Endovascular management of carotid artery stenosis

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Abstract: Background: Internal carotid artery atherosclerotic stenosis is an important cause for transient ischemic attacks (TIAs) and ischemic strokes. Treatment of carotid artery stenosis could be achived by medical, surgical, endovascular intervention and stenting or combined treatment. **Objectives:** The aim of this study was to avaluate the outcome and follow up of internal carotid artery stenting and detect the rate of in-stent restenosis. **Patients and methods:** The present study was a prospective study performed in the Neuroinervential Unit at Al-Hussein University Hospital Al-Azhar University. Internal carotid artery stenting is done for 50 patients have internal carotid artery stenosis aged 64.6 ± 7.6, 30 patients (60 %) were males and 20 (40 %) were females, 33 patients (66 %) were symptomatic, 17 (34 %) were asymptomatic. **Results:** Succesful internal carotid artery stenting was done for those patients however, transient bradycardia occured in two patients (4 %), one patient (2 %) had local hematoma in the groin. There were no reported complains of chest pain or any ECG changes after stenting. One patient (2 %) developed ipsilateral stroke, three patients (6 %) developed TIA immediately after stenting and symptoms resolve within 3 hours. On follow up one month after stenting no new neurological deficits and modified Rankin scale (MRS) score of the stroke patient was 1 and carotid artery duplex showed no restenosis. On follow up 6 months after stenting there was one patient died suddenly from acute myocardial infarction and one patient developed stroke and National Institutes of Health Stroke Scale (NIHSS) score was 5 and carotid artery duplex showed no restenosis. **Conclusion:** Carotid artery stenting is a safe, feasible and efficacious procedure and can be considered as an alternative to carotid endarterectomy especially in high surgical risk patients.

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Key Words: Atherosclorosis, endovascular stenting, stroke, TIAs.

1. Introduction

Stroke is the third leading cause of death and a leading cause of serious and long term disability. One fourth of cerebrovascularevents are attributable to atherosclerotic carotid artery disease. Patients with carotid artery stenosis have a 51 % recurrence rate of stroke with medical therapy failure ***(Fowl et al., 1991, Rosamond et al. 2007, Minino et al. 2010).*** Carotid artery stenosis may be asymptomatic or symptomatic with transient monocular blindness (amaurosis fugax), TIAs, stroke in evolution or completed stroke (***Brott et al., 2011)***. Treatment for patients with carotid artery stenosis depends on the degree of stenosis, the cause (atherosclerosis or nonatherosclerosis), and whether the patient is a symptomatic or symptomatic. The aim of the treatment is to prevent neurological complications and this could be achieved by medical treatment, surgical treatment, endovascular treatment or combined treatment ***(Furberg et al. 1994 and Adrian and Randolph 2011).*** Medical treatment includes antiplatelet, statins and control of risk factors, carotid revascularization is reserved for those patients who have persistent symptoms of ischemia despite adequate antiplatelet. Carotid artery stenting (CAS) is a less invasive method of carotid revascularization, devoid of some complications that are typical for carotid endarterectomy (e.g. vocal cord injury, large neck incision, prolonged hospital stay and exposure to the risks of general anesthesia especially in high risk surgical patients, and with comparable outcomes ***(Halliday et al. 2004, Gurm et al. 2008, Brott et al. 2011).*** Because of its proven efficacy and safety as a treatment alternative to carotid endarterectomy, the FDA in 2004 approved the first self-expanding carotid for high-risk surgical patients ***(Centers for Medicare and Medicaid Services 2008).***

Different studies evaluated the outcome, feasibility, and the complications of carotid artery stenting in addition to the follow up of the patients with carotid artery stenting for in stent restenosis and recurrence of symptoms ***(Adrian and Randolph 2011*)**.

2. Patients and Methods

The present study is a prospective, single-center study carried out during the period from December, 2012 to December 2016 in the Neurointervential Unit at Al-Hussein University Hospital, after obtaining informed consent. The study protocol was approved by the local ethics committee in Al-Azhar University.

The study included 50 patients with 52 internal carotid artery endovascular stenting, patient had been recruited from Al-Hussein and Sayed Galal Hospital outpatient's clinics, internal departments and stroke units or referred from other hospitals to our department with the following inclusion and exclusion criteria:

Inclusion criteria:

1. Patients with symptomatic carotid artery stenosis 50-99 % (Symptomatic stenosis isconsidered in the presence of TIA or stroke affecting the corresponding central nervous system territory in the last 6th months).

