ORIGINAL ARTICLE

Carotid Stenting Versus Endarterectomy in Symptomatic Carotid Stenosis

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Abstract

Background: ***Carotid artery stenosis is a leading cause of TIA, acute stroke, recurrent stroke and chronic cerebrovascular insufficiency, so this needs effective management.***

Aim: ***To compare carotid endovascular stenting and carotid endarterectomy in the treatment of symptomatic carotid stenosis patients in terms of efficacy, durability, and safety.***

Patients and methods: ***This is a retro and prospective comparative study in Al Azhar university and other hospitals on fifty cases of symptomatic carotid stenosis and were divided into two equal groups of CAS and CEA.***

Results: ***In this study, the mean patient's age was 62.2 in the CAS group and 63.6 in the CEA group, with 46 males and 4 females. Presented with TIA 46% (n=23), headache or unsteadiness in 6% (n=3), and established deficits in 48% (n=24) of all cases. The most preferable outcomes in the CAS group are (70-89%) of stenosis. The outcomes of the CEA group increase with higher degrees of stenosis except in cases with (80-89%) of stenosis. Intraoperative complications occurred in 4% (n=2), including vasospasm in the CAS group. Perioperative complications occurred in 20% (n=10) of our patients.***

Conclusion: ***TIA is the most frequent presentation of carotid stenosis, and the increased degree of stenosis was associated with more favorable outcomes. males are more liable for carotid artery stenosis. Hypertension is the most associated risk factor to carotid stenosis. Both groups were associated with favorable outcomes, maybe due to precise selecting symptomatic patients in our study.***

Keywords: Carotid stenosis; Endarterectomy; Carotid-stenting

1. Introduction

Carotid atherosclerosis is always present at the level of the carotid bifurcation into its main branches. The beginning of the internal carotid artery is often affected. Intracranial segments of the ICA and their branches are rarely affected by atherosclerosis. The occurrence rate of carotid stenosis changes with different study samples, the use of diagnostic equipment, and the criteria used. The prevalence of considerable carotid stenosis was 7% in females and 9% males, where colored duplex US was used to measure stenosis, and stenosis was more than 50%.[1]

Complex plaques, defined as plaques with neovascularity, ulceration, echolucency or intraplaque hemorrhage, have a 4 times higher risk of ischemic stroke than standard plaques.[2]

Michael DeBakey had the honor of performing the 1st successful carotid endarterectomy in 1953. He excised the plaque and a fresh blood clot from the carotid bifurcation of a 53-year-old male who presented with transient ischemic attacks.[3]

Our study was designed to compare carotid endovascular stenting and carotid endarterectomy in treatment of symptomatic carotid stenosis as regard efficacy, durability, and safety.

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2. Patients and methods

The study was done retro and prospectively in Al Azhar university and other hospitals on fifty cases that admitted with symptomatic carotid stenosis. The study was carried out to compare endovascular carotid stenting with surgical endarterectomy as regard safety, efficacy, and durability.

Inclusion Criteria: the cases that have any degree of symptomatic occlusive carotid disease due to congenital or developmental causes, Patients with chronic or acute cerebrovascular occlusion, and Patients with post-traumatic or post-surgical carotid injuries.

Exclusion criteria: the patient who refuses intervention, asymptomatic patients, and patient with chronic totally occluded carotid artery.

Surgical Procedures: endovascular carotid stenting in twenty-five cases. And carotid endarterectomy in another twenty-five cases.

Associated conditions: hypertension, diabetes mellitus, smoking and hyperlipidemia were evaluated.

Outcomes: the outcomes of the operated patients were evaluated clinically and radiologically.

Intraoperative complications and difficulties, such as intraoperative rupture, dissection, thromboembolic complications, neurovascular injury, or difficulty due to vasospasm and technical failure, were noted.

Perioperative complications, such as vasospasm, cerebrovascular stroke, hematoma, pulmonary, and cardiac complications, were observed.

Follow up: for at least 1 year after the procedure.

3. Results

Carotid Stenting Cases:

Table.1. CAS group Statistics.

		Age	GCS	Percent of Stenosis
N	Valid	25	25	25
	Missing	0	0	0
Mean		62.20	14.92	82.40%
Std. Deviation		7.869	.400	10.319%
Minimum		48	13	60 %
Maximum		75	15	95%

Demographic data of the CAS group shows:

Forty-eight Percent of cases in the seventh decade of age, thirty-two per cent in sixth decade, twelve per cent in eighth decade and eight per cent in fifth decade. Twenty-one male patient and four are females.

