CardioRenal Medicine

Cardiorenal Med 2018;8:285–295
DOI: 10.1159/000490768
Received: April 6, 2018
Accepted: June 10, 2018
Published online: August 3, 2018

© 2018 S. Karger AG, Basel
www.karger.com/crm

Original Paper

Detection of Atherosclerotic Cardiovascular Disease in Patients with Advanced Chronic Kidney Disease in the Cardiology and Nephrology Communities

Rafia I. Chaudhry[a] Roy O. Mathew[b] Mandeep S. Sidhu[c] Preety Sidhu-Adler[d] Radmila Lyubarova[c] Janani Rangaswami[e] Loay Salman[a] Arif Asif[f] Jerome L. Fleg[g] Peter A. McCullough[h] Frank Maddux[i] Sripal Bangalore[j]

[a]Division of Nephrology and Hypertension, Albany Medical College, Albany, NY, USA; [b]Division of Nephrology, WJB Dorn VA Medical Center, Columbia, SC, USA; [c]Division of Cardiology, Albany Medical College, Albany, NY, USA; [d]Cardinal Health, Cleveland, OH, USA; [e]Division of Nephrology, Department of Medicine, Einstein Medical Center, Philadelphia, PA, USA; [f]Department of Medicine, Jersey Shore University Medical Center, Seton Hall-Hackensack Meridian School of Medicine, Neptune City, NJ, USA; [g]Division of Cardiovascular Sciences, National Heart, Lung and Blood Institute, Bethesda, MD, USA; [h]Baylor University Medical Center, Dallas, TX, USA; [i]Fresenius Medical Care North America, Waltham, MA, USA; [j]New York University School of Medicine, New York, NY, USA

Keywords
Chronic kidney disease · Coronary artery disease · Atherosclerotic cardiovascular disease

Abstract
Background: Atherosclerotic cardiovascular disease (ASCVD) is a leading cause of morbidity and mortality among patients with chronic kidney disease (CKD) with a glomerular filtration rate of <60 mL/min/1.73 m^2 body surface area. The availability of high-quality randomized controlled trial data to guide management for the population with CKD and ASCVD is limited. Understanding current practice patterns among providers caring for individuals with CKD and CVD is important in guiding future trial questions. ***Methods:*** A qualitative survey study was performed. An electronic survey regarding the diagnosis and management of CVD in patients with CKD was conducted using a convenience sample of 450 practicing nephrology and cardiology providers. The survey was administered using Qualtrics® (https://www.qualtrics.com). ***Results:*** There were a total of 113 responses, 81 of which were complete responses. More than 90% of the respondents acknowledged the importance of CVD as a cause of morbidity and mortality in patients with CKD. Outside the kidney transplant evaluation setting, 5% of the

Roy O. Mathew
Division of Nephrology
WJB Dorn VA Medical Center
Columbia, SC 29209 (USA)
E-Mail roy.mathew@va.gov

respondents would screen an asymptomatic patient with advanced CKD for ASCVD. Outside the kidney transplant evaluation scenario, the respondents did not opt for invasive management strategies in advanced CKD. ***Conclusions:*** The survey results reveal a lack of consensus among providers caring for patients with advanced CKD about the management of ASCVD in this setting. Future randomized controlled trials will be needed to better inform the clinical management of ASCVD in these patients. The limitations of the study include its small sample size and the relatively low response rate among the respondents. © 2018 S. Karger AG, Basel

Introduction

Cardiovascular disease (CVD) is the leading cause of death among patients with advanced chronic kidney disease (CKD), i.e., with an estimated glomerular filtration rate (eGFR) <30 mL/min/1.73 m^2, especially end-stage renal disease (ESRD), with approximately 41% mortality in ESRD attributed to CVD [1, 2]. Nevertheless, patients with advanced CKD and ESRD are underrepresented in clinical trials of CVD [3]. The Kidney Disease Outcome and Quality Initiative 2005 Cardiovascular Disease in Dialysis Patients guidelines recommend the assessment and treatment of risk factors and end organs for CVD in dialysis patients, but they lack detailed specifics on screening modalities and risk stratification beyond transthoracic echocardiography for valvular disease in dialysis patients [4]. The most extensive set of guidelines has been outlined for patients with CKD undergoing transplant evaluation [5]. The majority of recommendations were class IIa or lower due to a lack of strong randomized controlled trial data addressing the topics outlined. No similar set of guidelines is available for advanced CKD or ESRD populations who are not being evaluated for renal transplantation.

Understanding variation in clinical practice in assessing and managing CVD risk factors in such patients can guide future clinical trial designs in addressing knowledge gaps, thereby leading to higher-class recommendations. We evaluated clinical practice patterns among nephrologists and cardiologists regarding the identification and management of atherosclerotic CVD (ASCVD), the most common cause of CVD in the population with advanced CKD – i.e., with an eGFR <30 mL/min/1.73 m^2 – and ESRD.

Methods

A 22-question survey (5 general questions and 17 clinical scenarios), designed by the authors (A.A., M.S.S., R.I.C., R.L., R.O.M., and S.B.), that assessed provider perceptions and practice patterns concerning the epidemiology, diagnosis, and management of ASCVD in patients with advanced CKD stages 4–5 (eGFR ≤30 mL/min/1.73 m^2) and ESRD (eGFR <15 mL/min/1.73 m^2 and on dialysis – hemodialysis or peritoneal dialysis, or with a kidney transplant) was developed by a group of 3 nephrologists and 3 cardiologists based on clinical guidelines and the published literature.