2. Patients with asymptomatic carotid artery stenosis 70-99 % discovered accidently during routine checkup or prior to coronary artery by pass graft.

3. Patients have one or more high surgical risks for carotid endarterectomy which include.

a- Age ≥ 80 years.

b- History of open-heart surgery.

c- Need for open-heart surgery within 30 days.

d - History of myocardial infarction.

e- Known multivessel cardiac disease.

f- Left ventricular dysfunction with left ventricular ejection fraction ≤ 30%.

g- Severe broncho-pulmonal disease.

h- Significant contralateral carotid disease.

i- Previous endarterectomy, these high risk criteria for carotid endarterectomy is similar to that of SAPPHIRE trial ***(Yadav 2004),*** or patients without high risk for CE and refusing surgery.

Exclusion criteria:

1. Major functional impairment [modified Rankin scale (MRS) ≥ 3].

2. Major stroke within 4 weeks [National Institutes of Health Stroke Scale (NIHSS) score ≥ 4].

3. Severe renal impairment precluding safe contrast medium administration.

4. Inability to achieve safe vascular access.

5. Severe tortuosity of aortic arch, common carotid artery (CCA) or internal carotid artery.

6-Total occlusion of the carotid artery.

7- Long subtotal occlusion (string sign).

8- Refusal of intervention.

Methods:

All the patients underwent the following:-

1. Full medical and neurological history including history of associated comorbidities and risk factors.

2. Neurological examination at four points before stenting, immediately after stenting one month after stenting and 6th month after stenting with assessment of any neurological disorder (Headache, delirium, altered mental state, TIA or stroke) severity of the disease determined byusing NIHSS score and functional disability determined by MRS.

3. Assessment of the degree of carotid stenosis by using carotid artery duplex ultrasound before the procedure, MRA and/or CTA on the arch and supra-aortic vessels may be used in some cases to confirm the stenosis and anatomy of the carotid vessels origins.

4- Electrocardiography (ECG) before, during and after the procedure.

5- Laboratory investigations: complete blood count, PT, PTT, liver and renal function tests, random blood sugar, lipid profile, serum uric acid, CRP and cardiac enzymes if needed.

6- The degree of stenosis was determined according to North American Symptomatic Carotid Endarterectomy Trial (NASCET) criteria (Figure 1). All patients received 325 mg aspirin and 75 mg clopidogrel daily, at least three days before the procedur. Alternatively, a loading doseof Aspirin 325 mg orally and clopidogrel 300 mg orally can be given the day before or atleast 5th before the procedure ***(Harrigan and Deveikis 2013).***

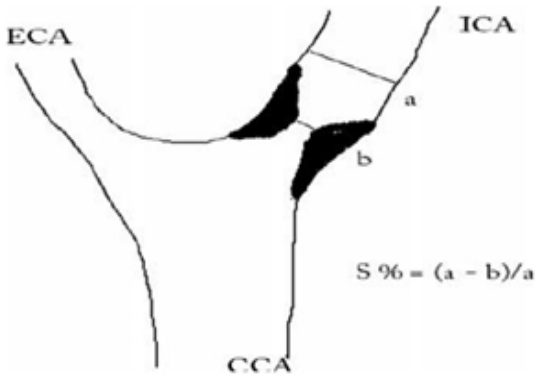

Fig (1): Measurement of the degree of Carotid artery stenosis by NASCET.

Pre-procedural medications:

Procedure:

1. All patients selected for CAS underwent with local anesthesia in the femoral puncture site or axillary area in axillary approach and appropriate cardiac monitoring, general anesthesia for patients could not follow commands.

2. Puncture is done using an 18-gauge puncture needle and 0.035" J-tipped hydrophilic guide wire with puncture and wire insertion (Seldinger technique).

3. Heparin (100U/kg) was administered during the procedure to maintain an activated clotting time of 200-250 seconds.

4. During the initial placement of the diagnostic catheter in the CCA, use a 0.035 hydrophilic wire to advance the diagnostic catheter into a branch of the ECA the used catheteris 5 French diagnostic catheter (Vertebral or Simmon II catheter -Boston Scientific or Cordis).

5. Diagnostic angiography consists of visualization both carotid bifurcations in several projections, both vertebral arteries and intracranial study of both carotid arteries.

