From the Society for Vascular Surgery

The impact of chronic kidney disease on lower extremity bypass outcomes in patients with critical limb ischemia

Vishnu Ambur, MD,[a] Peter Park, MD,[a] John P. Gaughan, PhD,[b] Scott Golarz, MD,[c] Frank Schmieder, MD,[c] Paul Van Bemmelen, MD, PhD,[c] Eric Choi, MD,[c] *and* Ravi Dhanisetty, MD,[c] *Philadelphia, Pa; and Camden, NJ*

ABSTRACT

Objective: Patient selection for open lower extremity revascularization in patients with chronic kidney disease (CKD) remains a clinical challenge. This study investigates the impact of CKD on early graft failure, postoperative complications, and mortality in patients undergoing lower extremity bypass for critical limb ischemia.

Methods: The National Surgical Quality Improvement Program database was queried for all patients with critical limb ischemia from 2012 to 2015 who underwent lower extremity bypass using the targeted vascular set. The glomerular filtration rate was calculated using the Chronic Kidney Disease Epidemiology Collaboration Study equation. CKD categories were determined from the National Kidney Foundation Kidney Disease Outcomes Quality Initiative staging criteria. Patients were classified into three groups: CKD stages 3 or lower (mild to moderate CKD), CKD stages 4 or 5 (severe CKD), and on hemodialysis (HD). Multiple variable analysis was used to examine graft failure, mortality, and postoperative complications.

Results: The Surgical Quality Improvement Program database identified 6978 patients who underwent infrainguinal lower extremity arterial bypass during the study period. There were 6101 patients (87.4%) with mild to moderate CKD, 327 (4.7%) with severe CKD, and 550 (7.9%) on HD. Patients with severe CKD and on HD were more likely to have revascularization for tissue loss (54.9% vs 68.8% and 74.7%; $P < .01$). Patients with severe CKD and those on HD had higher rates of early graft failure, postoperative myocardial infarction, and rates of reoperation. Multiple variable analysis confirmed these results showing that HD was associated with postoperative myocardial infarction, readmission, and increased mortality. It also demonstrated that severe CKD was associated with graft failure (odds ratio [OR], 1.67; 95% confidence interval [CI], 1.12-2.50; $P = .01$), postoperative myocardial infarction (OR, 2.16; 95% CI, 1.35-3.45; $P < .01$), and readmission (OR, 1.38; 95% CI, 1.06-1.80; $P = .02$). Other factors associated with graft failure include functional status (OR, 1.39; 95% CI, 1.08-1.80; $P = .01$), African American race (OR, 1.72; 95% CI, 1.39-2.13; $P < .01$), and distal bypass (OR, 1.33; 95% CI, 1.09-1.61; $P < .01$).

Conclusions: CKD is a significant predictor of perioperative morbidity after lower extremity bypass. Patients with severe CKD have worse postoperative outcomes without increased mortality. Those on HD have worse survival and postoperative outcomes. (J Vasc Surg 2019;69:491-6.)

Keywords: Critical limb ischemia; Lower extremity bypass; Kidney disease; Dialysis; Peripheral arterial disease

There has been an increasing trend of patients diagnosed with chronic kidney disease (CKD) in the United States with more patients ultimately developing end-stage renal disease.[1,2] The prevalence of CKD is estimated at approximately 14% in the general adult population with more than 26 million adults being affected. The majority have mild to moderate CKD (96%) with the remainder having severe CKD and end-stage renal disease. These patients are more than twice as likely to have peripheral artery disease (PAD) as those with normal kidney function.[3]

Critical limb ischemia (CLI) marks the end point of PAD and is associated with increasing morbidity and mortality.[4] Over a 5-year period, 30% to 50% of patients with PAD suffer adverse cardiovascular events such as myocardial infarction (MI) and stroke; however, patients with CLI experience this same risk over a 1-year period. Similarly, the risk of major amputation is less than 5% over 5 to 10 years in patients with PAD, whereas the risk of a major amputation is 30% to 50% in the first year in patients with CLI who do not undergo revascularization.[5] CLI is emerging as one of the major causes of morbidity and mortality among patients with

From the Department of Surgery[a] and Division of Vascular Surgery,[c] Temple University Hospital, Philadelphia; and the Biostatistics Department, Cooper Medical School of Rowan University, Camden.[b]

Author conflict of interest: none.