As regards risk factors, etiology and presentations of CAS group:

Hypertension is the most associated risk factor in twenty patients (80%) then Smoking in seven patients (28%) then Obesity in six patients (24%) lastly Diabetes in three cases. Degenerative atherosclerosis is the cause of stenosis in all our patients except one case with post-radiation carotid stenosis. Forty-eight percent of our patients were presented with TIA and the remaining were presented with other symptoms like headache, dizziness, and motor weakness. Only one disturbed patient with 13 GCS score and the others were fully conscious.

As regards stenosis criteria of CAS group:

Rt proximal ICA stenosed in thirteen patients (52%), Lt proximal ICA in five patients (20%), Rt CCA bifurcation in three cases (12%), Rt ICA 2cm distal to bulb in two cases (8%) and two patients their stenosis was in Rt and Lt CCA. Degrees of stenosis were ninety percent in eight patients (32%), 80-89% in seven patients (28%), 70-79% in five patients (20%), ninety-five percent in three patients (12%), and sixty percent in two patients (8%).

As regards complications and outcomes of CAS group:

Vasospasm occurred in two cases only (8%) intraoperatively. Post-operative Rt sided hemiplegia, single attack of seizure and femoral artery pseudoaneurysm occurred in three cases (12%) of our patients. After post-procedural evaluation of our patients according to Glasgo Outcome Score fourteen patients got GOC5 (56%), ten patients got GOS4 (40%), and one case got GOS3. Post-procedural radiological evaluation of our patients showed twelve patients had 80% caliber restoration (48%), seven cases had 70% restoration (28%), four cases had 90% restoration (16%), and two cases had 100% restoration (8%).

As regards neurological and radiological follow-up of CAS group:

After one year of neurological and radiological follow-up of our patients, thirteen patients were excellent (52%) who had radiological patent stents, and twelve patients (48%) hadn't available radiological follow up. Six of them were good (24%), four were very good in neurological follow-up (16%) and two patients weren't available.

Statistical study of CAS group shows:

There was an approximate significant association between risk factors and peri-operative complications and a strong statistical association between percentage of stenosis and neurological outcomes. (Fig. 1)

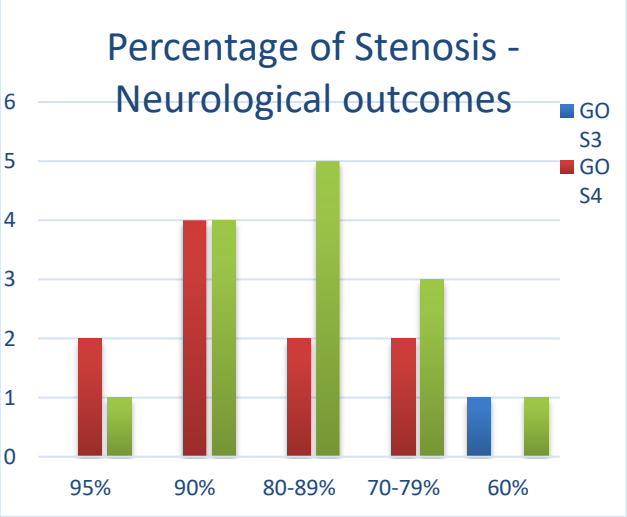

Figure 1. Column chart of Relation between Percent of Stenosis and Neurological outcomes in CAS group.

Endarterectomy Cases

Table. 2. CEA group Statistics.

		Age	GCS	Percent of Stenosis
N	Valid	25	25	25
	Missing	0	0	0
Mean		63.60	14.88	75.20%
Std. Deviation		5.930	.332	7.837%
Minimum		53	14	60%
Maximum		80	15	90%

Demographic data of the CEA group shows:

Sixty Percent of cases in the seventh decade of age, thirty-six per cent in sixth decade, and one patient in eighth decade. Twenty-one male patient (84%) and four are females.

As regards risk factors, etiology and presentations of CEA group:

Hypertension is the most associated risk factor in nineteen patient (76%) then Smoking in five patients (20%) then Diabetes in five cases (20%) and lastly Obesity in two patients. Degenerative atherosclerosis is the cause of stenosis in all our patients. Forty-four percent of our patients were presented with TIA and the remaining were presented with other symptoms like headache, unsteadiness, and motor weakness. Only three disturbed patients with 14 GCS score and the others were fully conscious.

