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Progress in Surgical Treatment of Atrial Fibrillation

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Abstract

Atrial fibrillation AF, abbreviated as atrial fibrillation, is a common rapid supraventricular arrhythmia, and its incidence is gradually increasing with age. In recent years, the long-term effect of general drug treatment of atrial fibrillation is unsatisfactory, and the rate of cardioversion is low, the antiarrhythmic drugs may induce other arrhythmias and other extracardiac side effects, and the long-term survival rate is not significantly improved. The treatment of atrial fibrillation is DC cardioversion, catheter ablation, radiofrequency ablation followed by open heart surgery, left atrial appendage occlusion, etc., and with the study of the mechanism of atrial fibrillation, combined with the application of clinical new energy; surgical treatment of atrial fibrillation has become an important method. This article reviews the progress of surgical treatment of atrial fibrillation.

Keywords: atrial fibrillation; maze surgery; surgical treatment

Introduction

Atrial fibrillation is a common type of arrhythmia. The main risks of atrial fibrillation are: 1. Subjective symptoms caused by arrhythmia: palpitations, anxiety, etc. 2. In the case of atrial fibrillation, atrioventricular synchronous contraction loss, atrial contractile function declines the cardiac output is reduced by about 10%. If valvular heart disease is combined, the cardiac output will be reduced by 15%-20%. In severe cases, heart failure can also be induced. Third, the heart rate is fast and irregular due to hemodynamic. Changes in the atrium blood form a vortex, leading to blood stasis, thrombosis; embolism may result in different parts of the body, serious complications, seriously affecting the quality of life of patients.

Classification of Atrial Fibrillation

At present, different types of atrial fibrillation have great differences in clinical manifestations and risks, and treatment options are also completely different. Therefore, a correct understanding of the type of atrial fibrillation has important clinical significance for the effective prevention and treatment of atrial fibrillation. At present, according to the characteristics of atrial fibrillation, atrial fibrillation is divided into four types [1]:

1. Initial atrial fibrillation: the first detected atrial fibrillation; patients may have symptoms, or without any symptoms, can also be expressed as Paroxysmal atrial fibrillation, persistent atrial fibrillation, permanent atrial fibrillation.
2. Paroxysmal atrial fibrillation: The duration of atrial fibrillation is less than 48 hours and the duration of the disease are no more than 7 days.
3. Persistent atrial fibrillation: the duration of atrial fibrillation is more than 7 days, no self-limiting, requiring medical treatment or cardioversion to convert to sinus rhythm.
4. Permanent atrial fibrillation: The sinus rhythm cannot be restored after treatment with atrial fibrillation or cardioversion, or the drug cannot maintain sinus rhythm after successful conversion.

Epidemiology and Pathogenesis of Atrial Fibrillation

There are many reasons for atrial fibrillation. Various types of cardiac organic diseases, degenerative diseases, hyperthyroidism, obesity, increased age, and rheumatism can cause atrial fibrillation. According to a large-scale epidemiological survey of atrial fibrillation, the overall incidence of atrial fibrillation in China is 0.77% and with the increase of age, the proportion of population aging is increasing, and the incidence of atrial fibrillation is common. [2] The population also increased significantly, reaching 0.4%-1.0%, and the incidence of atrial fibrillation increased by 5 times in 70-80 years. [3] In the United States, the incidence of atrial fibrillation is 0.1% under the age of 55, but after 80 years of age, the incidence of atrial fibrillation can reach 9.0%, and the prevalence of atrial fibrillation increases with age. [4]

The mechanism of atrial fibrillation is complex, although people started research very early, but so far there is no single mechanism to fully clarify the root cause of atrial fibrillation. The two classic theories are as follows: 1. It is the multi-wave reentry theory in the atrium proposed by Moe in 1962, that is, the excitatory conduction signal of the heart is reciprocated and transmitted through multiple paths of different sizes and directions in the atrium. Related to the number of reentry

rings in the atrium, conduction velocity and other factors this chaotic, uneven conduction mode, the formation of many reentry impulses, eventually leading to the formation of atrial fibrillation [5, 6]. In 1984, Allessie also confirmed the number of reentry loops with different numbers and sizes in the atrium of patients with atrial fibrillation. It is speculated that the mechanism of atrial fibrillation is the conduction of abnormal excitatory signals in the atrial reentry loop. The size of the reentry loop can be refracted. The length of time is measured. 2. Single ectopic excitatory doctrine, Rothberg and Winterberg believe that the mechanism of atrial fibrillation is due to the presence of ectopic excitatory pacemakers in the atria, which generate excitatory impulses at high frequencies, making the atrial muscles arrhythmetic, ineffective contraction, Atrial fibrillation occurs [7, 8]. It is generally believed that abnormal electrical activity triggered by special excitatory pacemakers in the atria is the main mechanism triggering atrial fibrillation, and multiple wave reentry is the maintenance mechanism of atrial fibrillation. [9]

