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Endoscopy-assisted surgical treatment of carotid artery kinking

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ABSTRACT

Objective — to evaluate the results of endoscopy-assisted surgical treatment of patients with «high» tortuosity of the ICA.

Material and methods. Endoscopy-assisted surgical reconstruction of high tortuosity of the ICA was made in 11 patients. All procedures were carried out at the Sklifosofsky Research Institute for Emergency Medicine (Moscow) and Republican clinical hospital of Kabardino-Balkaria (Nalchik) for the period from 01.01.18 to 31.12.18.

Results. There were no intraoperative and postoperative complications (blood flow velocity increased by 66.2% after surgery). Neurological improvement after surgery was noted in all patients. Partial or complete regression of dizziness was observed in 5 (45.5%) patients. Tinnitus disappeared in 7 (63.6%) patients.

Conclusion. Approach to the distal parts of ICA is traumatic, requires the use of additional techniques and considerable surgical experience. Endoscopic technique is valuable to reduce the risk of injury of soft tissues, neurovascular structures and improve functional outcomes.

Keywords: ICA tortuosity, endoscopic assistance, surgical treatment, outcomes.

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Background

Hemodynamic disturbances in patients with internal carotid artery (ICA) kinking is one of the causes of ischemic strokes. Kinking is found in 25% of patients with cardiovascular failure [1, 2]. Surgical correction of tortuosity reduces hemodynamic deficiency in certain cerebral hemisphere and is considered as preferable treatment for this pathology. Certain surgical difficulties are observed in patients with so-called «high» tortuosity. This kinking is localized above the line between the mandibular angle and the apex of the mastoid process (projection of CI—CII). Visualization of these ICA deformations is traumatic and requires additional techniques and surgical experience. We used endoscopy-assisted dissection of high kinking of the ICA in order to reduce injury of soft tissues, neurovascular structures and improve the functional outcomes.

Purpose — to evaluate the results of endoscopy-assisted surgical treatment of distal ICA kinking.

Material and methods

There were 11 patients with high ICA kinking who were underwent endoscopy-assisted surgical treatment for the period from 01.01.18 to 31.12.18. All patients were operated at the Sklifosovsky Research Institute for Emergency Care (Moscow) and Republican Clinical Hospital (Nalchik). Age of patients ranged from 43 to 82 years [Me=54; 47; 68]. Men/women ratio was 1: 3.

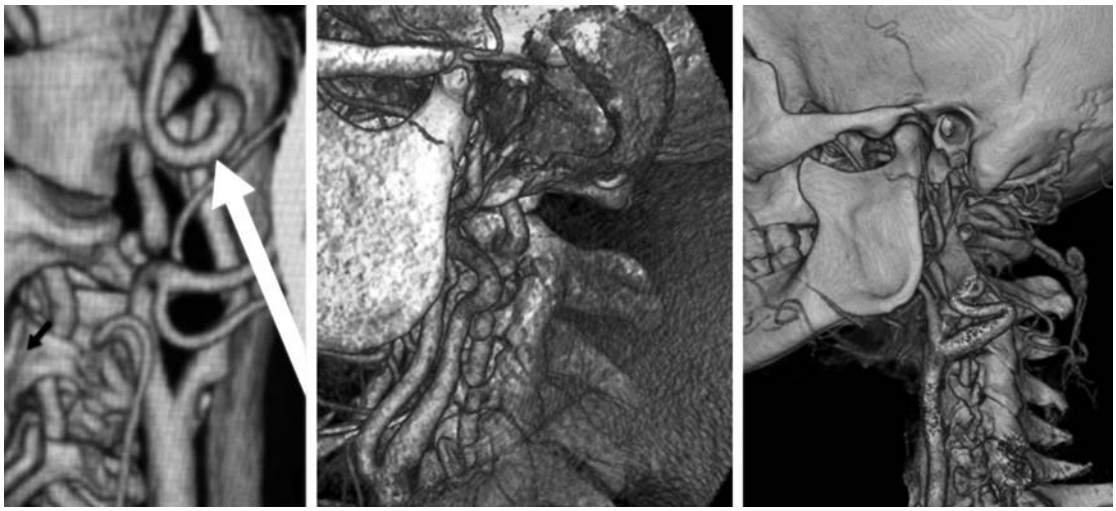
Tinnitus was predominant complaint in 9 (81.9%) patients, dizzy — in 7 (63.6%), permanent headache — in 4 (36%). Previous transient ischemic attack in unilateral middle cerebral artery pool was noted in 2 (18%) patients, ischemic stroke — in 1 (9%). Concomitant arterial hypertension was diagnosed in 7 (63.6%) patients, diabetes mellitus 2 type — in 2 (18%). Doppler ultrasound of supraaortic arteries with analysis of blood flow velocity before and after tortuosity, MRI of the brain and CT angiography were performed in all patients. According to Doppler ultrasound data, all patients were diagnosed with hemodynamically significant «high» ICA tortuosity (with more than 2-fold difference in blood flow velocity before and after tortuosity) **(Fig. 1).** Concomitant atherosclerotic lesion of ICA wall was detected in 3 patients. However, septal stenosis did not exceed 30%.

