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Research Progress in Surgical Management of Head and Neck Tumors Involving the Carotid Artery

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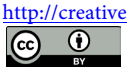

Abstract

The surgeons adopt the comprehensive treatment method basing on surgery When head and neck tumors involve the carotid artery. At present, there are four surgical treatments, namely, dissection of carotid artery tumor, resection of carotid artery, revascularization after carotid resection, endoarterial implantation of covered stent combined with surgical resection. However, there is currently no consensus on the standard surgical approach to choose. This paper describes the four surgical methods, which are expected to be helpful for head and neck surgeons to choose the surgical methods for head and neck tumors involving the carotid artery.

Keywords

Head and Neck Tumor, Carotid Artery, Surgical Management

1. Introduction

Based on the statistics provided by GLOBOCAN, it is projected that there will be over 930,000 newly diagnosed cases of head and neck cancer worldwide in 2020. This particular type of cancer is ranked 7th in terms of incidence rate. Additionally, approximately 15% of these cases are expected to occur in my country [1]. In 2020, over 460,000 individuals lost their lives due to head and neck cancer, making it the 8th leading cause of cancer-related fatalities [2] [3]. Advanced head and neck tumors often invade the carotid arteries, and the effects of radiotherapy and chemotherapy are ineffective. In clinical settings, the primary approach for comprehensive treatment involves a combination of different treatment modalities, with surgery being the main option [4] [5] [6]. There are four main

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surgical methods, namely dissection of carotid artery tumor, resection of carotid artery, revascularization after carotid resection, endoarterial implantation of covered stent combined with surgical resection. Based on the presence of both benign and malignant tumors, the patient's ability to develop collateral circulation, perioperative monitoring capabilities, perioperative management, and potential postoperative complications, the selection of a surgical approach is a topic of debate in clinical practice. This article aims to provide information on four different surgical techniques to assist surgeons specializing in head and neck tumors in selecting the most appropriate surgical method for cases involving the carotid artery.

Preoperative evaluation of blood flow is crucial irrespective of the surgical method selected. Currently, commonly used preoperative blood flow evaluation methods include: DSA (digital subtraction angiography), Matas test, BTO (balloon test occlusion), cerebral blood flow imaging with computer, 133Xe-CT cerebral perfusion imaging, SPECT (Single Photon Emission Computed Tomography) cerebral perfusion imaging, and PET (Positron Emission Tomography). DSA can assess the degree of arterial compression, tumor invasion, and whether there is any abnormality in the circle of Willis in the brain. It is a necessary preoperative examination. The Matas test, developed by Matas, is the earliest test for carotid artery occlusion. However, using this method alone cannot provide quantitative data, and it is difficult to completely occlude the carotid artery only by finger pressure. The BTO experiment can analyze the relationship between the tumor and the carotid artery, whether it is wrapped, and the source of the blood supply of the tumor. If necessary, preoperative embolization can be performed [7]. The use of 133Xe-CT imaging technique enables direct assessment of the hemodynamics of the brain. However, it is limited to measuring cerebral blood flow (CBF) and cannot provide information about the function of brain cells. Moreover, its lack of reproducibility has resulted in its limited clinical application. Both PECT and PET imaging techniques can assess blood flow in the entire brain and provide an estimation of the brain's functional status. However, due to its higher cost, PET is less commonly used in clinical settings compared to SPECT, which has a wider range of clinical applications [8] [9]. Even though there are multiple ways to assess brain collateral circulation capacity, the results obtained from different assessment methods may contradict each other. Chen Fei and colleagues conducted the Matas test on 29 patients over a period of four weeks. During this time, the patients did not experience any significant discomfort. However, in two cases, positive reactions were observed in the BTO test monitoring [10] [11]. Zhang Zhi Yuan evaluated the blood flow before the surgery by using a combination of BTO, SPECT, measuring carotid artery stump pressure, and detecting cerebral blood flow with transcranial Doppler. Based on the results, He selected the most suitable surgical method. Fortunately, none of my patients experienced any noticeable symptoms after the resection or reconstruction, indicating that there was no neurological dysfunction [12].

