# Impact of Chronic Renal Insufficiency on the Early and Late Clinical Outcomes of Carotid Artery Stenting Using Serum Creatinine vs Glomerular Filtration Rate

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**BACKGROUND:** This study analyzed the impact of chronic renal insufficiency (CRI) on early and late clinical outcomes of carotid artery stenting (CAS) using serum creatinine and glomerular filtration rate (GFR).

**STUDY DESIGN:** There were 313 CAS patients classified into 3 groups: normal (serum creatinine <1.5 mg/dL or GFR ≥ 60 mL/min/1.73 $m^2$); moderate CRI, and severe CRI (serum creatinine ≥3 or GFR < 30 mL/min/1.73 $m^2$). Major adverse events ([MAE] stroke, death, and myocardial infarction) were compared for all groups.

**RESULTS:** Using serum creatinine, perioperative stroke rates for normal, moderate, and severe CRI were: 5%, 0%, and 25%, respectively, ($p = 0.05$) vs 4.6%, 3.7%, and 11.1%, respectively, ($p = 0.44$) using GFR. The perioperative MAE rates for symptomatic patients were 9.3% and 0% ($p = 0.355$) and 2% and 5.9% ($p = 0.223$) for asymptomatic patients for normal and moderate/severe CRI, respectively, using serum creatinine vs 8.1% and 7.8%, respectively, for symptomatic patients and 2.5% and 3%, respectively, for asymptomatic patients using GFR. At a mean follow-up of 21 months, late MAE rates in normal vs moderate/severe CRI patients were 8.2% and 14%, respectively, ($p = 0.247$) using serum creatinine vs 6.6% and 13.3%, respectively, ($p = 0.05$) using GFR. Late MAE rates for symptomatic patients in normal vs moderate/severe CRI were: 8.7% vs 27%, respectively, ($p = 0.061$) using serum creatinine and 5.7% vs 18.8%, respectively, ($p = 0.026$) using GFR. Late death rate was 0.55% in normal vs 7.6% ($p = 0.002$) for moderate/severe CRI. Freedom from MAE at 3 years in symptomatic patients was 81% in normal and 46% in moderate/severe CRI ($p = 0.0198$). A multivariate Cox regression analysis showed that a GFR of < 60 mL/min/1.73 $m^2$ had an odds ratio of 1.6 ($p = 0.222$) of having a MAE after CAS.

**CONCLUSIONS:** The GFR was more sensitive in detecting late MAE after CAS. Carotid artery stenting in moderate CRI patients can be done with a satisfactory perioperative outcome; however, late death was significant. (J Am Coll Surg 2014;218:797−807. © 2014 by the American College of Surgeons)

Carotid artery stenting (CAS) has been viewed as an alternative to carotid endarterectomy (CEA) for treatment of carotid stenosis in symptomatic and asymptomatic patients, especially in those deemed high risk for surgical revascularization.[1,2] There is strong evidence in the literature that suggests that patients with chronic renal insufficiency (CRI) have higher morbidity and/or mortality rates after CEA.[3-12] However, the effect of CRI on patients undergoing CAS, especially long-term outcomes, is not as well established, but a few studies have suggested that CRI does confer an increased risk.[12-14]

Only 2 previous studies[12,14] have reported on the outcomes of CAS in patients with CRI using the glomerular filtration rate (GFR); one used the Modification of Diet in Renal Disease (MDRD) equation,[12]and the other used the Cockcroft-Gault equation.[14] This study analyzed the impact of CRI on early and late clinical outcomes of CAS, using both serum creatinine levels and the GFR (MDRD).

**Disclosure Information: Nothing to disclose.**

Presented at the Southern Surgical Association 125th Annual Meeting, Hot Springs, VA, December 2013.

Received December 11, 2013; Accepted December 12, 2013.