According to CT angiography, severe S-shaped tortuosity was revealed in 5 (45.5%) patients, coiling in 3

а/a б/b

***Fig. 1*. Duplex scanning of ICA. Distal ICA tortuosity.**

a — right ICA (white arrow); b — left ICA (white arrow).



а/a б/b в/c

***Fig. 2.* 3D-CT angiography of the brain.**

a — CT-scan, direct plane, left ICA coiling; b — CT-scan, left lateral plane, left ICA kinking; c — CT-scan, left lateral plane, S-shaped tortuosity of the left ICA.

(27.3%) and kinking in 3 (27.2%) (Fig. 2). Circle of Willis was closed in all patients. MRI signs of previous stroke in unilateral ICA pool were found in 2 patients.

Surgical technique

Surgical treatment of high ICA tortuosity implied marking of common carotid artery (CCA) and ICA tortuosity using Doppler ultrasound, endoscopy-assisted surgical approach to ICA tortuosity. The following stages were ICA redressation and resection of tortuosity followed by anastomosis with ICA ostium.

Preoperative planning is carried out at the first stage using duplex scanning.

Angle of the mandible, projection of common carotid artery bifurcation, proximal (point 4) and distal (point 5) ends of tortuosity are marked on the skin. Segment between the points 4 and 5 is marked as «B». Point 6 is a center of this segment (center of tortuosity). Perpendicular from the center of tortuosity to the ramus of the mandible is a segment «A». A line is drawn on the skin through the point 1 (bifurcation C) along the inner edge of the projection of sternocleidomastoid muscle. It is a segment «C» with a length of 3 cm **(Fig. 1)**.

Surgical intervention is performed under endotracheal anesthesia in patient's supine position with a roller under the ipsilateral shoulder and head turned in the opposite direction. An incision of soft tissues is made along the anterior edge of sternocleidomastoid muscle with a length of 3 cm **(Fig. 2)**.

Dissection of soft tissues results exposure of common, internal and external carotid arteries. Retractor of the

а/a б/b

***Fig. 3*. Preoperative planning.**

a — marking of the course and level of ICA tortuosity on the skin; b — marking of skin incision and approach in projection of medial edge of sternocleidomastoid muscle and CCA bifurcation.

