Incidence and risk factors for medical complications after carotid artery stenting

Klaus Gröschel, MD,a,b Ulrike Ernemann, MD,c Axel Riecker, MD, a Friederike Schmidt, MD,a Christoph Terborg, MD,b and Andreas Kastrup, MD,a,b Tübingen and Jena, Germany

Objective: Carotid angioplasty and stenting (CAS) is being evaluated as an alternative to carotid endarterectomy for the treatment of carotid artery stenosis; however, to date little is known about the incidence of medical complications after CAS. The goal of this study was to determine the frequency of, and to identify potential clinical risk factors for, the development of medical complications after CAS.

Methods: Medical complications that occurred ≤30 days after CAS in 327 consecutive patients (241 men, 86 women; mean age, 69 ± 9 years; range, 45 to 90 years) treated for symptomatic (n = 182, 56%) or asymptomatic (n = 145, 44%) carotid artery stenosis were recorded. The effect of clinical characteristics on the subsequent development of medical complications was analyzed by logistic regression.

Results: Fifty-one patients (15%) had 62 medical complications: 3 (0.9%) myocardial infarctions, 3 (0.9%) cardiac arrhythmias, 4 (1.2%) episodes of angina pectoris, 3 (0.9%) episodes of symptomatic hypertension, 10 (3.1%) chest infections, 9 (2.7%) had periods of confusion, 5 (1.5%) had urinary retention, and 9 (2.7%) urinary tract infections. One chest infection was fatal and 16 complications prolonged the intensive care unit monitoring period >24 hours. Advanced age (odds ratio [OR], 1.1; 95% confidence interval [CI], 1.05 to 1.14) and a symptomatic carotid stenosis (OR, 2.1; 95% CI, 1.07 to 4.1) independently predicted the occurrence of medical complications.

Conclusion: Although life-threatening or fatal non-neurologic events were uncommon in this series, the overall incidence of medical complications after CAS might be higher than currently anticipated. Older and symptomatic patients are at the highest risk, and these subgroups should be monitored closely. (J Vasc Surg 2005;42:1101–7.)

During the past decade, carotid angioplasty and stenting (CAS) has emerged as a potential therapeutic alternative to carotid endarterectomy (CEA) for the treatment of severe symptomatic or asymptomatic carotid stenosis. Data from several case series and trials suggest that CAS can be performed with acceptable procedure-related neurologic complication rates compared with CEA.1-8

Aside from the frequency of neurologic deficits, the benefit of either CEA or CAS is also highly dependent on the risk of medical complications such as myocardial infarctions or respiratory complications. In the North American Symptomatic Carotid Endarterectomy Trial (NASCET) for instance, approximately 10% of patients experienced medical complications.9,10 Although most of these non-neurologic complications resolved completely, 3.5% of all patients had life-threatening or fatal cardiovascular disorders.9 Hemodynamic instability, most likely due to stretching of the carotid sinus and manipulation in the vicinity of the adventitial baroreceptors, occurs frequently after CAS11-16 and has been shown to correlate with increased hospital complications and long-term risk of death.11

Against the background of these data, it is evident that the identification of potential risk factors for medical complications after either CAS or CEA will become a key feature for future patient selection and patient counseling. Therefore, the aim of this study was to determine the incidence of medical complications after CAS and identify predictors of these complications.

PATIENTS AND METHODS

Patient population. We retrospectively reviewed a prospectively collected database of all patients with high-grade carotid stenosis (≥70% in symptomatic patients and ≥90% in asymptomatic patients assessed with ultrasound scanning) who underwent CAS at our institution from April 1999 to December 2004. After giving informed consent, all patients were treated with a prospective protocol approved by our Institutional Ethics Review Board.

A multidisciplinary team comprising a vascular surgeon, an interventional neuroradiologist, and a stroke neurologist evaluated all patients. It is a special policy of our hospital that principally all patients with a symptomatic or asymptomatic carotid stenosis are first admitted to the Department of Neurology. Before treatment (either CEA or CAS), all patients therefore received identical and standardized medical as well as neurologic evaluations. The neurologic complications rates for this study population have been presented in detail elsewhere.3,17,18

Before April 1999, only patients with severe medical comorbidities and a high surgical risk had been treated with CAS at our institution. Based on satisfactory preliminary results, patients suitable for either CAS or CEA were of-
ferred a choice of procedure at the beginning of April 1999 after they had received detailed information about potential risks and benefits as well as the investigational nature of CAS. Those patients treated with CAS after April 1999 were entered into our prospective database.

