an AVF as first AV access placed[9,10,14-16]. In a nationally representative cohort of 115,425 incident HD patients ≥67 years old derived from the US Renal Data System, dialysis survival analysis as a function of first vascular access placed indicated no significant mortality difference between those patients with a graft as the first access placed and those patients with a fistula (HR=1.05; 95%CI=1.00 to 1.11; P=0.06)[10]. In a separate cohort of 138,245 incident patients who started HD with a CVC, patient survival across the entire cohort was equivalent between those who had AVF or AVG placement (HR 0.98; 95%CI 0.93–1.02; P=0.349), but among patients ≥80 years old with albumin levels >4.0 g/dL, AVF creation was associated with higher mortality hazard compared to AVG creation (HR1.22; 95%CI 1.04–1.43; P=0.013)[16].

Age-related AVG outcomes have been less well studied. In one retrospective analysis of over 70,000 patients who underwent AVG placement, there was no significant difference in graft primary patency, primary assisted patency, and secondary patency with increasing age. Interestingly, the study found a slight decrease in severe prosthetic graft infection requiring graft excision (HR 0.99; 95%CI 0.99-0.99; P<0.001) and increase in mortality (HR 1.03; 95%CI 1.03-1.03; P<0.001) for the older age categories compared with the younger patients[4]

In addition to the association between age and AV access patency and infection rate, age can also modulate CVC-related infectious complications. In a 3-year retrospective study of 464 incident and prevalent patients, the rate of CVC-related bacteremia was 67% lower in patients ≥75 years of age than in younger patients; analyses adjusted for comorbidities, catheter lock solutions, catheter location, and use of immunosuppressive medications[11].

The success of an AV access depends on the biology of older patients' vascular beds, particularly in regard to vascular calcification and endothelial dysfunction. Studies have shown that the prevalence of arterial calcification increases with age and negatively affects AVF maturation[17,18]. On the contrary, vascular calcifications and fibrosis present in preoperative tissue specimens do not associate with inferior unassisted primary AVG survival, and might confer a protective effect against recurrent AVG interventions[19]. Finally, intact endothelial function is important for native, autologous AV access because it allows synthesis of mediators that promote vasodilation and inhibit vascular stenosis in response to injury. A study using brachial artery flow-mediated vasodilatation in a cohort of *healthy* adults indicated that endothelial dysfunction was present in 25% of individuals ≥60 years of age and 9-13% of individuals <50 years of age (P<0.001)[20].

Therefore, besides morbidity, age-dependent pathophysiological changes could explain why older age (assessed as ≥65 years in many reports) correlates with higher rates of primary and secondary AVF failure[9,21-23]. Nevertheless, similar fistula patency rates between older and younger individuals have also been reported; and although data suggests that grafts could be a better vascular access strategy in older adults, not all the literature supports this concept[24,25].

Sex differences in AV access outcomes

The issue of patient sex has been extensively studied with respect to vascular access failure. Study results are conflicting regarding the association between female sex, AVF non-maturation, and reduced patency[26-29]. A prospective study of 200 patients with upper extremity access creations found on univariate analysis that female sex was significantly associated with failure to achieve an AVF used successfully for HD (P=0.05)[30]. However, on multivariable analysis, with age, ischemic heart disease, prior central venous catheter or pacemaker, inflow artery diameter and outflow vein diameter in the model, the only significant predictor of failure was artery diameter (P<0.01). In another cohort of 300 patients, who were dependent on a central venous catheter for HD at the time of AVF creation, there was no association between patient sex and clinical AVF maturation, defined as removal of the catheter within 180 days after AVF creation[3].

