Egyptian Journal of Surgery Vol. (22), No. (1), Jan., 2003

CAROTID ENDARTERECTOMY: PRIMARY CLOSURE VERSUS PATCH ANGIOPLASTY

By

Ehab M.Saad, M.D. [(1)], Hesham Sharaf, M.D. [(1)], Atif Abd El-Latif, M.D. [(1)], Khalid Mowafy [(1)] , Azza Al-Mongy M.D., [(2)]

Vascular Surgery Unit, Department Of General Surgery, [(1)] Department Of Neurology [(2)], Mansoura Faculty of Medicine

Objective: *Carotid endarterectomy closure remains controversial.The aim of this work is a comparative study between primary closure and patch angioplasty after carotid endarterectomy as regard recurrent stenosis,recurrent stroke,and other operative complication.*

Patients and methods: *Forty Five patients with symptoms and signs suggestive of carotid artery occlusiove disease were admitted, investigated, treated and followed up in vascular surgery unit and neurology department of Mansoura University Hospital during the period from August 1998 to April 2002. Only twenty patients (Out of Forty five) fulfilling the criteria of surgical interference of carotid endarterectomy (CEA) with other twenty-five patients excluded from the study. They were divided into two main groups: group I CEA with primary closure (10 patients). Group II CEA with patch closure (10 patients, 5 saphenous vein patch, and 5 PTEE patch). Life table analysis was used to compare recurrent stenosis(>50%),recurrent stroke and other postperative complication for each group.*

Results: *No perioperative stroke or mortality in both groups. Life table analysis for patency rate (recurrent stenosis free rate) showed stenosis free rate 100% at 18 months and 50% after three years for primary closure group, and it was 100% free till 18 months and 85.7% after three years for patch closure group. Comparison between the two groups using the log rank test showed no significant difference (P= 0.45). Stroke free rate at three years was 80% in patients in whom primary closure was done, and 85.7% in patients in whom patch closure was done (p=O.51).*

Conclusion: *In patients with occlusive carotid artery disease, it is advised to do patching after endarterectomy rather than to do simple closure. This procedure give better results as there is less incidence of post operative recurrent stenosis and/or thrombosis, also there is less incidence of recurrent stroke on long term follow up. Saphenous vein patch gives better results compared to PTFE patch on log term follow up.*

Keywods: ***carotid endarterectomy – patch angioplasty - primary closure***

INTRODUCTION

Stroke is the third leading cause of death in the United States each year. It is the second leading cause of cardiovascular death and most common cause of death as a result of neurologic disorders. In addition to death, the disability following cerebral infarction must be considered from the standpoint of the crippling effect on the patient as well as the socioeconomic burden on the patient, his or her family and society [(1)].

Prevention of stroke is the primary objective of surgery for extracranial lesion involving the cerebrovascular system. Operation is justified to the extent that surgery alters the natural history of the disease and represents a safe and more effective therapeutic alternative to anticoagulant or antiplatelet medical management [(2)]. Carotid endarterectomy closure remains controversial between 1ry closure and patch angioplasty [(3,4,5)] .So a comparative study between primary closure and patch angioplasty was done as regard recurrent stenosis, recurrent stroke and other operative complications after carotid endarterectomy.

PATIENTS AND METHODS

Forty Five patients with symptoms and signs suggestive of carotid artery disease were admitted, investigated, treated and followed up in vascular surgery unit of Mansoura University Hospital during the period from August 1998 to April 2002. They were referred from Neurology Department and Vascular out patient clinics.

All patients were subjected to:

- Thourogh history taking including name, age, sex, occupation, residence and any special habits.
- History of previous attacks of stroke that necessitated medical consultation and treatment.
- Medical examination including: pulse, blood pressure, lower limb vascular assessment and, cardiac examination.
- Neurological examination: For assessment the neurological function of the patients after their persentation that may be: Transient ischaemic attacks, Amaurosis Fugax, Cerebral stroke (Hemiparesis) or Combination of the above.
- Complete blood picture, prothrombine time,serum creatinine, fasting and postprandial blood sugar,cholesterol and trigylceride level.
- ECG and Echocardiography for high-risk cases and to rule out cardiac embolism.
- Computed scan was done for all patients in our study to rule out structural lesions that may be mistaken for cerebrovascular disease (Fig. 1).
- Duplex ultra sound was done for all patients (Fig. 2): The following data were obtained and categorized for every patient: Size and extent of atheromatous plaque and wheather complicated or not, degree of stenosis and its percentage, distal end point of the plaque, and other associated anomalies e.q. Coiling, kinking or aneurysms of the carotid vessels