Presented at the 2017 Vascular Annual Meeting of the Society for Vascular Surgery, San Diego, Calif, June 1, 2017.

Correspondence: Vishnu Ambur, MD, Department of Vascular Surgery, Cleveland Clinic, 9500 Euclid Ave F30, Cleveland, Ohio 44195 (e-mail: vishnu.ambur@gmail.com).

The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2018.05.229

end-stage renal disease. However, the impact of varying levels of CKD on patients undergoing lower extremity revascularization for CLI has not been well-studied. In this study, we use the National Surgical Quality Improvement Program (NSQIP) database to investigate whether patients with moderate to severe CKD have worse outcomes after infrainguinal bypass for CLI.

METHODS

Database. The NSQIP is a deidentified database generated by the American College of Surgeons. It provides risk-adjusted data from participating academic and community hospitals with an emphasis on 30-day postoperative outcomes, including mortality and morbidity. The inclusion of 30-day outcomes in retrospective studies is critical to the accurate reporting of surgical outcomes.[6] Institutional review board approval was not required nor was informed consent obtained because this database is in the public domain and lacks patient identifiers.

Study population. All patients with CLI who underwent lower extremity bypass from 2012 to 2015 were identified using the targeted vascular set in the NSQIP Database. The glomerular filtration rate (GFR) was calculated using the Chronic Kidney Disease Epidemiology Collaboration Study equation ($GFR = 141 \times \min[Scr/k, 1]^{\alpha} \times \max[Scr/k, 1]^{-1.209}\ 0.993^{Age} \times 1.018$ [if female] $\times 1.159$ [if black]; $k = 0.7$ if female, $k = 0.9$ if male, $\alpha = -0.329$ if female, $\alpha = -0.411$ if male, min = minimum of Scr/k or 1, max = maximum of Scr/k or 1, Scr = serum creatinine [mg/dL]). CKD categories were determined from the National Kidney Foundation Kidney Disease Outcomes Quality Initiative staging criteria. Patients were classified into three groups: CKD stages 3 or less (mild to moderate CKD, GFR of ≥30 mL/min/1.73 m^2), CKD stages 4 and 5 (severe CKD not on hemodialysis (HD; GFR of <30 mL/min/1.73 m^2), and those on HD.

Data and statistical analysis. The primary outcome was perioperative mortality after lower extremity bypass. Secondary outcomes included readmission, graft failure, postoperative complications, and morbidity. Continuous and categorical variables were compared with analysis of variance and χ^2 tests. Continuous variables were presented as mean ± standard deviation. Multiple variable logistic regression with backward selection was used to examine the relationship between kidney disease and graft failure, mortality, and postoperative complications. We adjusted for the following variables: age, sex, ethnicity, diabetes mellitus, chronic obstructive pulmonary disease, hypertension, congestive heart failure, type of conduit, tobacco use, functional status, and distal bypass with this being defined as those to infrapopliteal targets. Odds ratios (ORs) with 95% confidence intervals (CIs) were presented for each covariate. $P < .05$ was considered statistically significant. Data were analyzed using SAS 9.4 software (SAS Institute, Cary, NC).

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected American College of Surgeons National Surgical Quality Improvement Program data
- **Key Findings:** Infrainguinal bypass for critical limb ischemia in 6978 patients in the American College of Surgeons National Surgical Quality Improvement Program database was associated with an increased rate of readmission and postoperative myocardial infarction in patients with severe chronic kidney disease (stage 4/5) or on hemodialysis with increased perioperative mortality found only in patients on hemodialysis.
- **Take Home Message:** This study suggests that patients with critical limb ischemia and severe chronic kidney disease have an increase in perioperative cardiovascular events and readmission after infrainguinal bypass.

