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Progress of Middle Meningeal Arterial Embolization for Chronic Subdural Hematoma

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Abstract: ***Chronic subdural hematoma (intermediate intracranial hemorrhage, CSDH) is a space-occupying disease, which is mostly common in neurosurgery and more common in old age. At present, surgical treatment is mainly used, but the postoperative recurrence rate is high, which is the most important treatment method at present. As a new treatment for CSDH, meningeal artery embolization has been found to block the blood supply of CSDH, but there is no further research and recognized consensus. The authors summarized the progress of anatomical research, technical methods and precautions, material selection and therapeutic effect of meningeal arterial embolism for CSDH.***

Keywords: Chronic subdural hematoma, CSDH, Middle Meningeal Arterial Embolization**.**

1. Introduction

Subdural hematoma (CSDH) refers to the dural and interarachnoid venous blood on the surface of the brain, with high morbidity, recurrence rate and mortality, which is more common in the elderly [1]. According to statistics, the incidence rate is 1.72~20.60/10 million [2]. Due to the aging of the population and the wide use of anticoagulants, the incidence and mortality of CSDH are increasing year by year, and its incidence is expected to increase within 10 years [3].

2. Current Status of CSDH Treatment

2.1 Surgical Treatment Plan

Established visit guidelines for patients with CSDH, which are not currently well documented in the literature. CT suggests that patients with significant disturbance of consciousness, and difficulty in walking, such as hematoma with a maximum thickness of 10mm, and hematoma with midline deviation of 5mm, often tend to prefer surgical treatment. Drilling and drainage is a major clinical treatment of chronic subdural hematoma with obvious symptoms improvement and advantages of simple operation and high surgical safety [3-5]. However, with clinical studies, complications such as intracranial injury, intracranial emphysema and infection also occur after drilling and drainage surgery for chronic subdural hematoma. Therefore, in order to improve the treatment plan of chronic subdural hematoma, improve the prognosis of patients, and reduce the complications, it is urgent to explore more effective treatment methods.

2.2 Conservative Treatment Methods

Since the incidence of chronic subdural hematoma is more common in the elderly, the elderly patients without obvious symptoms and tolerance, such as advanced age and long-term history of anticoagulants for cardiovascular diseases, are important factors to be considered in surgical decision-making [6]. The complex pathophysiological process involves the formation, expansion, and recurrence of CSDH [7-8], such as persistent complex inflammatory response, instability of new angiogenesis, abnormal coagulation function and abnormal fibrinolysis, these processes involve CSDH formation, expansion and recurrence of CSDH. Based on pathological and physiological characteristics, some effective therapeutic drugs have been discovered, which have anti infective and protective effects, promote myocardial ischemia reperfusion, accelerate blood clot dissolution, inhibition of arteriosclerosis progression and improve heart function glucocorticoid drugs (such as dexamethasone), statins (such as atorvastatin calcium), etc. Atorvastatin can also prevent the occurrence of cardiovascular disease, help to stabilize atherosclerotic plaque, enhance endothelial function at the same time, slow down the speed of atherosclerosis, ensure that nerve function is not damaged, produce vascular endothelial effect, reduce inflammatory response. Recent studies have shown that in addition to reducing the recurrence risk of chronic subdural hematoma, the use of atorvastatin can also promote the improvement of related symptoms, effectively relieve cerebral vasospasm, and also well improve the recovery of cerebral blood supply and cerebral compression tissue. However, for elderly patients with no history of diabetes or fair blood glucose level control, eosinophils of the outer membrane of subdural hematoma, reduce fibrinysis and prevent coagulation plate caused by control of chronic bleedingSet of glucocorticoid combination therapy. And reduce the permeability of the hematoma envelope, prevent exudation, regulate the inflammatory response, and effectively reduce cerebral edema, relieve intracranial pressure, remove free radicals, promote cerebral reduction and other effects. However, the effect of drug therapy is relatively limited, and for patients with large blood loss and more severe disease, drug treatment alone may not achieve the ideal treatment effect. At the same time, studies have shown that 84% of patients eventually need surgery (56/6) [9].

2.3 Current Treatment Status of MMA Embolization

Studies [10] in recent years have shown that the arterial responsible branch (MMA) can effectively block the blood supply of CSDH by embolization of the meninges, thus promoting the reabsorption of the hematoma. There have been more and more research results, especially in patients with

CSDH or high risk of recurrence, that MMA embolization can be used as a surgical alternative therapy for CSDH, with the guarantee and effectiveness of adjuvant or remedial therapy before or after surgery. However, currently, relevant consensus guidelines are lacking, and the embolic materials used clinically also vary greatly. This paper aims to summarize the relevant anatomical basis, technical methods and precautions of MMA embolization for CSDH, as well as the research progress of clinical embolization materials, and to deeply study the clinical application of MMA embolization, which will be explained.