The potential association between patient sex and AVF outcomes has been postulated to be related to smaller vein diameter in females compared with males. To refute this belief, one study of 148 consecutive patients showed no association between sex and diameter of the cephalic vein[31]. Similarly, another study found lower AVF maturation rates in females that were not explained by differences in vein diameter[32]. The aforementioned 300 patient cohort study demonstrated that there was no significant difference in median vein diameter between women and men (0.37mm vs 0.38mm, P=0.62)[3]. However, the median arterial diameter was significantly smaller at 0.35mm in women, compared to 0.42mm in men (P<0.001). On multivariable analysis, each 1 mm increase in preoperative arterial diameter was significantly associated with increasing likelihood of achieving both unassisted (OR 1.5, P<0.001) and assisted maturation (OR 1.36, P=0.002). Another study of outcomes after adopting a practice of preferentially creating brachiocephalic AVFs, unless the patient was an ideal anatomic candidate for radiocephalic AVF, demonstrated a significant increase in primary functional patency at 1 year[33]. This may be related to larger arterial diameter at the brachial artery vs radial artery.

Given these findings, it is possible that inferior outcomes associated with female sex may be related to smaller arterial diameter in females, rather than vein diameters. At this time, it remains unclear what the contribution of patient sex is to vascular access outcomes. However, it may be prudent to prioritize anatomic findings over patient sex itself in the vascular access decision-making process.

***Racial disparities in vascula*r access practice and outcomes**

Epidemiologic research demonstrated presence of a significant difference in the prevalence of AVF creation among racial groups with Black patients having an approximately 10% lower prevalence of AVF compared to White patients[7,34-36]. It is unclear why this is the case. Some authors have suggested the cause relates to Blacks having smaller vein diameters, but the evidence is far from conclusive[37,38]. In fact, one recent study demonstrated no association between race and vein or artery diameters[3].

Black patients are more likely to experience primary access failure, undergo repeat vascular access after an index access and have a shorter time to repeat access[6,7,39]. Compared to White patients, Black patients have significantly decreased primary, primary assisted and secondary AVF patency (HR 0.81, 0.83, 0.89, respectively)[5]. A similar phenomenon has been demonstrated in treatment of peripheral arterial disease in Black patients who have been shown to be at significantly higher risk of graft failure after lower extremity bypass, in both dialysis dependent and non-dialysis dependent populations[40-42]. The reason for the increased risk of failure in both dialysis vascular access and in peripheral bypass grafting is unclear. Investigators have demonstrated that Black patients have higher serum levels of lipoprotein(a) which has variable associations with risk of atherosclerosis and myocardial infarction[43,44]. However, it is uncertain whether lipoprotein(a) is responsible for increased risk of dialysis access and/or lower extremity bypass graft failure and it does not appear that this has been specifically investigated in the literature.

There is scant evidence that Hispanics may have slightly better outcomes after fistula compared to White patients,[5] however, the majority of the little available literature demonstrates no difference in outcomes between Hispanics and Whites[2,7,39]. There is a strong possibility that the lack of statistically significant difference may be due to the smaller relative sample size and an associated Type II error. Negligible evidence is available on the outcomes of vascular access in the Asian/Pacific Islander patients with end-stage kidney disease. Further investigation in all of the racial/ethnic subpopulations is required to better understand outcome disparities and their drivers.

Expectations and trade-offs

An integral component of patient-tailored vascular access care is setting *expectations* relative to vascular access outcomes. Access-related expectations need to be discussed in short- and long-term contexts. Besides the risk of primary AV access failure and potential need of adjuvant procedures to aid AV access maturation (short-term expectations), the chance of longitudinal transitions from one type of access to another must be considered (long-term expectations). Recent studies showed that even with successful conversion from a CVC to an AV access, only 30% to 50% of the patients achieved CVC-free dialysis for more than 90% to 80% of their HD treatments[45,46]. Interestingly, the proportion of CVC-free HD treatments after AV access placement was not different between older and younger patients[46]. As pointed out by Allon, Lee, Voorzaat and colleagues, each type of access modifies the balance between short-term and long-term expectations, creating a *trade-off* between short-term and long-term experiences[47-49]. Compared to grafts, fistulas have better long-term survival and require fewer interventions. At the same time, fistulas have a higher primary failure rate, require more interventions to achieve maturation and require greater catheter dependence compared to grafts[47-49]. As a result, patients more likely to benefit from a graft are those with history of primary AVF failure, poor vascular anatomy or short life expectancy[47-49]. Thus, many times there is no clear 'right answer', but rather a series of trade-offs to consider, the value of which might be perceived differently by people with differing value systems and priorities.