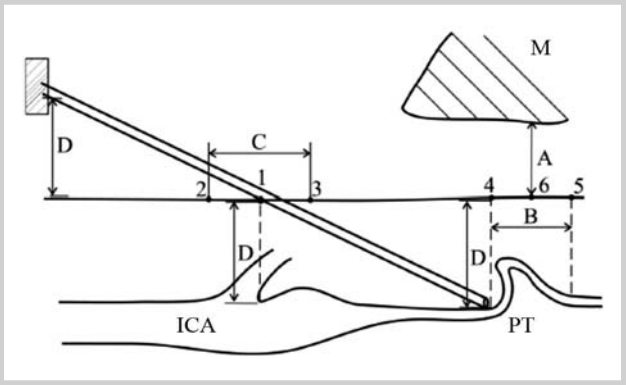


***Fig. 4*. Scheme of endoscopic dissection of ICA high tortuosity.**

ICA — internal carotid artery; PT — pathological tortuosity, M — mandible, A — segment from the mandible to the projection of the middle of ICA tortuosity on the skin (perpendicular from the center of tortuosity marked on the skin to the ramus of the mandible); B — interval between the points in projections of proximal and distal ends of ICA tortuosity, C — segment on the inner edge of projection of the sternocleidomastoid muscle with a length of 3 cm, center of this segment corresponds to the projection of common carotid artery bifurcation; D — depth of ICA bifurcation that is equal to the depth of ICA tortuosity and height of endoscopic camera position above the skin.

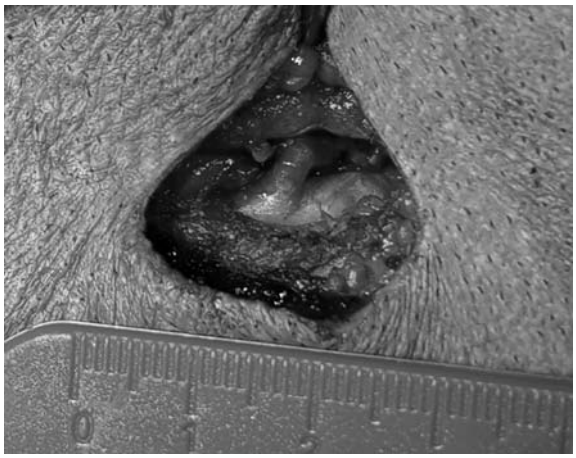
endoscope is installed, endoscope is deployed within surgical wound in cranial direction in accordance with depth of CCA bifurcation (D), tortuosity (D) and distance (A) from the angle of the mandible. Endoscope is fixed in the holder, so that proximal and distal parts of ICA and surrounding soft tissues are visualized on the screen. Internal carotid artery is dissected from CCA bifurcation in distal direction under endoscopic control. Endoscope is consistently passed in cranial direction during these manipulations parallel to the arterial wall. Then, we visualize and dissect ICA tortuosity and perform redressation of ICA loop into surgical wound.

Vascular clamping and assessment of brain tolerance to arterial occlusion are followed by intersection of the ICA within its ostium and resection of excessive length of the artery. At the next stage, we create anastomosis between internal and common carotid arteries in end-to-side fashion using 6/0 suture. Blood flow restoration and ultrasound control of patency of the anastomosis are followed by closure of the wound with drainage according to Redon **(Fig. 4)** [3].

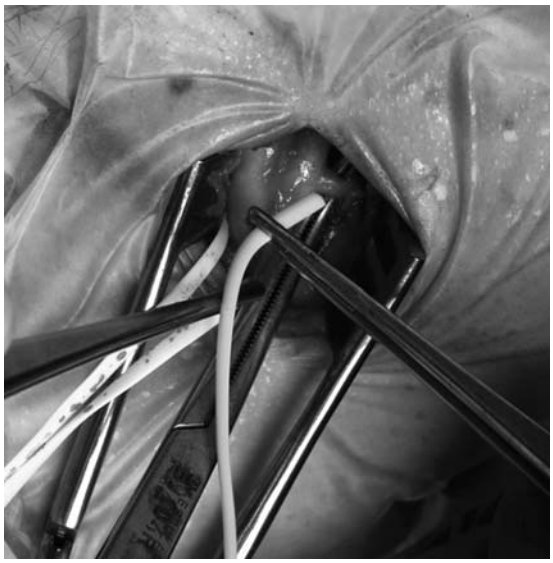
Results

Above-described method was applied in all patients (100%) for resection and redressation of the ICA. We used endoscopic assistance for dissection of ICA tortuosity. There were no intraoperative complications (blood flow velocity increased by 66.2% after resection of tortuosity). Patients were followed-up at the intensive care unit within 1 day after surgery. Mean hospital-stay was 10 days (range 5—13 days). There were no postoperative acute cerebrovascular accidents and mortality within follow-up period (90 days). In-hospital partial or complete regression of dizziness was noted in 5 (45.5%) patients. Tinnitus disappeared in 7 (63.6%) patients.

