Carotid Revascularization in Patients with Ongoing Oral Anticoagulant Therapy: The Advantages of Stent Placement

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ABSTRACT

Purpose: To assess the influence of oral anticoagulant therapy conversion to heparin (OAT-CH) on carotid endarterectomy (CEA) outcomes and the influence of unmodified oral anticoagulant therapy (OAT) on carotid artery stenting (CAS) and to compare the outcomes of CEA in OAT-CH with CAS in ongoing OAT.

Materials and Methods: The 30-day results from all patients who underwent CEA and CAS in a 6-year period were analyzed for stroke, death, myocardial infarction (MI), and hematoma of the access site requiring surgical evacuation. We evaluated the influence of OAT-CH in CEA and the influence of OAT in CAS and compared CEA and CAS outcomes in patients receiving OAT-CH and OAT.

Results: Among 1,222 carotid revascularizations, there were 711 CEAs (58.1%) and 511 CAS procedures (41.9%). In the CEA group, 31 (4.4%) patients were treated with OAT-CH, and these patients had a significantly higher complication rate compared with patients not receiving OAT, including death (1 [3.2%] vs 4 [0.6%]; $P = .04$), stroke (4 [12.9%] vs 10 [1.4%]; $P = .001$), and hematoma (3 [9.6%] vs 11 [1.6%]; $P = .02$). In CAS, the results were similar in patients receiving OAT (30 [5.8%]) and patients not receiving OAT. Patients receiving OAT who underwent CAS had better outcomes than patients receiving OAT-CH who underwent CEA, including stroke, death, MI, and hematoma combined (0 [0.0%] vs 7 [22.5%]; $P = .01$).

Conclusions: OAT management significantly influences the results of carotid revascularization. Because CAS with unmodified OAT had a significantly better outcome than CEA with OAT-CH, carotid revascularization strategies should favor CAS rather than CEA in this setting.

ABBREVIATIONS

ASA = acetylsalicylic acid, CAS = carotid artery stenting, CEA = carotid endarterectomy, INR = international normalized ratio, MI = myocardial infarction, OAT = oral anticoagulant therapy, OAT-CH = oral anticoagulant therapy conversion to heparin

The best carotid revascularization method for stroke prevention is actively debated in the literature. Although carotid endarterectomy (CEA) continues to be the "gold standard" technique, carotid artery stenting (CAS) may be an alternative in selected patients with carotid disease (1). More recent randomized controlled trials have shown an improved perioperative outcome in patients who underwent CEA rather than CAS when evaluating stroke; however, some subgroups, such as younger symptomatic patients, may benefit more from CAS (2–4). Subgroup identification to determine the appropriate carotid revascularization technique may be clinically useful.

According to current guidelines, the common management of patients on long-term oral anticoagulant therapy (OAT) who are candidates for any surgical procedure, including carotid revascularization, is oral anticoagulant therapy conversion to heparin (OAT-CH). This approach allows for better coagulation control (5). However, OAT-CH has several limitations, including patient discomfort, cost, and the risk of thrombosis or hemorrhage due to incorrect dosage or an adverse reaction to heparin even

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with low-molecular-weight or unfractionated heparin (6–12). Nonetheless, endovascular revascularization procedures, including percutaneous coronary interventions, are currently performed under ongoing OAT without any apparent increase in the complication rates (13–23). In a previous study, Pini et al (24) showed that patients undergoing CAS with ongoing OAT had outcomes similar to patients who did not receive OAT. The aim of the present study was to evaluate and compare the influence of OAT and its management on the outcomes of patients undergoing either surgical or endovascular carotid revascularization and to compare patients undergoing CEA with OAT-CH with patients undergoing CAS with ongoing OAT.