Arteriography:

Transfemoral selective carotid catheterization (DVI) was done for patients showing significant lesions by duplex ultrasound to delineate more anatomical and pathological details and to show any lesion in the cerebral vessels that could not be visualized by duplex U/S ,with measurment the degree of stenosis by theNASCET method[6];the narrowest part of the lumen(stenosis) in relation to the internal carotid diamter distal to the stenosis. .(Fig.3 a,b). C.T. angiography or MR angiography was done in last patients in whom DVI arteriography was risky (Fig. 4 a, b).

Carotid endarterectomy was done only in 20 patients fulfilling the criteria of surgical interference which include:

(1) When the carotid lesion was associated with 50% stenosis or more with reccurent hemispheric transient ischaemic attack and/or, Amaurosis fugax, and/orHemispheric cerebrovascular accidents with completed or near complete recovery.(2)Symptomatic carotid ulcer(type B&C)+30-50% stenosis in patients with previous stroke. They were divided into two main groups:

- Group I CEA with primary closure (10 patients)
- Group II CEA with patch closure (10 patients)

Group II was divided into two subgroups:

- Group IIa CEA with saphenous vein patch closure
- Group IIb CEA with synthetic patch closure (PTFE)

The remaining 25 patients were excluded from the study and treated medically due to the following causes:

(1) The carotid lesion <30% stenosis.

(2) Total internal carotid occlusion.(Fig.5)

(3) Complete stroke without residual neurological function.

(4) Bad general conditions (unfite for general anathesia).

Operative technique:

All patients in our study were done under general anaesthesia using the standard technique of carotid endarterectomy(7)with prophylactic antibiotics and systemic heparinization during routine carotid shunting.(Figs.6&7&8)

In 10 patients,simple closure of the arteriotomy was done using 6/0 polypropylene suture(Fig.9).

In 5 patients autogenous patch(saphenous vein) was used from the lower leg.(Fig.10) In another 5 patients synthetic patch(PTFE) was used to close the arteriotomy.(Fig.11)

All patients were transferred postoperatively from the operating theatre to the intensive care unit for 24 hours where the following parameters were recorded and dealt with: Blood pressure monitoring, Palpation of the carotid and superficial temporal pulsations,Neurological examination including: Extermity strength, Fine hand movements, Speech and visual acuity

All patients were transferred from the I.C.U. to the surgical ward(for about one week Fig 12 a ,b) after stability of the measures recorded before. all patients received Low molecular weight heparin in prophlactic dose for one week postoperatively,and antiplatlet (Aspirin) 325 mg daily forever.

Post operative follow up (Survillence programm):

All patients were followed up in the out patient clinic of vascular surgery unit as regard complications including TIA, reversible ischaemic neurologic deficits (RINDs), or stroke morbidity and asymptomatic occlusive events.The data were recorded according to the Ad Hoc committee suggested standards for reports dealing with cerebrovascular disease.[8]

Duplex examination was done before discharge, one-week post operatively, to assess patency of the carotid vessel and any possible complications.

Duplex examination at 6, 12 months and every one year to detect recurrent stenosis (Fig.13,14). Recurrent stenosis was considered to be present only if the abnormality detected was not present in the immediate post operative duplex and if persistant for at least two examination done within 6 months of the original one.The spectral broadening throughout systole and increased diastolic frequency were consistent with significant(>50%) stenosis.[9]

Statistical Methods:

The time to occurrence of events (stenosis>50%, stroke or death) was calculated with life table analysis and comparison was made between patency rate or strock rate of each group using logrank test.

Statistical comparisons of demographic data and risk factors were examined with chi square test or fisher exact tests.

