The Application of Intracardiac Ultrasound in Atrial Septal Puncture

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Abstract: **Objectives:** To investigate the safety and effectiveness of atrial septal puncture assisted by intracardiac ultrasound, and to evaluate the value of intracardiac ultrasound in atrial septal puncture. **Methods:** Sixty patients who underwent radiofrequency ablation for the first time were randomly divided into two groups. Patients in experimental group underwent intraventricular ultrasound-assisted atrial septal puncture, while those in control group underwent X-ray guided atrial septal puncture. The success rate, puncture time and complications of the two groups were compared. **Results:** All atrial septal puncture was successful in the experimental group, while one-time puncture was successful in 21 cases and unsuccessful in 9 cases in the control group with a success rate of 83.33%. There was significant difference in puncture success rate between the two groups. Moreover, the puncture time of the experimental group (5.00±1.5 min) was significantly shorter than that of the control group (6.90±1.32 min). Furthermore, the complication rates of the experimental group and the control group were 10% and 13.33%, respectively, with no significant difference. **Conclusion:** Ultrasound-assisted atrial septal puncture was significantly superior to X-ray guided atrial septal puncture, with high puncture success rate, short puncture time and fewer complications.

Keywords: Intracardiac Echocardiography; X-Ray; Atrial Septal Puncture

Introduction

Radiofrequency catheter ablation for atrial fibrillation, ventricular arrhythmia, supraventricular tachycardia and other arrhythmias is increasing. Atrial septal puncture is an important surgical procedure for atrial fibrillation, ventricular arrhythmias originating from the left ventricle, superior ventricular tachycardia caused by the left atrium, and occlusion of the left atrial ear. It is also a technical approach for many cardiovascular interventions. With the recent development of radiofrequency catheter ablation for atrial fibrillation (AF), the safety of atrial septal puncture becomes particularly important [1]. There are certain risks of atrial septal puncture under the guidance of X-ray, especially for patients with abnormal atrial septal anatomy, intracardiac echocardiography (ICE) has real-time imaging of the internal structure of the heart and adjacent tissues, and real-time imaging of the process of atrial septal puncture. The position of fossa ovale and the anatomical structure of the abnormal, so as to safely guide the atrial septal puncture. As the technology continues to mature, ICE guided catheter ablation of atrial fibrillation (AF) is increasingly widely used in the clinic [2]. In this study, by comparing the effect of ICE-assisted and X-ray-guided atrial septal puncture, the existing problems in atrial septal puncture and the value of intracardiac ultrasonic-assisted atrial septal puncture are discussed.

1. Materials and methods

1.1 Object of study

Sixty patients admitted to the Department of Cardiovascular Medicine of Jinan Third People's Hospital from January 2021 to March 2023 who met the indication of atrial septal puncture were selected as the research objects. All patients received Transesophageal echocardiography (TEE) before surgery and received radiofrequency ablation for the first time. The patients were randomly divided into two groups with 30 cases in each group. All patients were excluded from the following conditions： left atrial thrombus; left atrial myxoma; severe deformities of heart, chest and spine; severe coagulation dysfunction or inability to tolerate anticoagulant therapy; thrombosis of lower limb vein, femoral vein, iliac vein, hemodynamic instability, contrast agent allergy. Informed contents were obtained in advance.

1.2 Methods

All patients had stable hemodynamics and fasting for more than 6 hours. Warfarin or rivaroxaban was stopped before surgery for 3 days, and low molecular weight heparin was used as anticoagulant. Intra-esophageal ultrasound was performed within 24 hours before surgery to exclude left atrial thrombus. Cardiac ultrasound was performed to determine cardiac function and structure, and routine biochemical examination was performed. Then an atrial septal puncture was performed.