MATERIALS AND METHODS

Patients and Data Collection

A retrospective study of all carotid artery revascularization procedures (CEA and CAS) was conducted from January 2005 to December 2011. Institutional review board authorization was obtained for this study. Patients' clinical characteristics, risk factors, perioperative therapy, technical aspects of carotid revascularization, and clinical outcomes were collected in a database and retrospectively analyzed. The clinical characteristics considered were hypertension (presence of systolic blood pressure $>$ 140 mm Hg or diastolic blood pressure $>$ 90 mm Hg or specific therapy), dyslipidemia (total cholesterol $>$ 200 mg/dL or low-density lipoprotein $>$ 120 mg/dL or specific therapy), diabetes mellitus, current smoking, coronary artery disease (defined as a history of angina pectoris or myocardial infarction or coronary revascularization), chronic obstructive pulmonary disease (defined as chronic bronchitis and emphysema), and chronic renal failure (glomerular filtration rate $<$ 60 mL/min). The events considered in the intraoperative period and 30-day postoperative period were ischemic or hemorrhagic stroke; myocardial infarction (MI); death; and hematoma, which was defined as bleeding from the surgical or endovascular point of access that required surgical evacuation.

Carotid revascularization procedures were performed for symptomatic carotid artery bifurcation stenosis $\geq$ 60% (European Carotid Surgery Trial criteria [25]). Neurologic symptoms were evaluated by independent in-hospital neurologists and were defined as cerebral ischemic events (major or minor stroke or transient ischemic attack or amaurosis fugax) if they occurred in the hemisphere ipsilateral to the carotid stenosis in the preceding 6 months. Asymptomatic patients with $>$ 70% carotid artery stenosis (European Carotid Surgery Trial criteria [25]) also underwent carotid revascularization.

In patients undergoing CEA, OAT was stopped 5 days before surgery, and low-molecular-weight heparin (Clexane; Sanofi Winthrop Industrie, Alfort, France) was administered twice per day (1,000 IU/10 kg) to achieve a preoperative international normalized ratio (INR) value in the range of 1–1.15. This INR was maintained until discharge, when OAT was restarted, and heparin was continued until the target therapeutic INR range was achieved. Concomitant antiplatelet therapy was left unmodified.

In CAS, double antiplatelet therapy (acetylsalicylic acid [ASA] + clopidogrel) was administered to all patients for 30 days. After that period, only ASA was continued indefinitely unless otherwise indicated. Patients undergoing CAS treated with OAT maintained their regimen unmodified, and the target INR was assigned according to the appropriate pathology (atrial fibrillation, mechanical prosthesis, or deep vein thrombosis); in these patients, the typical heparin bolus was not administered during the CAS procedure (2,500 IU of unfractionated sodium heparin). In patients receiving OAT with a high hemorrhage risk (ie, severe hepatic insufficiency; active peptic ulcer; proliferative diabetic retinopathy; or previous severe gastrointestinal, urologic, intraocular, or intracranial bleeding [26]), no adjunct antiplatelet medication was administered in combination with OAT.

The neurologic outcome was evaluated according to the National Institutes of Health Stroke Scale and the modified Rankin Scale at the end of the procedure and in the following 24 hours by a neurologist.

CEA Procedure

Standard CEA was conducted under general anesthesia through exposure of the carotid bifurcation with intraoperative heparin administration and a longitudinal arteriotomy of the carotid bulb. Shunting to maintain cerebral vascularization was performed routinely in all patients. The arteriotomy closure was performed with a direct running 6-0 or 7-0 suture or with the use of a synthetic patch (polyethylene terephthalate [Dacron, DuPont], polytetrafluoroethylene). A wound drain was positioned and left in place for at least 24 hours in all cases. The neurologic outcome was evaluated by a neurologist according to the National Institutes of Health Stroke Scale and the modified Rankin Scale at the end of the procedure and in the following 24 hours.