RESULTS

Baseline characteristics. There were 6978 patients who underwent infrainguinal lower extremity arterial bypass during the study period. A comparison of patient demographics by CKD stage is shown in Table I. The severe CKD group was older (72.3 years; $P < .01$), more likely to be female (45%; $P < .01$), and to have diabetes mellitus (68.9%; $P < .01$). Patients on HD were more likely to be African American (40.2%; $P < .01$), to have high-risk physiologic factors (83.8%; $P < .01$), and to be revascularized for tissue loss (74.7%; $P < .01$).

Postoperative outcomes (univariate analysis). Postoperative outcomes by CKD stage are shown in Table II. Patients with severe CKD and on HD were more likely to experience death, graft failure, MI, amputation, readmission, and reoperation on univariate analysis. Patients with severe CKD were statistically more likely to require HD postoperatively (2.7% vs 0.7%; $P < .01$).

Postoperative outcomes (multiple variable analysis). On multiple variable analysis, graft failure was associated with severe CKD (OR, 1.67; 95% CI, 1.12-2.50; $P = .01$), functional status (OR, 1.39; 95% CI, 1.08-1.80; $P = .01$), African American race (OR, 1.67; 95% CI, 1.12-2.50; $P < .01$), and distal bypass (OR, 1.33; 95% CI, 1.09-1.61; $P < .01$), but not HD (Tables III and IV). MI was associated with severe CKD (OR, 2.16; 95% CI, 1.35-3.45; $P < .01$), HD (OR, 2.56; 95% CI, 1.73-3.78; $P < .01$), and diabetes mellitus (OR, 1.72; 95% CI, 1.29-2.28; $P < .01$). Reoperation was associated with functional status (OR, 1.99; 95% CI, 1.13-3.49; $P = .02$),

Table I. Baseline demographics

	CKD ≤ 3	CKD 4-5	HD	*P*
Patients	6101 (87.4)	327 (4.7)	550 (7.9)	
Age, years	68.2 ± 11.7	72.3 ± 11.3	66.4 ± 10.7	<.01
Female sex	2211 (36.2)	147 (45.0)	202 (36.7)	<.01
African American	1224 (20.1)	46 (14.1)	221 (40.2)	<.01
Diabetes	2924 (47.9)	225 (68.9)	349 (63.5)	<.01
Hypertension	5019 (82.3)	300 (91.7)	493 (89.6)	<.01
COPD	785 (12.9)	36 (11.0)	65 (11.8)	.49
History of CHF	188 (3.0)	25 (7.6)	42 (7.6)	<.01
Tobacco use	2601 (42.6)	71 (21.7)	134 (24.4)	<.01
Functional status				
Partially dependent	476 (7.8)	40 (1.2)	86 (1.6)	<.01
Totally dependent	47 (1.0)	3 (1.0)	7 (1.2)	.09
High-risk factors: Anatomic	1442 (23.6)	66 (20.2)	76 (13.8)	<.01
High-risk factors: Physiologic	1259 (20.6)	131 (40.1)	461 (83.8)	<.01
Statin	4185 (68.6)	251 (76.7)	391 (71.1)	<.01
Aspirin	4867 (79.8)	271 (82.9)	428 (77.8)	<.01
Beta-blocker	3592 (58.9)	250 (76.5)	437 (79.5)	<.01
Indication				
Rest pain	2750 (45.1)	102 (31.2)	139 (25.3)	<.01
Tissue loss	3351 (54.9)	225 (68.8)	411 (74.7)	<.01

CHF, Congestive heart failure; *CKD,* chronic kidney disease; *COPD,* chronic obstructive pulmonary disease; *HD,* hemodialysis.
Values are presented as number (%) or mean ± standard deviation.

Table II. Postoperative outcomes

	CKD ≤ 3	CKD 4-5	HD	*P*
Graft failure	366 (6.0)	29 (8.9)	46 (8.4)	.04
Death	100 (1.6)	13 (4.0)	46 (8.4)	<.01
MI	164 (2.7)	22 (6.7)	34 (6.2)	<.01
Amputation	233 (3.8)	17 (5.2)	33 (6.0)	.01
Readmission	1086 (17.8)	79 (24.2)	135 (24.5)	<.01
Reoperation	1065 (17.5)	76 (23.2)	132 (24.0)	<.01

CKD, Chronic kidney disease; *HD,* hemodialysis; *MI,* myocardial infarction.
Values are presented as number (%).

