Transjugular Approach for Implantation of Active Fixation Leadless Pacemakers: A Feasibility Study

Sponsor: Xijing Hospital, Air Force Medical University

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NCT Number: To be assigned after registration

Study Period: July 10, 2026 – December 31, 2027

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Protocol Summary

Study Title	Transjugular Approach for Implantation of Active Fixation Leadless Pacemakers: A Feasibility Study
Study Objectives	To evaluate the feasibility and acute safety (from intraoperative period through 48 hours post-procedure) of transjugular implantation of the Aveir VR active-fixation leadless ventricular pacemaker, and to assess the stability and effectiveness of intraoperative and short-term (1 – 3 months) pacing parameters, including pacing threshold, R-wave sensing amplitude, and lead impedance.
Study Design	Prospective, single-arm, single-center, exploratory feasibility clinical study
Total Number of Cases	15
Case Selection	**Inclusion Criteria** 1. Aged 18 to 85 years, regardless of gender. 2. Symptomatic bradyarrhythmia meeting the ventricular pacing indications recommended by the 2023 ACC/AHA/HRS Guideline for the Evaluation and Management of Bradyarrhythmias, the 2020 Chinese Expert Consensus on the Evaluation and Management of Patients with Bradycardia and Conduction Disorders, and the 2022 Chinese Expert Consensus on the Clinical Application of Leadless Pacemakers, including any of the following conditions: - Third-degree or advanced atrioventricular (AV) block; - Second-degree type II AV block, alternating bundle branch block, or bifascicular/trifascicular block with intermittent advanced/third-degree AV block; - Adult congenital complete AV block; persistent irreversible advanced/third-degree AV block following myocardial infarction or cardiac surgery; - Symptomatic bradycardia (e.g., dizziness, presyncope, syncope, fatigue, decreased exercise tolerance) or sick sinus syndrome (including chronotropic incompetence and tachy-brady syndrome); - Drug-induced persistent symptomatic bradycardia with no alternative treatment options; - Atrial fibrillation with slow ventricular response requiring long-term ventricular pacing; - New-onset persistent complete left bundle branch block after TAVR, or new-onset advanced AV block after hypertrophic cardiomyopathy ablation; - Neuromuscular disease, infiltrative cardiomyopathy, or adult congenital heart disease with progressive AV/branch conduction abnormalities and bradycardia-related symptoms; - High infection risk populations (e.g., recurrent pacing system infection, diabetes mellitus, long-term corticosteroid use, end-stage renal disease on dialysis) or patients with abnormal conventional pacing access or at extremely high risk of

conventional pacing lead complications.
3. Anatomical feasibility and vascular access assessment:
- Preoperative imaging confirms suitable right internal jugular vein access to accommodate the delivery sheath, without thrombosis, severe stenosis, or anatomical malformations;
- Right ventricular anatomy is suitable with adequate trabeculation to support active fixation of the leadless pacemaker, without severe structural abnormalities;
- Priority for enrollment: patients with limited femoral or inferior vena cava access (e.g., iliac/inferior vena cava stenosis, thrombosis, prior venous surgery, obesity precluding femoral access).
4. New York Heart Association (NYHA) functional class ≤ III, and expected survival > 1 year.
5. Able to cooperate with preoperative evaluation, intraoperative procedure, and 3-month follow-up.
6. Voluntarily signs written informed consent and agrees to complete all scheduled observations per the study protocol.

Exclusion Criteria

1. Anatomical malformations, severe stenosis, occlusion, or thrombosis of the internal jugular vein or superior vena cava that preclude transjugular access for the procedure.
2. Abnormal right ventricular anatomy, including but not limited to right ventricular hypoplasia, severe right ventricular dilation, or severe right ventricular myocardial fibrosis, preventing safe implantation of an active-fixation leadless ventricular pacemaker.
3. Severe tricuspid regurgitation, or status post-mechanical tricuspid valve replacement, significantly affecting pacemaker implantation, device fixation, or function.
4. NYHA functional class IV, or refractory heart failure, cardiogenic shock, rendering the patient unable to tolerate the procedure and perioperative management.
5. Severe hepatic or renal impairment (eGFR < 30 mL/min/1.73m² , severe liver dysfunction), coagulopathy, or active bleeding disorders constituting clear surgical contraindications.
6. Confirmed allergy or severe intolerance to leadless pacemaker materials, intraoperative contrast media, or anesthetic agents.
7. Prior implantation of other cardiovascular implantable electronic devices (e.g., pacemaker, ICD, CRT) or retained intracardiac leads/devices that would interfere with the current implantation or device function.
8. Advanced malignancy, severe active infection, active autoimmune disease, or other serious systemic conditions with an expected survival < 12 months, precluding completion of the 3-month follow-up.
9. Pregnant or lactating women, or women planning pregnancy during the follow-up period.
10. Psychiatric disorders, cognitive impairment, or inability to cooperate with preoperative evaluation, intraoperative procedure, or regular postoperative follow-up