This de novo survey (see online suppl. Appendix for a full survey; for all online suppl. material, see www.karger.com/doi/10.1159/000490768) consisted of 3 broad domains: (1) epidemiological perspectives – the prevalence of coronary artery disease (CAD) in advanced CKD and ESRD; (2) screening – the ideal screening modality for CAD in advanced CKD and ESRD, as well as appropriate patient selection for screening; and (3) therapeutics – the best treatment for CAD in advanced CKD and ESRD, as well as appropriate targets for CAD risk reduction among patients with advanced CKD and ESRD. It was approved by the Albany Medical College Institutional Review Board and distributed to nephrology (n = 130) and cardiology (n = 20) providers (physicians, physician assistants, and nurse practitioners) who were contacts of the authors, and nephrologists with Fresenius Medical Care (n = 300), an international provider of dialysis services (only the US providers were contacted). All invited participants received a link to the survey via email (hereinafter, participants will

Table 1. Demographic features of the respondents with full responses (n = 81)

Gender	
Female	30 (37)
Male	51 (63)
Country	
Bahrain	1 (1.2)
Canada	4 (4.9)
Puerto Rico	1 (1.2)
USA	75 (92.6)
Provider type	
Nurse practitioner	3 (3.7)
Physician	78 (96.3)
Specialty	
Cardiology	6 (7.4)
Nephrology	75 (92.6)
Duration of practice	
<5 years	16 (19.7)
5–10 years	20 (24.7)
>10 years	45 (55.5)

be identified as respondents). The survey was administered between November 2016 and June 2017 using Qualtrics® (https://www.qualtrics.com). Data summaries were derived using the R statistical software package (https://cran.r-project.org/) and Qualtrics®.

Results

The overall response rate was 25% (30% among cardiology providers and 17% among nephrology providers); the complete response rate was 18%. Of the respondents with complete results, 96.3% were physicians, of which 77% were nephrologists and 5% cardiologists. The general demographic features of the respondents with complete information are presented in Table 1.

Perceptions of the Prevalence of CAD in CKD and Ideal Means of Diagnosis

The respondents generally agreed (96%) that CAD was more common among patients with CKD, irrespective of the CKD stage, than among those without CKD; 91% indicated that an atypical presentation of CAD was more common in CKD. In addition, 94% of the respondents felt that for an individual with advanced CKD, death due to cardiovascular causes was the more likely outcome than was ESRD requiring renal replacement therapy.

Diagnostic Modality of Choice

For patients with advanced CKD not yet on renal replacement therapy, the majority of the respondents (55%) preferred myocardial perfusion scintigraphy (MPS), followed by coronary angiography (16%) and exercise treadmill testing (11%) (Fig. 1a). For patients with ESRD on dialysis, coronary angiography was the preferred diagnostic modality for CAD (50%) (Fig. 1b).

Patient Selection for Screening

We ascertained which clinical scenarios would prompt screening for CAD in patients with advanced CKD or ESRD on hemodialysis (Fig. 2). Ninety-five percent of the respondents would not screen an asymptomatic patient with ESRD without known traditional CAD risk

