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Immediate and long-term results of various techniques for carotid bifurcation reconstruction

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Immediate and long-term results of various techniques for carotid endarterectomy (CEA) within the period of 6 months to 4 years in 363 patients are given. It was confirmed that if a xenopericardial patch is used the incidence of carotid artery restenosis is significantly lower than if a polytetrafluoroethylene (PTFE) patch is used. In the long-term postoperative period, eversion CEA and CEA with the common carotid artery (CCA) bifurcation remodeling using an autologous artery tissue show a significantly low incidence of restenosis in comparison with CEA with xenopericardial patch or PTFE patch angioplasty. Keywords: carotid endarterectomy; carotid artery; restenosis.

Carotid endarterectomy (CEA) is the gold standard for treating patients suffering from symptomatic carotid stenosis and certain groups of patients suffering from asymptomatic carotid stenosis [1-4]. Carotid endarterectomy is currently one of the most frequently performed vascular reconstructions. This is not only due to the high incidence of lesions in the common carotid artery (CCA) bifurcation, which accounts for 65-70% of all occlusive diseases of the aortic arch branches;

CEA is also particularly effective in the correction of cerebral blood flow, preventing the progression of circulatory system diseases and the development of cerebrovascular accidents (CVA) [5, 6].

Carotid artery surgery might cause perioperative complications [7]. Besides, restenosis in the treated carotid artery occurring in the long-term postoperative period may lead to relapse or development of CVA, thereby impairing the long-term results of brachiocephalic artery (BCA) revascularization [8]. Restenosis may develop because of the disease progression itself [9, 10], or it may be related to the operative technique [8, 11-13].

The prevalent technique for CEA is a procedure in which various types of expanding patches are used (Dacron, PTFE, xenopericardium, autologous vein, etc.). Plus, different authors give ambiguous data when comparing the use of a particular patch material [14-17].

Some authors prefer the eversion technique as the number of early and late restenoses is lower [12]. However, the use of this technique is extremely limited in cases of extensive stenosis in the carotid arteries. Some authors suggest using the microsurgical technique for CCA bifurcation angioplasty without any patches [13]. Others say there is no substantial difference in the incidence of restenosis when various CEA techniques are used [18].

Thus, taking into account the complexity and/or unfeasibility of eversion CEA in case of extensive carotid stenosis, developing an optimal technique for carotid bifurcation angioplasty using the autologous artery tissue is an urgent task in vascular surgery. Moreover, the issue of choosing the optimal patch material for carotid angioplasty with regard to restenosis prevention remains debatable. This study aims to evaluate the immediate and long-term results of various techniques for the CCA bifurcation reconstruction.

MATERIAL AND METHODS

A retrospective analysis of 388 reconstructions of CCA bifurcation in 363 patients with hemodynamically relevant carotid artery lesions was performed.

The operations were carried out in the Federal State Budgetary Institution Novosibirsk Research Institute of Blood circulation pathology named after E.N. Meshalkin of the Ministry of Health of the Russian Federation and State Budgetary Healthcare Institution of Novosibirsk Oblast, Novosibirsk State Regional Clinical Hospital in 2008-2011. The average age of patients was 62.1±7.6 years, men made up 81% of patients. The degree of carotid artery stenosis was 73.2±10.9%. 326 (90%) patients had concomitant coronary heart disease. The grade of carotid sinus stenosis was assessed according to ECST criteria. The indications for CEA were >60% internal carotid artery (ICA) stenosis according to ECST criteria with a symptomatic lesion and >70% stenosis according to ECST criteria with an asymptomatic lesion. The standard preoperative examination included BCA duplex ultrasound scanning, BCA MSCT angiography, coronary angiography, and echocardiography.