	due to personal or geographic reasons. 11. Concurrent participation in another cardiovascular device clinical trial that may interfere with the outcome assessment of this study. 12. Any other condition deemed by the investigator to make the participant unsuitable for enrollment.
Treatment Protocol	Transjugular implantation of the Aveir VR active-fixation leadless ventricular pacemaker
Efficacy Evaluation	Efficacy Evaluation Primary Efficacy Endpoint To evaluate the feasibility and acute safety (from intraoperative period through 48 hours post-procedure) of transjugular implantation of the Aveir VR active-fixation leadless ventricular pacemaker. Secondary Efficacy Endpoints 1. To assess the stability and effectiveness of intraoperative and short-term (1 to 3 months post-procedure) pacing parameters, including pacing threshold, R-wave sensing amplitude, and lead impedance. 2. Record procedure-related metrics, including technical success rate, procedure duration, fluoroscopy time, number of punctures, number of pacemaker fixation attempts, and incidence of complications. 3. Perform cardiac ultrasound or cardiac CT examination before discharge to determine the implantation site of the leadless pacemaker (right ventricular septum / right ventricular free wall), and describe the correlation between different implantation sites and pacing parameters. 4. Observe the incidence of adverse events (including serious adverse events) within 3 months after the procedure to evaluate short-term safety. 5. Summarize the operational characteristics, learning curve, and clinical application experience of transjugular implantation of the Aveir VR leadless pacemaker.
	Safety Evaluation Acute Safety (from intraoperative period through 48 hours post-procedure) No serious procedure-related adverse events occur, including: • Cardiac tamponade / cardiac perforation requiring interventional or surgical intervention • Major bleeding / cervical hematoma requiring blood transfusion • Pneumothorax • Air embolism • Severe arrhythmia (e.g., ventricular tachycardia, ventricular fibrillation

	requiring electrical cardioversion) • Device dislocation requiring emergency retrieval / re-procedure • All-cause death Short-Term Safety Endpoints (up to 3 months post-procedure) (1) Incidence of adverse events (AEs), including: • Cervical hematoma • Venous thrombosis • Minor arrhythmia • Abnormal pacing parameters (elevated threshold, poor sensing), etc. (2) Incidence of serious adverse events (SAEs), including: • All-cause death • Myocardial infarction • Stroke • Pulmonary embolism • Device-related infection / endocarditis • Pericardial complications requiring intervention • Pacemaker displacement requiring re-intervention, etc. (3) Incidence of device-related complications (e.g., pacemaker malfunction, abnormal helical fixation mechanism, etc.).
Statistical Methods	Statistical Methods This is an exploratory feasibility study. Descriptive statistics will be the primary analytical approach. No hypothesis testing, superiority tests, or non-inferiority tests will be performed. All results are exploratory and descriptive in nature. (1) Continuous variables: Data conforming to a normal distribution will be presented as mean ± standard deviation ($\bar{x} \pm s$), while data not conforming to a normal distribution will be presented as median (interquartile range) [M (Q1, Q3)]. (2) Categorical variables: Data will be presented as frequencies (n) and percentages (%). The 95% exact confidence intervals for adverse event rates, technical success rates, etc. will be calculated using the Clopper-Pearson method. (3) Correlation description: Descriptive comparisons of pacing parameters across different implantation sites (right ventricular septum / right ventricular free wall) will be performed, with results presented in textual descriptions and tabular formats.

Study Period	July 10, 2026 – December 31, 2027

一、Background

Leadless pacemakers serve as an important alternative to conventional transvenous pacing systems, offering advantages such as minimal invasiveness, absence of lead-related complications (e.g., lead fracture, insulation damage, infection), and good patient tolerability, and have been widely adopted in clinical practice. The Aveir VR active-fixation leadless ventricular pacemaker adopts a helical active-fixation design to improve implant stability, reduce the risk of device dislocation, and allow for retrievability, providing greater flexibility for clinical procedures.