RESULTS

This study included a total of 45 patients with symptoms and signs suggestive of occlusive carotid artery disease. Only 20 patients fulfilling the criteria of carotid endarterectomy(CEA). Ten patients did carotid endarterectomy with simple closure(groupI),other 10 patients did CEA with patch closure(group II);5 with saphenous vein patch(IIa) and 5 with syntcheticpatch PTFE(IIb).

They were managed in the vascular surgery unit Mansoura University Hospital (Mansoura, Egypt) during the period from August 1998 to April 2002. They were followed up over a period that ranged from 6 months to 3 years,with mean follow up period 25.9 $\pm$ 10.53 months for the primary closure group and 26.5 $\pm$ 9.75 months for the patch group.

Demographic data:

The mean age of the studied group was 62.7 + 8.6 for group I and 59.3 + 3.2 for group II(range 47 to 73) , with no significant difference in the studied group(P=0.79).

Eighty five percent of the studied groups were males and 15% were female with no significant difference regarding sex among studied group (P=0.12).

The risk factors of the studied groups are showen in (Table 1) with no significant difference among them.

Presentation:

Recurrent TIA was the most common presentation (60%) among the studied groups, followed by recurrent stroke (15%), as shown in (Table 2). Fifty percentage of the studied group were presented by right sided hemiparesis , 35% by left hemiparesis and 15% showed no hemiparesis.

Pre-operative duplex scan&Angiography:

The mean degree of internal carotid stenosis by pre-operative colour duplex among studied groups was 50 + 12.48 for primary closure group and 54 + 14.48 for patch closure group as shown in (Table 3)

Table (4) showed the angiographic finding of the studied groups.

Post-operative Complications:

No peri-operative stroke or mortality in both groups. Three patients developed wound haematoma (15%) and was managed conservatively after duplex examination to exclude disruption of the sutures line (pseudo-aneurysm) that may necessiate redo.

Two patients (10%) devloped postoperative cranial nerve affection, One hypoglossal and one glossopharyngeal nerve affection. These nerve affection were temporarily and improvement in their function was noted 6 months later

Recurrent stenosis:

Table (5) & Fig. 15) Showed life table analysis for patency rate or recurrent stenosis free rate (less than 50%) among primary and patch group. The cumulative stenosis free rate was 100% at 18 months and 50% at the end the study for primary closure group. It was 100% free till 18 months and 85.7% at the end of the study for patch closure group.

Comparison between the groups using the log rank

test showed no significant difference between the groups (P = 0.45).

The recurrent stenosis free rate for saphenous patch was 100% from the start till the end of the study,while for PTFE patch;it was 100% at 18 months and 71.4% at 30 months (fig.16). However comparison between the two groups yielded no statistical significance difference (p=0.13).

Recurrent strock:

Table (6) & Fig (17) Showed life table analysis for stroke free rate among primary and patch group. The cumulative stroke free rate was 80% at the end of the study for primary closure group, and 85.7% for patch closure group (P = 0.51). The cumulative stroke free rate for saphenous patch group was 100% allover the study, and 71.4% at the end of 30 months for PTFE patch group (p=0.26).

Table (1): ***Risk factors of the studied group.***

Studied group / *Risk factor*	*Smoking*		*Ischaemic heart disease*		*D.M.*		*Hypertension*		*High lipid profile*	
	No	%	No	%	No	%	No	%	No	%
Primary group	7	70	5	50	7	70	9	90	6	60
Patch group	7	70	6	60	7	70	8	80	8	80
P.Value	0.14		0.109		0.57		0.62		0.81	

Table (2): ***Presentation of the studied group.***

Studied group	*Recurrent TIA*		*Recurrent stroke*		*Amaurosis fugax*		*TIA + Amaurosis*		*Stroke + Amaurosis*	
	No	%	No	%	No	%	No	%	No	%
Total	12	60	3	15	2	10	1	5	2	10
Group I (P.C)	6	60	1	10	1	10	1	10	1	10
Group II patch	6	60	2	20	1	20	-	-	1	10

