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EFFICACY AND SAFETY OF A ZERO-FLUOROSCOPIC TECHNIQUE FOR ABLATION OF RIGHT ATRIAL ARRHYTHMIAS LITERATURE REVIEW

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Atrial arrhythmias result from defective Heart's electrical system or inappropriate response of heart muscles to their electrical stimuli, It can cause an accelerated and uneven heart rate which does not let the atria pump blood efficiently to the ventricles. Arrhythmias are categorized according to their rhythm, rate and where they are located in the heart. Atrial arrhythmias are always associated with several kinds of cardiac or non-cardiac risk factors, such as ischemic heart disease (IHD), heart failure, high blood pressure, diabetes, hyperlipidemia, alcohol abuse, obesity. They are associated with ageing and usually happen more frequently during middle age.

Atrial fibrillation (AF), atrial flutter (AFL), premature atrial contraction (PAC or premature atrial impulses), atrial tachycardia (AT), etcetera are various type of atrial arrhythmias.

This study compares the safety, efficacy and benefits of zero-fluoroscopy (ZF) ablation of right atrial arrhythmias guided only by Ensite-NavXTM three-dimensional mapping system, with two dimensional conventional fluoroscopic catheter ablation method.

After decades of development, conventional fluoroscopic catheter ablation has frequently been addressed as "cure" for atrial arrhythmias. With further understanding of cardiac anatomy and electrophysiology, the therapeutic effect of radiofrequency ablation has increased. It can not only treat simple arrhythmias such as, atrioventricular nodal reentry tachycardia (AVNRT) or Wolff-Parkinson-white syndrome (WPWs), but also treat complex rhythm disorders such as atrial fibrillation, incisional tachycardia and others.[1] Conventional X-ray fluoroscopy method is the result of the combination of the location and the electrophysiological characteristics of the electrode catheter, with anatomical features through a fixed X-ray image. However, the accuracy and reliability of this visual judgment are limited.[2]

Since its development, the Ensite-NavXTM three-dimensional mapping system has been constantly updated and improved. The Ensite-NavXTM can not only be applied to atrioventricular nodal reentry tachycardia (AVNRT), paroxysmal ventricular tachycardia (PSVT), Wolff-Parkinson-white syndrome (WPWs), but also it can be used in complicated arrhythmias such as, atrial flutter(AFL), atrial fibrillation(AF), ventricular premature beat, Atrial premature beat, ventricular tachycardia, etcetera.[3,4]

The three-dimensional mapping system based on cardiac anatomy, can perform following functions: (1) It can precisely replicate the cardiac anatomy underlying an arrhythmia; (2) The catheter operation can be repeated in the same model; (3) It can quickly and continuously update the characteristics of three dimensional model through ECG phase, pacing the characteristics of continuous and rapid update of the three-dimensional model. (4) It can accurately record the ablation site in the three dimensional model.

The Ensite-NavXTM three-dimensional mapping system is the world's most advanced three-dimensional electrophysiological mapping and navigation system; it works on the similar principal as the GPS global positioning system. Unlike the Ensite-ArrayTM, which is a non-contact type system[5], Ensite-NavXTM is a contact-type mapping system. While using Ensite-NavXTM mapping system, three pairs of electrode films are preoperatively attached on the patients' bodies. These electrode films are attached on the surface of the chest, the back, the right axillar midline, the left axillary midline, the posterior neck, and the medial left middle thigh, respectively. The three-dimensional orthogonal electric field along three axes (X, Y, and Z) is formed between the three pairs of electrode pads.

The Ensite-NavXTM positioning system can sense a variety of electrodes based on the electric field, including ordinary electrophysiological catheters, ablation catheters, cryoablation catheters, Pacemaker electrode lead, atrial septal puncture needle, guide wire, etc. It can be displayed in the system causing interference to the electric field. The signal is processed by the signal processor. The signal processor and the computer workstation determine the position of the catheter. The system can continuously collect the movement of

electrophysiological lead within the heart chamber. After processing the details, the system can construct a three-dimensional heart chamber.[6]

The purpose of the Ensite-NavXTM three-dimensional anatomical mapping system is shown in the following three aspects: 1, zero X-ray exposure; 2, information about the order of excitement (excitation) and voltage (voltage) in the heart cavity of the three-dimensional Display; and 3, the process of continuous movement during the collection point and synchronized display of heart cavity.

