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Research Article

Cerebral Revascularization: Boom or Doom for Neurosurgeons

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Abstract

Cerebral revascularization which was once commonly used technique became outdated and emerged in a new avatar. Fisher was the first person who promoted that most strokes were not due to vasospasm but due to CA disease. Improvement of various microsurgical methods and techniques are resulting in excellent outcomes. With the advent of modern techniques, cerebral revascularization has taken a back seat. However many diseases like moyamoya disease, complex intracranial aneurysms and skull based tumours, traditional cerebral revascularization methods play a very important role. Although an important method to treat strokes but is also associated with dreaded complication of intracranial haemorrhage. Cerebral collateral circulation channels are restored by cerebral revascularization. Although very commonly used treatment but underwent various modifications, implementations, expanding the horizons of diseases involved. All these innovations in the use of endovascular technique resulted in the decline of cerebral revascularization surgeries. New endovascular surgical approaches lead to shorter recovery times and the patients whose conditions are not indicated for the traditional cerebrovascular approaches can also be managed. One of the major and important drawback of Cerebral Revascularization is the intraoperative thrombosis which can result in severe motor and sensory disturbances. This article aims to weigh the pros and cons of cerebral revascularization.

Keywords

Cerebral Revascularization, Stroke, Ischemia

1. Introduction

Cerebral revascularization is a neurosurgical procedure used to restore the cerebral collateral circulation channel. After cardiovascular disease and carcinomas, Ischemic stroke is the third largest cause of mortality. Ischemic stroke is more common than any other stroke and has high recurrence rate. [1]

Complex aneurysms, skull base tumours, and vertebrobasilar ischemia in the posterior circulation can be treated with Revascularization. [2]

Occlusive lesion which can impair the vascularity of cerebellar region is a common problem. Amount of collateral circulation present will determine the degree of cerebral dysfunction associated with it. Treatment involves anastomization of superficial temporal artery to a branch of middle cerebral artery which will increase the collateral circulation to affected hemisphere. Revascularization has a 90% patency rate. [3]

2. History

The original cerebral revascularization technique was first

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described by Yasargil and Yonekawa in 1977 using the superficial temporal artery.

Table 1. *Developments in Cerebral Revascularization Surgery.*

YEAR	NAME	DEVELOPMENT
1902	Alexis Carrel	Published first arterial end to end anastomosis using fine suture material and triangulation
1939	German and Taffel	Did an experiment on dogs and apes with transposition of vascular muscle flap in the cortex
1942	Kradel	Attempted this on humans but later discontinued
1949	Beck &Colleague	Described revascularization technique of carotid juglar fistula
1957	Theodore Kurze	First to use microscope for neurosurgery
1961	Pool & Potts	Were the first ones to attempt cerebral revascularization with a synthetic graft
1962	Jacobson and Donagh	Reported first human microsurgical procedure in neurosurgery on MCA endarterisis
1963	Woringer and Cutis	Performed first EC-IC bypass of common carotid artery using sphenovenous graft
1970	Sundett &Collegue	Introduced post circulation revascularization
1972	Yasargil	First one to perform STA-MCA bypass for moyamoya disease
1978	Ausman	Used radial artery graft

[4-10]

3. Reasons for Decline in Revascularization Procedure

In spite of improved medical therapy patients with intracranial vertebrobasilar stenosis and occlusion experience significant stroke rates. Patients requiring revascularization of the posterior circulation, direct bypass revascularization or endovascular therapy has proven to be more fruitful. In a study done by Rafael, three patients with vertebrobasilar ischemic disease showed improvement following revascularization with omental transplantation. Indirect bypass with omental transplantation may be beneficial as a last resort, but without angiographic follow-up, the theoretical benefits of posterior fossa omental grafts are difficult to support. In order to refine the microsurgical revascularization various factors like screening, diagnosis, operative patient selection, and ideal surgical revascularization procedures of patients with brainstem and cerebellar ischemia. [11]

Revascularization gained popularity in 1900's but its fame started to decline with time. Although considered lifesaving but was associated with various devastating side effects.