Postinfarction cardiosclerosis was found in 174 patients (48%). Preoperative coronary artery revascularization was performed in 221 (61%) patients: coronary artery bypass grafting - 161 (73%) patients, PTCA with stenting – 60 (27%) patients. Disposition of patients based on cerebral vascular failure according to A.V. Pokrovsky classification: grade 1 - 14 (4%) patients, grade 2 – 36 (10%) patients, grade 3 – 221 (61%) patients, grade 4 – 92 (25%) patients. All patients underwent CEA under normothermic conditions and general anesthesia. The indication for using an internal shunt was the retrograde pressure index going below 0.4 during the carotid compression test. If the retrograde pressure was low (less than 40-30 mm Hg), a small dose of a vasopressor (mezaton) was administered (1 microgram/kg) by divided intravenous injections or intravenous infusion of a solution to induce hypertension with a 20-30% increase in systemic arterial pressure (AP) over the baseline pressure. The procedures are divided into 5 groups based on the type of reconstruction of CCA bifurcation: I - eversion CEA (124 (32%)), II – CEA with xenopericardial patch angioplasty (178 (45.5%)), III – CEA with PTFE patch angioplasty (61 (16%)), IV – ICA prosthetic reconstruction (15 (4%)), V - CEA with CCA bifurcation remodeling using an autologous artery tissue (10 (2.5%)). There were no significant differences in gender, age, or chronic cerebrovascular diseases in these groups.

To assess the success of CCA reconstruction, in the early postoperative period, all patients underwent duplex ultrasound scanning of the carotid arteries with measurement of the linear flow velocity in the ICA. >70% stenosis and linear flow velocity increase in the narrowing zone of more than 2 m/s were considered to be hemodynamically relevant restenosis of the treated ICA. In the long-term period, from 12 to 48 months, 302 (83%) patients were examined.

Statistical processing of the study material was carried out in the integrated statistical system Statistica 6.0. The normality of the parameter distribution was assessed using the Shapiro-Wilk test. For parameters that meet the criteria of normal distribution, parametric statistical methods were used. The data was presented as the arithmetic mean ± standard deviation (M±σ). Nonparametric statistical methods were used in other cases. The validity of differences was evaluated based on χ^2 criterion. Fischer's exact test was used to compare qualitative features with less than 5 observations. Differences were considered significant at $p<0.05$ when the probability of differences was greater than 95%.

Results

The duration of ICA occlusion on the operated side was 26±6.3 min. Perioperative stroke was diagnosed in 5 (1.3%) cases: in group I - 2 cases (1.6%),

in group II - 3 cases (1.5%). The structure of complications occurring in the CEA perioperative period is shown in table 1.

One (0.26%) patient from group II died in the early postoperative period. The cause of death was an ischemic stroke in the system of occluded contralateral ICA. Emergency reintervention for carotid artery thrombosis was performed in two patients. In one case, focal neurological deficits were successfully avoided; in the other, the restoration of blood flow in the thrombosed carotid artery was complicated by the development of a stroke in the system of the occluded contralateral ICA, which eventually led to the said fatality. Perioperative acute myocardial infarction was observed in one case without a fatality.

In the long-term follow-up of 302 (83%) examined patients, hemodynamically relevant >70% ICA restenoses were detected in 21 (6.9%) cases: in group I - 1 out of 119 (0.8%), in group II - 14 out of 142 (9.8%), in group III - 5 out of 16 (31.2%), in group IV - 1 out of 15 (6.6%) and in group V - 0 out of 10. The structure of long-term postoperative complications is shown in table 2.

It is worth noting that using the CEA techniques with CCA bifurcation angioplasty using the autologous artery tissue (eversion CEA and CCA bifurcation remodeling using an autologous artery tissue) clearly shows a lower number of restenoses compared to CEA with xenopericardial patch or PTFE patch angioplasty ($p<0.01\%$). When choosing a material for carotid artery angioplasty, using a xenopericardial patch is more favorable since the incidence of >70% restenosis development according to ECST is significantly lower than when a PTFE patch is used (9.8 vs. 31.2%; $p<0.05$). In the long-term period, there were no major differences in lethality, development of myocardial infarctions, strokes, or restenosis in the treated carotid artery between the CEA with CCA bifurcation angioplasty using the autologous artery tissue and the eversion CEA.