6. Lateral Projection; "Road map" is taken to show the origin of the external carotid artery (ECA), the guide wire is then removed for placement of an 0.035 Amplatz wir.

7. Advancement of the Amplatz wire through the 5 French catheter up into the ECA.

8. The 8 French guider Sof tip (Boston Scientific, USA) guide catheter or long sheath 7 french (Cordis) 90 cm with introducer is advanced slowly over the Amplatz wire to the CCA just below the bifurcation. Once in position the Amplatz wire and sheath introducer are removed.

9. Continuous irrigation of the guide with heparinized saline (5,000 U heparin per 500 mL saline) using Rotating hemostatic valve (Y-adapter) to identify thrombus or bubbles.

10. A soft 0.014" guide wire (Traxcess microvention) is carefully advanced through the lesion.

11. Advance EPD when used and deploy it (Filter Wire EZ, Boston Scientific, USA or SPIDER filter ev3, Plymouth, MN).

12. Atropine 0.5 mg IV for prophylaxis of bradycardia before balloon expansion.

13. Pre-dilation angioplasty using 2.0 or 2.5-mm diameter angioplasty balloon done in severe stenosis (done in 5 patients).

14. Self expandable stents closed cell including Wallstent (Boston Scientific, USA) Straight (7-9 mm×30–40 mm) and Leo stent (Balt Montmorency, France) or open cell stent Protégé (ev3, Irvine, CA) tapered (6-8 mm× 40 mm) are advanced over the 0.014" wire. The distal end of the stent is positioned 5 to 10 mm distal to the lesion using bony landmarks and lesion calcification as a guide.

15. Post-stenting dilatation using a low-profile 5 mm x 20 mm balloon.

16. Final angiographic assessment of the lesion site, cervical ICA and intracranial filling of the middle and anterior cerebral arteries (MCA and ACA).

17. Guide catheter Sheath removal and access site haemostasis.

Post-procedure:

1. The patients were transferred to the stroke unit for observation for two days.

2. Aspirin 150 mg once daily for life.

3. Colpidogrel 75 mg once daily for 6 month.

4. Duplex control after 1month, then after 6 months to identify in-stent restenosis of the stent (≥ 50 % in stent restenosis).

5. Recording of any procedural complications (puncture related, bradycardia, hypotension, hyperperfusion, stroke, TIA and MI).

6. Imaging of the brain CT or MRI in case of vascular complications (TIA or Stroke) occur.

Procedural success was defined as:

1. To cover the whole lesion by the use of a single stent.

2. To achieve a < 30 % residual diameter stenosis of the treated lesion in at least two matched views on angiography.

Statistical Analysis:

Statistical presentation and analysis of the study results were conducted using the mean, median standard deviation, frequency; chi-square was used to test significance for qualitative data.

3. Results

Patient demographics and clinical characteristic:

The study included 50 patients with ICA stenosis underwent 52 Carotid artery stenting, aged (64.6 ± 7.6), 30 (60 %) of them were males, 20 (40 %) were females, 33 (66 %) patients were symptomatic, 17 (34 %) patients were asymptomatic, stentingof the left ICA was done in 23 (46 %) patients, 25 (50 %) patients in the right side and 2 (4 %) patients in both sides. The major risk factors were hypertension presents in 29 patients (58 %), hypercholesterolemia in 23 patients (46 %), diabetes mellitus (DM) in 22 patients (44 %), 21 patients (42 %) have coronary artery disease (CAD), 16 (32 %) are smokers at the time of intervention, (5) patients (10 %) have heart failure (HF), 2 patients (4 %) have atrial fibrillation (AF) **(Table 1).**

Procedural Characteristics:

Among 50 patients, succesful stenting of ICA just at its origen was done in 47 patients (94 %), 2 patients (4 %) with petrous part stenting, one patient (2 %) with cavernous part stenting. The procedure was done under general anesthesia in 3 cases (6 %) and other cases under local anesthesia. Stenting was done using transfemoral approach in 49 cases (98 %) and one case (2 %) through axillary approach due to occlusion of the abdominal aorta. Self expandable stents were used in the study either closed cell {Wallstent (Boston Scientific, USA) Straight (7-9 mm×30-40 mm) in 29 patients (58 %) or Leo stent (Balt Montmorency, France) in 3 patients (6 %)} or open cell (Protégé) (ev3, Irvine, CA) tapered (6-8mm×40mm) in 18 (36 %) patients. Cerebral protection device (CPD) using distal filter is used in 14 patients (28 %) and 36 patients (72 %) without using CPD. Prestenting balloon dilatation of lesion used in 8 patients (16 %), and 42 (84 %) without prestenting balloon dilatation. Poststenting balloon dilatation of the lesion done in 29 patients (58 %), and

21 patients (42 %) without poststenting balloon dilatation (Table 2).