Surgical treatment of atrial fibrillation

Maze Surgery

Early surgical treatment of atrial fibrillation includes His beam severing, left atrial occlusion, vestibular surgery, nodular surgery, etc., but cannot completely eliminate atrial fibrillation, can only minimize the impact of atrial fibrillation on ventricular rate, from In terms of long-term effects, there is no cure for atrial fibrillation, and it may lead to a series of complications such as thromboembolism and decreased cardiac function. According to Moe's theory of multiple wavelet reentry in the atrium, Dr. James L Cox et, al [10] first applied maze surgery to the clinic in 1987, which is a historical advancement in surgical treatment of atrial fibrillation. All possible reentry loops, including common abnormal potential triggers such as pulmonary veins, superior and inferior vena cava, coronary sinus ostium, left and right atrial appendages, Marshall Ligaments, and posterior wall of the left atrium Cox cuts the atrial muscles at these sites. [11] The method of stitching is isolated into a plurality of mutually insulated regions, so that a folded loop cannot be formed, which is like a labyrinth, so it is called a maze surgery. Its advantage is to effectively prevent the occurrence of abnormal reentry loop, and the rate of atrial fibrillation has also progressed, but it has two shortcomings: 1. The sinus node pacing complex area controls sinus tachycardia during surgery The area is damaged, that is, the heart rate cannot be increased correspondingly during exercise; 2. The surgery damages the Bachmann beam that is transmitted to the left atrium, resulting in postoperative left atrial dysfunction. Over the next 16 years, Cox et al. continued to improve the surgical procedure, and experienced Maze II until now Maze III. Maze III is characterized by: 1. Cancel the incision at the top of the right atrium to avoid the sinus node and right atrium. Injury in the sinus impulse area; 2. Surround the 4 pulmonary veins as a cup-shaped incision to minimize the damage to the left atrium, preserve the electrical signaling function of the left atrium, and significantly improve the left atrial function of the patient. The Maze III procedure invented by Cox is recognized by the medical community as the standard procedure for surgical treatment of atrial fibrillation. [12] Cox reported in 2003 that Maze III was used to treat patients with atrial fibrillation, and the rate of conversion was 95%, although this procedure would increase the operation time and cardiopulmonary bypass time (149-195 minutes, average 165 minutes). [13] Blocking time (including mitral valve replacement, 85-120 minutes, average 97 minutes), but the results of the study showed that there was no increase in mortality, and very few postoperative cardiac pacemakers were needed. Wang Huishan et, al [14] performed a prospective randomized trial of 130 patients with rheumatic mitral valve disease complicated with atrial fibrillation. The results showed that mitral valve replacement with Maze III surgery did not increase early mortality and could be reduced by 1 The risk of stroke and death after the year. However, due to the complicated operation of Maze III, prolonged operation time, increased extracorporeal circulation time, and increased risk of bleeding, this procedure has not been widely used in the surgical field.