2. Dissection of Carotid Artery Tumor

This technique is suitable for tumors that are not closely adhered to the carotid artery, where the tumor surrounds the carotid artery by less than 180˚, and there is a gap that allows the tumor to be separated from the carotid artery. According to the research conducted by Jacobs *et al*., it has been proven that the extent of tumors surrounding the cervical arteries can be used to predict the prognosis. The study found that patients with tumors spanning over 180˚ around the cervical arteries have a lower total survival rate of 8.3%, compared to patients with tumors spanning less than 180˚ who have a higher total survival rate of 33% [13]. Therefore, if the tumor involves less than 180˚ of the carotid artery, consider tumor dissection. Otherwise, it is necessary to remove the carotid artery and perform vascular reconstruction. Because this arterial artery is not operated, it can largely avoid postoperative nervous system complications. However, it cannot obtain sufficient safety boundaries. The chance of recurrence after surgery is high, and the tumor stripping difficulty during surgery is high. Multiple studies have shown that in patients with head and neck tumors involving the carotid artery, approximately 40% of the carotid artery specimens show invasion. This means that if the tumor is removed along with the blood vessel, nearly 60% of the carotid artery is unnecessary to be removed [14] [15]. When performing a surgical resection, it is ideal for the surgical margin of the tumor to be as wide as possible. Within a certain range, a wider surgical margin increases the likelihood of completely removing the tumor and reduces the chances of local tumor recurrence [16] [17]. For malignant tumors, if they are not completely removed, it means that they do not have a safety margin. The margin of the head and neck malignant tumor is a critical factor that affects the outlook for patients. By effectively controlling the rate of positive margins after surgery, the risk of local recurrence can be reduced. In the case of avoiding unbroken arterial resection and reducing the positive rate of cutting edge, it is a dilemma for surgeons. Therefore, this surgical application is more commonly used in limited cases, particularly for benign tumors like Shamblin I cervical arterial tumors.

3. Resection of Carotid Artery

This technique is mostly used for patients with tumor and carotid adhesion that is seriously separated or tumor extends to patients with the bottom of the skull or intracranial [18]. Although the procedure of carotid artery resection completely blocks the blood supply to one side of the brain, the opposite side is supplied with blood through increased blood flow velocity and volume via the Willis circle, thus preventing cerebral ischemic attacks [19]. Even though the brain on the affected side can receive blood supply from the opposite side's cerebral arteries, if the preoperative circulation function exercise and blood flow assessment of the side branches are not conducted, blindly removing tissue can result in a postoperative stroke or a mortality rate of 30% [20] [21]. The majority of these complications occur between 1 to 5 days after the operation rather than imme-

diately after. These complications are caused by blood clot formation at the site of ligation, which then travels through the bloodstream to the brain, resulting in neurological complications [22]. According to the research conducted by Kiyoshi Togawa, out of the 156 patients who underwent carotid artery ligation, there were 16 cases (10.3%) of transient cerebral disorders, 47 cases (30.1%) of death, coma, and hemiplegia, and 93 cases (59.3%) of patients without any complications [23]. However, in the case of Zhang Yan and others, no surgical deaths or postoperative neurological complications occurred in 31 patients who underwent tumor resection combined with preoperative daily carotid artery compression exercise for 2 - 6 weeks and assessment of cerebral blood flow using computerized tomography [19]. The advantage of this technique is that it does not require the reconstruction of the carotid artery. The cost is that it requires adequate preoperative exercise of collateral circulation ability and thorough preoperative evaluation, with negative BTO test, negative SPECT occlusion test, and carotid residual reflux pressure greater than 70 mmHg. However, due to the fact that this technique does not preserve the carotid artery, the possibility of completely removing the tumor is high, the local control rate is high, and the risk of local tumor recurrence is low. Additionally, postoperative radiation therapy can start earlier [23]. Although this technique has significant advantages in local control, the incidence of postoperative neurological complications is high, so it is not widely used in clinical practice.