Currently, femoral venous access is the predominant approach for leadless pacemaker implantation. However, some patients cannot undergo this approach due to femoral vein occlusion, thrombosis, severe obesity, or inguinal anatomical abnormalities, which limits the broader application of leadless pacing technology. The transjugular approach, as an alternative access, features a superficial anatomical location, straightforward puncture, and fewer bleeding complications. It has been increasingly applied in leadless pacemaker implantation in recent years. Nevertheless, data on the feasibility, acute and short-term safety, and efficacy of transjugular leadless pacemaker implantation remain scarce, especially in China, with only a few case reports available.

Published English studies to date include:

- A prospective observational study by Saleem-Talib S et al. published in *Pacing and Clinical Electrophysiology* in 2022 (N=82);
- A retrospective study by Buchanan EB et al. published in the *Journal of Interventional Cardiac Electrophysiology* in 2025 (N=56);
- A retrospective study by Shmaila Saleem-Talib et al. published in *Pacing and Clinical Electrophysiology* in 2026 (N=18).

These studies collectively demonstrate that the right internal jugular vein approach is a safe and feasible alternative, with low incidences of access-site complications (e.g., hematoma, pseudoaneurysm), enabling immediate post-procedural ambulation and facilitating the selection of non-apical pacing sites such as the right ventricular outflow tract or mid-septum to achieve narrower paced QRS duration. Drawing on the study designs of these previous works, the present study plans to enroll 15 patients to explore the feasibility and relevant clinical outcomes of transjugular implantation of the Aveir VR leadless pacemaker, aiming to address the gap in domestic preliminary research in this field.

二、Study Objectives

Primary Objective:

To evaluate the feasibility and acute safety (from intraoperative period through 48 hours post-procedure) of transjugular implantation of the Aveir VR active-fixation leadless ventricular pacemaker.

Secondary Objectives:

(1) To assess the stability and effectiveness of intraoperative and short-term (1–3 months post-procedure) pacing parameters, including pacing threshold, R-wave sensing amplitude, and lead impedance.

(2) To record procedure-related metrics, including technical success rate, procedure duration, fluoroscopy time, number of punctures, number of pacemaker fixation attempts, and incidence of complications.

(3) To determine the implantation site of the leadless pacemaker (right ventricular septum / right ventricular free wall) by cardiac ultrasound or cardiac CT before discharge, and to describe the correlation between different implantation sites and pacing parameters.

(4) To observe the incidence of adverse events (including serious adverse events) within 3 months after the procedure, so as to evaluate the short-term safety.

(5) To summarize the operational characteristics, learning curve, and clinical application experience of transjugular implantation of the Aveir VR leadless pacemaker.

三、Study Design Type, Principles and Trial Procedures

1. Study Design

• Study Type: Prospective, single-arm, single-center, exploratory feasibility clinical study

• Study Population: Patients with indications for ventricular pacing who are assessed by the operator as suitable for transjugular implantation of a leadless pacemaker

•Sample Size: 15 cases

•Access Approach: Transjugular approach (the internal jugular vein is preferred; the external jugular vein will be selected if the internal jugular vein is unsuitable, as determined by the operator based on the patient's anatomical structure and venous conditions)

• Study Device:Aveir VR active-fixation leadless ventricular pacing system (including the leadless pacemaker, delivery system, and related auxiliary instruments)

•Observation Periods:

•Acute observation period (intraoperative period to discharge)

•Short-term observation period (1 month and 3 months post-procedure)

•Study Site: Department of Cardiovascular Medicine, Xijing Hospital

•Study Duration: July 2026 – December 2027

2. Study Procedures and Operational Standards

2.1 Study Timeline

2.1.1 Screening Period (≤7 days before procedure)

(1) Collect detailed patient medical history and perform physical examination; record demographic data (age, sex, height, weight, underlying diseases, etc.).

(2) Complete preoperative examinations:

•Electrocardiogram (ECG)

•24-hour Holter monitoring

•Cardiac ultrasound (to evaluate cardiac structure, right ventricular size, and valvular function)

•Jugular vein ultrasound (to evaluate jugular venous anatomy and detect occlusion/stenosis)

•Complete blood count

•Coagulation function

•Liver and kidney function

•Electrolytes

•Myocardial enzyme spectrum, etc.