Towards the Goal of SDM in Vascular Access Care

A hallmark of quality in healthcare, SDM is defined as care that is respectful of, and responsive to, individual patient preferences, needs, and values, while ensuring patients are informed and engaged in the medical decision-making process.[51]. SDM is important when more than one reasonable option to medical care exists, and its key ingredient is incorporation of patients' values and preferences to the available options into medical care. We condense SDM in a framework based on evidence-preference-practice approach (**Figure 1b**). Working towards this goal, we pinpoint components of care and highlight complexities that need to be addressed through future research in partnership with all healthcare stakeholders (**Table 1**).

Quality of information that supports SDM

Standard practice, which is integral in the framework for defining what is medically reasonable, is ideally based on high-quality, reproducible scientific evidence. However, this level of evidence is generally lacking in vascular access literature. Current vascular access practice—centered on surgical fistula creation—is based on 30-year-old retrospective research and observational studies[52-55] and has not been evaluated in clinical trials[56]. It can be contended an intervention that is considered standard practice but is based on low-quality evidence might require a different medical-reasonableness assessment than a treatment option that is informed by several randomized controlled trials. Thus, obtaining comparative results between alternative AV access strategies through rigorously performed, randomized studies is a critical need[57-59].

Precision of medical information used to predict vascular access outcomes

Clinicians lack sensitive tools to predict preoperatively the risk of AV access maturation failure. Factors other than inadequate vascular anatomy contribute to failure of AV access development[60-62]. As reviewed above, age, sex, race, and peripheral arterial disease are known risk factors for higher likelihood of AV access primary failure yet our ability to relay each individual's risk of short-term and long-term adverse access events remains poor[21,63]. The order and anatomical location of AV access placement adds more nuances adds to the complexity of access outcome prediction. Retrospective studies showed the outcomes of a second or third AVF are inferior to outcomes of the initial fistula[45,64]; in contrast, the outcome of second or third AVG are superior to those of the initial graft[45]. After primary failure of an initial forearm fistula, placement of an upper arm AVF carries two-fold higher risk for primary failure, more adjuvant interventions, and longer CVC dependence with three-fold higher frequency of catheter-related bacteremia than placement of an upper arm AVG[47].

Patients' values and preferences for vascular access care

Presently, vascular access planning is largely driven by the patient's nephrologist and vascular access surgeon, with little attention to individual patient preferences. Because vascular access practice has been dominated by disease-centered outcomes, studies on patients' preferences for different types of vascular access have not been done. A general impression about patients' preferences for vascular access care could perhaps be gleaned from qualitative studies that analyzed patients' self-reported experiences with access care. These studies revealed themes of heightened vulnerability, device intrusiveness on the body, disfigurement, mechanization of the body, impinging on way of life, imposing burdens, self-preservation and ownership, and confronting decisions and consequences[65,66]. In-person semi-structured interviews have probed patient reports on vascular access decision making and outcomes attitudes[58,67]. In one qualitative study, the majority of patients interviewed (14 of 15) disclosed minimal engagement in vascular access decision making and accepted vascular access recommendations from physicians. While the patients took ownership of the vascular access decision, they lacked clear understanding about the different types of access and their consequences. All (15 of 15) patients viewed the vascular access as "intertwined and interrelated" with dialysis and did not differentiate between dialysis and vascular access in decision making[67].

Patient-reported attitudes towards vascular access outcomes were also explored in a cohort of 10 patients (mean [SD] age 76 years) who started HD with a CVC, enrolled in a pilot clinical trial of vascular access placement, and underwent AVF (n=4) or AVG placement (n=6)[58]. At the time of the interview, 6 months after AV access placement, 6 patients achieved successful cannulation of the AV access. While all patients (10 of 10) perceived the intervention of AV access placement as "no other choice" and "something that needed to be done", 6 of 10 patients expressed that the decision of AV access placement was made collaboratively between physician, patient and/or family members. When asked to reflect on each access (CVC vs. AV access received) and compare access-related experiences, most patients (7 of 10) reported a preference for CVC rather than AV access if they were given a choice. Reasons for CVC preference were AV access failure (n=3) and dislike of needles (n=4). Two patients declared they would rather give up any length of their life in order to keep the CVC as their dialysis access (unpublished data).