Table (1): patient demographics, risk factors and comorbidities.

Age ±SD (mean)	64.6±7.6
Males **Females**	30 (66 %) 20 (40 %)
Hypertension	29 (58 %)
Hypercholesterolemia	23 (46 %)
Coronary artery disease	21 (42 %)
DM	22 (44 %)
AF	2 (4 %)
History of open heart surgery	3 (6 %)
Left ventricular dysfunction with left ventricular ejection fraction ≤ 40.	5 (10 %)
History of myocardial infarction	4 (8 %)
Severe broncho-pulmonal disease	3 (6 %)
Multi-vessel disease	10 (20 %)

(AF atrial fibrillation, DM diabetes mellitis, HF heart failure).

Procedural Results and Complications:

Table 2: Procedural Characteristics

Right side	25 (50 %)
Left side	23 (46 %)
Bilateral stenting	2 (4 %)
Closed cell stent Wall stent Leo stent	32 (64 %) 29 (58 %) 3 (6 %)
Open cell stents	18 (36 %)
Trans-femoral approach	49 (98 %)
Local anesthesia	47 (94 %)
Use of CPD	14 (28 %)
Pre-stenting dilatation	8 (16 %)
Post-stenting dilatation	29 (58 %)
ICA at the origen	47 (94 %)
Petrous part stenting	2 (6 %)
Cavernous part stenting	1 (2 %)
Mean stenosis pre procedural	82 %
Mean stenosis post procedural	17.7 %

(CPD Cerebral protection device, ICA internal carotid artery)

Transient bradycardia occured in two patients (4 %) without significant decreased in blood pressure and treated with atropine 1 mg. One patient (2 %) had local hematoma in the groin and treated conservatively with no surgical interference. There was no patient complains of chest pain or ECG changes after stenting. The mean stenosis before the procedure was 80.2 %. Procedural success rate was 100 % with mean residual stenosis 17.7 %. One patient (2 %) developed ipsilateral stroke with NIHSS score = 6, three patients (6 %) developed TIA immediately after stenting and symptoms resolve within 3 hours. The periprocedural vascular complications increased with increased degree of stenosis. One month after stenting no new neurological deficits and MRS score of the stroke patient was 1 and carotid artery duplex showed no restenosis. Six months after stenting there was one patient (2 %) died suddenly from acute myocardial infarction and another patient (2 %) developed stroke with NIHSS score (5) and carotid artery duplex showed no restenosis.

Table (3): Vascular complications immediately, one month and six months after stenting:

	Immediately after stenting	**One month**	**Six month**
Stroke	**1 (2 %)**	**0 %**	**1 (2 %)**
TIA	**3 (6 %)**	**0 %**	**0 %**
Restenosis	**0 %**	**0 %**	**0 %**
Death	**0 %**	**0 %**	**1 (2 %)**

Periprocedural vascular complications and patients characteristics:

The frequency of periprocedural vascular complications (stroke and TIA) were more in patients more than 70 years than the younger patients 10 % (1/10) and 20 % (2/10) versus (0 % and 2.5 % (1/40) respectively as shown by the following figure (fig 2).

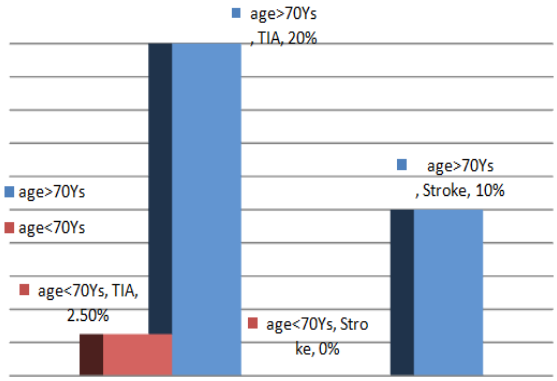

Fig (2): Frequency of periprocedural vascular complications among patients older and younger than 70 years.