With increasing personal experience and in line with two recent publications, patients with long and multiple carotid artery stenoses, severe peripheral vascular disease precluding femoral artery access, or with an extremely tortuous carotid artery anatomy were excluded from CAS during the course of the study period. Also excluded were patients with known allergies to aspirin, clopidogrel, or contrast media, a total carotid occlusion, a disabling stroke, arteriovenous malformations, intracerebral tumors, a diagnosis of dementia limiting informed consent, a cerebral hemorrhage in the past months, severe intracranial stenoses, a severe renal insufficiency, evolving myocardial infarction, or a stroke in evolution.

In all patients, the diagnosis of a high-grade carotid artery stenosis was made by carotid duplex ultrasound scanning using a combination of direct and indirect criteria and the presence and extent of intra- and poststenotic turbulent flow. As a key feature, a stenosis ≥70% was diagnosed if the peak systolic velocity was >200 cm/s and ≥90% if it was >300 cm/s. In all patients, the presence of an internal carotid artery stenosis ≥70% was determined by using the estimated diameter of the artery at the point of maximum stenosis as the denominator, according to European Carotid Surgery Trial (ECST) criteria, and was confirmed angiographically during the stent procedure.

**Carotid angioplasty and stenting procedure.** CAS was performed in all patients using a standardized protocol. At least 3 days before the procedure, patients received orally administered aspirin (100 mg daily) and clopidogrel (75 mg daily). Patients taking hypertensive medications received their morning dose before stenting. Additional doses were withheld until after the procedure and were then given if necessary.

With the exception of eight cases, all procedures were performed with the patient under conscious sedation with continuous control of heart frequency, blood pressure, and PaO₂. Before balloon inflation, 0.5 mg atropine was administered intravenously in each patient as a prophylaxis against reflex bradycardia or asystole. All patients received oxygen by a nasal cannula (5 L/minute) to reach a >95% oxygen saturation.

Filter-type embolic protection devices were used during the CAS procedures in 207 patients, and 120 patients were treated without cerebral protection devices. According to physician preference and commercial availability, two different filter-type cerebral protection devices (Neuroshield, MedNova, Galway, Ireland; and a Cordis Angioguard Filter, Cordis Corp, [Johnson&Johnson], Miami Fla) were used in this study.

After the stent procedure, all patients were transferred to the neurointensive care unit for overnight observation. Heart rate and respiratory rate were monitored continuously and two electrocardiograms (ECG) were obtained immediately after CAS and at day 1. Blood pressure was monitored 4 times per hour at the left upper arm by an automated cuff-inflation sphygmomanometer. Cardiac enzymes were only drawn in patients with suspected myocardial infarction (based on either clinical grounds or ECG abnormalities).

A physician evaluated any episode of neurologic change. In addition, routine medical examinations were scheduled the day after CAS and at day 30. Postprocedural symptomatic hypotension was treated with an intravenous infusion of dopamine or norepinephrine, postprocedural hypertension was usually treated with intravenous urapidil, and symptomatic sinus bradycardia was treated with intravenous atropine. Patients with asymptomatic hypotension were prophylactically treated with bed rest, intravenous fluids, or both. Clopidogrel was continued for 6 weeks and aspirin given indefinitely. To document patency of the stent, an ultrasound follow-up study was performed routinely 1 to 2 days after CAS in all patients.

**Data collection.** A stroke neurologist took a careful history from each patient and performed precise neurologic examination. In patients with symptomatic internal carotid artery stenosis, symptoms and timing of cerebral ischemic events as well as date and time of symptom resolution in the case of a transient ischemic attack (TIA) were recorded. Diagnosis of a hemispherical TIA was based on the classic definition of a transient focal neurologic dysfunction of presumed ischemic cerebrovascular etiology lasting <24 hours. A carotid stenosis was considered symptomatic if the patient had experienced an ipsilateral ocular or cerebral (transient or permanent) ischemic event within the past 6 months. A carotid stenosis that had not caused any stroke or TIA in the past 6 months was considered asymptomatic.

The following cerebrovascular risk factors were recorded in all patients: hypertension, diabetes mellitus, hyperlipidemia, smoking (current or within the previous year), peripheral vascular disease, previous TIAs and strokes. **Hypertension** was defined as occurring when systolic blood pressure was >160 mm Hg, diastolic blood pressure was >95 mm Hg, or in the presence of antihypertensive drugs. **Diabetes** was defined as previously diagnosed insulin-dependent or noninsulin-dependent diabetes mellitus, and **hyperlipidemia** as cholesterol levels >220 mg/dL or in the presence of lipid-lowering drugs.