All patients with >70% restenosis underwent carotid artery stenting. 6 months later, according to the BCA duplex ultrasound scanning, no restenoses of stented ICA were found. Ischemic strokes were diagnosed in 3 (1%) cases within 6 to 48 months. Occlusions of the treated ICA

Table 1 *Structure of CEA complications in the perioperative period*

Feature	Group					Number of complications
	I	II	III	IV	V	
	n = 124	n = 178	n = 61	n = 15	n = 10	
Perioperative mortality	0	1 (0.5%)	0	0	0	1 (0.26%)
Ipsilateral stroke in the perioperative period (1.6%)	2	3 (1.5%)	0	0	0	5 (1.3%)
Perioperative myocardial infarction	0	1 (0.5%)	0	0	0	1 (0.26%)
Total by group (1.6%)	2	5 (2.8%)	0	0	0	7 (1.8%)

Table 2 *Structure of CEA complications in the long run*

Feature	Group					Number of complications
	I	II	III	IV	V	
	n = 119	n = 142	n = 16	n = 15	n = 10	
Mortality in long-term period	0	2 (1,4%)	1 (6,2%)	1 (6,6%)	0	4 (1,3%)
Ipsilateral stroke in the perioperative period	1 (0,8%)	1 (0,7%)	1 (6,2%)	0	0	3 (1%)
Long-term myocardial infarction	1 (0.8%)	2 (1.4%)	2 (12.5%)*	0	0	5 (1.6%)
> 70% carotid artery restenosis as per ECST	1 (0,8%)	14 (9,8%)*	5 (31,2%)**	1 (6,6%)	0	21 (6,9%)
including occlusion in the treated ICA	1 (0.8%)	3 (2.1%)	1 (6.2%)	0	0	5 (1.6%)

the validity of differences with: * group I ($p<0.01$); ** group II ($p<0.05$)

were found in 5 cases: in group I - 1 case, in group II - 3 cases, and in group III - 1 case; but only two patients (1 – II gr., 1 – III gr.) had clinical signs of cerebrovascular accidents (CVA). Acute myocardial infarction was diagnosed in 5 (1.6%) patients who underwent myocardial revascularization before CEA.

Discussion

Currently, the vast majority of surgeons use various angioplasty materials when performing CEA, both synthetic and biological. The need to use angioplasty material arose when the long-term results of operations using the linear repair techniques were analyzed. Numerous reports by different authors on a high incidence of restenosis [14, 17, 19] forced the surgeons to apply an expanding patch for arteriotomy closure [5, 14, 15, 17].

The central problem with using synthetic materials lies in their increased thrombogenicity and, subsequently, a relatively high incidence of early thrombosis, perioperative strokes, and late restenoses [5, 14, 16]. For carotid angioplasty, we used a xenopericardial patch treated with epoxy compounds as well as a PTFE synthetic patch. It was confirmed that in the follow-up period from 6 to 48 months (27 months on average), the incidence of >70% carotid artery restenosis according to ECST criteria was significantly lower with a xenopericardial patch than with a PTFE patch (9.8 vs. 31.2%; $p<0.05$). Thus, when choosing a material for carotid artery angioplasty using a xenopericardial patch is more favorable.

According to the study data, despite the good results obtained after eversion CEA, this technique is associated with a greater incidence of perioperative strokes than classical CEA [20, 21]. This is due to the difficulties of performing an adequate endarterectomy, the risk of intimal dissection with the development of carotid artery thrombosis, and the difficulties of shunt implantation in case of extensive ICA lesions [20, 22].

For extensive plaque in ICA, we developed a CEA technique with CCA bifurcation remodeling using an autologous artery tissue, which allows for adequate endarterectomy with autologous artery tissue angioplasty and preservation of branches of the external carotid artery (ECA).

It is demonstrated that in the perioperative period and in the long run, the effectiveness and safety of the CEA technique with CCA bifurcation remodeling using an autologous artery tissue are not lower than those of the eversion CEA.

Conclusion

1. The clinical effectiveness of carotid endarterectomy in ischemic stroke prevention in the long-term postoperative period of up to 48 months was 97.8%. Strokes developed in 2.2% of cases.