Radiofrequency ablation

Radiofrequency ablation is to clamp the myocardial tissue through the electrode probe of the radiofrequency ablation clamp, and use the local high-heat effect generated by the high-frequency vibration of the molecule to heat the myocardial tissue to 50-55 ° C, so that the myocardial cells are coagulated and necrotic, and irreversible changes occur. A continuous, transmural ablation line is formed to block the abnormal reentry loop that causes and maintain atrial fibrillation, thereby achieving the purpose of eliminating atrial fibrillation. [15] The development of radiofrequency ablation, through unipolar radiofrequency ablation, unipolar endocardial and epicardial ablation, to the current bipolar radiofrequency ablation. [16] Basu collected 256 articles and proved the effectiveness of unipolar radiofrequency ablation for atrial fibrillation. The follow-up time ranged from 12 months to 5 years, and the postoperative conversion rate reached 83%. [17] However, unipolar radiofrequency ablation is difficult to grasp the transmurality of ablated myocardial tissue due to high local tissue temperature and lack of indicators for monitoring transmural wall, which may lead to incomplete blockade. In addition, the energy of unipolar radiofrequency ablation penetrates tissue Peripheral diffusion may cause damage to the atria, esophagus, and pulmonary veins, causing complications such as atrial esophageal spasm and pulmonary vein stenosis [18]. Bipolar radiofrequency ablation can simultaneously ablate the endocardium and epicardium, ensuring transmural permeability to myocardial tissue ablation, shortening ablation time and reducing damage to surrounding tissue. Clinically, the combination of bipolar radiofrequency ablation and Maze III surgery, also known as modified maze, is currently the most common method for surgical treatment of atrial fibrillation. In China, Zhang Wei et al. [19] performed a modified maze procedure on 100 patients with valve replacement at the same time. The average radiofrequency ablation time was 15-25 minutes, and

the postoperative sinus transformation rate reached 91%. After 6 months of follow-up, the sinus was maintained. The number of patients with sexual heart disease reached 82.5%. In foreign Daminao, 282 patients with confirmed atrial fibrillation were treated with modified maze. [20] The follow-up rate was 94% and 83% after 6 months and 1 year follow-up. With the development of medicine, clinically, the heart does not stop to perform modified maze, Yang Yan and other 84 patients with valvular heart disease complicated with atrial fibrillation undergoing valve replacement and improved maze, 46 of which are in the heart In the perioperative period, the sinus rhythm of the non-stop group was 91.3% (42/46), and the valve replacement and modified maze were performed in 38 patients. [21] Compared with the sinus rhythm of the stop group, 73.7% (28/38), one year after surgery, the rate of conversion in the non-stop group was 89.1% (41/46), still higher than 78.9% in the stop group (30/38).), indicating that improving the maze in the heart beating is a better and safer way to treat atrial fibrillation. Radiofrequency ablation replaces the traditional labyrinth of cutting and slitting. It has the advantages of simple operation, reduced operation time and less complications, and has a very broad prospect.

Cryoablation

Harrison first applied cryoablation in clinical practice in 1977. It used a liquid refrigerant such as liquid nitrogen to contact the myocardial tissue through a radio frequency ablation probe, so that the local temperature dropped to -60 ° C in a short time, and the myocardial tissue was degenerated and necrotic. An ablation line that blocks electrical signal conduction is formed to treat atrial fibrillation. In cryoablation, the frozen RF catheter is applied to the ablated tissue without catheter displacement, which improves the safety of the operation, does not destroy the ultra structure of myocardial tissue, reduces endocardial damage, and reduces postoperative Complications such as thrombosis, esophageal fistula, and pulmonary vein stenosis [22]. Packer et al randomly assigned 245 patients with paroxysmal atrial fibrillation to cryoablation and drug therapy. [23] After 12 months of follow-up, 69.9% of patients in the cryoablation group had no recurrence of atrial fibrillation, much higher than the drug-treated group. . However, the current cryoablation procedure still has its limitations: First, because the frozen balloon catheter is designed for pulmonary vein anatomy, it is mostly used for pulmonary vein isolation; second, cryoablation is mainly used for patients with paroxysmal atrial fibrillation, for persistent housing. The efficacy of tremor is limited [24]; Third, the most common postoperative complications of cryoablation are easy to cause radial nerve palsy, most of which is reversible [25]. Fourth, the permeability of frozen ablation to ablated tissue cannot be determined, after the frozen tissue is thawed, there is a risk of recurrence of atrial fibrillation. In short, cryoablation has the characteristics of simple operation, high surgical safety, and less postoperative complications. However, due to its limitations and high technical requirements for the surgeon, it has not been fully promoted worldwide.