We note that it is not known whether age-based differences exist in patients' perceptions and desired level of involvement in decision making about vascular access choice on HD. In one study of patients with end-stage kidney disease on peritoneal dialysis, differences in the importance of outcomes were noted across participant subgroups in terms of patients' age. In comparison to younger participants (aged <55 years) for whom mortality was ranked first overall, participants in the older age group (>55 years) ranked mortality 11th, and gave higher priority to quality-of-life outcomes, including ability to travel and sleep[68]. This underscores that decision making requires consideration of the patients' different goals and priorities across age groups.

Communication between healthcare providers, patients and family

Attention to the timing and continuity of communication between access care providers, patients, and families is an important mechanism underlying the quality of SDM[69]. These discussions need to elicit and explore patient and family experiences, values and preferences. Not infrequently, patients have had either immediate and/or distant family members with end-stage kidney disease whose experience with dialysis that might have impacted patients' decision towards various processes of care. Involving patients and their caregivers in the choice of HD vascular access is also important when the decision making is influenced by variables such as religion, health literacy, cognitive ability, and length of patient–clinician relationship. Following dialysis initiation, older patients can experience substantial declines in their cognitive and functional abilities, with most clinical and physical deterioration taking place in the initial 3 months on dialysis[70]. Despite awareness of evolving disabilities in older patients following dialysis initiation, little emphasis has been placed on patients' willingness to pursue what many times is either failed or repetitive interventions to create an AV access. These attempts at AV access creation could erode the remaining quality of life by subjecting patients to costly, recurrent and painful interventions with multiple physician visits, hospitalizations and time away from loved ones[71,72]. Input from caregivers and other healthcare providers is necessary to formulate care plans congruent with patient's expressed wishes and general goals of care.

System support to improve interprofessional collaboration, patient navigation and quality of care

Interprofessional collaboration

Vascular access care is a multistep process with different providers involved at different levels of care such as nephrologists, access educators, surgeons, interventional nephrologists, radiologists, and nurses. In the absence of interprofessional communication, opportunities to convey patients' expression of their experience and preference at different levels of care is lost[73]. Often, this leads to a fragmented approach to care. In fact, in healthcare, professional divides[74,75], organizational silos[76], isolated clinics, uncommunicative teams and disconnected departments[77] are often the norm[78]. Thus, vascular access coordinator-coordinated care to networks all providers and extend complex information to patients/families is an essential resource in order to streamline vascular access care and SDM[79]. Research showed that using a dedicated vascular team approach increases the prevalence of AVF use and early identification of complications, and improves vascular access outcome[80-83].

Patient navigation

Patients need help to navigate the maze of healthcare. As other patients with chronic health conditions, patients with advanced chronic kidney disease often require hospitalizations, several emergency room visits, and/or countless appointments with specialists. Giving consumers the tools and support they need to navigate such complex care is paramount to improve patient outcomes across the spectrum of kidney disease care[84-87]. A recent quality improvement project within the Geisinger Health System showed that patient education, needs assessment, peer support, care navigation, and electronic supports yielded improvements in patient self-efficacy and knowledge, and trends toward improvements in patient and provider confidence[88].

Quality of care

Communicating a comprehensive picture of vascular access outcomes includes consideration of local practices such as access to care, surgeons' experience and dedication to angioaccess surgery, and dialysis staff cannulation skills.

Regarding access to care, the supply of surgeons placing vascular access is key. Geographic variation in AVF placement and maturation rates, independent of patient-level comorbid burden, has been well described[89,90]. Research showed the supply of vascular access surgical specialists is highest in socially and economically advantaged areas[91]. The utility and safety of a mobile vascular access surgical unit in providing quality vascular access surgery for the indigent rural population with poor access to care should be the subject of further study. Moreover, it has been recognized that the surgical skill is an important factor affecting AVF surgery success[92-94]. Surgeons' prior volume of AV access placements is strongly associated with AV access maturation [94], particularly for the forearm access compared to those located on the upper arm[92]. Sharing benchmarked performance data with surgeons could be an actionable step in achieving more high-value care in HD access surgery[93].