Table (3): ***Degree of stenosis as detacted by duplex (pre-operative)***

Studied group	*Mean*	*Range*
Total	52 ± 13.17	40 – 75
Group I (PC)	50 ± 12.48	40 – 70
Group II patch	54 ± 14.48	40 – 75
Group II a (Saph.)	56 ± 12.24	40 – 75
Group II b (PTFE)	53 ± 16.8	45 – 60

Table (4): ***Angiographic finding of the studied group***

Studied group	*Angiographic finding*							
	Atheroma with stenosis > 50%		Atheroma with ulcer		Atheroma with aneurysm		Atheroma with kinked I.C.A.	
	No	%	No	%	No	%	No	%
Total	9	45	9	45	1	5	1	5
Group I (PC)	4	40	6	60	-	-	-	-
Group II patch	5	50	3	30	1	10	1	10
Group II a Saph.	2	40	2	40	1	20	-	-
Group II b PTFE	3	60	1	20	-	-	1	20

Table (5): ***Life table analysis for recurrent stenosis free rate (less than 50%) among primary and patch groups***

Interval	*Member entering*	*Number with drawan*	*Number exposed to risk*	*Number of terminal*	*Interval recurrent stenosis free rate*	*Cummulative recurrent stenosis free rate*	*SE standard*
Primary							
0	10	0	10	0	100%	100%	0
6	10	2	9	0	100%	100%	0%
12	8	0	8	0	100%	100%	0%
18	8	1	7	0	100%	100%	0%
24	7	2	6	1	83.35	83.3%	15.2%
30	4	0	4	0	100%	83.3%	15.2%
36	4	3	2	1	60%	50%	27.3%
Patch							
0	10	0	10	0	100%	100%	0
6	10	1	9	0	100%	100%	0
12	9	0	9	0	100%	100%	0
18	9	0	9	0	100%	100%	0
24	9	4	7	1	85.7%	85.7%	13.2%
30	4	0	4	0	100%	85.7%	13.2%
36	4	4	2	0	100%	85.7%	13.2%

Log rank test = 0.55 ***P= 0.45***

Table (6): ***Life table analysis for stroke free rate among primary and patch groups***

Interval	Member entering	Number with drawan	Number exposed to risk	Number of stroke	Interval stroke free rate	Cummulative stroke free rate	SE standard
Primary							
0	10	0	10	0	100%	100%	0
6	10	0	10	2	80%	80%	12.6%
12	8	0	8	0	100%	80%	12.6%
18	8	1	7	0	100%	80%	12.6%
24	7	3	4	0	100%	80%	12.6%
30	4	0	4	0	100%	80%	12.6%
36	4	4	2	0	100%	80%	12.6%
Patch							
0	10	0	10	0	100%	100%	0
6	10	1	9	0	100%	100%	0
12	9	0	9	0	100%	100%	0
18	9	0	9	0	100%	100%	0
24	9	4	7	1	85.7%	85.7	13.2%
30	4	0	4	0	100%	85.7	13.2%
36	4	4	2	0	100%	85.7	13.2%

Log rank test = 0.42 ***P= 0.51***

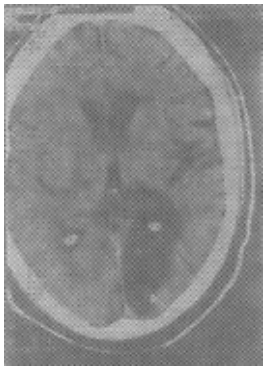

Fig (1): CT scan showing area of ischaemic cerebral infarction

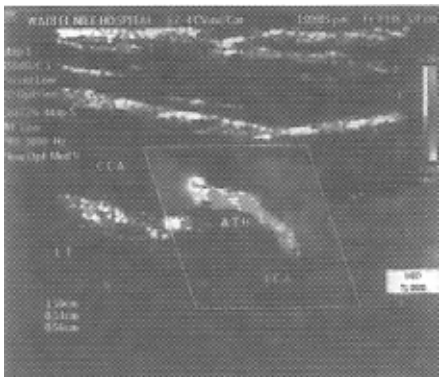

Fig (2): Preoperative colour duplex of left carotid system showing severe stenosis in left common carotid bifurcation