(3) The operator will assess the patient's pacing indications, feasibility of transjugular access, and suitability for leadless pacemaker implantation.

(4) Explain the study objectives, procedures, potential risks, and benefits to the patient and their family in detail; obtain written informed consent.

(5) Complete the baseline section of the Case Report Form (CRF).

2.1.2 Intraoperative Period (start of acute observation period)

(1) The patient enters the catheterization laboratory; establish intravenous access; monitor vital signs (heart rate, blood pressure, blood oxygen saturation); administer local anesthesia.

(2) Jugular vein puncture: The right internal jugular vein is preferred. Puncture is performed using the Seldinger technique; after successful puncture, a sheath is inserted to establish the operative pathway.

(3) Pacemaker delivery and deployment: The Aveir VR leadless pacemaker is advanced to the target site in the right ventricle (preferably the right ventricular septum) via the delivery system. Under fluoroscopy, the position is confirmed to be appropriate, the pacemaker is deployed, and the active helical fixation mechanism is screwed out to secure the device.

(4) Intraoperative parameter testing: Test pacing threshold, R-wave sensing amplitude, and lead impedance to ensure parameters meet the standard. If parameters are suboptimal, adjust the pacemaker position and retest until standards are met.

(5) Record procedure-related data: number of punctures, number of pacemaker fixation attempts, procedure duration, fluoroscopy time, parameter values, and intraoperative complications (e.g., puncture failure, arrhythmia, bleeding, etc.).

(6) End of procedure: Remove the sheath, apply local compression for hemostasis, dress and secure the puncture site; transfer the patient to the CCU or general ward for observation.

2.1.3 In-hospital Observation Period (post-procedure to discharge, ≤7 days)

(1) At 24–48 hours post-procedure: Monitor vital signs and ECG; observe the cervical puncture site for bleeding or hematoma; recheck pacing parameters; record acute adverse events.

(2) Before discharge: Perform cardiac ultrasound or cardiac CT to determine the pacemaker implantation site (right ventricular septum / right ventricular free wall) and retain imaging data; recheck complete blood count and coagulation function to assess patient recovery.

(3) Discharge instructions: Inform the patient of postoperative precautions (avoid vigorous neck movements, adhere to regular follow-up, seek prompt medical attention if discomfort occurs); provide a follow-up manual specifying follow-up time and location.

2.1.4 Postoperative Follow-up Period

(1) 1 month post-procedure: Outpatient follow-up; perform ECG and pacing parameter testing; inquire about clinical symptoms; record adverse events; complete the CRF.

(2) 3 months post-procedure: Outpatient follow-up; perform ECG, cardiac ultrasound (to evaluate pacemaker position and cardiac function), and pacing parameter testing; record adverse events; complete all endpoint assessments; complete the CRF. The study follow-up ends.

2.2 Operational Standards

2.2.1 Puncture Operation Standards

Performed by physicians with more than 5 years of experience in cardiovascular interventional procedures and familiarity with leadless pacemaker implantation techniques. Strictly adhere to the Seldinger technique. Closely monitor patient vital signs during puncture to avoid injury to surrounding tissues such as the carotid artery and trachea.

2.2.2 Pacemaker Implantation Standards

Follow the Aveir VR leadless pacemaker operation manual and the procedures described in published English studies. Avoid kinking or twisting of the device during delivery. Confirm the pacemaker position repeatedly before deployment to ensure firm active helical fixation and 达标 parameter testing before release.

2.2.3 Imaging Examination Standards

• Transthoracic echocardiography is performed before discharge to focus on pacemaker position (right ventricular septum / free wall) and fixation status.

• Cardiac CT is performed using coronary CTA scanning to clearly display the relationship between the pacemaker and the right ventricular wall, ensuring accurate determination of the implantation site.

2.2.4 Follow-up Standards

Follow-up is conducted by designated personnel who strictly adhere to the follow-up schedule to complete all examinations. Patient symptoms, pacing parameters, and adverse events are recorded in detail to ensure authentic and complete data.

2.3 Emergency Alternative Management Strategy for Intraoperative Access Failure

The primary planned procedure for this study is transjugular implantation of an active-fixation leadless ventricular pacemaker. If transjugular access is determined to have failed during the procedure, an alternative treatment strategy will be initiated immediately to ensure patient safety and meet pacing therapy needs.