4. Revascularization after Carotid Resection

After exposing the tumor during surgery, it first dissociates around the tumor to the adhesion between the tumor and the carotid artery, then temporarily blocks the far and near ends of the carotid artery, and inserts a bypass tube. After cutting off the carotid artery at both ends of the tumor, autologous or artificial blood vessels are used for anastomosis, and then covered with muscle flaps after anastomosis [24]. Carrea and his team successfully performed arterial reconstruction for the first time in 1951. Due to the procedure of cervical artery revascularization, there is some restoration of the anatomical structure, resulting in fewer neurological complications compared to cervical artery resection. According to the meta-analysis conducted by Satoshi Katsuno, it was found that among 148 patients who underwent carotid artery revascularization after resection, 4.7% experienced neurological complications [25]. However, a study conducted by Leif J. J. Bäck *et al.* involving a meta-analysis of 491 patients demonstrated that carotid artery reconstruction could potentially lower the risk of stroke to 3.7% [26]. Compared with blind carotid artery resection, vascular reconstruction significantly reduces postoperative neurological complications, which is also the reason for its widespread clinical application. At present, clinically mature reconstructed blood vessels include autologous saphenous vein, artificial blood vessel, and superficial femoral artery. Although there are many types of reconstruction vessels available, the great saphenous vein is currently

the most widely used transplant vessel in clinical practice. Kenji Nishinari and colleagues utilized the great saphenous vein as a graft vessel. Among the 19 patients, only one patient experienced vascular occlusion during the perioperative period. The patency rate at 5 years was 93.1%. Artificial blood vessels are porous hydrophobic polymers with negative charges on the surface. After transplantation, fibroblasts and connective tissue can grow in micropores, ultimately forming a complete vascular intima. The team of Zhensyuan and others successfully performed a complete tumor resection using polytetrafluoroethylene artificial blood vessels, without any temporary or permanent central nervous system complications [27]. Giulio Illuminati *et al.* used polytetrafluoroethylene artificial blood vessels as transplant materials in 31 cases. Within 1 month after surgery, there was no patient death or stroke, only mild neurological damage such as swallowing difficulty and vocal cord paralysis. No occurrences of stroke, graft infection, thrombosis, or anastomotic fistula were observed during the 5-year follow-up period [28]. The femoral artery has the advantages of high mechanical strength and strong infection resistance. Ramon Berguer *et al.* achieved continuous patency of blood vessels in 11 cases over a 14-month follow-up period by using the superficial femoral artery as a graft material [29]. Although performing vascular reconstruction reduces postoperative complications of the nervous system, the use of bypass grafts may potentially lead to vascular damage and secondary thrombus formation [30]. Moreover, the majority of patients have a history of preoperative radiotherapy or surgery, which leads to weakened arterial wall elasticity and disappearance of normal anatomical structures, resulting in increased intraoperative bleeding and delayed postoperative radiotherapy. Currently, this surgical technique is the most commonly used and mature method in clinical practice. However, it requires strict criteria such as patient's own condition, preoperative assessment, surgeon's skills, absence of wound infection, use of perioperative anticoagulant drugs, effective wound drainage, and adequate hardware facilities.