Microwave Ablation

Microwave ablation is performed by a high-frequency electromagnetic wave acting on ablated tissue, causing high-frequency vibration of water molecules in the tissue to generate energy, increasing local tissue temperature, causing continuity and transmural damage to atrial tissue, and blocking abnormalities. The reentry loop achieves the purpose of eliminating atrial fibrillation. Slatman et al first reported in 2003 the application of microwave ablation in the clinical treatment of atrial fibrillation. [26] The advantages of microwave ablation are: 1. the device is simple, the operation is simple, and the operation time is reduced. 2. When the microwave ablate the tissue, the local temperature can be controlled, and the tissue will not be carbonized due to overheating, thereby reducing the risk of thrombosis. Basu et al summarized the relevant literature; patients who were treated with valve replacement and microwave ablation at the same time, after 6-12 months of follow-up, patients who maintained sinus rhythm were 62%-87%. [17] However, there are few literatures on the efficacy of microwave ablation for atrial fibrillation in the long-term, and the cure rate of long-term atrial fibrillation is not clear.

Ultrasound Ablation

The principle of ultrasonic ablation is to accumulate ultrasonic energy into a certain target of the tissue through a sound-transmitting mirror, so that the temperature of the ablation zone instantaneously reaches a high temperature, the aseptic necrosis of the local tissue is generated, and the abnormal reentry loop in the atrium is blocked, thereby achieving The purpose of treating atrial fibrillation. Davies et al reported that 110 patients with atrial fibrillation underwent microwave ablation. [27] They were divided into three groups according to the type of atrial fibrillation: paroxysmal atrial fibrillation, persistent atrial fibrillation, and permanent atrial fibrillation. In the year, the success rate of atrial fibrillation in the three groups was 81%, 56%, and 18%, respectively. After 2 years, the average atrial fibrillation elimination rate was 49%. Therefore, ultrasound ablation should be used to pay attention to the patient's choice. Ultrasound ablation has the advantages of simple operation, shortened operation time, and the focused energy does not damage the tissue other than the target, and does not damage the surrounding blood vessels and the conduction beam, and the safety is relatively high. However, Narawudt et al reported a 5-year history of persistent atrial fibrillation recurrence and antiarrhythmic drug therapy for a 63-year-old woman who underwent high-frequency ultrasound ablation and esophageal spasm. [28] It is likely due to excessive ultrasonic energy. At present, the application of ultrasound ablation in the treatment of atrial fibrillation is still in its infancy. The technique is not yet mature. High-frequency ultrasound has uncertainty on tissue penetration, and the efficacy needs further study.

Laser ablation

The light wave of 980nm wavelength is radiated to the ablated

tissue, and the water molecules of the local tissue absorb the light wave to generate energy, which is converted into heat energy. High heat causes coagulation necrosis of tissue cells and forms transmural damage, thereby blocking the abnormal reentry loop and fundamentally treating atrial fibrillation. The advantage of laser ablation is that it has strong penetrating ability, better ablation of endocardium and pericardial viscera, rapid recovery after operation, and reduced risk of thrombosis. However, its shortcomings are clear. It is difficult to obtain laser energy during surgery. The damage to atrial tissue cannot be judged directly, and there is a risk of atrial penetration. Therefore, it is rarely used clinically. Its safety and efficacy need further study.

Cryoballoon-Based Ablation (CBA)

Cryo-ball ablation for atrial fibrillation (AF) uses cryo-energy to isolate the pulmonary veins for the treatment of atrial fibrillation. The cryogen used is N2O, and two balloons of 23 and 28 mm diameter are currently used. Studies have shown that frozen balloon catheter ablation can effectively isolate the pulmonary veins. It is a new technology for the treatment of real estate ablation. Compared with the circumferential pulmonary vein ablation, the operational complexity and learning curve of CBA are relatively easier and shorter. Experimental studies have confirmed that in 106 cases of frozen balloon atrial fibrillation ablation cases found that only 2 cases of radial nerve injury, 1 case of ischemic stroke, through follow-up observation, after atrial fibrillation CBA Six months, 86% of patients maintained sinus rhythm [29]. Compared with RF energy, the advantages of CBA are: 1 The balloon catheter adheres to the tissue when frozen, and the catheter stability is better; 2 The scar boundary generated by balloon ablation is continuous and uniform, and it is not easy to cause postoperative arrhythmia; 3 After cryoablation The adjacent tissue integrity is good, the risk of myocardial perforation and esophageal injury after ablation is low, and the tissue contraction is small when the scar is healed, which may reduce the occurrence of postoperative pulmonary vein stenosis; 4 scar endocardial surface damage caused by freezing energy Small, and the extent of activation of platelet coagulation pathway is lower than radiofrequency ablation, so thrombus is not easy to form, and the risk of thromboembolism is low; 5 patients with cryoablation have good tolerance and less discomfort. Despite the risk of paralysis of the sacral nerves, most cases are transient, with only about 0.4% of phrenic nerve paralysis for more than one year.