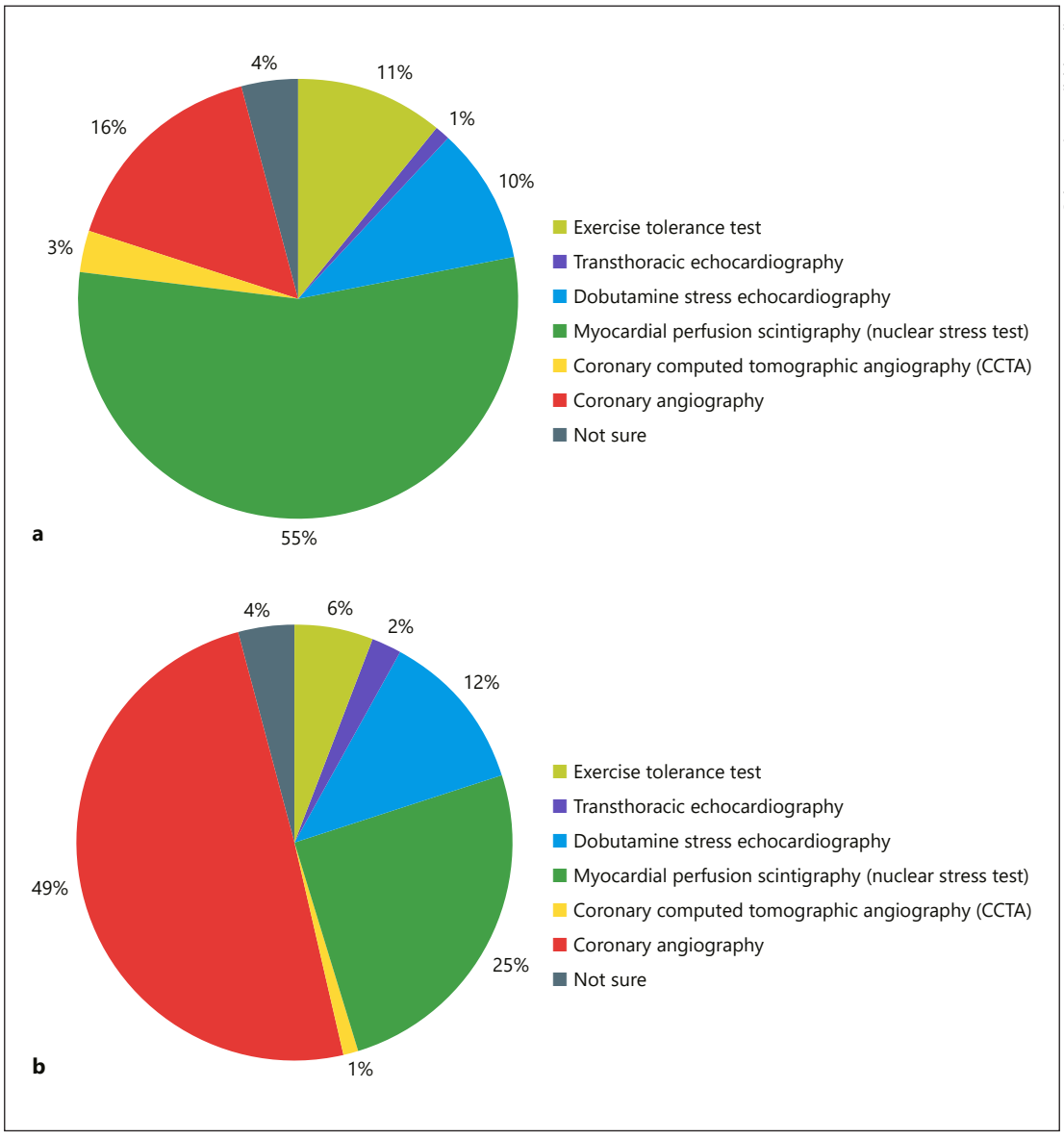

Fig. 1. a Preferred diagnostic test to screen for clinically significant coronary artery disease (CAD) in patients with chronic kidney disease (CKD) not on dialysis. **b** Preferred diagnostic test to screen for clinically significant CAD in patients with CKD on dialysis.

factors. In patients symptomatic for possible cardiac disease (e.g., dyspnea on exertion or persistent hypotension on dialysis), or with objective evidence of reduced systolic function as reflected in the left ventricular ejection fraction, at least 85% of the respondents preferred evaluation for CAD as a possible cause of the findings in each scenario. The preference for preoperative cardiac testing depended on the type of surgery. In contrast to the pre-renal transplant workup in essentially asymptomatic patients (in whom >95% of the respondents would evaluate for CAD), prior to laparoscopic bariatric surgery on an advanced CKD patient with traditional risk factors for CAD (hypertension, diabetes, and smoking), only 73% indicated they would formally evaluate for CAD.