2.3.1 Criteria for Determination of Transjugular Access Failure

Any of the following conditions constitutes transjugular access failure, and further attempts via this approach will be abandoned:

• Vascular access failure: Inability to successfully puncture the jugular vein, or inability to advance the guidewire through the superior vena cava into the right heart system.

• Device delivery failure: Inability to advance the delivery system smoothly to the right ventricle via the jugular vein pathway, even after reasonable adjustments.

• Leadless pacemaker fixation failure: Inability to achieve stable fixation of the active fixation mechanism at the intended right ventricular site after multiple attempts.

•Hemodynamic or electrical parameters not meeting standards: Pacing threshold, sensing, or impedance remain non-compliant with international or domestic implantation standards after repeated optimization.

• Serious complications: Occurrence of cardiac tamponade, severe arrhythmia, vascular laceration, thrombosis, or other conditions requiring emergency termination of the procedure.

2.3.2 Alternative Treatment Options

Once transjugular access failure is determined, the principal investigator will evaluate and select an alternative option in the following order:

(1) Implantation of the same type of active-fixation leadless ventricular pacemaker via the femoral vein approach

• If the patient's hemodynamics are stable, switch to the femoral vein approach to complete the implantation.

• Strictly adhere to leadless pacemaker operation standards during the procedure, and record the reason for access change and related data.

(2) Conversion to traditional transvenous pacing system implantation

• If reattempted leadless pacemaker implantation remains infeasible or contraindicated, convert to traditional pacemaker implantation.

• A single-chamber or dual-chamber pacing system may be selected; the specific model and implantation site will be determined by the operator based on individual patient conditions.

四、Case Selection

1、Inclusion Criteria

1.1 Age ≥ 18 years and ≤ 85 years, of any sex.

1.2 Patients with bradyarrhythmia meeting the indications for ventricular pacing recommended by the *2023 ACC/AHA/HRS Guideline for the Evaluation and Management of Patients With Bradycardia and Cardiac Conduction Delay*, the *Chinese Expert Consensus on the Evaluation and Management of Patients with Bradycardia and Conduction Disorders (2020)*, and the *Chinese Expert Consensus on the Clinical Application of Leadless Pacemakers (2022)*, and presenting with any of the following conditions:

- Third-degree or high-grade atrioventricular block;
- Mobitz type II second-degree atrioventricular block, alternating bundle branch block, or bifascicular / trifascicular block with intermittent high-grade / third-degree atrioventricular block;
- Adult congenital complete atrioventricular block; persistent irreversible high-grade / third-degree atrioventricular block following myocardial infarction or cardiac surgery;
- Symptomatic bradycardia (e.g., dizziness, amaurosis, syncope, fatigue, decreased exercise tolerance, etc.), sick sinus syndrome (including chronotropic incompetence and tachy-brady syndrome);
- Drug-induced persistent symptomatic bradycardia with no alternative treatment options;
- Atrial fibrillation with slow ventricular rate requiring long-term ventricular pacing;
- New-onset persistent complete left bundle branch block after TAVR, or new-onset high-grade atrioventricular block after ablation for hypertrophic cardiomyopathy;
- Neuromuscular disorders, infiltrative cardiomyopathy, or adult congenital heart disease complicated by progressive atrioventricular / fascicular conduction abnormalities accompanied by bradycardia-related symptoms;
- Populations at high risk of infection (e.g., recurrent pacing system infection, diabetes, long-term corticosteroid use, end-stage renal disease on dialysis, etc.), patients with abnormal conventional pacing access, or those at extremely high risk of conventional pacing lead complications.

  1.3 Anatomical feasibility and vascular access assessment:
- Preoperative imaging indicates that the right internal jugular venous access is suitable to accommodate the delivery sheath, without thrombosis, severe stenosis, or anatomical malformations;
- The right ventricular anatomical structure is appropriate, with sufficient trabeculations to support active fixation of the leadless pacemaker, and without severe right ventricular structural abnormalities;
- Priority will be given to patients with limited femoral vein or inferior vena cava access (e.g., iliac vein / inferior vena cava stenosis, thrombosis, history of vascular surgery, difficult femoral vein puncture due to obesity, etc.).

  1.4 New York Heart Association (NYHA) functional class ≤ III, with an expected survival of > 1 year.

1.5 Ability to cooperate with preoperative assessment, intraoperative procedures, and 3-month postoperative follow-up.

1.6 Voluntary signing of written informed consent, and agreement to comply with the study protocol and complete all observation items.