Table III. Multiple variable analysis for hemodialysis (HD)

Postoperative outcomes	OR	95% CI	*P*
Graft failure	2.04	0.61-6.76	.25
MI	2.56	1.73-3.78	<.01
Amputation	1.98	0.46-8.49	.36
Readmission	1.41	1.15-1.74	<.01
Reoperation	5.93	4.04-8.73	<.01
Death	5.94	4.04-8.73	<.01

CI, Confidence interval; *MI,* myocardial infarction; *OR,* odds ratio.

chronic obstructive pulmonary disease (OR, 2.06; 95% CI, 1.38-3.08; $P < .01$), congestive heart failure (OR, 1.99; 95% CI, 1.13-3.49; $P = .02$), and HD (OR, 5.93; 95% CI, 4.04-8.73; $P < .01$). Amputation was associated with African American race (OR, 2.22; 95% CI, 1.73-2.85; $P < .01$), distal bypass (OR, 1.69; 95% CI, 1.31-2.16; $P < .01$), vein conduit (OR, 0.37; 95% CI, 0.19-0.69; $P < .01$), and functional status (OR, 1.57; 95% CI, 1.18-2.09; $P < .01$). Using multiple variable analysis, mortality was associated with age (OR, 1.05; 95% CI, 1.04-1.07; $P < .01$), HD (OR, 5.94; 95% CI, 4.04-8.73; $P < .01$), and functional status (OR, 95% CI, 1.80; 1.29-2.51; $P < .01$). In summary, patients with severe CKD were associated with postoperative MI, graft failure, and readmission, whereas patients on HD were associated with MI, readmission, and increased postoperative mortality.

Procedural characteristics. The majority of the bypass procedures (3692; 53%) were femoral to popliteal (vein, 54%) with the remaining 2391 (34%) being femoral to distal and popliteal to distal (808; 11%). Most of these procedures were performed with autologous vein graft (4144; 59%) with the rest being performed with prosthetic (2747; 39%) or other conduit (87; 2%). Subgroup analysis of patients with severe CKD and on HD showed no difference regarding conduit type and graft failure.

DISCUSSION

In this study, we used the targeted vascular set in the NSQIP database to investigate the impact of CKD on graft failure, postoperative complications, and mortality in patients undergoing lower extremity bypass for CLI. Owens et al[7] previously demonstrated that CKD staging

Table IV. Multiple variable analysis for severe chronic kidney disease (CKD)

Postoperative outcomes	OR	95% CI	*P*
Graft failure	1.67	1.12-2.50	.01
MI	2.16	1.35-3.45	<.01
Amputation	2.31	0.52-10.30	.27
Readmission	1.38	1.06-1.80	.02
Death	1.74	0.22-13.82	.60

CI, Confidence interval; *MI*, myocardial infarction; *OR*, odds ratio.

is associated with long-term mortality among patients undergoing lower extremity bypass. This study built on their work to determine whether severe CKD had a significant impact on perioperative outcomes.

This is one of the largest studies to date that evaluates the effects of severe CKD on perioperative outcomes after open lower extremity revascularization for CLI. In this study, patients on HD and with severe CKD formed a small but significant portion (12%) of the entire cohort. This prevalence of CKD in patients with chronic limb ischemia was similar to other studies.[8] The majority of the bypasses performed were femoropopliteal bypass with vein graft. The type of conduit had no effect on perioperative graft failure. This finding is not unexpected; the NSQIP database records only include 30-day outcomes and graft failures that occur within this time could be secondary to a technical error.[9] On multiple variable analysis, distal bypass was associated with graft failure (OR, 1.33; 95% CI, 1.09-1.61; $P < .01$) and amputation (OR, 1.68; 95% CI, 1.31-2.16; $P < .01$) which has been demonstrated in prior studies.[10]