Additionally the following comorbidities were collected for each patient: prior ipsilateral carotid endarterectomy, coronary artery disease; history of previous coronary bypass, valvular heart disease, or cardiac arrhythmias; pulmonary, renal, or liver failure; unstable congestive heart failure, unstable angina, intracranial atherosclerosis worse than a cerebral lesion, and cancer with life expectancy <5 years.

Similar to the North American Symptomatic Carotid Endarterectomy Trial, the following medical complications ±30 days after CAS were recorded for all patients: myocardial ischemia as determined by ECG and cardiac enzymes; cardiac arrhythmias that required antiarrhythmic medication or a pacemaker, congestive heart failure, angina...
pectoris, symptomatic hypertension (symptoms due to systolic blood pressure >180 mm Hg or diastolic blood pressure >100 mm Hg requiring intravenous medication), symptomatic hypotension not associated with bleeding or cardiac failure (symptoms due to systolic blood pressure <90 mm Hg requiring administration of vasopressor agent), chest infection requiring antibiotics, confusion requiring restraint or sedative medication, renal failure (doubling of preinterventional urea and/or creatinine), urinary retention requiring urinary catheterization, and urinary tract infection requiring antibiotics. Also recorded were all periods of asymptomatic bradycardia (heart rate <60 beats/min), asymptomatic hypotension (systolic blood pressure <90 mm Hg), or hypertension (diastolic blood pressure >100 mm Hg).

Access-site related complications such as groin hematomas, aneurysms, and pseudoaneurysms were excluded from analysis.

**Statistical analysis.** Continuous values are expressed as mean ± SD and nominal variables as counts and percentages. The associations between potential clinical risk factors and the incidence of any postprocedural medical complication ≤30 days after CAS were first assessed by univariate methods and then by logistic regression methods. For comparisons of categoric data, two-tailed χ² statistics with Yates correction and the univariate Fisher’s exact test were used. The Fisher’s exact test was used when the predicted contingency table cell values were <5.

Multiple logistic regression analysis was then performed to determine independent predictors of any postprocedural medical complication. Variables were considered for inclusion in the multivariate models if they were significant at the P < .10 level in the univariate analysis. For this analysis, age was considered as continuous variable. The selected clinical variables were entered into the logistic regression model using the occurrence of any medical complication as dependent variable. Backward stepwise exclusion was performed using a criterion of P >.1 and with variables in the final model considered significant at P < .05.

Interaction was assessed by using additive and multiplicative interaction terms and the overall model fit was determined using a Hosmer-Lemeshow test for global model fit. P < .05 was considered to indicate a statistically significant difference. All statistical analyses were performed with SPSS (version 12) software (SPSS, Inc, Chicago, Ill).

**RESULTS**

The study population consisted of 327 CAS patients (241 men, 86 women; mean age, 69 ± 9 years; range, 45 to 90 years), of which 145 patients (44%) were treated for an asymptomatic carotid stenosis and 182 patients (56%) for a symptomatic carotid stenosis. Of the symptomatic patients, 40 (21%) had presented with an amaurosis fugax, 85 (47%) with a hemispheric TIA, and 57 (32%) with a minor stroke. According to ECST criteria, the mean degree of stenosis before stenting was 92% ± 3% in asymptomatic patients and 89% ± 7% in symptomatic patients.