CAS Procedure

The CAS procedure was performed as described previously (27). Briefly, patients were medicated with 100 mg of ASA and 75 mg of clopidogrel for 3 days before the procedure. Patients were then taken to the angiographic suite after giving informed consent and undergoing a cardiology evaluation. All procedures were performed with local anesthesia, systemic unfractionated heparinization according to activated clotting time values (unless OAT was ongoing), and an 8-F groin introducer. Common carotid cannulation was achieved with 40-degree Boston Scientific (Natick, Massachusetts) or Medtronic (Minneapolis, Minnesota) HS I and II catheters over a Terumo (Somerset, New Jersey) stiff guide wire. When cannulation was not achievable by these means, several alternative techniques were used (eg, buddy

wire, coaxial). Brachial or carotid access was not attempted in any case. Routine cerebral protection was achieved using FilterWire EZ (Boston Scientific), and stent placement was achieved using a closed-cell Wallstent (Boston Scientific). Technical success was defined as the ability to treat the stenosis with < 30% residual stenosis. Hemostasis of the point of access was achieved with a vascular closure device platform (Angio-Seal; St. Jude Medical, St. Paul, Minnesota) or manual and elastic groin compression (an elastic groin bandage maintained for 24 hours after the percutaneous access).

Statistical Analysis

Categorical variables are expressed as relative and absolute frequencies. Analyses of the differences between the two groups were performed with χ^2 test or Fisher exact test. Univariate and multiple logistic regression analyses were performed to evaluate the influence of the different variables on the outcomes. A P value of $< .05$ was considered significant. Statistical tests were performed using SPSS 13.0 for Windows computer software (SPSS, Chicago, Illinois).

RESULTS

Overall Carotid Revascularization

In the 6-year study period, 1,222 carotid revascularization procedures were performed, including 711 (58.1%) CEAs and 511 (41.9%) CAS procedures. There were 61 (5%) patients treated with OAT (warfarin).

CEA Results

A total of 711 CEAs were performed. Clinical characteristics, current therapy, and technical aspects are reported in **Table 1**. Of the 31 patients treated with OAT-CH (4.4%), 16 (51.6%) were treated for atrial fibrillation, 12 (38.7%) for a cardiac mechanical valve, and 3 (9.6%) for deep vein thrombosis. Patients on OAT also received antiplatelet therapy (single ASA) in 16 (51.6%) cases and double antiplatelet therapy in 2 (6.4%) cases with a recently placed coronary drug-eluting stent. No significant differences were noted in the clinical characteristics between patients undergoing CEA treated with OAT-CH or without OAT. **Tables 1** and **2** compare the current therapy, technical aspects, and outcomes of these patients.

Of the variables examined, only the type of treatment (OAT-CH) significantly increased the risk of complications (**Table 2**). The only hemorrhagic stroke observed in the study occurred in the OAT-CH group; the one death that occurred in the OAT-CH group was due to a cerebral hemorrhage.

A multiple logistic regression analysis was performed to identify factors associated with the composite endpoint of death, stroke, MI, and hematoma in the CEA group. The following variables were considered: age > 80 years, gender, previous neurologic ischemic symptoms, hypertension, dyslipidemia, diabetes, smoking, chronic obstructive pulmonary disease, coronary artery disease, glomerular filtration rate < 60 mL/min, antiplatelet therapy, and OAT-CH. Only OAT-CH (odds ratio, 8.2; 95% confidence interval, 2.9–23.4; $P = .001$) and previous neurologic ischemic symptoms (odds ratio, 2.8; 95% confidence interval, 1.2–6.0; $P = .009$) were independently associated with adverse outcomes.

CAS Results

CAS was performed in 511 patients. The clinical characteristics, current therapy, and technical aspects are reported in **Table 1**. Of patients who underwent CAS, 30 were receiving OAT (5.8%); OAT was administrated for atrial fibrillation in 20 cases (66.6%; INR, 2.59 ± 0.7), cardiac mechanical valve prosthesis in 8 cases (26.6%; INR, 2.61 ± 0.4) and deep vein thrombosis in 2 cases (6.8%; INR, 2.36). **Table 2** compares patients undergoing CAS with OAT and no OAT. No significant clinical or technical differences were present between patients treated with OAT or no OAT, and no adverse events occurred in the patients undergoing CAS with OAT.