On multiple variable analysis, severe CKD was associated with increased graft failure, which has not been shown previously in the literature. HD was not associated with graft failure. Some studies submit that patients with CKD exhibit a hypercoagulable state that could potentially contribute to early graft failure.[11] Chong et al[12] demonstrate that CKD patients with PAD also have worse endothelial dysfunction which could be another contributing factor. This finding needs to be investigated further as other studies also suggest that there may be factors other than technical error that contribute to early graft failure.[13]

Patients on HD had increased mortality on multiple variable analysis, which has been demonstrated in prior studies.[14] However, severe CKD was not associated with perioperative mortality on multiple variable analysis. Both cohorts were associated with postoperative MI on multiple variable analysis. Previous studies show that these patients are known to have increased mortality from a higher incidence of cardiovascular events.[15,16] It is likely attributed to the greater burden of atherosclerosis as well as comorbidities such as coronary artery disease, diabetes mellitus, and hyperlipidemia in these patient populations.[17]

Previous studies have shown an independent association between CKD and cardiovascular outcomes.[18] Our results demonstrate that the long-term risk of cardiac events translates to the perioperative period. However, this increase in postoperative cardiac events did not translate to increased postoperative mortality in patients with severe CKD not on HD. Patients on HD had both increased perioperative MI and mortality. This difference could be from greater cardiovascular disease burden in patients on HD. Another explanation could be the increased use of antiplatelet and statin medications in severe CKD patients. Our study demonstrated that 76.7% of these patients took a statin and 82.9% took aspirin. Interestingly, this rate is significantly increased from the study by Owens et al,[7] where only 43.8% of these patients took a statin which suggests that use has increased over time.

There are no trials demonstrating a clear benefit of statins and aspirin in patients on HD; however, there are numerous studies supporting the National Kidney Foundation's recommendation to prescribe them in patients with severe CKD.[19-21] Despite this recommendation, patients with severe kidney dysfunction underuse proven therapies such as cardiac catheterization and antiplatelet therapy because of concern for complications.[18] Subgroup analysis in patients with severe CKD showed no difference in postoperative complications when comparing patients taking and not taking best medical therapy with an antiplatelet and statin; however, this study was limited by a small sample size. Future studies should focus on the implementation of quality programs to improve medication use in this patient population and to investigate its impact on perioperative mortality and morbidity.

Numerous studies have demonstrated the negative effect of CKD on long-term mortality.[7,8] Patients with severe CKD and CLI have increased long-term mortality rates that are comparable with those treated for acute MI or congestive heart failure.[3] The effect of severe CKD on long-term survival is well-documented, but few studies have commented on the impact of severe CKD on perioperative morbidity after lower extremity bypass for CLI.[22] Our results showed that, although severe CKD had no significant impact on early mortality, it contributes significantly to perioperative morbidity, including early graft failure, cardiovascular morbidity, progression to dialysis, and increased readmission rates. Given the increased morbidity observed in our study, this cohort of patients with severe CKD undergoing open infrainguinal bypass comprise a high-risk group. These patients may benefit from risk factor modification and medical management. Additional studies are needed to clarify the benefit of medical management and quality programs in this cohort.

Patients with severe CKD and patients on HD were also more likely to be readmitted after discharge. These patients had a readmission rate of approximately 24% which is similar to the 15% to 25% reported in prior studies.[14,23] None of the readmissions in the severe CKD cohort were related to progressive renal insufficiency. CLI, CKD, dialysis dependence, graft failure, and reoperation in these prior studies were shown to be independent predictors of readmission.

The major limitations of this study are those inherent to the use of any large database, including the American College of Surgeons NSQIP database. Participation in this quality improvement program is voluntary and therefore subject to selection bias, because most of the reporting hospitals are major academic centers. Clinically relevant variables such as surgeon experience, hospital volume, and socioeconomic status are not included. Additionally, important procedural characteristics including type of popliteal bypass (above knee vs below knee), vein diameter, and quality of targets were not available in this database. Longitudinal analysis cannot be performed because outcomes are limited to 30 days. Despite these limitations, the NSQIP database allowed us to investigate a large population of patients with severe CKD and on HD undergoing bypass that would not be possible at a single institution.