As regards the stenosis criteria of CEA group:

Rt CCA bifurcation stenosed in nine patients (36%), Lt proximal ICA in six patients (24%), Lt CCA bifurcation in five cases (20%), Rt proximal ICA in three cases (12%) and two patients their stenosis was in Rt and mid Lt CCA. Degrees of stenosis were 70-79% in eleven patients (44%), 80-89% in ten patients (40%), ninety percent in two patients (8%) and sixty percent in other two patients (8%).

As regards procedures, complications and outcomes of CEA group:

We operated on fourteen patients without shunt and primary arteriotomy repair (56%) and the remaining eleven patients were operated with shunt and grafts (44%). Post-operative transient dysphasia, transient hoarseness of voice, hematoma and wound infection occurred in seven cases (21%), and only one patient was lost in car accident after discharge. After post-procedural evaluation of our patients according to Glasgo Outcome Score fourteen patients got GOC5 (56%), and eleven patients got GOS4 (40%). Post-procedural radiological evaluation of our patients showed normal flow of operated vessels.

As regards neurological and radiological follow-up of CEA group:

After one year of neurological and radiological follow-up of our patients, thirteen patients were excellent (52%), nine patients (36%) were very good, and two were good in neurological follow-up (8%). Sixteen patients got normal arterial flow (64%), and nine weren't available in radiological follow-up.

Statistical study of CEA group shows:

There was an insignificant association between risk factors and peri-operative complications, and a low statistical association between percentage of stenosis and neurological outcomes.

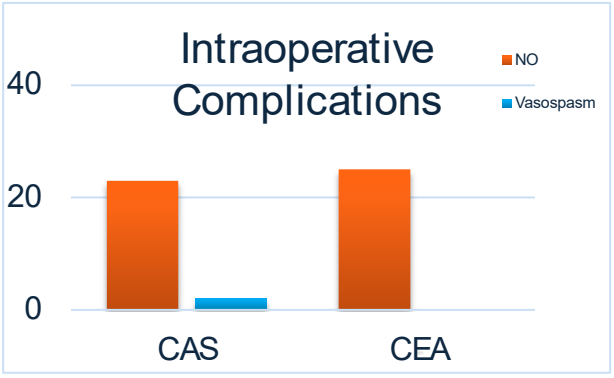

Figure 2. Column chart of Relation between Procedures and the occurrence of Intraoperative complications.

The following table shows the percentage of perioperative complications in every used procedure and as you see variable perioperative complications noticed in twenty percent of all cases (n=10) three of them in CAS group and seven in CEA group.

Table. 3. Relation between Procedures and the occurrence of Perioperative complications.

Peri operative complications / Procedures		Death due to MCA	Femoral artery pseudoaneurysm	Hematoma	No	Rt sided hemiplegia	single attack of fits controlled by antiepileptic drugs	Transient dysphasia	Transient hoarseness of voice	Wound infection	Total
CAS	Count	0	1	0	22	1	1	0	0	0	25
	% of Total	0.0 %	2.0%	0.0%	44.0 %	2.0%	2.0%	0.0%	0.0%	0.0%	50.0%
CEA	Count	1	0	1	18	0	0	1	1	3	25
	% of Total	2.0 %	0.0%	2.0%	36.0 %	0.0%	0.0%	2.0%	2.0%	6.0%	50.0%
Total	Count	1	1	1	40	1	1	1	1	3	50
	% of Total	2.0 %	2.0%	2.0%	80.0 %	2.0%	2.0%	2.0%	2.0%	6.0%	100.0%

Pearson Chi-Square	50.000[a]
Likelihood Ratio	69.315
Fisher's Exact Test	57.709
Phi	1.000
Cramer's V	1.000

a. 16 cells have expected count less than 5. The minimum expected count is .50.

This table shows a very strong association between perioperative complications and CEA group in comparison to CAS group.

The following chart shows the neurological outcomes in the two study groups: fourteen cases in each group have GOS 5, eleven cases in CEA group & ten cases in CAS group have GOS 4 and only one case in CAS group has GOS 3.