At the time of agitation mapping, the Ensite-NavXTM navigation system can simultaneously obtain local anatomical sites and agitation time, which can be displayed on a three-dimensional model and distinguished by different colors.

At present, this mapping method is mainly used in easily induced, persistent, hemodynamic stable arrhythmias. For patients who are hemodynamic unstable , difficult to induce arrhythmia, discontinuous arrhythmia, a localized voltage amplitude mapping site is usually used to develop a linear ablation strategy under sinus rhythm - called voltage mapping. Another approach is directly dependent on the three-dimensional anatomy of the heart, mainly used in the atrial fibrillation ablation.[6]

The outstanding benefit of this system is that it can combine the location of the lead and the anatomical information stored in the computer and the structure of the heart itself. Although, this image fusion technology is currently not widely used, over time, this technology certainly will be electrophysiologist's favorite.

The combination of two different data makes the model more accurate under the navigation of Ensite-NavXTM. In the process of atrial fibrillation ablation, especially, it is more conducive to mark pulmonary vein, pulmonary vein vestibules and left atrial appendage structure. This image fusion technology can replace the selective or non-selective angiography and decrease the intraoperative radiation exposure. The objective of this system is not only to decrease the amount of radiation exposure, but also safety, reliability and effectiveness of the ablation process, the basic goal is to improve the success rate and reduce intraoperative and postoperative complications.

In this study, to implant the catheter venous entry was obtained from femoral and the left subclavian veins using standard Seldinger puncture, after an initial optimization and a respiratory compensation were performed. Under the guidance of Ensite-NavXTM system, a tetrapolar electrode and a controllable bending electrode were inserted in the right ventricle and coronary sinus (CS) respectively, with external skin patch set as the reference. The interscapular area can be used for pasting the body reference. After the catheter had been placed in the target chamber, optimization and respiratory compensation were conducted once again.

While for fluoroscopy group who were undergoing the conventional ablation, catheter implantation was guided by X-ray plus three-dimensional mapping system. Fluoroscopy had been used throughout the procedure, including catheter implantation, EPS, mapping, and ablation.

When a long sheath (SR0) was required in some cases with atrial flutter, it was introduced into the vein 2-3 centimeters deep via the guide wire; then the guide wire was removed and replaced by an ablation catheter. The ablation catheter was inserted into the right ventricle and was made a sharp curve guided by Ensite-NavXTM. Finally, the sheath was then introduced into the desired position in right atrium along the ablation catheter.

The Ensite-NavXTM three-dimensional navigation system can display the position of the intra-cardiac catheter, construct the three-dimensional structure model of the heart, and display the location of the mapping electrode (CC, CS, HIS) and the location of the catheter to guide the operation. As soon as the three-dimensional model of the target chamber was built the tricuspid annulus and the position of His bundle were labelled both in right anterior oblique (RAO) view and in left anterior oblique (LAO) view. It is very important to determine the extent of the His bundle, His bundle is very fragile, and does not rule out anatomical variations. More importantly, an injury to His bundle revealed the characteristic on electrocardiogram of high frequency of junctional arrhythmia > 130 beats/minute, atrioventricular conduction blocks, cardiac conduction block at the junction. Even if the ablation is stopped, the injury to the ablation point continues to increase, resulting in irreversible high degree of atrioventricular block. Thus, determining the extent of the His bundle and the slow pathway and to maintain the stability of the catheter during ablation is very important.

To do the ablation, keep the catheter head down. The surgeon should not only monitor the catheter head's position, but also monitor the ablation process, heart rate and any changes in the heart rate. Intracavitary ultrasound (ICE) can be used to determine the microstructure and catheter location of the heart cavity, especially for the three-dimensional ultrasound catheter, to achieve non-contact modeling, identification of complex anatomical sites, to guide atrial septal puncture, and real-time monitoring infusion and other complications. It not only reduces operational risk, but also shortens the operation time.