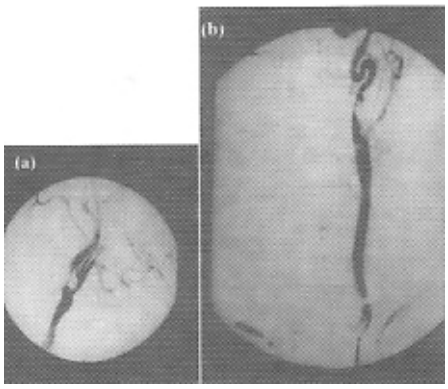

Fig (3): Selective carotid angiography showing:
(a) Marked degree of stenosis at the carotid bulp.
(b) Tigh stenosis with kink of internal carotid artery.

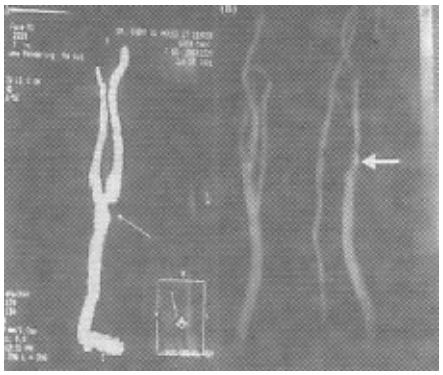

Fig (4a): CT. angiography showing severe stenosis at the common carotid bifurcation.

Fig (4b): MR angiography showing severe stenosis at the common carotid bifurcation.

Fig (5): Arch aortogram showing complete occlusion of the left internal carotid artery

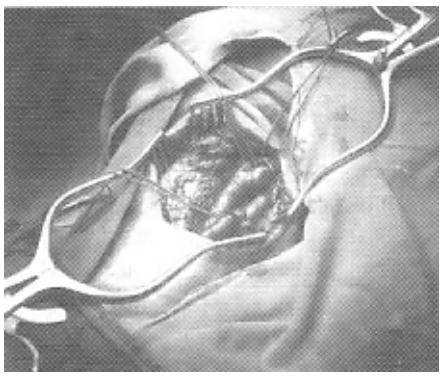

Fig (6): Exposure of carotid vessels and encircling of C.CA, I.C.A, and E.C.A. before incision of carotid bifurcation.

Fig (7): Posterior wall atheroma after exposure with insertion of carotid shunt.

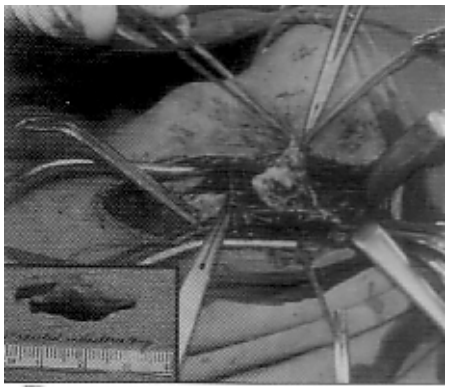

Fig (8): Atheroma completely extracted from the carotid wall circumferentially.

Fig (9): Primary closure of the internal carotid artery.

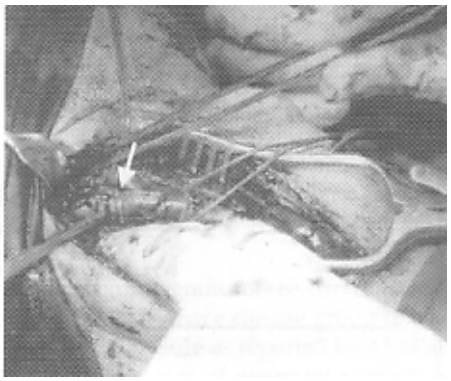

Fig (10): Closure of the aretriotomy with saphenous vein patch.

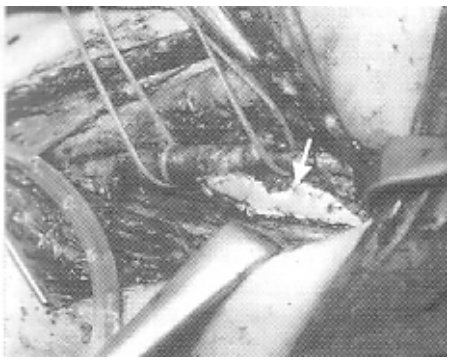

Fig (11): Closure with PTFE graft.