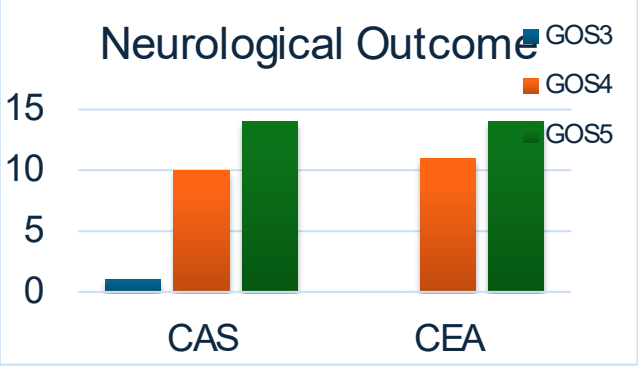

Figure 3. Column chart of Relation between Procedures and Neurological Outcomes.

Statistical analysis for comparison between both groups shows:

There was a very strong association between intraoperative complications and CAS group in the form of vasospasm in comparison to CEA group. (fig. 2), a very strong association between perioperative complications and CEA group in comparison to CAS group. (table. 3), a very strong association between high neurological outcomes and CEA group in comparison to CAS group. (fig. 3), and a very strong association between the preferred neurological follow up and CEA group in comparison to CAS group.

4. Discussion

Carotid artery stenosis is one of the most common diseases in elderly patients and is the leading cause of stroke, which is the third leading cause of death worldwide.[4]

In this study, the mean patient's age was 62.2 in the CAS group and 63.6 in the CEA group.

This goes in accordance with the literature that concluded that carotid artery stenosis becomes more noticeable with the advancement of age.

In one systematic review and meta-analysis, they demonstrate encouraging evidence for sex correlations in carotid artery atherosclerosis. All figures of plaque features: plaque size, composition, and morphology were more common and/or greater in men compared to women.[5]

In this study, carotid artery stenosis is more common in men than in women; only four women were in every study group.

Atherosclerosis is the main cause of cardiovascular and cerebrovascular morbidity and results from a multifactorial etiology. Obesity, hyperlipidemia, diabetes mellitus, hypertension, and smoking are traditional risk factors.[6]

In this study, hypertension, DM, smoking, and obesity were associated with risk factors.

Clinical examinations are useful for estimating prognosis, must be on a grading basis for standardizing assessment to facilitate communication between health care providers, and possibly for improving outcome measures in multicenter studies. Finally, repeated standardized assessment with some type of semiquantitative neurological scale is essential to detect deterioration in the patient's condition. Assessment of the level of consciousness with the GCS, which is the basis of the WFNS scale, was based on the observation that in a large clinical trial, the clinical features that best predicted outcome were the level of consciousness and the

presence of a focal neurological deficit. The GCS is probably the most useful aspect of the grading scale.[7]

GCS is the selected grading system for this study.

Symptomatic carotid stenosis is usually due to transient or permanent cerebral ischemia; detecting hypoperfusion and embolic causes is mandatory to eliminate the cause of ischemia, usually presenting as permanent stroke or transient ischemia. Symptoms and signs may be a contralateral hemineurological deficit and cranial nerve affection. Hypoperfusion also may cause the same presentation. Patients presented with other symptoms, such as tremors, retinal impairment, pulsatile headache, syncope, and generalized exhaustion. About thirty percent of all ischemic strokes are caused by cervical carotid disease. The etiology usually detaches the embolus from the carotid bifurcation unstable plaque, but only stenosis may be the cause. The dangers of embolization and hypoperfusion increase with the greater stenosis degree.[8]

Incidence of symptomatic ICA occlusion is 6 per 100,000 yearly, but the incidence of asymptomatic ones is unknown, as screening isn't done routinely. Although Black persons are at a higher risk of stroke than White persons, they are rarely diagnosed with severe stenosis (>70%). So, we notice lower CEA intervention in blacks. Native Americans suffer from severe stenosis more than foreign White persons. Males are also more liable to carotid stenosis than females.[9]

In our study the most frequent presentation was transient cerebral hypoperfusion in the form of TIA of forty-six percent of all cases (n=23) and headache or unsteadiness in six percent of all cases (n=3). Others are presented by permanent cerebral hypoperfusion and established neurological deficits of forty-eight percent (n=24).

Carnicelli et al. tested the accuracy of CTA using CDUS as a surrogate for true stenosis and concluded that there is no significant difference between diameter and area measurements.[10]

Bartlett et al., testing the diameter and area of stenosis measurements, concluded that carotid stenosis quantification based on the narrowest diameter reliably predicts the more precise area measurements.[11]

The effect of CEA is directly proportional to the degree of stenosis; the greater the benefit, the higher the degree of carotid stenosis. Carotid endarterectomy is a risky intervention, with 4% to 7% risk rate of permanent ischemia and mortality in the first month of surgery. This catastrophic complication is due to the detachment of intraluminal plaque. Perioperative risk can't be quantified precisely because the natural development of transient and permanent ischemia results in recurrent stroke or even death.[12]

In this study the neurological outcomes of CEA group increase with higher degrees of stenosis except in zone of (80-89%) stenosis.