Patients in control group received atrial septal puncture under the guidance of X – ray. Firstly, the SWARTZ or Mullins sheath tube or Preface of the puncture should be used, and the sheath tube should be fully rinsed with heparin saline before the puncture. The puncture sheath was sent to the superior vena cava through the 0.032-inch 145cm guide wire, then the guide wire was removed and sent to the atrial septal puncture needle. The puncture needle indicator was kept pointing to 12 o 'clock, and the tail was kept about 2cm away to ensure that the puncture needle tip was in the inner sheath. The left and right hands rotated the sheath and puncture needle simultaneously. The tail indicator pointed to 4-5 o 'clock, the head of the sheath turned to the atrial septum, and kept the puncture needle and the sheath retreating synchronously along the septum to the fossa ovale. After fluoroscopy, the anterior position could be used to retreat, and there were 2-3 beats at the head of the inner sheath canal during the process, indicating the right atrium and fossa ovale respectively. Before and after the puncture point was determined by the 45 degree puncture needle at RAO position and the curvature of the distal segment of the sheath canal disappeared close to a straight line, the puncture point was determined by the height of a vertebral body at the lower margin of the left atrial shadow at PA position. After the internal sheath canal tightened the atrial septum, the puncture needle rotated slightly backward along the clock to smoothly pass through the atrial septum. Contrast agent was injected, such as linear ejection of contrast agent to confirm successful introduction into the left atrium. The fixed puncture needle pushed the dilator tube so that its tip covered the puncture needle, and then pushed the outer sheath tube into the left atrium, fixed the outer sheath tube, and pulled the dilator tube and the puncture needle out of the body together.

The experimental group received intraventricular ultrasonic-assisted atrial septal puncture. The ultrasound catheter was rotated clockwise from the Home View to the left pulmonary vein fan, P curve was made to make the aortic root appear, R curve was made to make the superior vena cava appear, the long guide wire was sent to the superior vena cava, the atrial septal puncture sheath was introduced into the superior vena cava, the guide wire was withdrawn and the puncture needle was sent. Coaxial rotation makes the tail indicator point to 4-5 o 'clock. At the same time, pull down the puncture needle and sheath tube. The ultrasonic catheter is slightly bent L to track the puncture sheath head. When the puncture needle and sheath tube slip into the fossa ovalis, the "tent" sign can be seen under ultrasound; after the puncture point is determined, the puncture needle passes through the atrial septum, and the "tent" sign disappears; bright red arterial blood can be seen after extraction, and the "blister" sign of the left atrium can be seen after injection of normal saline. The puncture needle is fixed

and pushed to the dilator tube so that its tip covers the puncture needle, then the puncture needle is withdrawn, and the guide wire is sent to the left upper pulmonary vein. The catheter was sent to the atrial septal sheath along the guide wire to complete the puncture.

1.3 Evaluation index

1.3.1 Comparison of puncture success rate

Puncture failure was defined as failure of puncture for 3 times (changing the surgeon's puncture or changing to X-ray combined with ICE interatrial septal puncture) or the use of X-ray exposure during puncture.

1.3.2 Comparison of Puncture time

The time of puncture device from the beginning of superior vena cava withdrawal to the time when the sheath catheter was irrigated with heparin saline after entering the left chamber.

1.3.3 Comparison of complication rate

Complications associated with atrial septal puncture, including pericardial tamponade, aortic perforation, stroke or transient cerebral ischemia (TIA), were counted.

2. Results

2.1 Patients' general data

As shown in Table 1, there were 19 males and 11 females in the experimental group, with an average age of 60.17±3.16 years old. The left ventricular ejection fraction was 60.87±5.37%, and the anterior and posterior left atrium 39.13±2.52 mm. In the control group, there were 22 males and 8 females, with an average age of 59.07±3.45 years old. The left ventricular ejection fraction was 59.33±6.15%, and the left anterior and posterior atrial diameter was 38.83±2.25 mm. There were no significant differences in gender, age and echocardiogram parameters between the two groups, which were comparable.

Table 1. Comparison of patients' baseline data

	Experimental group（n=30）	Control group（n=30）	χ^2/t-value	P-value
Gender			0.693	0.405
Male	19	22		
Female	11	8		
Age	60.17±3.16	59.07±3.45	1.287	0.203
LVEF（%）	60.87±5.37	59.33±6.15	1.029	0.308
LAD（mm）	39.13±2.52	38.83±2.25	0.486	0.629

LVEF: Left Ventricular Ejection Fraction; LAD: Left Atrial Diameter.