Cannulation of the fistula is a procedure requiring significant skill development and refinement and if not done well can have negative consequences on access outcomes and patients' experience. In clinical practice, procedures for vascular access cannulation vary from clinic to clinic[95]. Some nurses remain in a state of a 'perpetual novice' resulting in a viscous cycle of negative patient consequences (bruising, pain), further influencing patients' decisions not to pursue a fistula or abandon cannulation. The risk of a miscannulation could be reduced with appropriate training of nurses and creating a practice environment that is patient-centered and cultivates teamwork[96,97].

Patient decision aids

Decision aid tools that are peer- and patient-reviewed and use patient-friendly language must be developed to convey a holistic picture of the components of vascular access journey with each type of access. In collaboration with key stakeholders, a research group recently developed mixed-media vascular access education materials (available at go.unc.edu/dialysis access) and their preliminary findings suggest that the decision aids improved patients' understanding and experiences as they navigated vascular access care[98]. In accordance with particular care contexts (e.g., pre- or post-dialysis initiation, with or without a previously failed AV access), more than one category of decision aids will be required. The decision aids will need to contain information as it pertains to their specific care context and relay unbiased information of the pros and cons of each type of vascular access. Ensuring patients are informed according to their context of care, physicians should present each access type as an *option* and elicit their preference to each process of care and incorporate their preference into practice (**Figure 1b**).

Policy and quality measures

We acknowledge the objectives of presenting vascular access types as options and integrating patient's preference may not be achieved as long as dialysis reimbursement is designed around disease-centered metrics, i.e., prevalence of AVF use at outpatient dialysis units[99]. Notwithstanding this limitation, it is rational for policy changes to occur after research generate substantial evidence of SDM feasibility, clinical advantage, and patient satisfaction. A critical step in SDM implementation is producing a reliable instrument that measures the SDM experience, from the perspective of patients and providers, based on which the quality and impact of SDM can be appraised and tied with quality measures and reimbursement. The experience with SDM measurement instruments in other areas of medicine heralds the objective of instrument development for measuring SDM experiences and clinical consequences in vascular access practice will require diligent work[100-102]. Contingent upon accumulation of high-quality, patient-centered data, and SDM instruments, the performance standards will need to be modified to better accommodate individualized patient care.

A Fluid Approach to Accommodate Evolving Vascular Access Care and Complications

The dynamic nature of health status in adults with advanced kidney disease may lead to changes in patient's priorities . Thus, temporal changes in vascular access planning will be an inherent part of access care. As physicians, we must recognize that relative benefits and harms of each form of access are critically dependent not only on patient characteristics but also on disease circumstances and prognosis which in turn, may cause temporal changes in patient preferences for a particular type of access. Not infrequently, patients express a desire to maintain a CVC for dialysis, even when they understand the risks associated with catheter use[103]. Patients for whom an AV access strategy was originally elected and who developed an intercurrent illness that profoundly impacted the quality of life (e.g., stroke, advanced malignancy) will need to have their goals of care and vascular access approach revisited; dialysis with a CVC may be an acceptable approach in those scenarios. Thus, the exercise evidence-preference-practice for HD vascular access may need to be applied more than once during the lifetime of an individual with advanced kidney disease.

Physicians are habitually unwilling to accept a patient's preference for and choice of using a CVC. Conceding to a patient's preference to keep a CVC might be perceived as a significant departure from previously held dogma that physicians have the ethical and legal obligation to resist "patient's self-destructive choices"[104]. We contend that physicians have the moral obligation to abide by the patient's choices, provided a) the patient has decision-making capacity, and b) there is correct understanding—by the patient and caregivers—of risks associated with the choice. There are other circumstances when the physicians abide to unfavorable decisions made by patients regarding treatment of their kidney disease with kidney replacement therapy, a chief example being patient's choice regarding dialysis therapy. Legal and ethical principles have long been put into place to support a person's right to either forego dialysis initiation or withdraw dialysis[105]. Notably, stopping kidney replacement therapy in a patient with end-stage kidney disease is a direct and unequivocal cause of death; physicians properly accede to patient's wishes in these scenarios. In contrast, physicians target AV access creation often at odds with patient's desires and in spite of mounting literature showing that a CVC is not a direct mediator of death in patients with end-stage kidney disease[106-108]. Efforts should continue to identify and implement measures that minimize and ideally eliminate the risk of CVC-related complications, some of which are dialysis-staff dependent[109-112]. Future qualitative research should explore and elucidate contextual differences of the individual experiences with different vascular accesses to bring a deeper awareness and understanding of contextual vascular access care.