2、Exclusion Criteria

2.1 Anatomical malformations, severe stenosis, occlusion, or thrombosis of the internal jugular vein or superior vena cava that preclude completion of the procedure via the transjugular approach.

2.2 Abnormal right ventricular anatomy, including but not limited to right ventricular hypoplasia, severe right ventricular dilation, or severe right ventricular myocardial fibrosis, rendering safe implantation of an active-fixation leadless pacemaker infeasible.

2.3 Concomitant severe tricuspid regurgitation, or status post-artificial tricuspid valve replacement, which significantly affects pacemaker implantation, device fixation, and functional performance.

2.4 New York Heart Association (NYHA) functional class IV, or complicated by refractory heart failure or cardiogenic shock, making the patient intolerant to the procedure and perioperative management.

2.5 Concomitant severe hepatic or renal impairment (eGFR < 30 mL/min/1.73 m^2, or severe hepatic insufficiency), coagulation disorders, or active bleeding disorders, with clear contraindications for surgery.

2.6 Clear allergy or severe intolerance to the materials of the leadless pacemaker, intraoperative contrast agents, or anesthetics.

2.7 Previous implantation of other implantable cardiac electronic devices such as cardiac pacemakers, ICDs, or CRTs, or residual intracardiac leads or devices that interfere with the current implantation and device operation.

2.8 Advanced malignant tumors, severe infections, active autoimmune diseases, or other severe systemic diseases, with an estimated survival of < 12 months, rendering completion of the 3-month postoperative follow-up impossible.

2.9 Pregnant or lactating women, or women planning pregnancy during the follow-up period.

2.10 Presence of psychiatric disorders or cognitive impairment, or inability to cooperate with preoperative examinations, intraoperative procedures, and regular postoperative follow-up due to personal or geographical reasons.

2.11 Simultaneous participation in other cardiovascular device clinical trials that may interfere with the evaluation of this study's results.

2.12 Any other conditions deemed by the investigator as unsuitable for inclusion in this study.

3、 Dropout and Exclusion Criteria

3.1 Dropout Criteria

Participants who, after enrollment, are unable to complete all follow-up visits and assessments due to personal reasons (e.g., refusal to continue participation, transfer to another hospital, death) or changes in medical condition (e.g., occurrence of serious complications requiring withdrawal from the study) will be considered as dropouts.

3.2 Exclusion Criteria (from analysis set)

Participants who, after enrollment, are found to be ineligible (not meeting inclusion criteria), or have committed serious protocol violations (e.g., failing to complete required examinations, unauthorized use of medications/devices that may affect study evaluations), or have severely incomplete data that cannot be analyzed, will be excluded from the analysis set.

3.3 Management of Dropout and Excluded Cases

The reasons for dropout or exclusion must be recorded in detail. Dropout cases will be included in the Intention-to-Treat (ITT) analysis set. Excluded cases will not be included in the Per-Protocol (PP) analysis set. The expected dropout rate of this study is ≤10% (≤1 case). If the

dropout rate exceeds 10%, the reasons will be analyzed and reported in the final study report.

五、Adverse Event Monitoring

1. **Adverse Event Monitoring**
   From the time the patient signs the informed consent form until the end of the 3-month postoperative follow-up, all adverse events will be monitored throughout the entire study period, including all events occurring during the procedure, hospitalization, and follow-up that are related to or potentially related to the study.
2. **Adverse Event Documentation**
   Upon identification of an adverse event, the sub-investigator shall promptly record the time of onset, symptoms, severity, management measures, and outcome, and complete the Adverse Event Report Form.
3. **Reporting of Serious Adverse Events (SAEs)**
   In the event of an SAE, the investigator must report it to the Hospital Ethics Committee and the Principal Investigator within 24 hours. The investigator shall track the progress of the event until resolution or loss to follow-up, and submit an SAE follow-up report.
4. **Management of Adverse Events**
   For any adverse event that occurs, the investigator shall promptly take appropriate clinical measures to ensure patient safety. If necessary, the study may be suspended and the protocol amended.