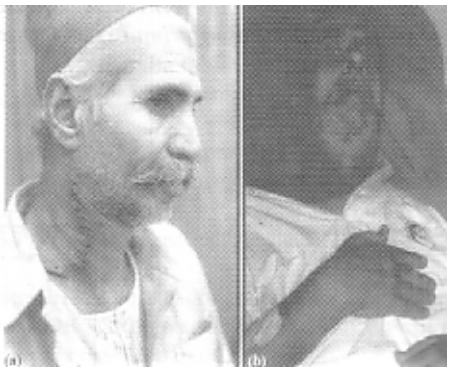

Fig (12): Postoperative carotid endarterctomy patients: (a) With previous recurrent TIA. (b) With previous stroke.

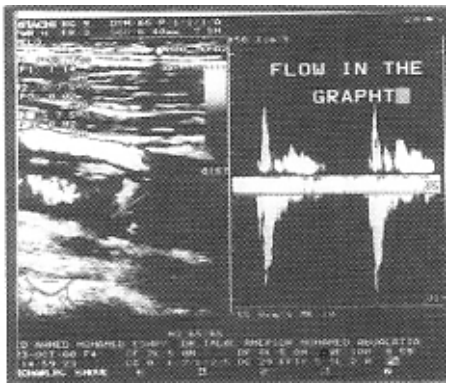

Fig (13): Postoperative colour duplex after carotid endarterectomy with saphenous vein patch showing patent lumen and normal flow in carotid vessels (24 months postoperatively)

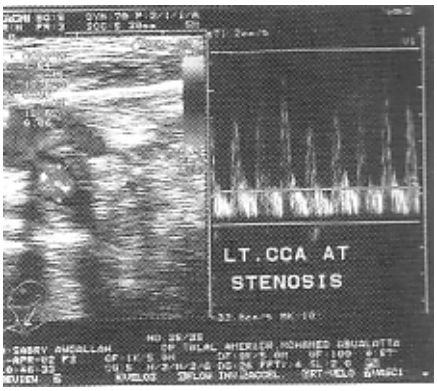

Fig (14): Postoperative colour duplex showing marked stenosis at carotid bifurcation (65%) after primary closure.

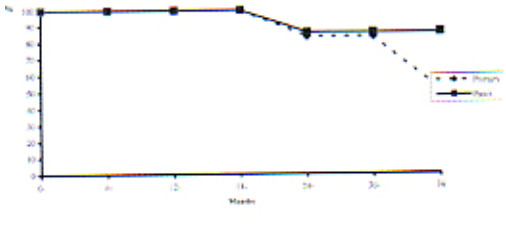

Fig (15): Lift table analysis for recurrent stenosis free rate (Less than 50%) among primary and patch groups.

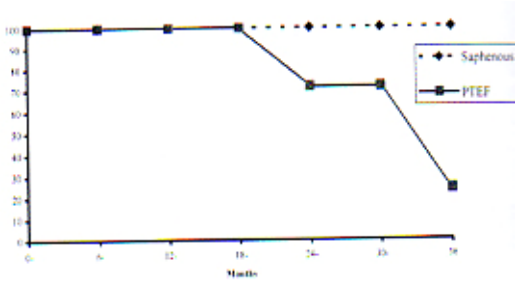

Fig (16): Lift Table analysis of recurrent stenosis free rate (Less than 50 %) among saphenous and PTFE groups.

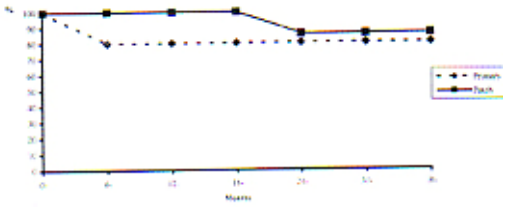

Fig. (17): Lift table analysis for stroke free survival rate among primary and patch groups.