These vascular complications were more in female patients than male patients 5 % and 10 % versus 0 % and 3.3 % respectively (table 4). The frequency of these complications occured more on the left side 4.3% and 8.6 % than right side 4 % and 0 % respectively, however in case of bilateral stenting no complications is noticed as shown in the following table **(table 4)**

Table (4): Periprocedural vascular complications and patients characteristics:

Variable		Periprocdural vascular complications	
		Stroke	**TIA**
Age	**Older than 70**	1 (10 %)	2 (20 %)
	Younger than 70	0 (0 %)	1 (2.5 %)
Sex	**Male**	0 (0 %)	1 (3.3 %)
	Female	1 (5 %)	2 (10 %)
Side	**Left**	1 (4.3 %)	2 (8.6 %)
	Right	0 (0 %)	1 (4 %)
	Bilateral	0 (0 %)	0 (0 %)
Clinical	**Symptomatic**	1 (3.1 %)	2 (6.2 %)
	Asymptomatic	0 (0 %)	1 (5.8 %)
Prestenting Balloon dilatation	**+ve**	1 (12.5 %)	12.5 %
	-ve	0 %	4.6 %
Filter use	**+ve**	0 (0 %)	(7.1 %)
	-ve	(2.7 %)	(5.4 %)
Cell stent	**Closed**	(3.1 %)	(6.2 %)
	Open	0 (0 %)	(5.5 %)

4. Discussion

Carotid artery stenting (CAS) has become an alternative to carotid endarterectomy (CEA) in revascularization therapy of carotid artery stenosis, especially in some high-risk patients for surgical intervention ***(Werner et al., 2012).***

In the present study, the mean age of patients was (64.6 ± 7.6 years) which was younger than most studies as Stenting and angioplasty with protection in patients at high risk for endarterectomy population ***(SAPPHIRE by Yadav et al., 2004).*** Endarterectomy Versus Stenting in patients with Symptomatic Severe Carotid Stenosis ***(EVA-3SMas et al., 2008)***, by Carotid and Vertebral Artery Transluminal Angioplasty Study ***(CAVATAS by Brahmanandam, 2008)***, Stent Protected Angioplasty versus Carotid Endarterectomy ***(SPACE study by Ringleb et al., 2006)*** and the study done by ***Naylor et al., (1998).*** In these studies, the mean age by years was 72.6, 69.7,67, 67.9 and 71 respectively. The presence of patients with younger age in the current study may be explained by the difference in life style and vascular risk factors between the current study and the other studies. The frequency of diabetes mellitus was more in our study than other studies. The frequency of other risk factors as hypercholesterolemia, hypertension, ischemic heart disease and smoking was equal or slightly higher in our study than other studies. Diabetes mellitus helps in early atherosclerosis of the vessels especially when combined with other risk factors **(*Singh* et *al., 2003, J¨arvisalo et al., 2004*).** This leads to early atherosclerosis and subsequent early occurrence of carotid stenosis in young age.

Stroke rate in the current study was 2.1 % and this rate was more or equal to that observed in the community ***(Brooks et al. 2001 and Brooks et al. 2004)*** or ***Kentucky*** trial a single-center randomized comparison of CAS (without EPD) versus CEA, ***(CAST I by Bergeronet al., (1999)***. Carotid Artery Stent Trial, Carotid Revascularization using endarterectomy or Stenting Systems ***CARESS, (2003)*** in which the stroke rate was 0 %, 1 %, and 2.1 % respectively, and this rate was less than the Prospective Registry of Carotid Artery Angioplasty and Stenting ***(PRO-CAS by Theisset et al., (2004)***, ***SAPPHIRE by Yadav et al., (2004)***, ***CREST*** study by ***Hobson et al., (2004)*** the ***CREATE*** *study by* ***Safian et al., (2006)*** trial Carotid Revascularization With ev3 Arterial Technology Evolution), ***(ICSS) (Ederle et al., 2010),*** International Carotid Stenting Study, and ***(EVA-3S) Mas et al., (2006)*** in which stroke rate is 3.5%, 3.6%, 3.6%, 4.5%, 7% and 9.2% respectively. This difference in stroke rate between different studies may be explained by difference in symptomatic state of the patients, experience of the investigators, usage of embolic protection device, and components of the plaque (highly calcified lesion or presence of thrombus). For example in ***(EVA-3S) Mas et al., (2008)*** all the patients included are symptomatic, usage of EPD not in all cases and doctors performing procedure were certified after performing as few as five carotid stent procedures (5 carotid stents among at least 35 stent procedures of supra-aortic vessels or 12 carotid stents) or were allowed to enroll patients in the trial while they were receiving their training in carotid stenting *(**Sauvageau et al., 2008).***