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ISSN 1072-7515/14/$36.00
http://dx.doi.org/10.1016/j.jamcollsurg.2013.12.038

**Abbreviations and Acronyms**

CAS = carotid artery stenting
CEA = carotid endarterectomy
CRI = chronic renal insufficiency
GFR = glomerular filtration rate
MAE = major adverse events
MDRD = Modification of Diet in Renal Disease
MI = myocardial infarction
OR = odds ratio

## METHODS

This is a retrospective analysis of prospectively collected data on 313 CAS procedures (290 patients) that were done during a 10-year period (June 2001 through December 2011) at our institution. Only patients who had preoperative serum creatinine levels and/or GFRs using the MDRD equation were included in this analysis. This study was approved by the Institutional Review Board of Charleston Area Medical Center/West Virginia University. All patients were enrolled in carotid clinical trials of high-risk patients for CEA, as defined by the protocol of each trial, and included:

Parodi (Parodi Anti-Emboli System as an adjuvant cerebral protection device during carotid stent-supported angioplasty with the Boston Scientific Carotid Wallstent Monorail Endoprosthesis, October 2001)
SHELTER (Stenting of High Risk Patients: Extracranial Lesion Trial with Emboli Removal, October 2001)
MAVErIC 1, 2, and 3 (Evaluation of the Medtronic AVE Self-Expanding Carotid Stent System with Distal Protection in the Treatment of Carotid Stenosis, July 2002)
CAPTURE (Carotid Rx Acculink/Rx Accunet Post-approval Trial to Uncover Unanticipated or Rare Events, July 2004)
VIVA (ViVEXX Carotid Revascularization Trial, November 2005)
CHOICE (Carotid Stenting for High Surgical-Risk Patients, October 2006)
EXACT (rapid exchange carotid stent system Xact with Emboshield protection system by Abbott Medical, August 2007)

Inclusion and exclusion criteria were outlined by each clinical trial. Overall, the indication for CAS included $\geq$50% symptomatic and $\geq$80% asymptomatic carotid artery stenosis. Demographic and clinical characteristics and intraoperative data were verified by a medical records review.

Patients were classified into 3 categories according to their renal function using serum creatinine levels and GFRs (based on the MDRD equation): normal renal function (a serum creatinine $<$1.5 mg/dL or a GFR $\geq$60 mL/min/1.73 m$^2$), moderate CRI ( serum creatinine $\geq$1.5 to 2.9 mg/dL or a GFR $\geq$30 to 59 mL/min/1.73 m$^2$), and severe CRI (serum creatinine $\geq$3 mg/dL or a GFR $<$ 30 mL/min/1.73 m$^2$).

### Carotid artery stenting protocol

All procedures were done in an independent invasive vascular laboratory with an Advanced Imaging System (General Electric System) located outside the cardiac catheterization laboratory and the operating room. All patients were given a regimen of 75 mg of clopidogrel (Plavix, Bristol-Myers Squibb/Sanofi Pharmaceutical Partnership) and 325 mg of aspirin daily for 3 to 5 days before the CAS procedure, followed by a dose of 325 mg of aspirin daily and 75 mg of clopidogrel after the procedure. Clopidogrel was continued for 6 weeks, and aspirin was continued indefinitely. All procedures were done using distal cerebral protection devices, according to their carotid trial protocols. Predilatation (3- to 4-mm balloons) was performed before filter insertion in most patients with tight stenosis. Postdilatation (using 5-mm balloons) was also performed after stent deployment to achieve optimal stent strut position.

All patients had immediate postoperative duplex ultrasounds that were repeated at 30 days and every 6 months. Long-term follow-up consisted of an examination of the patient in the Vascular Center of Excellence of our institution. All patients were examined for incidence of stroke or transient ischemic attacks during their follow-up. Postoperative cerebral MRI/CT scans were performed only on those with documented neurologic events (stroke/transient ischemic attacks).

### Definition of endpoints

The primary endpoints were stroke, myocardial infarction (MI), and/or death. The combined major adverse events (MAE: stroke, MI, and death) were also determined. A minor stroke was defined as a neurologic deficit that persisted beyond 24 hours, resulting in grade I or II Rankin Scale, or a major stroke resulting in grades III through V Rankin Scale. A stroke was classified as ipsilateral if it affected the same cerebral hemisphere of the CAS, and contralateral if it affected the contralateral hemisphere. Myocardial infarction was defined as Q wave MI if seen in 2 or more leads, or non-Q wave MI was noted by an elevation of creatine kinase levels to greater than 3 times the upper limit of normal in the presence of elevated creatine kinase/myocardial bands (greater than the upper level of normal) and in the absence of new Q wave.