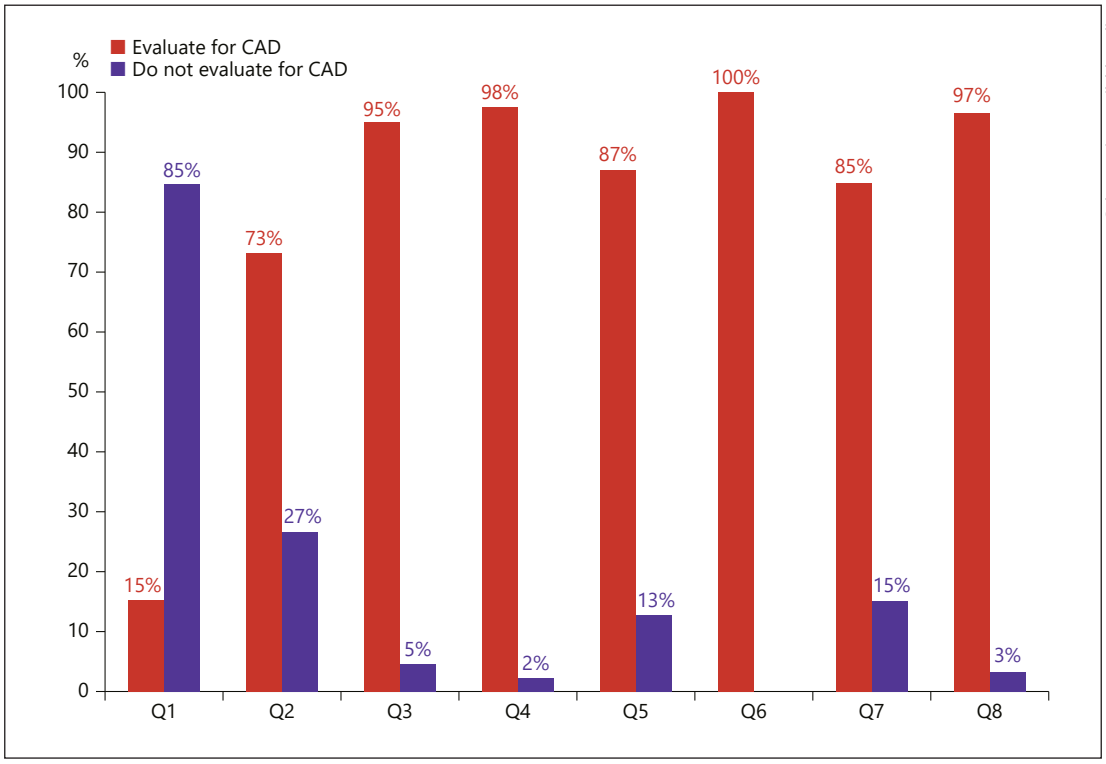

Fig. 2. For each of the following case scenarios listed below, indicate if you would evaluate this patient for CAD: (Q1) 50-year-old male with autosomal dominant polycystic kidney disease, not diabetic, nonsmoker, no history of CAD, no family history of premature CAD in any first-degree relative, who is about to start hemodialysis for advanced CKD, i.e., stage 5 (eGFR <15 mL/min/1.75 m^2); (Q2) 45-year-old female, diabetic with diabetic retinopathy, CKD stage 5, smoker, body mass index 39, uncontrolled hypertension and very little physical activity, scheduled for laparoscopic banding gastric bypass surgery; (Q3) 65-year-old male, nondiabetic, CKD stage 5 on hemodialysis, no known history of CAD, currently asymptomatic, who is being evaluated for renal transplantation; (Q4) 60-year-old female, diabetic, on maintenance hemodialysis for 1 year, who is being sent for renal transplantation evaluation; (Q5) 65-year-old male with a failed kidney transplant, on maintenance hemodialysis for the past 2 years, has had unexplained intradialytic hypotension for the past 6 treatments, not relieved with cessation of antihypertensive medications and less aggressive fluid removal on dialysis days; (Q6) 55-year-old female on hemodialysis for 5 years with persistent dyspnea on exertion despite maximizing fluid removal at dialysis; (Q7) 70-year-old male, diabetic, on maintenance hemodialysis for the past 3 years, with increasing lower extremity edema and intolerance to fluid removal to an adequate dry weight without hypotension; (Q8) 60-year-old diabetic female on maintenance hemodialysis for 10 years who is admitted with flash pulmonary edema; echocardiography performed during admission found an ejection fraction (EF) of 35%, whereas a routine echocardiography 1 year earlier revealed an EF of 50%. CAD, coronary artery disease; CKD, chronic kidney disease.

Therapies for CVD and Cardiovascular Risk Factors

Coronary Artery Revascularization (Percutaneous Coronary Intervention or Coronary Artery Bypass Grafting) versus Medical Therapy Alone for Suspected CAD

Four case scenarios were presented to the respondents of patients with advanced CKD or ESRD (renal transplant) with symptoms or stress test findings suggestive of CAD with a goal to assess management strategies (Fig. 3). In a patient found to have a positive stress test as part of the kidney transplantation evaluation, 73% (73% of the nephrologists, 80% of the cardiologists) preferred some form of coronary revascularization plus medical therapy over

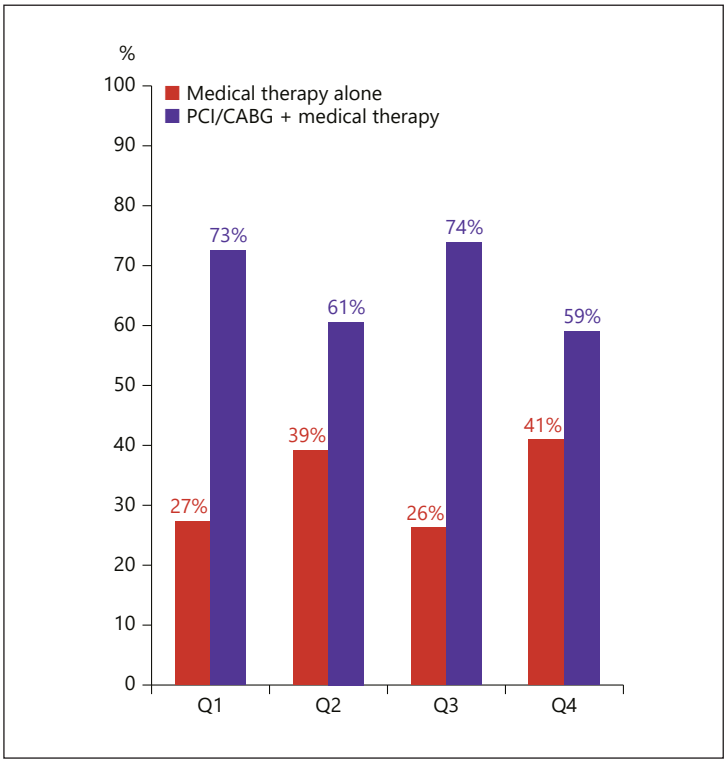

Fig. 3. What is the appropriate course of therapy for the patient: medical therapy alone or percutaneous coronary intervention (PCI)/coronary artery bypass grafting (CABG) plus medical therapy? (Q1) 50-year-old male with eGFR 15, was found to have a positive stress test as part of his renal transplant workup. He has no angina. (Q2) 60-year-old female with diabetes with eGFR 10 is being sent for creation of an arteriovenous fistula. She undergoes a stress test, which is positive. (Q3) 55-year-old female with stable renal transplant is presenting to you with new-onset chest pain that is present at rest. (Q4) 45-year-old male with diabetes, stable renal transplant function, is presenting to you with new-onset dyspnea on exertion.

medical therapy alone. Prior to nontransplant surgery (arteriovenous fistula creation), 61% (60% of the nephrologists, 90% of the cardiologists) preferred a revascularization approach over medical therapy alone. In each of these nontransplant case scenarios, the patient had CKD stage 5 (eGFR <15 mL/min/1.73 m^2), and a need for hemodialysis or peritoneal dialysis was not explicitly stated.