5. Endoarterial Implantation of Covered Stent Combined with Surgical Resection

The procedure requires the implantation of a covered stent in the carotid artery, extending at least 3 cm beyond the affected arterial segment. One month later, a second surgery is performed. By this time, a new layer of endothelial cells has formed inside the stent, preventing arterial bleeding and facilitating the removal of the tumor and affected artery. This significantly reduces the surgical risk and improves survival rates [31]. This technique is suitable for patients with high risk factors for intraoperative injury to the carotid artery, such as tumors that wrap around the carotid artery for more than 180˚, narrowed or irregular blood vessel walls, multiple lesions on the same side, or a history of radiation therapy or surgery [32] [33]. Currently, laminated stent is widely used in clinical practice for the prevention of vascular rupture, acute carotid artery injury, arterial aneu-

rysms, benign tumors such as paragangliomas, etc [34]. It is less commonly used in surgeries involving tumors that affect the carotid artery and lacks mid-to-long-term follow-up results. A case report published by foreign scholar Madison describes a successful intraoperative detachment of the affected carotid artery wall from the stent, followed by complete removal of the surrounding tumor. The exposed stent was wrapped circumferentially with a synthetic patch material. The patient tolerated the procedure well and postoperative vascular imaging showed normal filling of the internal carotid artery [35]. A group of scholars led by Zhenkun Yu in China published a case report that included six patients. In the treatment, they used a coated stent to cover and extend at least 1 cm beyond the affected arterial segment. Each patient received treatment with 5000 U of low molecular weight heparin for 6 - 10 days. After three days, surgical treatment was performed to remove the tumor and affected artery, followed by coverage with a muscle skin flap. Following 18 months of postoperative follow-up, one patient died from multiple organ failure at 6.5 months after surgery. Another patient underwent salvage surgery for tracheostomy recurrence and died 11 months later due to distant metastasis. One patient experienced lung metastasis and died at 18 months after surgery. The remaining three patients had no disease recurrence at the last follow-up [36] [37]. This technique allows for the removal of tumors and affected arteries without interrupting blood flow in the carotid artery, avoiding ligation and reconstruction of the carotid artery. It is becoming increasingly common in clinical practice due to its simplicity and shorter operation time. When the laminated stent is implanted, it may stimulate the carotid sinus and cause low blood pressure. And if there is severe narrowing of the carotid artery, wide infiltration of the vascular wall, a history of radiation therapy or surgery, it will make it difficult to implant the stent [38]. Clinical trial administration is difficult, and detailed case reports are scarce.

No matter which surgical method is chosen, there is a possibility of postoperative complications such as stroke, arterial infection, or rupture. Stroke is a common complication. Currently, there are two main theories explaining the mechanism of complications after stroke. According to one theory of cerebral ischemia, insufficient blood supply from the Willis circle after surgery can result in cerebral ischemia and hypoxia. Before surgery, it is important to thoroughly assess the vascular condition and select the appropriate surgical method. During the perioperative period, it is important to control hypertension. When performing vascular reconstruction, it is advisable to minimize the duration of blood flow obstruction. After surgery, it is necessary to maintain a systolic blood pressure above 90 mmHg. Sufficient circulating blood volume should be maintained, and vascular active drugs should be used if necessary to maintain circulatory stability [39] [40]. Another theory is the thrombosis formation theory, where thrombosis forms at the transplant or ligation site and leads to stroke as blood flows. It is necessary to minimize damage to the vascular wall. The transplanted blood vessel used should have a diameter as close as possible to the caro-

tid artery [41]. During the process of extraction and anastomosis of blood vessels, care should be taken to avoid damage to the vascular intima. Low molecular weight heparin, warfarin, and other anticoagulant drugs should be used during the perioperative period [42]. The infection or rupture of arteries often occurs in patients with localized infections or preoperative radiotherapy. During surgery, muscle-flap coverage is provided, and antibiotics are used during the perioperative period to reduce the risk of arterial infection or rupture [40] [43].

6. Discussion

Head and neck tumors that involve the posterior neck artery have a poor prognosis and pose significant challenges in treatment. Different surgical approaches have varying indications and advantages. A comprehensive preoperative evaluation is necessary, along with multidisciplinary discussions involving head and neck surgery, anesthesia, intervention, imaging, neurology, and neurosurgery, in order to develop an appropriate treatment plan that can improve the patient's survival rate, survival time, and quality of life.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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