There were no recorded cases with myocardial infarction (MI) in the periprocedural period. This finding is similar to findings of ***CARESS, (2003)*** *CAVATAS*, and the Community (or Kentucky***) (Brooks***

et al., 2001 and Brooks et al., 2004) trial, while in ***SAPPHIRE* (*Yadav* et al., 2004, *EVA-3S (Mas et al., 2008) CAPTUR (Gray et al., 2007), and ICSS (Ederle et al., 2010)*** the rate of MI is 2.4 %, 0.9%, 0.4 %, and 0.4 % respectively, in SAPPHIRE study in the CEA group the rate of MI was 8 %. ***Motamed and his colleagues***, **(2005)** found significant rise of troponin I among patients underwent carotid endarterectomy in comparison to those with stenting (13 % versus 1 % respectively). The decrease in the rate of MI in patients treated with carotid artery stenting can be explained by the difference in the type of anesthesia as most cases of carotid stenting done under local anesthesia while carotid endarterectomy mostly done under general anesthesia, and the routine use of double antiplatelets before and after carotid stenting in the first month decrease the rate of cardiac ischemia in carotid stenting patients which is not routine in those underwent carotid endarterectomy.

Periprocedural vascular complications (strokes and TIAs) occurred more common in patients aged more than 70 years than younger patients. The frequency of stroke and TIAs is 10 % and 20 % versus 0 % and 2.5 % respectively. The increase in risk of periprocedural vascular complications with increased age is consistent with ***CREST (Hobson et al., 2004)*** results in which the patients divided into three age groups younger than 65, 65-74 years, and 75 and older with stroke rates 3.5 %, 5.1 % and 10.9 % respectively ***(Voeks et al., 2011).*** Also, **SPACE (*Stingele* et al., *2008)*** study found that patients older than 68 years undergoing CAS were at a higher risk of 30- day stroke and/or death, in addition CAPTURE 2 showed that stroke rate within 30-day after carotid stenting 3.8 % in patients aged > 80 years as compared with 2.4 % in patients aged < 80 years **(*Chaturvedi* et al., 2010).** Also, single center studies from various sites have been consistent with these results ***Mathur et al., (1998)***. ***Roubin et al., (2001), Kastrup et al., (2005) Yadav et al., (2004)***, ***Sayeed et al. (2008)*** and ***Khatri et al., (2012)*** found the rate of postprocedural stroke, MI, and death in patients > 70 years was higher in CAS. On the other hand, and when results compared with CEA on The ***SAPPHIRE (Yadav et al., 2004)*** study demonstrated lower rates of stroke and/or death at 1 month with CAS compared with CEA in high surgical risk patients consisted of 66 patients aged > 80 years. The increase in periprocedural stroke rate in older patients may be explained by increased vessels tortuosity and changes of the aortic arch which became more steeper (type III aortic arch) with increased age, this leads to difficulty in navigation and stenting procedure, also character of the plaque itself which became more calcified and more vulnerable to thrombosis and may be detached during procedure which may increase the rate of periprocedural vascular complication during manipulation in their vessels, in addition the increase in the rate of associated comorbidities with increase age may lead to increase the periprocedural stroke rate.