In two separate patient scenarios with stable renal transplant function (Fig. 3), the respondents felt that a coronary revascularization approach was most appropriate (74%) when the patient was presenting with the classic symptom of chest pain at rest. Only 59% favored this approach for the patient with diabetes and atypical symptoms (dyspnea on exertion).

Risk Reduction: Blood Pressure Targets

The majority of the respondents were split regarding the systolic blood pressure (SBP) target in CKD patients with minimal albuminuria (<30 mg/g): 140 mm Hg (45%) or 130 mm Hg (40%) (Fig. 4). However, 57% favored the lower SBP target of 130 mm Hg for CKD patients with marked albuminuria (>300 mg/g). More liberal SBP targets of 140 mm Hg (59%) and 150 mm Hg (25%) were favored for patients with ESRD on maintenance hemodialysis therapy.

Risk Reduction: High-Intensity Statin Prescription

Sixty-seven percent of the respondents indicated that they would prescribe high-intensity statin to a dialysis patient previously on statin therapy with multivessel CAD requiring coronary artery bypass grafting (Fig. 5). The likelihood of prescribing high-intensity statin was somewhat lower (55%) for a dialysis patient previously on moderate-intensity statin with nonobstructive 2-vessel CAD on coronary angiography.

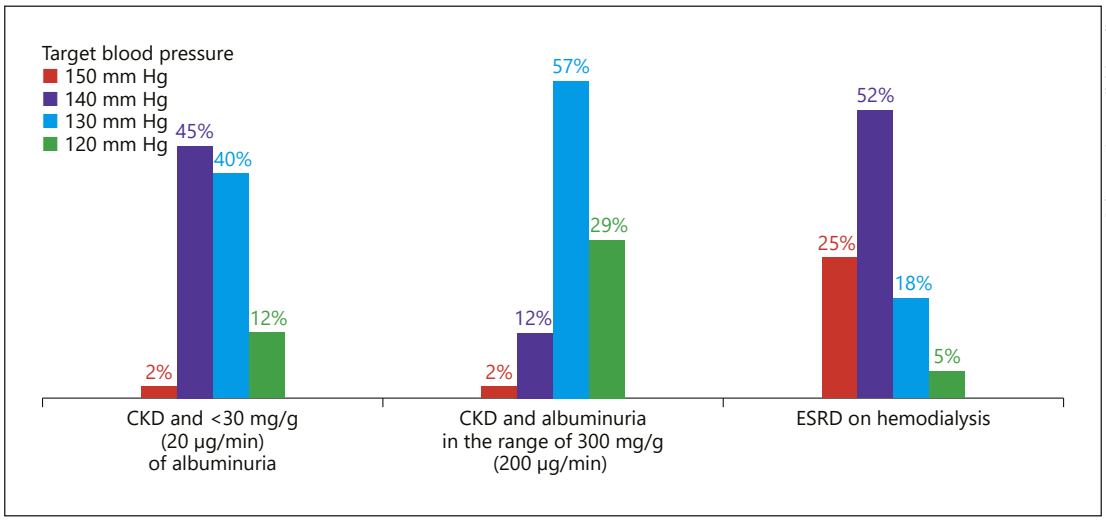

Fig. 4. Medical therapy: systolic blood pressure targets.