CONCLUSIONS

We believe that patients with severe CKD and CLI represent a high-risk cohort with increased systemic disease burden. Our results show that these patients have greater cardiovascular and graft-related morbidity, but not increased mortality when undergoing lower extremity bypass for CLI. However, patients on HD have both increased morbidity and mortality, which corroborates findings from previous studies. CKD and the accompanying comorbid conditions impart significant perioperative morbidity. Physicians caring for these challenging patients with CKD and CLI should account for their overall increased disease burden. These patients may benefit from aggressive medical management of comorbid conditions to lessen the risk of perioperative morbidity and mortality. Future studies are required to investigate the implementation of quality improvement programs to improve the use of statin and aspirin in nondialysis-dependent patients with impaired renal function to determine if this mitigates the elevated risk in these patients.

AUTHOR CONTRIBUTIONS

Conception and design: VA, RD
Analysis and interpretation: VA, PP, JG, SG, FS, PV, EC, RD
Data collection: VA, JG
Writing the article: VA, PP, JG, RD
Critical revision of the article: VA, JG, SG, FS, PV, EC, RD
Final approval of the article: VA, PP, JG, SG, FS, PV, EC, RD
Statistical analysis: JG
Obtained funding: Not applicable
Overall responsibility: VA

REFERENCES

1. Luke RG. Chronic renal failure–a vasculopathic state. N Engl J Med 1998;339:841-3.
2. Saran R, Robinson B, Abbott KC, Agodoa LYC, Ayanian J, Bragg-Gresham J, et al. US Renal Data System 2016 Annual Data Report: epidemiology of kidney disease in the United States. Am J Kidney Dis Off J Natl Kidney Found 2017;69:A7-8.
3. O'Hare AM, Glidden DV, Fox CS, Hsu C-Y. High prevalence of peripheral arterial disease in persons with renal insufficiency: results from the National Health and Nutrition Examination Survey 1999-2000. Circulation 2004;109:320-3.
4. Hirsch AT, Haskal ZJ, Hertzer NR, Bakal CW, Creager MA, Halperin JL, et al. ACC/AHA 2005 Practice Guidelines for the management of patients with peripheral arterial disease (lower extremity, renal, mesenteric, and abdominal aortic): a collaborative report from the American Association for Vascular Surgery/Society for Vascular Surgery, Society for Cardiovascular Angiography and Interventions, Society for Vascular Medicine and Biology, Society of Interventional Radiology, and the ACC/AHA Task Force on Practice Guidelines (Writing Committee to Develop Guidelines for the Management of Patients With Peripheral Arterial Disease): endorsed by the American Association of Cardiovascular and Pulmonary Rehabilitation; National Heart, Lung, and Blood Institute; Society for Vascular Nursing; TransAtlantic Inter-Society Consensus; and Vascular Disease Foundation. Circulation 2006;113:e463-654.
5. TASC Steering Committee, Jaff MR, White CJ, Hiatt WR, Fowkes GR, Dormandy J, et al. An update on methods for revascularization and expansion of the TASC lesion classification to include below-the-knee arteries: a supplement to the Inter-Society Consensus for the Management of Peripheral Arterial Disease (TASC II). Vasc Med Lond Engl 2015;20:465-78.
6. Bilimoria KY, Cohen ME, Ingraham AM, Bentrem DJ, Richards K, Hall BL, et al. Effect of postdischarge morbidity and mortality on comparisons of hospital surgical quality. Ann Surg 2010;252:183-90.
7. Owens CD, Ho KJ, Kim S, Schanzer A, Lin J, Matros E, et al. Refinement of survival prediction in patients undergoing lower extremity bypass surgery: stratification by chronic kidney disease classification. J Vasc Surg 2007;45:944-52.
8. Lacroix P, Aboyans V, Desormais I, Kowalsky T, Cambou JP, Constans J, et al. Chronic kidney disease and the short-term risk of mortality and amputation in patients hospitalized for peripheral artery disease. J Vasc Surg 2013;58:966-71.
9. Stept LL, Flinn WR, McCarthy WJ, Bartlett ST, Bergan JJ, Yao JS. Technical defects as a cause of early graft failure after femorodistal bypass. Arch Surg 1987;122:599-604.
10. Feinglass J, Pearce WH, Martin GJ, Gibbs J, Cowper D, Sorensen M, et al. Postoperative and amputation-free survival outcomes after femorodistal bypass grafting surgery: findings from the Department of Veterans Affairs National Surgical Quality Improvement Program. J Vasc Surg 2001;34:283-90.
11. Adams MJ, Irish AB, Watts GF, Oostryck R, Dogra GK. Hypercoagulability in chronic kidney disease is associated with coagulation activation but not endothelial function. Thromb Res 2008;123:374-80.
12. Chong KC, Owens CD, Park M, Alley HF, Boscardin WJ, Conte MS, et al. Relationship between kidney disease and endothelial function in peripheral artery disease. J Vasc Surg 2014;60:1605-11.
13. Singh N, Sidawy AN, DeZee KJ, Neville RF, Akbari C, Henderson W. Factors associated with early failure of