Carotid artery stenting is the management choice when stenosis of the carotid artery (50-99%) occurs in patients suffering from many comorbidities, with a tracheostomy tube, post-neck radiation, or a dissecting carotid artery. CAS is associated with higher rates of ischemic stroke. Due to the advancements in stent manufacture and techniques, CAS is comparable to CEA in most instances. Studies suggest that CAS has a higher procedural rate of stroke (primarily non-disabling), but CEA has a significantly higher risk of procedural myocardial infarction.[13]

The most preferable neurological outcomes in CAS group of 70-89% of stenosis and the worst outcomes was in a patient with 60% stenosis.

Some authors suggest the use of a patch in every case, and others report that they never use a patch during CEA. There are many reports in the literature that patching results in superior outcomes in terms of early postoperative thrombosis, perioperative stroke, and about 50% residual restenosis in the first year when compared to primary arteriotomy closure.[14]

In our study, fifty-six percent of the CEA group were operated on with primary arteriotomy repair, and the remaining were repaired by synthetic grafts and had insignificant statistical relations with outcomes and follow-up.

The main complication of carotid artery stenosis presenting with transient cerebral insufficiency, or other neurologic symptoms, is recurrent ischemic stroke. The primary complications of CEA or CAS are perioperative stroke, as well as surgical complications.[15]

Many authors fighting for CAS referenced the result of clinical trials involving more than 8,000 patients. Concluded that CAS is one of the most studied medical procedures of all time. As is the case with other surgical procedures, the less invasive stent procedure will largely replace the risky surgical procedure, with its accompanying wound infections, hematomas, and cranial nerve injuries in 5% of patients .[16]

On the other hand, there is conflicting data regarding the outcomes of patients treated by CAS in comparison with CEA from recent, large randomized controlled trials. Consequently, debate surrounds the appropriate use of CAS relative to CEA. Thirty-day results showed a combined stroke, death, myocardial infarction rate of 7.4% for CAS, and 4.0% for CEA, $P < .006$, an effect primarily driven by an increased stroke rate of 7.0% for CAS vs 3.3% for CEA.[17]

Overall Perioperative complications occurred in

twenty percent (n=10) of our patients and TIA was responsible for four cases of them (8% of total) followed by wound infection in three cases of CEA group (6% of total), one case of hematoma at surgical ped, one of femoral artery pseudo-aneurysm, and lost a patient due to car accident.

These results are in concordance with and slightly above the literature (4-7%) that records complications after carotid interventions and proves recurrent thromboembolic complications as the main one.

4. Conclusion

Pre-procedural percentage of stenosis influences the neurological outcomes of used procedures as high degree of stenosis associated with better outcomes; that statistically has strong association in CAS group and low association in CEA group.

TIA is the most frequent presentation of symptomatic carotid stenosis, and early diagnosis of patients with a high degree of stenosis will be associated with more favorable outcomes.

All patients, whether treated by CEA or CAS, should receive antiplatelet agents (dual anti-platelet agents in CAS patients), and proper blood pressure control and managing other avoidable risk factors like obesity and cigarette smoking.

Disclosure

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All authors have a substantial contribution to the article