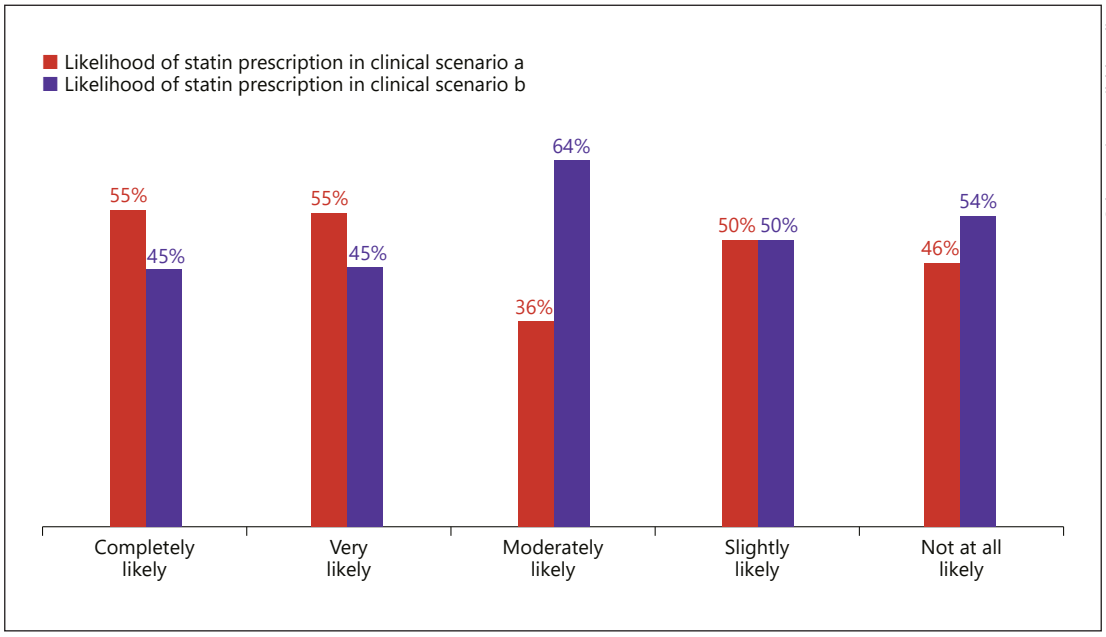

Fig. 5. Likelihood of prescribing high-intensity statin (e.g., atorvastatin 40–80 mg, rosuvastatin 20 or 40 mg). Scenario a: a 60-year-old male, diabetic on hemodialysis for 2 years, presents to the emergency department with substernal chest pain of 1 day duration. The patient has been on a stable dose of atorvastatin 20 mg (moderate intensity) prior to this event. The patient undergoes cardiac catheterization and is found to have multivessel coronary artery disease and undergoes coronary artery bypass grafting. Scenario b: a 50-year-old female on maintenance hemodialysis therapy undergoes coronary angiography and is found to have 2-vessel nonobstructive coronary artery disease. The patient is currently on a moderate-intensity statin. She has a cholesterol panel drawn and is found to have a low-density lipoprotein level of 110 mg/dL (2.85 mmol/L).

Discussion

The results of this survey study shed light on the current management of CAD among patients with advanced CKD or ESRD, and we feel that they afford important insights into this area. There is general agreement among providers that ASCVD is common, and CVD outcomes are more likely to occur than developing ESRD in patients with advanced CKD; this is well supported by a large mass of epidemiological data [6]. Whereas advanced CKD was widely recognized as an independent risk factor for ASCVD by the survey respondents, there was variation in their responses regarding the diagnosis and management of ASCVD in such patients.

Screening Domain

The choice of the screening modality depended on the need for renal replacement therapy (hemodialysis or peritoneal dialysis). The respondents felt that noninvasive modalities, primarily MPS (55%), should be utilized for case detection rather than invasive methods such as coronary angiography (3%) for nondialysis patients with advanced CKD. In patients already on hemodialysis, the preference was for coronary angiography, but only about half of the respondents chose this modality. The reasons for this discrepancy in the use of coronary angiography were not elicited; however, given the difference based on the need for hemodialysis, the concern about avoiding iodinated contrast medium in nondialyzed patients may have been the primary motivating factor. An analysis from the NCDR CathPCI registry showed that the risk of acute kidney injury following percutaneous coronary intervention (PCI) in patients with advanced CKD is higher than in those without CKD, but the risk may be independent of the dye load [7]. An important caveat from this analysis is that all patients were admitted for an acute coronary syndrome; the risk may be attenuated if the PCI is conducted under elective conditions.

Currently there are no randomized controlled trials to guide the choice of a noninvasive screening modality for CAD in patients with advanced CKD or ESRD. The best available data are from a meta-analysis by Wang et al. [8]. The authors identified that MPS (sensitivity 0.69, specificity 0.77) and dobutamine stress echocardiography (sensitivity 0.80, specificity 0.89) had the best test performance amongst the modalities studied, including stress electrocardiography, digital subtraction fluorography, and exercise ventriculography; the difference between MPS and dobutamine stress echocardiography did not meet statistical significance ($p = 0.07$).

In deciding which patient to send for CAD evaluation, the presence of CKD stage 5 alone, without symptoms suggesting cardiac disease or risk factors for cardiac disease, was not deemed as a reason for testing: 85% of the respondents decided against screening. This is an interesting finding, in that the majority of the respondents felt that cardiovascular morbidity and mortality was the most likely outcome of advanced CKD or ESRD. In other words, the implicit acknowledgement that advanced CKD and ESRD are possibly a CAD equivalent, as is suggested by some [9], has not translated into the evaluation and management of patients with advanced CKD or ESRD as such. On the other hand, when presented with a patient with ESRD and multiple traditional risk factors for CAD, most respondents (73%) felt that screening was appropriate. The KDOQI 2005 Cardiovascular Disease in Dialysis Patients guidelines recommend that "all patients – regardless of symptoms – require assessment for cardiovascular disease […] as well as screening for both traditional and nontraditional cardiovascular risk factors" [4]. The authors noted that the guidelines were vague due to the sparse nature of the available evidence and lack of randomized controlled trials regarding cardiac evaluation of patients with ESRD, and guidelines are lacking for screening of ASCVD in CKD patients not on dialysis, or being worked up for renal transplantation.

Evaluation for kidney transplantation has routinely involved screening for CAD. This includes assessing the presence of traditional risk factors (diabetes) as well as of nontradi-

tional risk factors such as being on dialysis for >1 year, as occurred in our case scenarios. The survey respondents seemed to identify with the most recent guidelines regarding CAD evaluation prior to kidney transplantation: >95% would screen for CAD prior to kidney transplant evaluation and 73% favored attempting revascularization if a positive stress test had been obtained prior to kidney transplant evaluation [5]. The ACC/AHA guidelines from 2015 suggest that screening for CAD prior to kidney transplantation should occur if ≥3 risk factors are present; these guidelines have been endorsed by the American Society of Transplantation, the American Society of Transplant Surgeons, and the National Kidney Foundation [5].

The KDOQI guidelines on cardiovascular evaluation provide additional guidance for nontransplant candidates on maintenance hemodialysis. Any patient on hemodialysis with recurrent intradialytic hypotension, inability to achieve a target weight due to hypotension, or a documented drop in ejection fraction (to <40%) should be evaluated for CAD. Intradialytic hypotension has been associated with a modest 14% increase in the relative risk for developing myocardial infarction [10].