CEA versus CAS

In 680 CEAs and 481 CAS procedures performed in patients who did not require anticoagulation therapy, the overall numbers of complications (death, stroke, MI, and hematomas) were 30 (4.4%) and 21 (4.1%; $P = 1.0$). In patients treated with OAT, 31 CEAs and 30 CAS procedures were performed. The clinical characteristics of the patients were similar in the two groups (**Table 2**). Although the frequencies of the single events (stroke, death, MI, hematoma) in the two groups were not significantly different, their combination was more frequent in patients treated with CEA and receiving OAT-CH (7 [22.5%] vs 0 [0%]; $P = .01$) (**Table 3**).

DISCUSSION

Our hypothesis-generating study suggests that CAS might be associated with a lower complication rate than CEA for patients on OAT who require carotid revascularization. Although the outcomes of patients undergoing CAS were not influenced by concomitant OAT, patients on OAT undergoing CEA had a higher incidence of both ischemic and hemorrhagic stroke, compared with patients who did not receive OAT, despite full adherence to the current recommendations for heparin bridging therapy. A direct comparison of the two strategies shows that patients on OAT have a higher risk of the occurrence of the composite stroke, death, MI, and hematoma endpoint when undergoing CEA than patients on OAT undergoing CAS.

OAT interruption and reinitiation is known to cause important coagulative changes, leading to an increased risk of thrombotic and hemorrhagic complications. In their literature review of the risks associated with OAT conversion to heparin in patients undergoing general surgery

Table 1. Clinical Characteristics, Current Therapy, and Technical Aspects of the Study Population

	Overall CEA (n = 711) No. (%)	CEA in OAT-CH (n = 31) No. (%)	CEA in No OAT (n = 680) No. (%)	*P*	Overall CAS (n = 511) No. (%)	CAS in OAT (n = 30) No. (%)	CAS in No OAT (n = 481) No. (%)	*P*
Age ≥ 80 y	58 (12.0)	6 (19.3)	52 (7.6)	.15	164 (32.1)	4 (13.3)	160 (33.2)	.20
Male gender	456 (64.6)	17 (54.8)	439 (64.5)	.45	333 (65.3)	19 (63.3)	314 (65.2)	.90
Neurologic ischemic symptoms	192 (27.3)	14 (45.1)	178 (26.1)	.23	147 (28.9)	8 (26.6)	139 (28.8)	.87
Hypertension	638 (91.0)	31 (100)	607 (89.2)	.90	449 (88.9)	28 (93.3)	421 (87.5)	.75
Dyslipidemia	444 (63.4)	12 (38.7)	432 (63.5)	.20	190 (37.6)	15 (50)	175 (36.3)	.23
Diabetes mellitus	205 (29.3)	7 (22.5)	198 (29.1)	.58	137 (27.2)	8 (26.6)	129 (26.8)	.87
Smoking	146 (20.9)	7 (22.5)	139 (20.4)	.82	47 (9.3)	3 (10)	44 (9.1)	.78
CAD	180 (25.7)	8 (25.8)	172 (25.2)	.90	194 (38.4)	13 (43.3)	181 (37.6)	.38
COPD	96 (13.7)	5 (16.1)	91 (13.3)	.76	110 (21.8)	5 (16.6)	105 (21.8)	.68
CRF	78 (11.2)	5 (16.1)	73 (10.7)	.48	92 (18.3)	6 (20)	86 (17.8)	.57
Current therapy								
Single antiplatelet therapy	618 (86.9)	16 (51.6)	602 (84.6)	.001	0 (0.0)	0 (0.0)	0 (0.0)	—
Double antiplatelet therapy	40 (5.6)	2 (6.4)	38 (5.3)	.94	481 (94.1)	0 (0.0)	481 (100)	—
OAT	31 (4.4)				0 (0.0)	0 (0.0)	0 (0.0)	—
OAT + antiplatelet	—	—	—	—	30 (5.8)	30 (100)		
Technical aspects								
Endarterectomy	661 (93.0)	29 (93.5)	632 (91.0)	.58	—	—	—	
Eversion	50 (7.0)	2 (6.4)	48 (7.1)	.34	—	—	—	
Patch	414 (58.2)	19 (61.2)	395 (58.0)	.26	—	—	—	
Cerebral protection	—	—	—		490 (95.9)	29 (96.6)	461 (90.2)	1.0
Closed cell	—	—	—		491 (96.0)	29 (96.6)	462 (90.2)	1.0
Femoral artery closure device	—	—	—		478 (93.5)	29 (96.6)	449 (87.8)	.73
Manual compression	—	—	—		33 (6.5)	1 (3.3)	32 (6.2)	.71