Doppler ultrasound and CT angiography confirmed resection of tortuosity in 100% of patients. Regression of hemodynamic deficiency was associated with maximum variation of blood flow velocity within 20% **(Fig. 6)**.



а/a



б/b

***Fig. 5*. Intraoperative images.**

a — skin incision for minimally invasive approach to ICA; b — dissection of CCA bifurcation through minimally invasive approach.

***Fig. 6.* Intraoperative image. Insertion of retractor and endoscope into surgical wound, endoscopy-assisted dissection of ICA in cranial direction.**

***Fig. 7.* Intraoperative image. Endoscopic image, ICA tortuosity is visualized, dissection of the distal parts of ICA is performed.**

Discussion

Surgical treatment of ICA tortuosity implies dissection of kinked ICA segment, resection of tortuosity and anastomosis in end-to-end or end-to-side fashion. In case of distal kinking, ICA tortuosity is covered by mandibular angle in front and mastoid process and cervical vertebrae from behind. Surgical approach is complicated by the proximity of parotid gland, facial, glossopharyngeal, hyoid nerves, pharyngeal nerve plexus and swallowing muscles. Resection of ICA kinking near skull base requires dissection of this segment with mandatory functional preservation of the vessels, nerves and glands [4—9].

The presented approaches for surgical treatment of distal ICA tortuosity are aimed at enlargement of the anatomical corridor in order to minimize cranial nerves injury and ensure enough space for creation of anastomosis.

R. De Palma [10] proposed a method with intersection of posterior belly of digastric muscle and stylohyoid muscle and occipital artery ligation. This technique is useful for safe isolation of sublingual, glossopharyngeal nerves and pharyngeal nerve plexus during distal dissection of the internal carotid artery.

A. Shaha et al. and W. Pearce et al. [11, 12] performed intersection of posterior belly of digastric muscle, stylo-

***Fig. 8*. Intraoperative image. Carotid bifurcation after resection and redressation of kinking.**

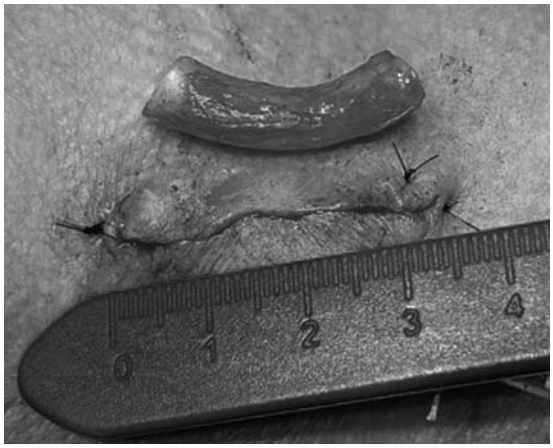
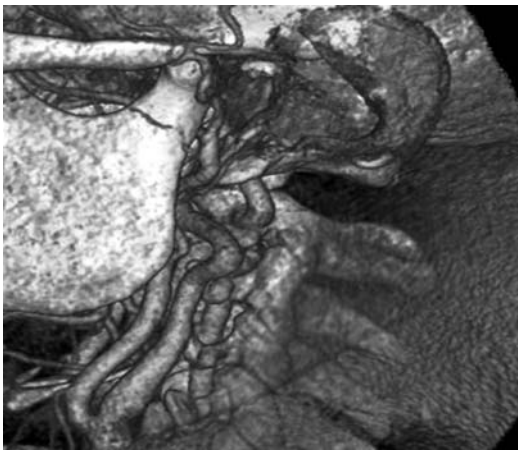