2.2 Puncture time and success rate of patients in two groups

The puncture time of patients in the experimental group was 5.00±1.5 min, and the success rate of puncture was 100%, among which 28 patients were successfully pierced by the first needle and 2 patients were successfully pierced by the second needle. In the control group, the puncture time was 6.90±1.32 min, and 21 cases were successfully pierced, the success rate was 83.33%. There was significant difference in puncture success rate between the two groups ($P<0.05$).

Table 2. Puncture time and success rate of patients in two groups

Groups	Puncture time（min）	success rate（n,%）
Experimental group（n=30）	5.00±1.58	30（100%）
Control group（n=30）	6.90±1.32	21（70%）
P-value	<0.001	0.042

2.3 Comparison of complications between the two groups

As shown in Table 3, a total of 3 patients in the experimental group developed complications, of which 2 were related to femoral vein puncture (6.67%) and 1 was subcutaneous hematoma (no special treatment required). In the control group, 1 case of pericardial tamponade, 1 case of complications related to femoral venipuncture and 2 cases of stroke occurred were occurred, and the complication rate was 13.33%. There was no significant difference between the two groups（P>0.05）。

Table 3. Comparison of complications between the two groups

Groups	with complications（n,%）	without complications（n,%）
Experimental group（n=30）	3（10%）	27（90%）
Control group（n=30）	4（13.33%）	26（88.67%）
χ^2 value	0.162	
P-value	0.688	

3. Discussion

In recent years, the incidence of atrial fibrillation (referred to as atrial fibrillation) has been increasing year by year. The United States, Europe, China and other countries have successively promoted transcatheter radiofrequency ablation as the first-line treatment for paroxysmal atrial fibrillation that is difficult to control with drugs in the guidelines for the treatment of atrial fibrillation[3]， For patients with symptomatic persistent or long-duration persistent atrial fibrillation who are ineffective with antiarrhythmic drugs, Catheter ablation may also be considered to improve symptoms. The ablation method currently in routine use is to perform atrial septal puncture, location and ablation of the pulmonary venous antrum via catheter combined with X-ray images, based on a 3D model built in contact with the CARTO3, etc [4]. With the increasing number of surgical patients, the safety of this method, including the duration of intraoperative X-ray exposure, has gradually drawn attention.

Trial septal puncture is an important step in radiofrequency catheter ablation of atrial fibrillation. It is commonly used in many percutaneous interventional treatments, including left heart radiofrequency ablation, left atrial ear occlusion and percutaneous mitral valvuloplasty. CE is an ultrasound imaging technology that uses an ultrasound probe sent through the peripheral blood duct to conduct real-time high-quality imaging and/or hemodynamic determination of the heart and its adjacent tissues, and has the ability to image the structures in the heart cavity and surrounding tissues in real time [5]. ICE visualization of atrial septum is an important tool to ensure the safety of atrial septum puncture [6, 7]. In this study, patients who underwent radiofrequency ablation underwent ICE-assisted and X-ray-guided atrial septal puncture respectively, aiming to study the effect and value of the two methods. The results showed that the puncture success rate of patients with ICE-assisted atrial septal puncture was much higher than that of patients with X-ray guided atrial septal puncture, and the puncture time was greatly shortened. This suggests that ICE is effective in atrial septal puncture.

One of the most important roles of ICE technology is the timely detection and prevention of potential complications during ablation procedures. In the process of atrial septal puncture, for patients with abnormal anatomy, due to the atypical position of the atrial septal and the difficulty of puncture through the atrial septal, it cannot be accurately positioned under conventional fluoroscopy, which may lead to complications such as pericardial tamponade, puncturing of the aortic root,

arterial embolism, pulmonary vein perforation, etc. In order to reduce and avoid life-threatening complications and improve the success rate of atrial septal puncture, ICE guidance can be considered for atrial septal puncture with anatomic abnormalities [8]. In this study, it was found that the incidence of complications in both ICE-assisted and X-ray guided atrial septal puncture was low, and the difference was not significant, which may be related to the small clinical sample size and no abnormal anatomical structure of patients. But at least ICE assisted septal puncture has been shown to be safe.

In conclusion, ICE assistance can greatly improve the success rate of atrial septal puncture in patients with atrial fibrillation, shorten the puncture time, and reduce the occurrence of complications. However, the sample size of this study is small, and the results need to be further verified.

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