It was noted that EC-IC anastomosis did not work in stopping strokes in patients with atherosclerotic arterial disease of CA &MCA. A notable increase in the incidence of strokes after surgery. Even after surgery the survival rates were not that high. Due to all these reasons the insurance companies in North America, Europe and Asia began to deny coverage for the procedure.

All of these lead to reluctance of surgeons to opt for revascularization surgeries resulting in increase in mortality rates from 2.8% in 1992-1996 to 5.7% in 1999 -2001.

Utilization of cerebral revascularization procedure is declining overtime. In context of giant and fusiform aneurysm this decline is seen with increasing use of endovascular flow diverting stents. There is also significant decrease in cerebral revascularization as a result of failure of COSS study. Starauss et al demonstrated not only the use of cerebral revascularization declined after introduction of flow diverting stents but also the patients selected for cerebral revascularization had poorer pre operative modified Rankin score Same was reported by Lawton that cerebral revascularization case reduced for aneurysm after FDA approved flow diverter stent. [12]

4. Recent Trends

Nowadays cerebral vascular surgeries are done for the patients of moyamoya disease or hemodynamic compromise. In case of CBF surgery, it is done for complex aneurysm, which gets trapped or in the skull base tumour surgery. Apart from pedicled arterial graft of STA-MCA, which has a patency rate of more than 95%, creating artificial conduits can be done.

Table 2. Various grafts for revascularization.

Interposition Vein graft	Greater saphenous vein
Free arterial graft	Radial artery
Artificial Grafts	Polytetrafluoroethylene tubes.

Table 3. Grafts used for different procedures.

Saphenous Vein Bypass graft	Giant intra cranial aneurysm Skull based tumours involving ICA, VA or CA
Internal CA bypass	
Radial artery Bypass	Giant aneurysm of cavernous supraglenoid ICA
Intracranial- Intracranial bypass	Occasional

With new advent and introduction of modern materials like microdoppler, transit time flowmetry (Charbel microflow probes) and cyanine green video angiography have improved the fate of revascularization surgeries. [4, 13-15]

Cerebral Revascularization was a way ahead of time live saving surgery, when its use was subjected to various innovations. With the emergence of endovascular technique, the dreadful complication are reduced and the post-surgery recovery time is also minimized. In case of moyamoya disease, complex intracranial aneurysm and skull base tumours. Cerebral Revascularization is must. [16-18]

5. Indications

The various indications of Cerebral Revascularization surgery are as follows: -

1) It serves as a best therapeutic option for recurrent transient ischemia that is not responding to medical management.
2) If patients remain symptomatic even after usage of aspirin and anticoagulants.
3) Cerebral blood flow studies showing hypoperfusion in the particular area.
4) Certain diseases like moyamoya disease, complex intracranial aneurysms and skull-based tumours.

5.1. Moyamoya Disease

An intracranial arteriopathy causing bilateral stenosis of Internal carotid artery and middle cerebral artery resulting in strokes and ischemic attacks. [19, 20]

Moyamoya is a Japanese word meaning smoke puff, as the newly formed vessel tries to compensate the stenosis obstruction. There has been an increase in strokes even after medical treatment. Data suggest that 40-82% patients suffer from another stroke within 5 years. Only the patients who underwent cerebral revascularization had a better prognosis. [21]

Most common approaches for Cerebral revascularization are direct anastomotic procedures in which surgeons use STA, the occipital artery or even the middle meningeal artery as donor vessels. MCA and anterior cerebellar artery or the posterior cerebral artery can be used as a recipient vessel. The most important drawback of performing direct anastomotic surgery is enlargement of anastomosis in half of the patients increasing the risk of rupture. [22]

While the indirect approach involves putting a tissue in the location of ischemia. Another similar approach to indirect approach is encephalo- duro-arterio-synangiosis (EDAS) which is performed by laying a branch of vessel in the ischemic area to create a new vessel. [23]