CAD = coronary artery disease; CAS = carotid artery stenting, CEA = carotid endarterectomy, COPD = chronic obstructive pulmonary disease, CRF = chronic renal failure, OAT = oral anticoagulant therapy, OAT-CH = oral anticoagulant therapy conversion to heparin.

Table 2. Perioperative Events in the CEA and CAS Groups

	Overall CEA (n = 711) No. (%)	CEA in OAT-CH (n = 31) No. (%)	CEA in No OAT (n = 680) No. (%)	P	Overall CAS (n = 511) No. (%)	CAS in OAT (n = 30) No. (%)	CAS in No OAT (n = 481) No. (%)	P
Events								
Stroke	14 (2.0)	4 (12.9)	10 (1.4)	.001	15 (2.9)	0 (0.0)	15 (3.1)	.38
Death	4 (0.6)	1 (3.2)	3 (0.4)	.04	1 (0.2)	0 (0.0)	1 (0.2)	.82
MI	6 (0.9)	0 (0.0)	6 (0.9)	.62	1 (0.2)	0 (0.0)	1 (0.2)	.82
Hematoma	14 (2.0)	3 (9.6)	11 (1.6)	.02	4 (0.8)	0 (0.0)	4 (0.8)	.65
Composite events								
Stroke/death	18 (2.6)	5 (16.1)	13 (1.9)	.001	16 (3.1)	0 (0.0)	16 (3.3)	.37
Stroke/death/MI	24 (3.3)	5 (16.1)	19 (2.7)	.001	17 (3.3)	0 (0.0)	17 (3.4)	.35
Stroke/death/MI/hematoma	38 (5.3)	8 (25.8)	30 (4.4)	.001	21 (4.1)	0 (0.0)	21 (4.3)	.29

CAS = carotid artery stenting, CEA = carotid endarterectomy, MI = myocardial infarction, OAT = oral anticoagulant therapy, OAT-CH = oral anticoagulant therapy conversion to heparin.

procedures, Spyropoulos and Turpie (10) reported an overall incidence of thromboembolic events of 1.22% and a risk of major bleeding of approximately 3%, with an overall complication rate of > 4%. The results of our study, which focused on the comparison of surgical and interventional carotid revascularization procedures, are consistent with these observations. Rosenbaum et al (28) analyzed morbidity, mortality, and bleeding complications in a small group of patients undergoing CEA and found that only clopidogrel, when compared with ASA and OAT, resulted in a significant risk for developing a neck hematoma, particularly when using a Dacron patch. The mean INR in the 10 patients receiving OAT of this series was below the accepted therapeutic range, and no patient underwent CAS.

In our series, the considerable changes in the INR values following the interruption and reinitiation of warfarin are the likely cause of the high complication rate in the OAT group because warfarin interruption is known to cause INR fluctuation and requires containment by the administration of the appropriate heparin. A transient prothrombotic state is caused by warfarin reinitiation because the anticoagulant factors protein C and S are vitamin K–dependent with a shorter half-life than the clotting factors. At the beginning of warfarin administration, the serum concentration of coagulant and anticoagulant enzymes may be unbalanced toward a procoagulative effect (29–31).