In this study, the frequency of stroke and TIA was more common in female more than male 5 % and 10 % versus 0 % and 3.3 % respectively this finding was congruent with ***CREST (Safianet al., 2006, and Howard et al., 2011)*** investigators in a subgroup analysis that women had trend toward a higher stroke rate (5.5 %) compared with men (3.3 %). On the other hand, **CAPTURE (*Gray* et al., 2007)** registry did not observe any significant difference in 30 day stroke and/or death rates between women and men undergoing CAS although there was a trend toward higher rates in women (5.6 % in women and 4.3 % in men). Also, ***SPACE (Rockman et al., 2005 and Stingele et al., 2008)*** study also did not observe any significant difference in 30 day stroke and/or death rates between women (8.2 %) and men (6.4 %) undergoing CAS. The higher stroke rate trend in the women can be explained by technical difficulties related to the fact that women, on average, have 40 % smaller internal carotid arteries than men ***(Bond et al., 2005, and Donas et al., 2010),*** this may lead to difficulty in manipulation of the smaller artery. In addition, the character of the plaque itself in symptomatic women is unstable and may produce more microemboli than in males ***(Donas et al. 2010, Ota et al. 2010, Troisi et al. 2010)***. Also, the presence of hormones regulating the menstrual cycle helps in stabilization of carotid plaques and in postmenopausal women this protective effect is lost and the plaques become more vulnerable. In this study, the included women are all postmenopausal, also women in this age when compared with men, have more associated risk factors as hypertension, diabetes, higher low-density lipoprotein cholesterol, and high C-reactive protein (CRP) levels.

In the current study the frequency of stroke and TIA was more common on stenting of the left carotid artery than right side 4.3 % and 8.6 % versus 0% and 4 % this finding is in accordance with ***Naggara and his colleagues, (2011)*** in an analysis of 34,398 patients which revealed that CAS performed for left ICA stenosis was associated with higher 30-day stroke and/or death rates 7.5 % versus 6.0 % in patients with CAS for the right carotid artery stenosis, conversely the results of other studies have not been found a differential rate of 30-day stroke and/or death **(*Gray et al., 2007 and Chaturvedi* et al., 2010).** The higher rate of periprocedural vascular complications during stenting of left ICA may be explained by difficulty in access to the left common carotid artery, which takes more time to reach stenotic segment, and so this causes more complications during stenting on the right

side and occurrence of strokes in the non-eloquent right hemisphere may pass asymptomatic.

In the current study, occurrence of the periprocedural vascular complications was correlated with the degree of stenosis, this is consistent with ***Mathur and his colleagues,* (*1998)*** who found that CAS performed in lesions with angiographic severity > 90% stenosis were associated with higher 30-day stroke rate of 14.9 % compared with lower rate of 3.5 % in patients with lesion severity < 90% stenosis. However other studies found no difference in the mean severity of stenosis [50 %–69 % versus 70 %–99 %] ***(Gray et al., 2007 and Chaturvedi* et al., 2010*).*** The cause of difference may be explained by the difference in pathology of the plaque more than the degree of the stenosis as most of cases in the current study are symptomatic which characterized by presence of plaques with fissures, intramural microthrombi or inflammation so stenotic lesions are more vulnerable to vascular complications.

There was no significant difference between the occurrence of stroke and TIA and diabetes mellitus and this finding was similar to that present in both CAPTURE and CAPTURE 2 trials ***(Gray et al., 2007 and Chaturvedi* et al., 2010*).*** However, in a single center study found that patients with diabetes mellitus undergoing CAS especially if they were older than 75 years had a higher 30 day stroke and/or death rates (6.3 %) compared with nondiabetics (3.2 %) ***(Schlüter et al. 2007).*** Because of DM is related to higher degree of atherosclerosis and the plaque become more vulnerable to rupture, and subsequent ischemic events especially type 2 DM ***(Bloomfield et al. 2006)***. Periprocedural vascular complication may be more with them however the severity and type of diabetes between different studies was not determined.

In the current study, the frequency of strokes and TIAs occurred more among patients with symptomatic carotid artery stenosis than asymptomatic carotid artery stenosis, 3 % and 6 % (2/23) versus 0 % and 5.8 % respectively. This finding was similar to the CREST investigators (one-month stroke and death rate 6.0 % in symptomatic versus 3.2 % in asymptomatic patients). A pooled analysis of 2104 patients derived from four major studies (***SAPPHIRE, CASES, CNC, and ADVANCE Aronow et al., (2010)*** of which 24.2 % patients were symptomatic found that asymptomatic patients had a 30 days stroke and/or death rate of 3.8 % compared with 5.3 % in symptomatic patients. ***Qureshi et al., (2008)*** found that 30 days stroke rates in symptomatic patients was 8.3 % compared with a lower rate of 6.0 % in asymptomatic patients. In addition to this multiple single center studies showed similar results by ***Naylor et al., (1998)***, ***Qureshi et al., (2000) Alberts, (2001)*** and ***Theiss et al., (2004)***. The higher rate of ischemic events among symptomatic patients may be due to plaque characteristics in symptomatic patients, which were characterized by fissure, intramural microthrombi, inflammation and higher embolic load ***(Setacci et al., 2010).*** This is the cause for recurrent strokes in patients with carotid artery diseases and may be a cause of cerebral embolization during the procedure.