Conclusions

All too frequently physicians refer to patients who require vascular access as a homogenous group. Contemporary research has shed light on a spectrum of individuals with different access outcomes and different needs. Inter- and intra-patient heterogeneity in health status, health priorities, and illness experiences not only revealed that access type-centered approach was inadequate, but also highlighted the need to shift the care to a patient-centered access-mindful approach with the expectation that the need for a particular vascular access type can change in time. Future clinical trials and qualitative research should provide a deeper understanding of the complexity of access-related outcomes and the lived experiences of vascular access intervention to complement clinical data with SDM for these patients. Vascular access planning needs to take into consideration local practices and identify areas in need of improvement. Strengthening vascular access care requires the reorganization of existing practices to coordinated care and provide equal and easy access to care. It is clear that personalized access care, based on a SDM model of evidence-preference-practice approach, will require dynamic care specifically relevant to the individual based on individual-level characteristics, values and preferences.

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M Murea: Conceptualization; Data curation; Investigation; Validation; Writing - original draft; Writing - review and editing

K Woo: Conceptualization; Data curation; Writing - original draft; Writing - review and editing

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Table 1. Components essential for implementation of effective SDM in vascular access practice	
Component of Care	*Complexities and Future work*
Quality of information that supports SDM	High-quality scientific evidence to compare outcomes based on different strategies of vascular access planning. Conduct research in general contexts of decision making: pre-dialysis, on-dialysis, with or without prior AV access.
Tools used to predict vascular access outcomes	Develop decision aids tools based on data from a wide breadth of providers, patients, and care settings to improve their generalizability. Risk prediction models need to accounts for patient's clinical (e.g., age, sex, race, BMI, frailty, co-morbidities) and vascular (e.g., anatomical location of AV access placement, order of AV access) characteristics.
Patients' values and preferences for vascular access care	Perform qualitative research that probes patients' preference for access type and choice of trade-offs. Examine the impact of caregiver involvement on vascular access planning. Analyze intra-individual longitudinal changes in access care preference.
System support to integrate and facilitate quality care	Organize existing practices to forge greater levels of connectivity between care teams and patient navigation across the entire journey of vascular access care, i.e., utilize vascular access coordinators. Mutidisciplinary encounters (e.g., nephrologist, surgeon, and patient/family) and patient education to facilitate vascular access creation. Increase availability to access care and analyze safety of care with mobile vascular access surgery units.
Patient decision aids	Clear communication of access options and potential complications with each access type. Develop decision aids specific to separate processes of care, e.g., pre-dialysis access planning, on-dialysis access choice following failure of a previous access.
Policy and quality measures	Develop instruments that measure SDM experiences and clinical consequences. Adjust performance metrics to accommodate patient preference-based vascular access practice.

Figure 1. The approach to hemodialysis vascular access care. a) The evidence-practice model; b) The evidence-preference-practice framework.