2. In the long term postoperative period, eversion CEA and CEA with CCA bifurcation remodeling using an autologous artery tissue have a significantly low incidence of restenosis ($p<0.01$) in comparison with CEA with xenopericardial patch and PTFE patch angioplasty.

3. When choosing a material for carotid artery angioplasty using a xenopericardial patch is more favorable since the incidence of restenosis is significantly lower than when a PTFE patch is used.

REFERENCES

1. Asymptomatic Carotid Surgery Trial (ACST) Collaborative Group. Prevention of disabling and fatal strokes by successful carotid endarterectomy in patients without recent neurological symptoms: randomised controlled trial // Lancet. 2004. V. 363. P. 1491–1502.

2. Endarterectomy for asymptomatic carotid artery stenosis: Executive Committee for the Asymptomatic Carotid Atherosclerosis Study // JAMA. 1995. V. 273. P. 1421–1428.

3. European Carotid Surgery Trialists' Collaborative Group. Randomised trial of endarterectomy for recently symptomatic carotid stenosis: final results of the MRC European Carotid Surgery Trial (ECST) // Lancet. 1998. V. 35 (1). P. 1379–1387.

4. North American Symptomatic Carotid Endarterectomy Trial Collaboration. Beneficial effect of carotid endarterectomy in symptomatic patients with high-grade stenosis // J. New England Medicine. 1991. V. 32 (5). P. 445–453.

5. Belov Yu.V. Manual of vascular surgery with an atlas of operative techniques. Moscow: Denovo, 2000. 448 p.

6. Pokrovsky A.V. // Angiologiya i sosudistaya khihurgiya (Angiology and vascular surgery) 2001. Vol. 7 (1). P. 101-104.

7. Rerkasem K., Rothwell P.M. // Cochrane Database Syst. Rev. 2011. V. 13. P. 4.

8. Van Lammeren G.W., Peeters W., de Vries J.P. et al. // Stroke. 2011. V. 42 (4). P. 965–971.

9. Clagett G.P., Rich N.M., McDonald P.T. et al. // Surgery. 1983. V. 93. P. 313–318.

10. Healy D.A., Zierler R.E., Nicholls S.C. et al. // J. Vasc. Surg. 1989. V. 10. P. 662–668.

11. Pokrovsky A.V., Kuntsevich G.I., Beloyartsev D.F. et al. // Angiologiya i sosudistaya khihurgiya (Angiology and vascular surgery). 2005. V. 11 (1). P. 93–101.

12. Raithel D. // J. Cardiovasc. Surg. 1997. V. 5 (5). P. 471–482.

13. Reinert M., Mono M.L., Kuhlen D. et al. // Acta. Neurochir. (Wien). 2012. V. 154 (3). P. 423–431.

14. AbuRahma A.F., Hopkins E.S., Robinson P.A. et al. // Ann. Surg. 2003. V. 237 (6). P. 885–892.

15. Ballard J.L., Romano M., Abou-Zamzam A.M.Jr. et al. // Ann. Vas. Surg. 2002. V. 16 (1). P. 12–16.

16. Hayes P.D., Allroggen H., Steel S. et al. // J. Vasc. Surg. 2001. V. 33. P. 994–1000.

17. Yamamoto Y., Piepgras D.G., Marsh W.R., Meyer F.B. // Neurosurgery. 1996. V. 39 (44). P. 670–675.

18. Katz M.M., Jones G.T., Degenhardt J. // J. Cardiovasc. Surg. 1987. V. 28 (2). P. 2–8.

19. Archie J.P. // J. Vasc. Surg. 2001. V. 33 (3). P. 495–503.

20. Cao P.G., de Rango P., Zanetti S. et al. // Cochrane Database Syst. Rev. 2001. V. 1. CD 001921.

21. Demirel S., Attigah N., Brujinen H. et al. // Stroke. 2012. V. 43 (7). P. 1865–1871.

22. Darling R.C., Shah D.M., Chang B.B. et al. // Semin. Vasc. Surg. 2000. V. 13 (1). P. 4–9.