Typical atrial flutter can be defined as an organized macroreentrant tachycardia restricted to the right atrium. It originates in a circuit around the tricuspid annulus restricted by anatomical blockade such as superior vena cava and inferior vena cava, the coronary sinus and crista

terminalis. The current may circle around this circuit clockwise or counterclockwise, results in the clockwise atrial flutter or the counterclockwise common atrial flutter.[7]

For typical tricuspid annular atrial flutter, high-density agitation mapping in Ensite-NavXTM three-dimensional navigation can show the reentry loop characteristics of the atrial flutter and the expansion of the RA, SVC and IVC. The construction of the tricuspid annulus geometrical structure is helpful for atrial flutter ablation. During the ablation process, the catheter passes through the isthmus line, and the ablation site is continuously collected. The three-dimensional model can be rotated to clarify the site has not yet been ablated; this memory function can avoid repeated ablation.

Patients who had surgery for congenital heart disease may present with incisional tachycardia after surgical repair, including typical atrial flutter (AFL) and focal atrial tachycardia. In addition, for patients who had an atrial incision or valve replacement surgery, the incision healing can form a large reentry ring. The three-dimensional anatomical mapping technique can identify the complex agitation sequence of such tachycardia and determine the centerline of the block. Due to the low voltage characteristics of the cardiac scar, the location of the atrial incision can also be determined by voltage mapping.

Ensite-NavXTM three-dimensional navigation system is based on the electric field system, it can perceive a variety of electrodes, and even pacemaker electrodes can be perceived. So it is possible to implant a permanent pacemaker at a zero X-ray.[8]

In this study, among the 324 consecutively enrolled patients, 108 patients with atrial arrhythmias [including typical atrial flutter(AFL), atrial premature complex (APC), atrial tachycardia (AT)] were enrolled in to Zero-fluoroscopy approach guided by Ensite-NavXTM, the immediate success rate was 97.2% (105 patients), 2.8%(3 patients) had to switch to fluoroscopic approach guide by X-rays. The average operation time was 52.3±33.2 minutes; follow-up studies were done one month, three months and on six months after the procedure to check for any recurrences. Only 1.9% (2 patients) of the cases had recurrence. The results of this study showed that Zero-fluoroscopy ablation guided by Ensite-NavXTM navigation is completely beneficial, effective and safe in ablation of atrial arrhythmias. There were no considerable variation between zero-fluoroscopy (ZF) group and fluoroscopy (F) group as to immediate success rate and recurrence rate. Both zero-fluoroscopy group and fluoroscopy group had no severe complications Fluoroscopy will still be used as a routine imaging modality in many centers, especially in some complex cases undergoing ablation.

However, there was a considerable variation between zero-fluoroscopy group and fluoroscopy group as to fluoroscopic time, which means fluoroscopic group patients and staff have to face radiation for the longer time, to avoid radiation they have to wear lead facilities for protection. They are very heavy, which makes staff fatigue. It only decreases risk partially and patients are at radiation risk.[9,10] The significant risks associated with the radiation are cancer and genetic abnormality, which can be eliminated by zero-fluoroscopic ablation.[11,12] So we can clearly say that zero-fluoroscopy ablation of right atrial arrhythmias guided only by Ensite-NavXTM non-fluoroscopic mapping system is beneficiary compare to convention fluoroscopic method.

The introduction of the Ensite-NavXTM three-dimensional anatomical mapping system enables the electrophysiologist to hold a sharp edge; they can eliminate patient's arrhythmias more accurately and effectively. The three-dimensional mapping system makes it difficult for the traditional X-ray ablation to achieve the stability and intuitive. At the same time, it shows us that medicine needs to evolve and medical technology needs to improve and be safer. Currently, electrophysiological surgery-related complications are arteriovenous fistula or pseudoaneurysm caused by arterial-venous puncture, pneumothorax caused by subclavian vein puncture, aortic operation leading to aortic valve injury, pericardial effusion caused by atrial septal puncture, atrial esophageal fistula caused by atrial fibrillation ablation. Most of the complications are serious and difficult to deal with. Some more serious complications are heart rupture, acute pericardial tamponade, and even death. Therefore, we need to adopt a more secure operating plan and develop new equipment in order to avoid these risks as much as possible.

Zero-fluoroscopic catheter ablation guided by Ensite-NavXTM electro-anatomical mapping system needs skilled surgeons who have rich knowledge and experience in this field. It also requires a long training.

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