Application of Contact Pressure Catheter in Radiofrequency Ablation

The contact pressure catheter directly displays the pressure between the catheter tip and the tissue to guide the surgeon to ablation. The principle of the catheter mainly uses the magnetic field to detect the slight movement of the head end, and these movements can be converted into the magnitude and direction of the pressure, the precision spring will continue to shift in the lateral and axial directions to correspond to the different contact of the catheter tip with the tissue. The pressure data will be fully integrated into the Cart03 system display, displayed in different areas of the screen, the surgeon can guide the ablation according to the pressure changes in real-time display during surgery, taking into account the effectiveness and safety of the ablation. After studying 122 patients [30], Natale had 4 cases of tamponade, 1 case of chest pain, 2 cases of pericarditis, and 3 cases of vascular puncture complications after catheter ablation. During the 12 months of follow-up, no symptomatic atrial fibrillation, atrial tachycardia, or atrial flutter was recorded as a focus of effectiveness, with a success rate of 71.9%. At the same time, the study further confirmed that the effectiveness and safety of the contact pressure catheter is more reliable, and the longer the pressure value is within the set range, the higher the success rate after surgery. Although some research institutions have demonstrated the effectiveness and safety of contact with pressure catheters, there is currently no complete multicenter, large-sample randomized controlled trial to systematically assess the safety of contact pressure catheters in radiofrequency ablation of atrial fibrillation catheters. And the role of effectiveness requires further research and exploration by relevant researchers.

Minimally Invasive Surgery

With the continuous development of thoracoscopic surgery, minimally invasive surgery has gradually entered the treatment of atrial fibrillation. Wolf et al first underwent surgical treatment of thoracoscopic atrial fibrillation in 2002. [31] They selected patients with paroxysmal atrial fibrillation and partial permanent atrial fibrillation as the main treatment subjects. The intercostals incision was made through the left chest wall. Jumping down the bipolar radiofrequency ablation, radiofrequency ablation of the left and right pulmonary veins, left atrial ring pulmonary vein ablation line, epicardial, ligation of the left atrial appendage, to prevent the risk of thrombosis after surgery. Compared with the traditional mid-thoracic surgery, the advantages of minimally invasive surgery are as follows: 1. the intercostals incision is used, the surgical trauma is small, the amount of bleeding is small, and the patient heals faster after surgery; 2. The radiofrequency ablation is performed without stopping the heart. Extracorporeal circulation avoids organ damage caused by myocardial and other organ ischemia; 3. Postoperative delayed bleeding, low cardiac output syndrome, pulmonary infection and other complications are reduced. Sirak et al reported 179 patients with atrial fibrillation undergoing thoracoscopic radiofrequency ablation. [32] After 3 months of follow-up, the rate of atrial fibrillation was 96% (137/142), demonstrating bipolar radiofrequency in thoracoscopy. Ablation, sinus conversion rate is high, and complications are reduced. Because of the obvious advantages of minimally invasive surgery for atrial fibrillation, it has great potential and application value in clinical practice. In addition, there are some other surgical methods for atrial fibrillation, such as the sub-surgical approach and the right chest wall approach of the robot. It is believed that with the advancement of technology,

minimally invasive surgery will open a new chapter in the surgical treatment of atrial fibrillation.

Outlook

Atrial fibrillation has become one of the diseases that threaten human health, and with the increase of age, the incidence rate has also increased significantly. The treatment is treated by symptomatic drugs, gradually over-surgery to the surgical treatment of the pathogenesis of atrial fibrillation. With the advancement of technology and the discovery of new energy, the combination of surgical and new energy technologies has become the mainstream, the sinus of atrial fibrillation the sexual conversion rate has also gradually increased. However, some new energy sources are currently difficult to obtain, safety has not been fully confirmed, and the results of long-term follow-up are lacking. These problems still need to be studied in large-scale, multi-center long-term studies. It is believed that the surgical treatment of atrial fibrillation will develop in the direction of minimally invasive, diversified and rapid, so that more patients with atrial fibrillation can get rid of the pain of disease as soon as possible.

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