***Fig. 9.* Intraoperative image. Image postoperative wound with resected ICA.**



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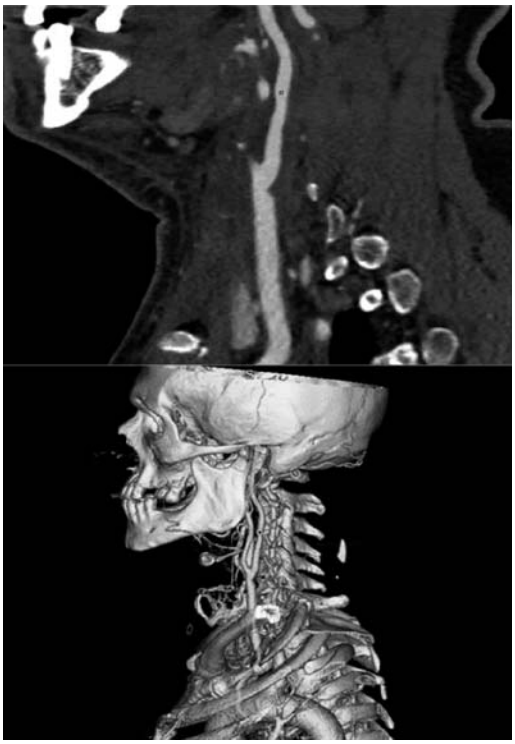

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***Fig. 10*. CT angiography of a 47-year-old patient.**

pharyngeus, stylohyoid muscles with partial resection of styloid process in patients with high ICA tortuosity. Some authors emphasize the traumatism of this approach due the risk of injury of facial, glossopharyngeal nerves, sympathetic trunk, accessory, vagus, hyoid nerves near the styloid process [13—15].

S. Nelson et al. [16] proposed osteotomy of the posterior margin and mandibular angle for approach to ICA. This technique of bone splitting and resection is performed in step-by-step fashion via intra— and extraoral approaches. M. Devil et al. [17] experimentally showed that displacement and osteotomy of the mandible increase the volume of surgical approach by 14.6 cm3 on the average. V. Valentini et al. [18] also proposed this method for dissection of distal parts of ICA.

V.V. Krylov et al. [9] reported the method for surgical treatment of high lesions of ICA. This technique implies temporary unilateral subluxation of the mandible in order to enlarge surgical approach and increase the angle of manipulations on the distal parts of ICA.

N.G. Khorev et al. [19, 20] reported original approach to distal ICA with preservation of stylohyoid muscle and posterior belly of digastric muscle. The approach is looked like a tunnel. Branches of retractor form the lateral walls,

digastric and stylohyoid muscles, facial and glossopharyngeal nerves form superior wall, segment of ICA — inferior wall. This approach is associated with dissection of pharyngeal plexus and hyoid nerve and their displacement upward to visualize ICA.

The main disadvantages of these methods are advanced traumatism with large skin incision and high risk of injury of cranial nerves (hyoid and facial nerves, pharyngeal plexus), submandibular and parotid glands, need for subluxation or osteotomy of the mandible, ligation of sternocleidomastoid branch of the external carotid artery, occipital artery, intersection of digastric and styloid muscles.

Considering of our experience of endoscopic vascular procedures (for example, artery and vein harvesting for various bypass interventions), we have developed and proposed a technique for dissection of hard-to-reach tortuosity of carotid arteries (distal ICA, proximal CCA) with endoscopic assistance [21, 22]. The proposed method is valuable to reduce surgical trauma and minimize dimension of skin incision.

Conclusion

Endoscopic assistance is advisable for mobilization and reconstruction of ICA tortuosity. This atraumatic and minimally invasive approach is associated with reduced risk of injury of cranial nerves, submandibular and parotid glands, suprahyoid muscles. The proposed technique may be used for correction of ICA tortuosity and improvement of cerebral circulation in patients with acute and chronic cerebrovascular disorders with maximum technical and clinical effect.

The authors declare no conflict of interest.