It should be noted that guidelines do not always ensure adequate adherence to evidence-based therapies among providers. The CRUSADE (Can Rapid Risk Stratification of Unstable Angina Patients Suppress Adverse Outcomes with Early Implementation) study sought to understand current acute coronary syndrome guideline implementation across the USA [11, 12]. The investigators identified that the mere presence of guidelines alone does not guarantee adherence by providers. Further measures that improve adherence to guidelines include collaboration between health care providers and administrators, demonstration of improved outcomes in patient care environments, and demonstrating institutional benefits from guideline implementation [12]. To engage administrators will require not only randomized controlled trial data but also cost-benefit analyses.

Therapeutic Domain

Of the >90% of the respondents advocating an evaluation for CAD prior to kidney transplantation workup, the majority (73%) would recommend coronary revascularization. The number was lower for nontransplant surgery: 61% advocated for revascularization prior to arteriovenous fistula creation. In both scenarios, the patients had positive stress test results. This likely reflects the uncertainty based on a lack of clinical trial data regarding the benefit of revascularization for stable ischemic heart disease in patients with advanced CKD. In one of the very few randomized controlled trials on such patients, published in 1992 by Manske et al. [13], coronary revascularization (2 of 13), as compared to medical therapy alone (10 of 13), was associated with a lower incidence of cardiovascular events before or after kidney transplantation in type 1 diabetic patients with advanced CKD (p = 0.002), resulting in an early termination of the study. At the time of that study, optimal medical therapy consisted of aspirin and a beta-blocker or non-dihydropyridine calcium channel blocker and long-acting nitrates. Since then, no randomized trial of coronary revascularization versus medical therapy has focused on patients with advanced CKD or ESRD. The ongoing International Study of Comparative Health Effectiveness of Medical and Invasive Approaches-Chronic Kidney Disease (ISCHEMIA-CKD) (NCT01985360) and the Coronary Artery Disease Screening in Kidney Transplant Candidates (CAD Screening) (NCT02082483) study will help elucidate the best treatment strategy in this population. Furthermore, Bangalore et al. [14] assessed propensity-matched scores in 5,920 patients with CKD who underwent PCI (with everolimus-eluting stents) versus coronary artery bypass grafting for multivessel CAD. PCI was associated with lower short-term (within 30 days) risk of death (HR = 0.55; 95% CI: 0.35–0.87), stroke (HR = 0.22; 95% CI: 0.12–0.42), and early repeat revascularization; however, there was no difference in mortality rate in the long term (mean 2.9 years) with an increased risk of repeat revascularization in the PCI group (HR = 2.42; 95% CI: 2.05–2.85).

Several studies have evaluated the effect of blood pressure reduction in patients with CKD [15–17]. The peculiarity in blood pressure management among patients with CKD is the importance of albuminuria in selecting targets for blood pressure reduction. The Kidney Disease Improving Global Outcomes (KDIGO) Clinical Practice Guidelines for Management of Blood Pressure in CKD recommend lower blood pressure goals for the CKD population with micro- or macroalbuminuria than for those without micro- or macroalbuminuria (>30 or >300 mg/24 h, respectively) [18]. The respondents demonstrated adherence to these recommendations in their survey responses. The SBP targets were more liberal for the ESRD patient, with most respondents (64%) suggesting 140 or 150 mm Hg as the target. This finding likely reflects the numerous uncertainties about blood pressure management in patients with ESRD, including appropriate blood pressure monitoring and which outcomes derive a benefit from blood pressure reductions [19]. This is an area in great need of randomized controlled trial data to better guide clinical practice and inform guidelines in the future.

Preliminary evidence suggests that the 10-year Pooled Cohort risk assessment for CAD has validity in CKD patients not on hemodialysis [20]. However, a 10-year risk >7.5% is very common in this population; hence, the KDIGO Lipid Guidelines recommend blanket statin use for CKD patients >50 years of age and not on dialysis [21]. This recommendation is in contrast to that for patients on dialysis, for whom neither Die Deutsche Diabetes Dialyse Studie nor the Rosuvastatin and Cardiovascular Events in Patients Undergoing Hemodialysis (AURORA) trials demonstrated any benefit in reducing primary cardiovascular end points with statin therapy [22, 23]. LDL and total cholesterol levels alone do not adequately risk-stratify dialysis patients, in whom low levels of both lipids are common due to malnutrition and chronic disease, despite their high risk for cardiovascular mortality [23]. The Study of Heart and Renal Protection (SHARP) randomized 446 patients on dialysis to statin plus ezetimibe or placebo, but it was not powered to detect the outcome of atherosclerotic events within the dialysis population independent of the larger CKD cohort [24]. Additionally, limited data are currently available regarding the safety profile of higher-dose statins in the CKD population. Therefore, the KDIGO guidelines recommend statin dosing based on the limited randomized trials done on the CKD population, and do not recommend initiation of statin therapy for patients on dialysis [21].

The limitations of the study include its small sample size and low response rate. Additionally, there was a disproportionally higher number of nephrology providers who responded compared to cardiology respondents, translating into underrepresentation of the latter group.

The uncertainties regarding the most appropriate diagnostic strategy, risk factor reduction, and treatment of CAD in patients with advanced CKD or ESRD can only be rectified by greater inclusion of such patients in randomized trials. Steps to rectify this deficiency have been initiated by the SHARP and the ongoing ISCHEMIA-CKD, as well as CAD screening trials. Higher-quality evidence from such trials, as well as a cost-benefit analysis of the utilization of resources, is needed to better define optimal diagnostic and therapeutic strategies for this high-risk population.

Statement of Ethics

The authors have no ethical conflicts to disclose.