5.2. Complex Intracranial Aneurysms

A complex intracranial aneurysm is a surgical term for all those untreatable, large aneurysms. The most common symptom of these complex intracranial aneurysms is headache. The less common symptoms are transient ischemic attacks, cranial nerve palsies and altered mental state. Sometimes there is no presenting feature and they are diagnosed while treating any other disorder. Endovascular treatment is the treatment of choice for these aneurysms as they have less complications, but in some cases where endovascular procedures are not recommended, Surgeons have to opt for Cerebral revascularization. [24]

5.3. Skull Based Tumors

There is limited use of cerebral revascularization in the oncological procedures, but its use cannot be denied in the surgery of tumours where a vessel has to be removed or in cases where there is high risk of intraoperative vessel injury. In meningiomas that can compress internal carotid artery or vertebral artery or when there are not enough collaterals, Gross total resection should be avoided and subtotal resection

should be considered. Data suggests that even after undergoing cerebral revascularization of skull base tumours, development of focal stenosis and occlusion is seen in long term. [25]

6. Conclusion

The improved medical sector including the latest advances in microsurgical procedure can result in revival of life saving Revascularization surgeries. New budding AI and other microscopical advancement can be used to alleviate the game of Neurosurgery. In spite of new trends, the traditional methods of bypass should be learnt by new neurosurgeons as there are many instances where only cerebral revascularization works. Indication and Contraindications must be clearly outlined in order to consider a patient for revascularization surgeries. Although the admirable advances showed in the recent years in endovascular, medical and radiation therapies, there is a limited number of patients respectively affected by complex aneurysms, atherosclerotic occlusive disease, and skull base tumors which should undergo, as primary treatment, to bypass procedures. Thus, it is important that the surgeons, mainly the young generation, continue to improve their bypass technique using laboratory training in order to have this skill in their surgical armamentarium for the cases they will encounter. [26] With deeper knowledge of cerebral ischemia and careful selection of patient's, Neurosurgeons will be able to save many precious lives. Further research and advancement in this field is required to amplify the benefits from this surgery.

Abbreviations

IC: Internal Carotid
EC: External Carotid
VA: Vertebral Artery
MCA: Middle Cerebral Artery
STA: Superficial Temporal Artery
EDAS: Encephalo Duro Arterio Synangiosois

Author Contributions

Avatar Singh is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Ding Q, Liu S, Yao Y, Liu H, Cai T, Han L. Global, regional, and national burden of ischemic stroke, 1990-2019. Neurology 98, E279-E290.

[2] Kawashima M, Rhoton AL, Tanriover N, Ulm AJ, Yasuda A, Fuji K. Microsurgical anatomy of cerebral revascularization. Part II: Posterior circulation. February 2005Journal of Neurosurgery 102(1): 132-47. https://doi.org/10.3171/jns.2005.102.1.0132

[3] Hodje C J, Gross CE, Cerebral revascularization. Acta Neurochir 44. 115-130(1978).

[4] HaydenMG, Lee M, Guzman R, Steinberg GK. The evolution of cerebral revascularization surgery. Neurosurg Focus. 2009; 26(5): E17.

[5] Carrel A: Nobel price in physiology or medicine 1912. Amsterdam: Elsevier Publishing company, 1967.

[6] German WJ, Taffel W: Surgical production of collateral intracranial circulation: An experimental study. Proc Soc Exp Biol. Medf 42: 349-353, 1939.

[7] Kradel FE: Collateral cerebral circulation by muscle graft: technique of operationwith report of 3 cases. South Surgeon 10: 235-244, 1942.

[8] Jacobson JH II, Wallman LJ, Schumacher GA, Flanagan M, Suarez EL, DonaghyRM: Microsurgery as a aid to middle cerebral artery endarterectomy. J Neurosurg 19: 108-115, 1962.

[9] Jacobson JH II, SuarezEL: Microsurgery in anastomosis of small vessels. Surg Forum 11: 243-245, 1960.

[10] Kurze T: Microtechniques in neurological surgery. Clin Neurosurg 11: 128-137, 1964.