In this study, the frequency of periprocedural strokes and TIAs occurred more frequent in patients with pre-stenting balloon dilatation in which both stroke and TIA rates were 12.50 % than those without pre-stenting balloon dilatation 0 % and 4.6 %. This finding was consistent with ***CAPTURE Gray et al., (2007)*** study that found pre-stenting balloon without the use of EPD was associated with higher stroke rates in the first 30-days of stenting (15.4% compared with a lower stroke rates of 4.3% in patients without pre-stenting balloon with an EPD). Pro-CAS registry data also showed that pre-stenting balloon led to higher periprocedural stroke rate of 4.1 % versus 3.0 % ***(Theiss et al. 2004).*** This higher rate in lesions with presenting balloon dilatation may be explained by that lesions needs predilatation have degree of stenosis severe enough to permit the passage of EPD easily and during manipulation with the balloon distal embolization may occurs.

In this study, there is difference in the frequency of periprocedural vascular complications and cases with usage of EPD and cases without usage of it not reach statistical difference. This finding was partially consistent with ***Barbato and their colleagues, (2008)*** who found no significant in 30 day post procedural. Also, they found higher number of diffusion-weighted images (DWI) lesions in patients undergoing CAS with EPDs (72 %) compared with the CAS group without EPD use at 1 month (44 %). However, in a multicenter study they found lower 30 days stroke rates (1.7 % with EPD use versus 4.1 % without EPD use) ***(Zhang et al., 2004)***. The explanation of occurrence of ischemia with usage of filter as filters when crossing the lesion, the crossing of stenotic segment without cerebral protection have the potential risk of arterial injury during deployment. In addition, malposition can cause distal embolization and the filter itself can be filled with debris due to its limited volumetric capacity. Most of the devices are calibrated to filter particles > 100 u (70–140 u) ***(Kastrup et al. 2003, Schonholz et al. 2006 and Celis and Chaer 2013)***. So particles < 70 u can pass through the filter mish, also filters can induce vasospasm of arterial wall. ***Jim and his colleagues (2011***) found that there was no significant difference in outcomes after CAS using open or closed stent cell designs). In addition, a randomized controlled trial includes 40 patients with CAS using either closed cell design or open-cell design stents found no significant difference in

embolization events detected by DWI-MRI and TCD ***(Timaran et al., 2011)***. However, in a multicenter study from Europe of 3,179 patients found that in an open cell design stents a free-cell area of more than 7.5 mm is associated with higher 30-day stroke rates (1.3 % versus 3.4 %) suggesting that closed cell design stents may be associated with lower rates of ischemic events ***(Bosiers et al., 2007).*** Although the free cell area in closed cell design stent is less than the open cell, [free cell area in wallstent (1.08 mm^2) and protégé (10.71 mm^2) ***(Morr et al., 2014).*** However the closed cell design is more rigid and may need more manipulation during stenting (pre and post stenting balloon dilatation which may cause distal embolization, however open-cell stent is more conformable to follow the vascular anatomy and therefore is easier to navigate through tortuous vessels and is less likely to kink a vessel distal or proximal to the stent, in addition the unique memory effects of open cell design stent they show a delayed 10 – 20 % additional expansion within the first month following implantation ***(Bjoern et al., 2009, Eller and Sidiqui, 2015)***, and so when it is deployed easily and further expansion may occurs without post stenting balloon dilatation. In the current study, there were no recorded cases with in-stent restenosis six months after stenting. However, in a study of ***Wholey et al., (1997)***, ***Henry et al., (2002),*** and ***Powell etal., (2004)*** who followed up patients with carotid artery stenting for six months to detect the rate of restenosis and found the rate of in-stent restenosis was 1.2 %, 0.6 % and 2.7 % respectively. This difference can be explained by that all cases included in the current study carotid stenosis due to atherosclerosis while other studies carotid in-stent restenosis occurred mostly in nonatherosclerotic carotid stenosis lesions (radiation induced carotid stenosis and postendarterectomy restenosis) which are more liability to restenosis.

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