3. Anatomic Basis of MMA Embolization for Chronic Subdural Hematoma

Intracranial chronic space-occupying disease, or CSDH. Research on the formation mechanism of CSDH found in the subarachnoid boundary cells, fibroblast cells and inflammatory cells, after receiving external factors such as injury, release of fibrin dissolve blood clot, produce angiogenic factors, prompted the dura lateral membrane and arachnoid lateral membrane the dura and arachnoid outer membrane, namely the lateral membrane and the arachnoid membrane formation, causing the dura boundary cell layer covered in hematoma cell inflammation factors [3,6]. A large number of new microvessels exist in the adventitial structure, and the repeated rupture of these unstable vessels will cause continuous bleeding in the subdural space and the formation of an enlarged source of hematoma. For the histological features of CSDH, Nagahori et al [11] found that it has 2-3 layers, and the outer membrane contains a large number of fine new blood vessels. It is assumed that the inflammatory reaction of the outer membrane and the structure related to the microvessels in the hematoma expansion, which provides a theoretical basis for subsequent research, and assume that the outer membrane inflammatory reaction and hemorrhage play an important role in the expansion of hematoma. In 1997, in 31 patients operated on for CSDH [12], after the collection of adventitial and dural pathological samples and tissue science examination, the adventitia of CSDH contains veins, arteries, and microvessels, which are associated with MMA. And Tanaka and Kaimori [13] proposed the possibility of branch artery CSDH embolization when identifying the branches of MMA that provide outer membrane blood supply to CSDH and dividing it into all small branches of the entire outer membrane. Some researchers have performed angiographic imaging of patients with CSDH [3,6], found that the ends of the MMA branch were stained into cotton wool, which makes it possible to supply the hematoma outer membrane to the microvessels. Meanwhile, this characteristic staining appeared more prominent for selective contrast MMA. All the above results showed that the MMA terminal branch provides blood supply support for the epidural hematoma envelope, while the rupture of the terminal tiny vessels promotes the bleeding and enlargement of the hematoma. In principle, by embolizing the middle meningeal artery, the blood supply to the hematoma can be blocked from the source. After embolization of the middle meningeal artery, the blood supply within the hematoma is reduced, which contributes to the gradual absorption of the blood within the hematoma and promotes the reduction of the hematoma. At the same time, this method can prevent the injection of fresh blood and further reduce the risk of hematoma enlargement. After treating one patient with CSDH by embolizing MMA was first reported in 2001 by Mandai et al [14]. Since then, the efficacy of middle meningeal artery embolization for chronic subdural hematoma has been recognized by more neurosurgeons.

4. Meningeal Artery Embolic Procedure and Material Selection

4.1 The MMA Embolization Procedure was Performed

Depending on the patient condition, embolization can usually be performed under general or local anesthesia [6,13]. Angiography should be performed before surgery to avoid dangerous collateral (e.g., facial paralysis caused by embolization of MMA branch, MMA and ophthalmic artery branch) [4,6], To evaluate the responsible vessel and branch of the hematoma. For embolization, a 5F or 6F catheter was used to enter from the femoral artery to the trunk of the maxillary artery on the affected side [4,13]. The apical branch and frontal branch of the meningeal artery were identified as the target vessels. After confirming the end position of the catheter was correct, the material was slowly put into the embolization, and attention to avoid the return of the material. The blocking of the responsible vessel was confirmed again through angiography, and the catheter was finally withdrawn to complete the operation, so as to complete the closure of the catheter.

4.2 Material Selection for MMA Embolization

The embolic materials commonly used for MMA embolization are divided into two main categories, solid state and liquid state. Solid materials include polyvinyl alcohol (PVA) particles, gelatin sponge particles and nonelastic spring coil, etc. Among them, PVA material is the most used embolic material in clinical practice, because of its good water solubility, it is not easy to absorb in the body [15-16]. Fiorella et al [17] suggested that PVA material is a particle of uneven size of the friction catheter, which may be embolized, not made for blood vessels. Moreover, because the crude catheter needs to be used during the operation, resulting in vasospasm, and the possibility of embolizing small and tortuous blood vessels cannot be ruled out. The gelatin sponge granule belongs to the protein matrix, which has good compressibility and can reexpand when it meets water. It is a kind of absorbable solid embolic substance and belongs to the protein matrix that can be absorbed by tissues [14]. According to the meta-analysis of studies by Dian [18], 42% (81/200) of the experimental group were selected for the extraction of gelatin sponge particles. However, the gelatin sponge in the gelatin sponge is not the same as the permanent substance, and there is the possibility of a vascular embolism again. The use of unspring coils in embolization of CSDH is rare and extensive studies are lacking. Wang Chao et al [19] reported a case of a recurrent chronic subdural hematoma (CSDH) with MMA with a detspring coil. At review one month after surgery, the patients hematoma volume decreased significantly and his preoperative tinnitus symptoms improved significantly. However, some studies have shown that the cost of coil coil is high and there is a risk that the material can not reach the distal end of MMA. At present, the material is less used in clinical practice.