Disclosure Statement

S. Bangalore received grant support from the National Heart, Lung, and Blood Institute (NHLBI) for the ISCHEMIA-CKD. The content of this manuscript is solely the responsibility of the authors and does not necessarily reflect the views of the NHLBI, National Institutes of Health, the US Department of Health and Human Services, or the US Department of Veterans Affairs.

Funding Sources

No funding was received for this study.

References

1 Pradel FG, Jain R, Mullins CD, Vassalotti JA, Bartlett ST: A survey of nephrologists' views on preemptive transplantation. Clin J Am Soc Nephrol 2008;3:1837–1845.
2 Herzog CA, Asinger RW, Berger AK, et al: Cardiovascular disease in chronic kidney disease. A clinical update from Kidney Disease: Improving Global Outcomes (KDIGO). Kidney Int 2011;80:572–586.
3 Konstantinidis I, Nadkarni GN, Yacoub R, et al: Representation of patients with kidney disease in trials of cardiovascular interventions: an updated systematic review. JAMA Intern Med 2016;176:121–124.
4 K/DOQI Workgroup: K/DOQI clinical practice guidelines for cardiovascular disease in dialysis patients. Am J Kidney Dis 2005;45(suppl 3):S1–S153.
5 Lentine KL, Costa SP, Weir MR, et al: Cardiac disease evaluation and management among kidney and liver transplantation candidates: a scientific statement from the American Heart Association and the American College of Cardiology Foundation. J Am Coll Cardiol 2012;60:434–480.
6 Gansevoort RT, Correa-Rotter R, Hemmelgarn BR, et al: Chronic kidney disease and cardiovascular risk: epidemiology, mechanisms, and prevention. Lancet 2013;382:339–352.
7 Tsai TT, Patel UD, Chang TI, et al: Contemporary incidence, predictors, and outcomes of acute kidney injury in patients undergoing percutaneous coronary interventions: insights from the NCDR Cath-PCI registry. JACC Cardiovasc Interv 2014;7:1–9.
8 Wang LW, Fahim MA, Hayen A, et al: Cardiac testing for coronary artery disease in potential kidney transplant recipients: a systematic review of test accuracy studies. Am J Kidney Dis 2011;57:476–487.
9 Briasoulis A, Bakris GL: Chronic kidney disease as a coronary artery disease risk equivalent. Curr Cardiol Rep 2013;15:340.
10 Stefansson BV, Brunelli SM, Cabrera C, et al: Intradialytic hypotension and risk of cardiovascular disease. Clin J Am Soc Nephrol 2014;9:2124–2132.
11 Hoekstra JW, Pollack CV, Roe MT, et al: Improving the care of patients with non-ST-elevation acute coronary syndromes in the emergency department: the CRUSADE initiative. Acad Emerg Med 2002;9:1146–1155.
12 Blomkalns AL, Roe MT, Peterson ED, et al: Guideline implementation research: exploring the gap between evidence and practice in the CRUSADE Quality Improvement Initiative. Acad Emerg Med 2007;14:949–954.
13 Manske CL, Wang Y, Rector T, et al: Coronary revascularisation in insulin-dependent diabetic patients with chronic renal failure. Lancet 1992;340:998–1002.
14 Bangalore S, Guo Y, Samadashvili Z, et al: Revascularization in patients with multivessel coronary artery disease and chronic kidney disease: everolimus-eluting stents versus coronary artery bypass graft surgery. J Am Coll Cardiol 2015;66:1209–1220.
15 Ruggenenti P, Perna A, Loriga G, et al: Blood-pressure control for renoprotection in patients with non-diabetic chronic renal disease (REIN-2): multicentre, randomised controlled trial. Lancet 2005;365:939–946.
16 Wright JT Jr, Bakris G, Greene T, et al: Effect of blood pressure lowering and antihypertensive drug class on progression of hypertensive kidney disease: results from the AASK trial. JAMA 2002;288:2421–2431.
17 Peterson JC, Adler S, Burkart JM, et al: Blood pressure control, proteinuria, and the progression of renal disease. The Modification of Diet in Renal Disease Study. Ann Intern Med 1995;123:754–762.
18 KDIGO Work Group: KDIGO clinical practice guideline for the management of blood pressure in chronic kidney disease. Kidney Int Suppl 2012;2:338–414.
19 Turner JM, Peixoto AJ: Blood pressure targets for hemodialysis patients. Kidney Int 2017;92:816–823.
20 Colantonio LD, Baber U, Banach M, et al: Contrasting cholesterol management guidelines for adults with CKD. J Am Soc Nephrol 2015;26:1173–1180.
21 KDIGO Lipid Work Group: KDIGO clinical practice guideline for lipid management in chronic kidney disease. Kidney Int Suppl 2013;3:259–305.
22 Wanner C, Krane V, März W, et al: Atorvastatin in patients with type 2 diabetes mellitus undergoing hemodialysis. N Engl J Med 2005;353:238–248.
23 Fellström BC, Jardine AG, Schmieder RE, et al: Rosuvastatin and cardiovascular events in patients undergoing hemodialysis. N Engl J Med 2009;360:1395–1407.
24 Baigent C, Landray MJ, Reith C, et al: The effects of lowering LDL cholesterol with simvastatin plus ezetimibe in patients with chronic kidney disease (Study of Heart and Renal Protection): a randomised placebo-controlled trial. Lancet 2011;377:2181–2192.