infrainguinal lower extremity arterial bypass. J Vasc Surg 2008;47:556-61.
14. Zhang JQ, Curran T, McCallum JC, Wang L, Wyers MC, Hamdan AD, et al. Risk Factors for Readmission Following Lower Extremity Bypass in the ACS-NSQIP. J Vasc Surg 2014;59:1331-9.
15. Wright RS, Reeder GS, Herzog CA, Albright RC, Williams BA, Dvorak DL, et al. Acute myocardial infarction and renal dysfunction: a high-risk combination. Ann Intern Med 2002;137:563-70.
16. Brunner FP, Selwood NH. Profile of patients on RRT in Europe and death rates due to major causes of death groups. The EDTA Registration Committee. Kidney Int Suppl 1992;38:S4-15.
17. Levey AS, Beto JA, Coronado BE, Eknoyan G, Foley RN, Kasiske BL, et al. Controlling the epidemic of cardiovascular disease in chronic renal disease: what do we know? What do we need to learn? Where do we go from here? National Kidney Foundation Task Force on Cardiovascular Disease. Am J Kidney Dis Off J Natl Kidney Found 1998;32:853-906.
18. Freeman RV, Mehta RH, Al Badr W, Cooper JV, Kline-Rogers E, Eagle KA. Influence of concurrent renal dysfunction on outcomes of patients with acute coronary syndromes and implications of the use of glycoprotein IIb/IIIa inhibitors. J Am Coll Cardiol 2003;41:718-24.
19. Palmer SC, Craig JC, Navaneethan SD, Tonelli M, Pellegrini F, Strippoli GF. Benefits and harms of statin therapy for persons with chronic kidney disease: a systematic review and meta-analysis. Ann Intern Med 2012;157:263-75.
20. Guidelines and Commentaries [Internet]. The National Kidney Foundation; 2014. Available at: https://www.kidney.org/professionals/guidelines/guidelines_commentaries. Accessed April 4, 2017.
21. Sharp Collaborative Group null. Study of Heart and Renal Protection (SHARP): randomized trial to assess the effects of lowering low-density lipoprotein cholesterol among 9,438 patients with chronic kidney disease. Am Heart J 2010;160:785-94.e10.
22. Willenberg T, Baumann F, Eisenberger U, Baumgartner I, Do D-D, Diehm N. Impact of renal insufficiency on clinical outcomes in patients with critical limb ischemia undergoing endovascular revascularization. J Vasc Surg 2011;53:1589-97.
23. Gupta PK, Fernandes-Taylor S, Ramanan B, Engelbert TL, Kent KC. Unplanned readmissions after vascular surgery. J Vasc Surg 2014;59:473-82.

Submitted Dec 4, 2017; accepted May 28, 2018.