Liquid embolic materials include vinyl alcohol copolymer (Ethylenevinylalcoholcopolymer, EVOH) and n-butyl-2-cyanopropionate (N-Butyl-2-Cyanoacylaslate, NBCA), etc. Compared to solid-state embolic materials, a miniature catheter can be used when entering into the EVOH, which not only reduces the possibility of vasospasm, but also has some benefit to permanent embolization, thus affecting the embolization of the MMA branch. Fiorella et al [17] found that EVOH is more likely to be developed as a liquid embolic agent in angiography, and EVOH is not easy to absorb, so the operator can achieve permanent angiography by observing the results of embolization and the possibility of material reflux. But some studies [20] were pointed out that EVOH should be combined with dimethyl sulfoxide, which has strong vascular toxicity and too fast infusion will cause pain and then affect the coordination, not local anesthesia. What kind of material to choose, to determine the use of the material, so far still needs further comparative research.

5. Efficacy of MMA Embolization in CSDH

Catapano [21] et al first reported a case of recurrent episodes after drilled drainage of an embolized MMA in a patient with CSDH complicated with coagulopathy. Kang [22] reported that MMA embolization combined with drilling and drainage for one recurrent CSDH, with no recurrence after surgery. Link [23] found that 41 of 45 patients (91.1%) could receive conservative treatment, and subsequent CT indicated a significant decrease in hematoma, and 31 (68.9%) decreased hematoma volume by more than 50%. Ban [9] conducted logistic regression analysis to compare the follow-up results of the interventional embolization group (72 cases) six months later, and found that none of the 72 patients in this group had postoperative complications. In the 469 drill hole group, 20 had complications with a calculated odds ratio of 0.145 (P-value of 0.182). Studies have demonstrated that MMA embolization has significant efficacy for the treatment of CSDH. 20 comparative studies data from Ironide et al were included in the meta-analysis [24]. The hematoma recurrence rate of patients in the MMA embolization treatment group was 5.5%, 26.7% of the patients were in the traditional surgery group, 42.8% (307/718), patients with embolic MMA as a surgical adjuvant were 27.8% (197/718), 29.8% (214/718), no recurrence or retreatment was observed in patients undergoing preset embolization. After the surgical adjuvant therapy, the proportion of patients with hematoma recurrence or retreatment after MMA embolization was the recurrence rate after 29. MMA embolization of 4.2% (11 cases/256 patients), The retreatment rate was 2.9% (7 cases/239 cases). According to Dian's research [18], among 888 patients with chronic subdural hematoma, the recurrence rate was lower than that of the traditional surgery group (3.5%, P=0.01). However, the incidence of patients in the surgical group and the embolism group was not statistically significant, such as no statistically significant patients in the embolic group (38/688), no statistically different, no statistical difference (P=0. 59), such as no statistical difference (p=0. 01).

6. Summary and Outlook

In conclusion, MMA embolization as a new means of CSDH treatment has new advantages over traditional treatment regimens. In particular, MMA embolization is a new option for patients without obvious symptoms of CSDH and multiple high risk factors (coagulation disorder, advanced age, anesthesia intolerance). MMA embolization and MMA embolization combined with traditional surgery is an ideal option to patients. However, as an emerging technology, MMA embolization lacks a consensus on the indication of MMA embolization, the feasibility as a separate treatment, the reasonable selection of embolization materials and the timing of embolization. At the same time, most of the related studies are retrospective, single center of the randomized trial, there are inherent risk of bias, combined with the domestic MMA embolization further clinical research, its effectiveness and safety needs to be in clinical promotion and further research, the current domestic application of MMA embolization still has some deficiencies. Currently, clinical trials and randomized controlled studies of MMA embolization related to CSDH are being widely conducted internationally. In the future, with the continuous progress in medical technology and accumulating clinical experience, MMA embolization is expected to play a greater role in the treatment of chronic subdural hematoma.

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