DISCUSSION

Prevention of stroke is the primary objective of surgery for extra- cranial cerebrovascular occlusive disease.The same objective with the recurrent stenosis after carotid endarterectomy are the main targets and controversy between authors regarding closure after carotid endarterectomy;simple closure Vs.patch closure.

It has been suggested that the flow characteristics of patched carotid arteries may be superior to those of primary closed arteries in terms of preventing early thrombosis [3]. Dirrenberger and Sundt [10], said that the endarterectomized artery is thrombogenic for the first several hours after carotid CEA , during which time the carotid artery is most vulnerable to acute thrombosis.Other auther have attributed this improvement to widening of the artery with a corresponding reduction in the effect of intimal hyperplasia[4].

Opponents of carotid patching cite the increased operative time 15-20 minutes required for patch closure,risk of patch rupture and false aneurysm,and excellent results with primary closure[5].

It has been established that the perioperative stroke rate is the most devastating complication of carotid endarterectomy and most of perioperative strokes were dure to technical errors that resulted in thrombosis, or embolism from the endarterectomy site.Intra operative factors such as the use of general anaesthesia and the use of intra arterial shunt are risk factors for preoperative stroke [12].

Early carotid thrombosis complicates 2-3 % of CEAs and is amajor cause of perioperative permenant stroke in previous trials [13&14]. In our series, there was no postoperative thrombosis and no redo surgery for acute thrombosis was done .

The choice of patch material has been controversial.Many authors prefer using autogenous material(saphenous or neck veins),citing the advantage of using an intima lined patch with potential reduction of perioperative thrombosis and infection.[15&16]

Seabrook [15], Said that autogenous vein is superior to prosthetic materials because the luminal surface is less thrombogenic and more resistant to infection. In our series saphenous vein patch was superior to PTFE patch as regard patency rate after carotid endarterectomy and with stroke free survival rate was higher in vein patch (SVP) than PTFE patch.

Synthetic patch (PTFE) has the advantages of availability, resistance to aneurysmal formation or patch rupture . The bleeding from sutureline (needle holes) was controlled by temporary compression and reduction of such blood loss has been associated with needle suture diameter ratio of 1: 1 as stated by Rhodes [17], in our series bleeding from sutureline in PTFE patch closure group was controlled by temporary compression and the use of local hemostatic agents e.g. surgicel (Oxidized regenerated cellulose) . Opponents to synthetic patches fear bleeding through the patch material, intraluminal thrombosis, and infection.In our series no vein patch rupture occurred and there was no infection among patch closure (autogenous or synthetic patch).

In a series by AbuRahma [18], the cumulative recurrent stenosis free rate was 88% at end of 36 months follow up for saphenous vein patch (SVP) closure after carotid endarterectomy and the cumulative stroke free survival rate for (SVP) closure was 90% at end of 36 months follow up , in our series with cumulative recurrent stenosis free rate was 100% and with cumulative stroke free survival rate was 100% at the end of study (36 months).

In a series published by AbuRahma [18] the cumulative recurrent stenosis free rate for PTFE closure was 96% at end of 36 months and the cumulative stroke free survival rates was 90% at end of 36 months, in our series cumulative recurrent stenosis free rate was 23.8% at end of study and the cumulative stroke free survival rate was 41.4% at with end of the study.

The incidence of significant recurrent stenosis and occlusion was 34% for primary closure group, 2% for PTFE, and 9% for vein patch closure as reported by AbuRahma [18] , in our series with incidence of recurrent stenosis was 20% for P.C group , 0% for vein patch group and 20% for PTFE group.

The life table analysis showed that freedom from significant recurrent stenosis at 36 months was 70% for PC and 96% for PTFE group , 88% for vein patch in AbuRahma series [18] , in our series life table analysis showed that it was 50% for PC, 85.7% for patch closure.

The cumulative stroke free survival rate at 36 months was 82% for primary closure group and 86% for patch closure in AbuRahma series [17], in our series it was 80% for P.C and 85.7% for patch group.

The occurrence of 50% or more recurrent stenosis and the occurrence of stroke was associated more with primary closure , this was true also in our series .

This study (inspite in small number of cases) confirms that patching in general is superior to primary closure in lowering the incidence of perioperative stroke , acute postoperative internal carotid artery thrombosis or both .