### Table I. Baseline characteristics of study patients

<table>
<thead>
<tr>
<th>N</th>
<th>327</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographics</td>
<td></td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>69 ± 9</td>
</tr>
<tr>
<td>Male</td>
<td>241 (74%)</td>
</tr>
<tr>
<td>Female</td>
<td>86 (26%)</td>
</tr>
<tr>
<td>Presenting symptom</td>
<td></td>
</tr>
<tr>
<td>Symptomatic</td>
<td>182 (56%)</td>
</tr>
<tr>
<td>Previous stroke</td>
<td>57 (32%)</td>
</tr>
<tr>
<td>Hemispheric symptoms</td>
<td>85 (47%)</td>
</tr>
<tr>
<td>Retinal symptoms</td>
<td>40 (21%)</td>
</tr>
<tr>
<td>Asymptomatic</td>
<td>145 (44%)</td>
</tr>
<tr>
<td>Medical risk factors</td>
<td></td>
</tr>
<tr>
<td>Hypertension*</td>
<td>266 (81%)</td>
</tr>
<tr>
<td>Hyperlipidemia¹</td>
<td>176 (54%)</td>
</tr>
<tr>
<td>Tobacco use (current or former)</td>
<td>99 (30%)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>85 (26%)</td>
</tr>
<tr>
<td>Coronary artery disease</td>
<td>83 (25%)</td>
</tr>
<tr>
<td>Previous coronary bypass</td>
<td>21 (6%)</td>
</tr>
<tr>
<td>Peripheral vascular disease</td>
<td>55 (17%)</td>
</tr>
<tr>
<td>Congestive heart failure</td>
<td>10 (3%)</td>
</tr>
<tr>
<td>COPD</td>
<td>12 (4%)</td>
</tr>
<tr>
<td>Angiographic risk factors</td>
<td></td>
</tr>
<tr>
<td>Contralateral ICA occlusion</td>
<td>42 (13%)</td>
</tr>
<tr>
<td>Contralateral ICA stenosis &gt;70%</td>
<td>125 (38%)</td>
</tr>
</tbody>
</table>

*COPD, Chronic obstructive pulmonary disease; ICA, internal carotid artery.
*Defined as systolic blood pressure >160 mm Hg, diastolic blood pressure >95 mm Hg.
¹Cholesterol levels >220 mg/dL.

### Table II. Medical complications within 30 days after carotid artery stenting

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%) of events</th>
<th>No. of patients with stroke or death</th>
</tr>
</thead>
<tbody>
<tr>
<td>Myocardial infarction</td>
<td>3 (0.9)</td>
<td>0</td>
</tr>
<tr>
<td>Arrhythmia</td>
<td>3 (0.9)</td>
<td>0</td>
</tr>
<tr>
<td>Angina pectoris</td>
<td>4 (1.2)</td>
<td>0</td>
</tr>
<tr>
<td>Symptomatic hypotension</td>
<td>16 (4.9)</td>
<td>0</td>
</tr>
<tr>
<td>Symptomatic hypertension</td>
<td>3 (0.9)</td>
<td>0</td>
</tr>
<tr>
<td>Chest infection</td>
<td>10 (3.1)</td>
<td>3</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0 (0)</td>
<td>0</td>
</tr>
<tr>
<td>Urinary retention</td>
<td>5 (1.5)</td>
<td>0</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>9 (2.7)</td>
<td>3</td>
</tr>
<tr>
<td>Confusion</td>
<td>9 (2.7)</td>
<td>3</td>
</tr>
<tr>
<td>Total complications</td>
<td>62 (19)</td>
<td></td>
</tr>
</tbody>
</table>

Table I summarizes the demographic and clinical characteristics of the patients. For the entire study population, the overall 30-day minor stroke rate was 5% (18/327), the major stroke rate was 0.6% (2/327), and the death rate was 0.6% (2/327). All strokes were ischemic except one major stroke, which was secondary to a cerebral hemorrhage.

Table II summarizes the medical complication rates ≤30 days after CAS. Of the 327 patients, 51 patients (15%) had 62 medical complications, which included myocardial ischemia (Q-wave in 1, non-Q-wave in 2), cardiac arrhythmias (ventricular fibrillation in 1, bradycardia in 2), angina pectoris (n = 4), symptomatic hypertension (n = 3), symptomatic hypotension (n = 16), chest infection (n = 10), confusion (n = 9), urinary retention (n = 5), and urinary
tract infection (n = 9). Nine patients had two, and one had three medical complications. One chest infection was fatal, and in 16 (31%) patients, the period of intensive care unit (ICU) monitoring was prolonged >24 hours (mean ICU stay, 2.1 ± 2.0 days).

With the exception of one chest infection, all medical complications began in the first 24 hours after CAS. For the entire study population, the overall 30-day combined complication rate (any stroke, death or any medical complication) was 19.3%.

Two patients with urinary retention had benign prostatic hypertrophy. Two of the 10 chest infections were due to aspiration after a major and a minor stroke, six chest infections were associated with myocardial infarctions (n = 2), periods of confusion (n = 3), or an episode of pulmonary edema. The cause of the chest infections was unclear in two instances. None of these patients had received a general endotracheal anesthesia.