ЛИТЕРАТУРА/REFERENCES

1. Стародубцев В.Б., Карпенко А.А., Альсов С.А., Марченко А.В., Чернявский А.М. Хирургическое лечение патологической извитости внутренней сонной артерии у пациентов с сосудисто-мозговой недостаточностью. *Патология кровообращения и кардиохирургия*. 2009;(1):58-60.
Starodubtsev VB, Karpenko AA, Alsov SA, Marchenko AV, Chernyavsky AM. Surgical treatment of internal carotid artery pathological tortuosity in patients with cerebrovascular insufficiency. *Patologiya krovoobrashcheniya i kardiohirurgiya*. 2009;(1):58-60. (In Russ.)
2. Zanetti PP, Rosa G, Cavanenghi D, Sorisio V, Amerio GM, Stillo R, Zappa A, Muncinelli M, Franco M, Cardellino S. Surgical treatment of carotid kinking. *J Cardiovasc Surg* (Torino). 1997;38(1):21-26. PMID: 9128117.
3. Крылов В.В., Муков М.Б., Кожаев З.У., Лукьянчиков В.А., Хасауов Р.Х. *Способ выполнения редрессации и резекции внутренней сонной артерии (ВСА) с применением эндоскопии у пациентов с высокой извитостью ВСА*. Патент РФ №2678412 от 28.01.19. Бюлл. №4. Ссылка активна на 30.04.19.
Krylov VV, Mukov MB, Kozhaev ZU, Lukyanchikov VA, Hasauov RKh. Patent RF №2678412 ot 28.01.2019. Byull. №4. *Sposob vypolneniya redressatsii i rezektsii vnutrennej sonnoj arterii (VSA) s primeneniem endoskopii u patsientov s vysokoj izvitost'yu VSA*. Patent RF No 2678412 on 28.01.19. Bull. No 4. Accessed 30.04.19. (In Russ.)
4. Лукьянчиков В.А., Хасауов Р.Х., Кожаев З.У., Гекиева Ж.С., Крылов В.В., Виноградов Р.А. Минимально инвазивное хирургическое лечение пациента с патологической извитостью сонной артерии с применением эндоскопии. *Нейрохирургия*. 2018;20(4):80-86.
Lukyanchikov VA, Khasauov RKh, Kozhaev ZU, Gekieva ZhS, Krylov VV, Vinogradov RA. Minimally invasive surgical treatment of a patient with pathological tortuosity of the carotid artery using endoscopic assistance. *Neyrokhirurgiya*. 2018;20(4):80-86. (In Russ.)
https://doi.org/10.17650/1683-3295-2018-20-4-80-86
5. Ballotta E, Da Giau G, Baracchini C, Manara R. Carotid eversion endarterectomy: perioperative outcome and restenosis incidence. *Ann Vasc Surg*. 2002;16(4):422-429.
https://doi.org/10.1007/s10016-001-0114-8
6. Markovic DM, Davidovic LB, Cvetkovic DD, Maksimovic ZV, Markovic DZ, Jadranin DB. Singlecenter prospective, randomized analysis of conventional and eversion carotid endarterectomy. *J Cardiovasc Surg* (Torino). 2008;49(5):619-625. PMID: 18670379.
7. Partsakhashvili J, Rtveliashvili N, Philishvili O, Kurdadze R, Ukkat J. Correlating the length of internal carotid artery stenosis to the technique of endarterectomy and anesthesia used. *Georgian Med News*. 2014;(234):7-11. PMID: 25341231.
8. Knight FW, Yeager RM, Morris DM. Cranial nerve injuries during carotid endoarterectomy. *Am J Surg*. 1987;154(5):529-532. PMID: 3674303.
9. Далибалдян В.А., Лукьянчиков В.А., Шалумов А.З., Полунина Н.А., Токарев А.С., Шатохина Ю.И., Степанов В.Н. Временная сублюксация нижней челюсти по поводу высокого атеросклеротического поражения внутренней сонной артерии. *Нейрохирургия*. 2016;(1):60-68.
Dalibaldyan VA, Lukyanchikov VA, Shalumov AZ, Polunina NA, Tokarev AS, Shatokhina YuI, Stepanov VN. The temporary mandible subluxation during surgical treatment of high-level atherosclerotic damages of extracranial part of internal carotid artery. *Neyrokhirurgiya*. 2016;(1):60-68. (In Russ.)
10. DePalma RG. Optimal exposure of the internal carotid artery for endarterectomy. *Surg Gynecol Obstet*. 1977;144(2):249-250. PMID: 835067.
11. Pearce W, Whitehill T. Carotid and vertebral arterial injuries. *Surg Clin North Am*. 1988;68(4):705-723. PMID: 3046001.
12. Shaha A, Phillips T, Scolea T, Golueke P, McGinn J, Sclafani S, Hoover E, Jaffe BM. Exposure of the internal carotid artery near the skull base: the posterolateral anatomic approach. *J Vasc Surg*. 1988;8(5):618-622. PMID: 3184316.
13. Hye RJ, Mackey A, Hill MD, Voeks J, Cohen DJ, Wang K, Tom M, Brott TG. Incidence, outcomes and effect on quality of life of cranial nerve injury (CNI) in the Carotid Revascularization Endarterectomy versus Stenting Trial (CREST). *J Vasc Surg*. 2015 May;61(5):1208-1214. https://doi.org/ 10.1016/j.jvs.2014.12.039
14. Schauber MD, Fontanelle LJ, Solomon JW, Hanson TL. Cranial/cervical nerve dysfunction after carotid endoarterectomy. *J Vasc Surg*. 1997;25(3):481-487. PMID: 9081129.
15. Покровский А.В., Белоярцев Д.Ф., Колосов Р.В. Что влияет на стандарты «качества» выполнения каротидной эндартерэктомии? *Ангиология и сосудистая хирургия*. 2003;9(3):80-87.
Pokrovsky AV, Beloyartsev DF, Kolosov RV. Chto vliyaet na standarty «kachestva» vypolneniya karotidnoj endarterektomii? Angiologiya i sosudistaya khirurgiya. 2003;9(3):80-87. (In Russ.)
16. Nelson SR, Schow SR, Stein SM, Read LA, Talkington CM. Enhanced surgical exposure for the high extracranial internal carotid artery. *Ann Vasc Surg*. 1992;6(5):467-472.
https://doi.org/10.1007/BF02007006
17. Devlin MA, Hoffmann KD, Johnson WD. Comparison of mandibular surgical techniques for accessing cranial base vascular lesions. *Skull Base*. 2003;13(2):65-72.
https://doi.org/10.1055/s-2003-820560