By not interrupting OAT, the fluctuations toward hypercoagulable or hypocoagulable states are avoided, although the bleeding risk remains approximately the same because heparin bridging therapy still carries a higher probability of hemorrhage. In cases of extensive bleeding, the effect of heparin may be easily reversed, in contrast to the effect of warfarin. The anticoagulant effect of warfarin can be efficaciously overcome by concentrates of clotting factors II, VII, IX, and X or by vitamin K, whereas low-molecular-weight heparins that are typically employed in bridging therapy cannot be easily reversed because of the lack of a specific antidote. The better antithrombotic protection given by OAT is explained by the fact that heparin cannot prevent clot formation, which is independent of thrombin, but it can prevent thrombus formation, which requires thrombin to activate the fibrinogen-producing clot (32). Other evidence of the increased coagulability associated with warfarin interruption is the observation that spontaneous echocardiographic contrast, which has been shown to be a precursor of thrombus formation (29), was more common in patients in whom warfarin was stopped compared with patients with ongoing OAT (16). The current practice is to shift OAT to heparin in patients undergoing surgical procedures to prevent hemorrhagic complications. However, this change may be troublesome for some patients, particularly elderly patients, because it requires the interruption of an established therapeutic scheme and initiation of the administration of a new type of drug.

Table 3. Comparative Evaluation of Events in Patients Undergoing CEA with OAT-CH and Patients Undergoing CAS with Uninterrupted OAT

	CEA in OAT-CH (n = 31) No. (%)	CAS in OAT (n = 30) No. (%)	*P*
Clinical characteristics			
Age ≥ 80 y	6 (19.3)	4 (13.3)	.73
Male gender	17 (54.8)	19(63.3)	.60
Neurologic ischemic symptoms	14 (45.1)	8 (26.6)	.18
Hypertension	31 (100)	28 (93.3)	.23
Dyslipidemia	12 (38.7)	15 (50)	.44
Diabetes mellitus	7 (22.5)	8 (26.6)	.77
Smoking	7 (22.5)	3 (10)	.30
CAD	8 (25.8)	13 (43.3)	.18
COPD	5 (16.1)	5 (16.6)	1.0
CRF	5 (16.1)	6 (20)	.74
Perioperative events			
Stroke	4 (12.9)	0 (0)	.11
Death	1 (3.2)	0 (0)	1.0
MI	0 (0)	0 (0)	1.0
Hematoma	3 (9.6)	0 (0)	.23
Composite events			
Stroke/death	5 (16.1)	0 (0)	.053
Stroke/death/MI	5 (16.1)	0 (0)	.053
Stroke/death/MI/hematoma	8 (25.8)	0 (0)	.01

CAD = coronary artery disease, CAS = carotid artery stenting, CEA = carotid endarterectomy, COPD = chronic obstructive pulmonary disease, CRF = chronic renal failure, MI = myocardial infarction, OAT = oral anticoagulant therapy, OAT-CH = oral anticoagulant therapy conversion to heparin.

Our results have practical implications for candidates for surgical revascularization because they show that OAT interruption with heparin bridging therapy can lead to both hemorrhagic and thrombotic complications (14,30–32). This incremental risk should be considered when choosing carotid revascularization, particularly in neurologically asymptomatic patients in whom the benefit-to-risk ratio of revascularization is smaller.