Two patients with symptomatic hypertension developed typical symptoms of a hyperperfusion syndrome, with severe headache, nausea, vomiting, and a fully reversible transient focal neurologic deficit; one patient developed a headache only. Six patients with symptomatic hypotension developed focal neurologic deficits, which were also fully reversible after vasopressor agents were administered. None of these patients suffered any permanent cardiac or neurologic consequences.

Two hypotensive patients developed confusion, and the remaining eight hypotensive patients experienced severe dizziness or syncope. Another 22 (6.7%) patients had asymptomatic hypotensive reactions that were effectively treated with bed rest and intravenous fluid administration. None of the patients had a sudden death, pulmonary embolus, or depression requiring medication. A slight deterioration in renal function (serum creatinine concentration >1.2 μmol/L) occurred in 14 patients, which improved with intravenous fluid replacement.

The results of the univariate analysis are shown in Table III. Symptomatic patients had significantly higher medical complication rates than asymptomatic patients (19.8% vs 10.3%, P < .05). Age ≥75 years and absence of tobacco use were further clinical variables significantly related to a higher medical complication rate on univariate analysis. Patients with a history of hypertension also had a trend toward a higher medical complication rate (17.3% vs 8.2% without a history of hypertension; P = .08).

Multivariate regression analysis revealed advanced age (odds ratio [OR], 1.1; 95% confidence interval [CI], 1.05 to 1.14) and the presence of a symptomatic carotid stenosis (OR, 2.1; 95% CI, 1.07 to 4.1) as the only independent clinical predictors of all medical complications after CAS.

Two univariate subgroup analyses were performed to identify patients at risk for hemodynamic instability only (symptomatic hypotension or hypertension, bradycardia) and those patients at risk for severe medical complications. For the latter analysis, the medical complications considered as severe were all myocardial infarctions, hypotensive patients who had developed transient ischemic attacks, both hypertensive patients who had developed a hyperperfusion syndrome, and all patients with chest infections requiring antibiotics.

Age ≥75 years predicted postprocedural hemodynamic instability (4.3% in patients aged <75 years vs 10.4% in patients aged ≥75 years, P < .05) as well the occurrence of severe medical complications (3.5% in patients aged <75 years vs 13.5% in patients aged ≥75 years, P < .001). Further clinical or angiographic variables (including the degree of carotid stenosis) neither predicted postprocedural hemodynamic instability nor the occurrence of severe medical complications after CAS.

**DISCUSSION**

In the present study, we analyzed a consecutive series of patients to determine the overall incidence and risk factors for medical complications after CAS. Postinterventional...
medical complications occurred in approximately 15% of all patients. The risk of a medical complication after CAS was increased in older patients and in patients with a symptomatic carotid stenosis. Although life-threatening or fatal non-neurologic events were uncommon in this series, this result indicates that the overall incidence of medical complications after CAS might be higher than is currently anticipated.

Hemodynamic instability, in particular symptomatic hypotension requiring administration of vasopressor agents, was the most frequent medical complication (4.9%). This complication is probably mediated through a dysfunction of adventitial baroreceptors in arterial segments that are dilated and covered with intravascular stents. Extensive manipulation in the vicinity of adventitial baroreceptors during CAS stimulates excitatory impulses independently of the mean arterial blood pressure and thus may cause inadequate hemodynamic responses. Stent insertion likely leads to more prolonged effects on hemodynamics because the devices provide continuous tension on the carotid sinus.

Intraprocedural and postprocedural hypotension has, therefore, also been observed frequently after CAS in other studies. Dangas et al observed post-CAS hypotension in 25 (19%) of 133 patients. In the study of Qureshi et al, transient hypotensive episodes after CAS occurred in 22.4% of all patients.

Compared with these studies, the lower incidence of hypotensive episodes in our analysis could be because we only included patients who had symptoms requiring treatment with vasopressor agents. In support of this notion, Tan et al found a decrease in systolic blood pressure of 40 mm Hg after CAS in 50.3% of their CAS patients, but only seven patients (3.4%) had symptoms that required treatment. Notably in our series, an additional 22 (6.7%) patients experienced an asymptomatic hypotensive reaction that was effectively treated with bed rest, intravenous fluid administration, or both. The fact that six patients with symptomatic hypotension developed transient neurologic deficits during such an episode stresses the need to monitor the blood pressure carefully after CAS and to treat it appropriately.