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References

1. J. S. Fine-Edelstein, MD, P. A. Wolf, MD, D. H. O'Leary, MD, H. Poehlman, MS, A. J. Belanger, MA, C. S. Kase, MD, and R. B. D'Agostino, PhD. Precursors of extracranial carotid atherosclerosis in the Framingham Study. Neurology 1994;44(6):1046–1050
2. Waleed Brinjikji 1, Alejandro A Rabinstein, Giuseppe Lanzino, Mohammad H Murad, Eric E Williamson, J Kevin DeMarco, John Huston 3rd. Ultrasound characteristics of symptomatic carotid plaques: a systematic review and meta-analysis. Cerebrovasc Dis. 2015;40(3-4):165-174.
3. M E DeBakey. Successful carotid endarterectomy for cerebrovascular insufficiency. Nineteen-year follow-up. JAMA. 1975;233(10):1083–5.
4. Murat Ugurlucan,Hakki Tankut Akay,Ibrahim Erdinc,Didem Melis Oztas,Cenk Conkbayir,Erdal Aslim,Cenk Eray Yildiz,Kubilay Aydin, et al. Anticoagulation strategy in patients with atrial fibrillation after carotid endarterectomy. Acta Chir Belg 2018;119(4):209-216.
5. van Dam-Nolen DHK, van Egmond NCM, Dilba K, Nies K, van der Kolk AG, Liem MI, Kooi ME, Hendrikse J, et al. Sex differences in plaque composition and morphology among symptomatic patients with mild-to-moderate carotid artery stenosis. Stroke. 2022; 53:370–378.
6. Sriraman Priyanka, Gurumoorthy Kaarthikeyan, Jayakumar Doraiswamy Nadathur, Anbarasu Mohanraj, Avinash Kavarthapu. Detection of cytomegalovirus, Epstein-Barr virus, and Torque Teno virus in subgingival and atheromatous plaques of cardiac patients with chronic periodontitis. J Indian Soc Periodontol 2017; 21:456–460.
7. Axel J Rosengart, J Dezheng Huo, Jocelyn Tolentino, Roberta L Novakovic, Jeffrey I Frank, Fernando D Goldenberg, R Loch Macdonald: Outcome in patients with subarachnoid hemorrhage treated with antiepileptic drugs. J Neurosurg 107:253-260, 2007.
8. Doonan RJ, Abdullah A, Steinmetz-Wood S, Mekhaiel S, Steinmetz OK, Obrand DI, Corriveau MM, Mackenzie KS, et al. Carotid Endarterectomy Outcomes in the Elderly: A Canadian Institutional Experience. Ann Vasc Surg. 2019 Aug; 59:16-20.
9. Lal BK, Meschia JF, Brott TG, Jones M, Aronow HD, Lackey A, Howard G. Race Differences in High-Grade Carotid Artery Stenosis. Stroke. 2021 Jun;52(6):2053-2059.
10. Anthony P Carnicelli, Jonathan J Stone, Adam Doyle, Amit K Chowdhry, Doran Mix, Jennifer Ellis, David L Gillespie, Ankur Chandra. Cross-sectional area for the calculation of carotid artery stenosis on computed tomographic angiography. J Vasc Surg 58(3):659–665. 2013
11. Bartlett ES, Symons SP, Fox AJ. Correlation of carotid stenosis diameter and cross-sectional areas with CT angiography. AJNR Am J Neuroradiol 27(3):638–642. 2006
12. Rerkasem A, Orrapin S, Howard DP, Rerkasem K. Carotid endarterectomy for symptomatic carotid stenosis. Cochrane Database Syst Rev. 2020 Sep 12;9(9):CD001081.
13. Morris DR, Ayabe K, Inoue T, Sakai N, Bulbulia R, Halliday A, Goto S. Evidence-Based Carotid Interventions for Stroke Prevention: State-of-the-art Review. J Atheroscler Thromb. 2017 Apr 03;24(4):373-387.
14. B.A. Perler, F. Ursin, U. Shanks, G.M. Williams: Carotid Dacron patch angioplasty: Immediate and long-term results of a prospective series. Cardiovasc Surg 3:631-636, 1995.
15. Chang RW, Tucker LY, Rothenberg KA, Lancaster E, Faruqi RM, Kuang HC, Flint AC, Avins AL, et al. Incidence of Ischemic Stroke in Patients with Asymptomatic Severe Carotid Stenosis Without Surgical Intervention. JAMA. 2022 May 24;327(20):1974-1982.
16. Leo H Bonati, Joanna Dobson, Roland L Featherstone, Jörg Ederle, H Bart van der Worp, Gert J de Borst, Willem P Th M Mali, Jonathan D Beard, et al. Long-term outcomes after stenting versus endarterectomy for treatment of symptomatic carotid stenosis: the International Carotid Stenting Study (ICSS) randomised trial. Lancet 2015; 385:529-38.
17. Jörg Ederle, Joanna Dobson, Roland L Featherstone, Leo H Bonati, H Bart van der Worp, Gert J de Borst, T Hauw Lo, Peter Gaines, et al. Carotid artery stenting compared with endarterectomy in patients with symptomatic carotid stenosis (international carotid stenting study): an interim analysis of a randomised controlled trial. Lancet. 2010; 375:985–97.