Both saphenous vein patch and PTFE patch give superior results to primary closure in this regard and the use of short segment of lower part of long saphenous vein appears to be more economic in our locality and resistance to infection and blow out or dilatation ,with excellent long term results and follow up.

REFERENCES

1 Kuller LH, Cook LP, Friedman GD: Survey of stroke epidemiologic studies. Stroke 3: 1972; 579.

2 Moore WS, Barnett MJ, Beebe HE, et al. : Guidelines for carotid endarterectomy : A multidisciplinary consensus statement from the Ad. Hoc. Committee, American Heart Association. Stroke 1995; 26: 188-201.

3 Archie JP: Prevention of early restenosis and thrombosis – occlusion after carotid endarterectomy by saphenous vein patch angioplasty. Stroke 1986; 15:972-4.

4 Deriu GP, Ballotta E, Bonavinal et al.:The rational for patch graft angioplasty after carotid endarterectomy:early and long term follow up.Stroke 1984;15:972-9.

5 Katz MM, JonesGT, Degenhardt J, et.al.: The use of patch angioplasty to alter the incidence of carotid restenosis following carotid endarterectomy. J.Cardiovasc.Surg.1987; 28:2-8.

6 North American Symptomatic Carotid Endarterectomy Trial (NASCET) Collaborators : Benificial effect of carotid endarterectomy in symptomatic patients with high grade carotid stenosis. N Engl.J.Med. 1991; 325: 445-453.

7 Moore W, Quinones-Baldrich W, Krupski W : Indications, Surgical Technique, and Results For Repair of Extracranial Occlusive lesions.In Robert B Rutherford(ed): Rutherford Vascular Surgery. 5th ed.Philadelphia,WB Saunders, 2000, 1789-1822.

8 Baker JD,Rutherford RB,Bernstein EF,et al. :Suggested standards for reports dealing with cerebrovascular diseases.J.Vas.Surg.1988; 8:721-9.

9 AbuRahma AF, Richmand BK, Robinson PA, et al.:Effect of contralateral severe stenosis or carotid occlusion on duplex criteria of ipsilateral stenoses :Comparative study of various duplex parameters. J.Vasc.Surg. 1995; 22: 751.

10 Dirrenberger RA, Sundt TMJr. Carotid endarterectomy : temporal profile of the healing process and effects of anticoagulation therapy . J Neurosurg. 1978;48: 201-19.

11 Rockman CR, Cappadonac, Riles TS, et al.: Causes of the increased stroke rate after carotid endarterectomy in patients with previous strokes. Ann.Vasc Surg.1997; 11: 28-34.

12 Riles TS, Imparato AM, Jacobowitz GR et al. : The cause of perioperative stroke after carotid endarterectomy . J. Vasc. Surg. 1994; 19:206-216.

13 Takolander R, Bergentz SE, Bergquvist D,et.al.: Management of early neurologic deficits after carotid endarterectomy. Eur. J.Vasc. urg. 1987;1 :67-71.

14 Lord RSA, Raj B, Stary DL,et al. :Compaison of saphenous vein patch,polytetrafluroethylene patch,and direct arteriotomy closure after cartoid endarterectomy ; I perioperative results. J.Vasc.Surg. 1989; 9 :521.

15 Seabrook GR, Towne JB, Bandyk DF , et.al.: Use of the internal jug-vein for carotid patch angioplasty. Surgery 1989; 106:633-8.

16 Goldman KA, Su WT, Riles TS ,et.al.. : A comparative study of saphenous vein , internal jugular vein, and knitted Dacron patches for carotid artery endarterectomy . Ann . Vasc. Surg. 1995;9:71-9.

17 Rhodes VJ : Expanded polytetrafluoroethylene patch angioplasty in carotid endarterectomy . J. Vas . Surg . 1995; 22: 724-31.

18 AbuRahma AF, Khan JH, Robinson PA,et.al. : Prospective randomized trial of carotid endarterectomy with primary closure and patch angioplasty with saphenous vein, Jugular vein, and polytetrafluoroethylene : perioperative (30 days) results . J. Vasc. Surg. 1996; 24:9888-1007.