[11] Robert M. Starke, Mark Chwajol, Daniel Lefton, Chandranath Sen, E. Sander Connolly, Alejandro Berenstein, David J. Langer. Revascularization of brainstem and cerebellum. Researchgate.

[12] Mathew J. Gallagher, Joseph Frantzias, Ahilan Kailaya-Vasan, Thomas C. Booth, Christos M. Tolias. https://doi.org/10.3389/fradi.2022.981501

[13] Karasawa J, Kikuchi H, Furuse S, Kawamura J, Sakaki T: Treatment of moyamoya disease with STA-MCA anastomosis. J Neurosurg 49: 679–688, 1978.

[14] Ausman JI, Diaz FG, Vacca DF, Sadasivan B: Superficial temsporal and occipital artery bypass pedicles to superior, anterior inferior, and posterior inferior cerebellar arteries for vertebrobasilar insufficiency. J Neurosurg 72: 554–558, 1990.

[15] Sundt TM Jr, Whisnant JP, Piepgras DG, Campbell JK, Holman CB: Intracranial bypass grafts for vertebral-basilar ischemia. Mayo Clin Proc 53: 12–18, 1978.

[16] Lawton MT, Spetzler RF. Internal carotid artery sacrifice for radical resection of skull base tumors. Skull Base Surg. 1996; 6: 119–23 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1656574/

[17] Ramanathan D, Temkin N, Kim LJ, Ghodke B, Sekhar LN. Cerebral bypasses for complex aneurysms and tumors: long-termresults and graft management strategies. Neurosurgery. 2012; 70: 1442–57. https://doi.org/10.1227/NEU.0b013e31824c046f

[18] Sekhar LN, Natarajan SK, Ellenbogen RG, Ghodke B. Cerebralrevascularization for ischemia, aneurysms, and cranial base tumors. Neurosurgery. 2008; 62(Suppl 3): 1373–410. https://doi.org/10.1227/01.neu.0000333803.97703.c6

[19] Abla AA, Gandhoke G, Clark JC, Oppenlander ME, Velat GJ, Zabramski JM, et al. Surgical outcomes for moyamoya angiopathy at barrow neurological institute with comparison of adult indirect encephaloduroarteriosynangiosis bypass, adult direct superficial temporal artery-to-middle cerebral artery bypass, and pediatric bypass: 154 revascularization surgeries in 140 affected hemispheres. Neurosurgery. 2013; 73: 430–9. https://doi.org/10.1227/NEU.0000000000000017

[20] Starke RM, Komotar RJ, Connolly ES. Optimal surgical treatment or moyamoya disease in adults: direct versus indirect bypass. Neurosurg Focus. 2009; 26: E8. FOCUS08309. https://doi.org/10.3171/2009.01

[21] Extracranial to intracranial bypass and the prevention of stroke. Lancet 2: 1401–1402, 1985. https://www.ncbi.nlm.nih.gov/pubmed/

[22] Molyneux A, Kerr R, Stratton I, et al. International subarachnoid aneurysm trial (ISAT) of neurosurgical clipping versus endovascular coiling in 2143 patients with ruptured intracranial.

[23] aneurysms: a randomised trial. Lancet. 2002; 360(9342): 1267–74. https://www.ncbi.nlm.nih.gov/pubmed/12414200

[24] Spetzler RF, Roski RA, Kopaniky DR. Alternative superficial temporal artery to middle cerebral artery revascularization procedure. Neurosurgery. 1980; 7(5): 484–7. https://doi.org/10.1227/ 00006123-198011000-00012

[25] Narata AP, Yilmaz H, Schaller K, Lovblad KO, Pereira VM. Flowdiverting stent for ruptured intracranial dissecting aneurysm of vertebral artery. Neurosurgery. 2012; 70(4): 982–8. 1227/NEU.0b013e318236715e. https://doi.org/10.1227/NEU.0b013e318236715e

[26] Zaed S, Tinterri B, Giordano M. Use of Cerebral Revascularization Techniques in the Endovascular Era. Is it Still a Useful Technique? SN Comprehensive Clinical Medicine. https://doi.org/10.1007/s42399-019-00158-2