In the CAS group, we confirmed the results of a previous publication in a larger group of patients (24). No differences in perioperative outcomes were found between the antithrombotic regimens (OAT vs non-OAT). An effective and safe artery closure can be obtained with currently available devices, even in patients with low coagulable states (33). The anticoagulated status that CAS requires during the procedure can be obtained simply by maintaining OAT, with no additional perioperative heparin administration. This finding is consistent with numerous observations regarding other endovascular treatments, including coronary angiography and angioplasty, and in cardiac invasive maneuvers such as pacemaker and defibrillator implantation and atrial fibrillation ablation (**Table 4**). In all of these interventions, OAT continuation did not increase the incidence of adverse events or was associated with a lower complication rate compared with the heparin bridging strategy (21). In their series of pacemaker and defibrillator implantations, Ahmed et al (22) reported a minor incidence of pocket hematoma and a shorter hospital stay in patients treated with continued OAT compared with patients with heparin bridging therapy.

Another possible advantage of this approach is the possibility of urgent treatment in patients on OAT who develop neurologic symptoms. Although surgical carotid revascularization would be endangered by the low coagulative patterns, CAS could be safely performed in such a setting. Management of recently symptomatic carotid plaques with CEA requires several days to achieve complete OAT reversal and leaves the patient with a significant neurologic risk, which is particularly high in the first week (33,34). Urgent carotid revascularization in patients on OAT can be performed quickly and with a better outcome by CAS.

The value of our study is limited by the low number of patients treated with OAT and by the nonrandomized design that could lead to type 2 error. However, CAS typically has a slightly worse outcome than CEA in patients not treated with OAT, shown in the present series and in the current literature (2,3). We believe that our observation could be the basis for further studies and randomized multicenter clinical trials.

In conclusion, the management of OAT is an important issue in patients with carotid disease undergoing revascularization because it may significantly influence the results.

Table 4. Endovascular Experiences with Uninterrupted OAT in the Literature

Reference	Procedure	OAT Patients	OAT-CH Patients	Hemorrhagic Complications		Thrombotic Complications		Conclusions
				OAT	OAT-CH	OAT	OAT-CH	
Hildick-Smith et al, 2003 (13)	Cath	66	—	1 (1.5%)	—	—	—	Safe
Jessup et al, 2003 (14)	Cath + PCI	23	—	0 (0.0%)	—	0 (0.0%)	—	No differences
El-Jack et al, 2006 (15)	Cath + PCI	59	30	4 (6.8%)	2 (6.5%)	—	—	Safe
Lo et al, 2006 (16)	Cath	28	31	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	No differences
Wazni et al, 2007 (17)	AF ablation	150	205	1 (0.6%)	12 (5.8)	0 (0.0%)	3 (1.4%)	Safe and effective
Rubboli et al, 2007 (18)	Cath + PCI	16	88	1 (6.3%)	4 (4.5%)	1 (6.0%)	0 (0.0%)	No differences
Karjalainen et al, 2008 (19)	PCI	421	282	15 (6.2%)	46 (16.3%)	14 (5.8%)	11 (3.6%)	No differences
Annala et al, 2008 (20)	Cath	178	80	5 (2.8%)	2 (5 %)	0 (0.0%)	1 (1.0%)	No differences
Helft et al, 2009 (21)	PCI	50	—	0 (0.0%)	—	—	—	Feasible
Ahmed et al, 2010 (22)	PM/DEF implant	114	123	2 (1.7%)	8 (6.1%)	0 (0.0%)	1 (0.8%)	Safe and effective
Di Biase et al, 2010 (23)	AF ablation	2618	2488	0 (0.0%)	27 (1.1%)	10 (0.4%)	10 (0.4%)	Safe and effective
Pini et al (24), 2011	CAS	20	—	0 (0.0%)	—	0 (0.0%)	—	Safe and effective

AF = atrial fibrillation, CAS = carotid artery stenting, Cath = coronary catheterization, OAT = oral anticoagulant therapy, OAT-CH = oral anticoagulant therapy conversion to heparin, PCI = percutaneous coronary intervention, PM/DEF implant = pacemaker/defibrillation implantation.

The possibility of performing carotid revascularization without modifying ongoing OAT leads to significant advantages in terms of perioperative results because numerous thrombotic and hemorrhagic complications can be avoided.

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