18. Valentini V, Fabiani F, Nicolai G, Torroni A, Battisti A, Iannetti G, Irace L, Faccenna F, Siani A, Pascucci M, Valentini FB. Surgical approach to the third area of the internal carotid artery through vertical osteotomy of the mandibular ramus: case report. *J Craniofac Surg*. 2002;13(6):816-820. PMID: 12457099.

19. Хорев Н.Г., Беллер А.В., Шойхет Я.Н., Куликов В.П. Хирургическое лечение патологической извитости внутренней сонной артерии у детей. Барнаул: АГМУ; 2004.
Khorev NG, Beller AV, Shoykhet YaN, Kulikov VP. Hirurgicheskoe lechenie patologicheskoj izvitosti vnutrennej sonnoj arterii u detej. Barnaul: AGMU; 2004. (In Russ.)

20. Шойхет Я.Н., Хорев Н.Г., Куликов В.П. Патологическая извитость внутренней сонной артерии и ее хирургическое лечение. *Проблемы клинической медицины*. 2005;(1):80-90.
Shoykhet YaN, Horev NG, Kulikov VP. Pathological tortuosity of the internal carotid artery and its surgical treatment. *Problemy klinicheskoj meditsiny*. 2005;(1):80-90. (In Russ.)

21. Reichenspurner H, Damiano RJ, Mack M, Boehm DH, Gulbins H, Detter C, Reichart B. Use of the voice-controlled and computer-assisted surgical system ZEUS for endoscopic coronary artery bypass grafting. *J Thorac Cardiovasc Surg*. 1999;118(1):11-16. https://doi.org/10.1016/S0022-5223(99)70134-0

22. Kiaii B, Moon BC, Massel D, Langlois Y, Austin TW, Willoughby A, Guiraudon C, Howard CR, Guo LR. A prospective randomized trial of endoscopic versus conventional harvesting of the saphenous vein in coronary artery bypass surgery. *J Thorac Cardiovasc Surg*. 2002;123(2):204-212. https://doi.org/10.1067/mtc.2002.118682

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