Previous CAS studies reported that intra- and postprocedural bradycardia occurred in up to 71% of all CAS patients, but this was an uncommon medical complication in our series (0.9%). In fact, no patient required treatment with a temporary venous pacemaker. It is well conceivable that this finding can at least partially be attributed to advances in technique and equipment for CAS, especially the routine use of self-expanding stents and of atropine during CAS, as well as the cautious application of balloon postdilatation.

As with bradycardia, postprocedural symptomatic hypertension occurred less frequently (approximately 1%) than previously published (for instance in up to 40% of all CAS patients in the Qureshi et al study). On the other hand, two of three patients developed typical symptoms of a hyperperfusion syndrome, which underscores the importance of recognizing this important and potentially life-threatening complication.

In a subgroup, analysis advanced age was a significant predictor of hemodynamic instability after CAS, which confirms a prior report on this issue. It could be speculated that cerebral autoregulation, which maintains a constant cerebral circulation over a wide range of blood pressure changes, is altered by aging and the presence of cardiovascular risk factors. As a result, sudden blood pressure changes can render an older patient particularly vulnerable to hypotensive states after CAS.

Three patients (1%) in our study developed nonfatal myocardial infarctions post-CAS, indicating that this potentially severe medical complication might occur more frequently than suggested by several previous CAS series and trials. In line with our findings, 3.4% of all CAS patients had a non-Q-wave myocardial infarction in the recently published Stenting and Angioplasty with Protection in Patients at High Risk for Endarterectomy (SAPPHIRE) trial.

Aside from hemodynamic instability and cardiovascular disorders, chest infections requiring antibiotics and periods of severe confusion requiring restraint and treatment with sedatives occurred frequently in our study. Since one chest infection was fatal, and the other infections and periods of confusion prolonged the hospital stay, these two medical complications should be considered in future studies that evaluate the outcome of CAS and compare this procedure with CEA. In fact, identification of potential risk factors for medical complications after either CAS or CEA will generally become a key feature for future patient selection and patient counseling.

Based on stepwise logistic regression analysis, we identified advanced age and the presence of a symptomatic carotid stenosis as independent risk factors for medical complications after CAS. Moreover, advanced age was also associated with a higher frequency of severe medical complications. Therefore, symptomatic and, especially, older patients should be monitored closely after CAS in settings suited to expeditious management of medical emergencies. Since advanced age has also been associated with a higher frequency of neurologic complications after CAS, the elderly should generally be considered as high-risk patients for CAS. Even though the heterogeneity of patient populations might hamper the comparability of data across various institutions and treatment modalities, it is worth mentioning that advanced age is also a risk factor for medical complications after CEA for symptomatic carotid stenosis.

**Study limitations.** First, because of the relatively small sample size, the generalizability of our results in a larger randomized cohort of patients remains to be determined. On the other hand, it should be stressed that advanced age and the presence of a symptomatic carotid stenosis were also associated with an increased risk of hemodynamic instability in several other large single-center studies.
Second, several potential risk factors such as coronary artery disease or chronic obstructive pulmonary disease were only present in a few patients, so that this study might have lacked statistical power to adequately determine the relationship between these variables and the postprocedural medical complication rate after CAS. This notion is supported by a recent study that included a large number of patients with coronary artery disease and found an increased risk for hypotension and bradycardia after CAS in these patients.14

Third, we did not assess the potential effects of intra-procedural variables such as episodes of hemodynamic instability on the development of medical complications after CAS.

CONCLUSION

Life-threatening or fatal non-neurologic complications after CAS occur in a relatively low proportion of patients. Older and symptomatic patients are at highest risk, and these subgroups should be monitoring closely.

REFERENCES


Submitted Apr 12, accepted Aug 5, 2005.

INVITED COMMENTARY

William D. Jordan, Jr, MD, Birmingham, Ala

During the last 10 years, carotid artery stenting (CAS) has evolved into a valuable tool for treating carotid artery stenosis. After recent approval in the United States, CAS remains with specific and, at times, limited approval for reimbursement from the Center for Medicare and Medicaid Services. Regardless, carotid physicians are continuing to incorporate this valuable new technology into treatment algorithms for their patients.

This report from Dr Kastrup provides additional information about the non-neurologic problems that can be encountered during CAS. In a broad sense, one of five patients who undergo CAS should be expected to have some medical complication, ranging from myocardial ischemia to hypotension to chest infections. Specifically, the symptomatic patient and the patient >75 years old should be considered at higher risk for non-neurologic complica-