Figure 1

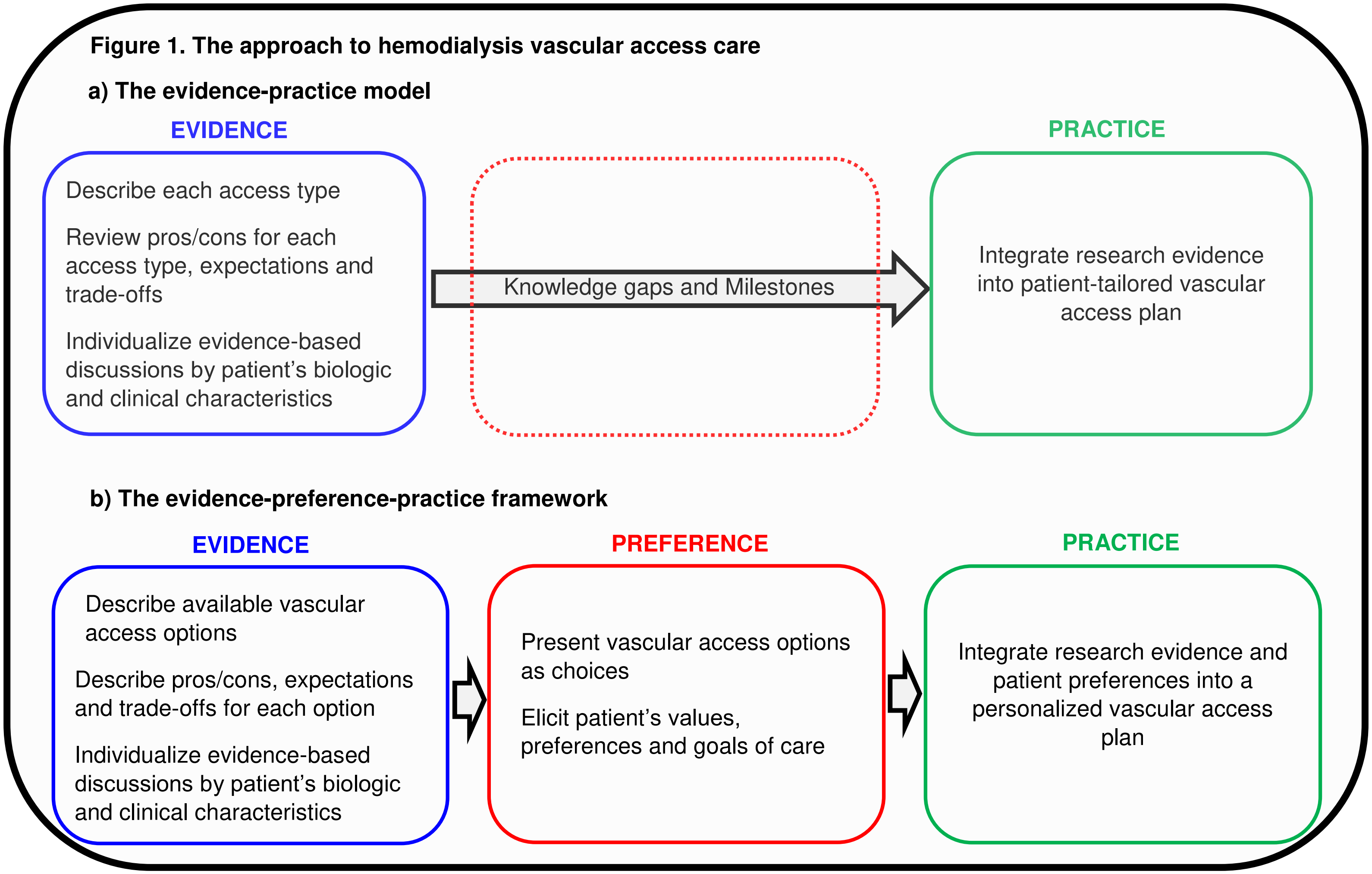
Figure 1. The approach to hemodialysis vascular access care
a) The evidence-practice model
EVIDENCE
Describe each access type
Review pros/cons for each access type, expectations and trade-offs
Individualize evidence-based discussions by patient's biologic and clinical characteristics
Knowledge gaps and Milestones
PRACTICE
Integrate research evidence into patient-tailored vascular access plan
b) The evidence-preference-practice framework
EVIDENCE
Describe available vascular access options
Describe pros/cons, expectations and trade-offs for each option
Individualize evidence-based discussions by patient's biologic and clinical characteristics
PREFERENCE
Present vascular access options as choices
Elicit patient's values, preferences and goals of care
PRACTICE
Integrate research evidence and patient preferences into a personalized vascular access plan