六、Quality Control and Quality Assurance

1. **Personnel Training**
   Before the study commences, all research team members will receive training on the study protocol, operational standards, CRF completion, adverse event reporting, and data management, to ensure that all members are fully familiar with the study requirements.
2. **Operational Quality Control**
   Operators must have prior experience in leadless pacemaker implantation, with a minimum of 5 leadless pacemaker implantation procedures performed. Jugular vein puncture must be performed in strict accordance with established standards to avoid operational errors.
3. **Imaging Quality Control**
   Imaging evaluators must have at least 3 years of experience in cardiovascular imaging diagnosis. Determination of the implantation site will be performed by two independent readers. In cases of disagreement, a third-party arbitrator will make the final judgment to ensure accurate determination.
4. **Data Quality Control**
   A data verification mechanism will be established. Regular audits of CRFs and electronic

data will be conducted to promptly identify and correct data errors, ensuring that data are authentic, complete, and accurate.

5. **Regular Monitoring**
   The Principal Investigator will conduct quarterly monitoring of study progress, data quality, and ethical compliance. Any issues identified will be corrected promptly to ensure the study proceeds smoothly in accordance with the protocol.

七、Statistical Methods

Analysis Sets

The Per-Protocol (PP) analysis set will include patients who strictly adhered to the study protocol, had no serious protocol violations, and completed all follow-up visits and assessments. This set will be used for further efficacy analysis.

2. Statistical Description Methods

This study is an exploratory feasibility study. Descriptive statistics will be the primary approach, and no hypothesis testing, superiority, or non-inferiority tests will be performed. All results are considered exploratory.

(1) Continuous variables: Data conforming to a normal distribution will be presented as mean ± standard deviation (x ± s). Data not conforming to a normal distribution will be presented as median (interquartile range) [M (Q1, Q3)].

(2) Categorical variables: Data will be presented as frequency (n) and percentage (%). For rates such as adverse event incidence and technical success rate, 95% exact confidence intervals will be calculated using the Clopper-Pearson method.

(3) Correlation description: A descriptive comparison of pacing parameters at different implantation sites (right ventricular septum / free wall) will be performed, with results presented in text and tables.

3. Sample Size Justification

This is a single-center, prospective, single-arm feasibility study. The sample size was determined with reference to published early feasibility studies of the Aveir VR leadless pacemaker and the feasibility study guidelines by Vickers AJ et al. (published in BMJ Open in 2021). A total sample size of 15 cases was set to adequately evaluate the operational feasibility, acute safety, and short-term effectiveness of the transjugular approach, obtain preliminary imaging data on implantation sites, and account for the feasibility of patient recruitment at a single center. Limited by the small sample size, this study will only provide preliminary clinical evidence and is not intended to confirm the safety and effectiveness of transjugular implantation of the Aveir VR leadless pacemaker. The generalizability of the study conclusions is limited, and the results will serve only as a reference for subsequent larger, multi-center studies.

八、Ethical Considerations

This clinical study will be conducted in compliance with the Declaration of Helsinki issued by the World Medical Association and other relevant regulations. Before the study commences, the study protocol must be approved by the Ethics Committee before the clinical study can be initiated.

Prior to each participant's enrollment, the investigator is responsible for providing a complete and comprehensive explanation to the participant or their legal representative regarding the purpose, procedures, potential benefits, and risks of this study. A written informed consent form must be signed. Participants must be informed of their right to withdraw from the study at any time. The signed informed consent form will be retained as an official study document for future reference.

Throughout the study, the personal privacy and data confidentiality of participants will be strictly protected.

九、Study Timeline

- **July 10, 2026 – August 30, 2026:** Submission of ethical review materials (study protocol, informed consent form, pilot data) and obtainment of the ethics approval document.
- **September 1, 2026 – August 1, 2027:** Completion of screening, enrollment, surgical procedures (jugular vein puncture + Aveir VR release), and in-hospital observation for all 15 patients.
- **October 1, 2026 – November 1, 2027:** Completion of postoperative follow-up for all 15 patients, including the 1-month follow-up (May–August) and the 3-month follow-up (July–October).
- **November 1, 2027 – December 31, 2017:** Conduct descriptive statistical analysis (procedure duration, fluoroscopy time, complication incidence, stability of pacing parameters) and prepare the final study report.

十、Study Personnel

Name	Title / Specialty	Responsibilities	GCP Training (Yes/No)
Min Shen	Associate Professor / Associate Chief Physician	1. Patient screening, enrollment evaluation, and performing key medical procedures in the study; 2. Supervising junior physicians in conducting research and providing academic mentoring to the team; 3. Assisting in the development of research-related academic outputs.	Yes
Liang Wen	Attending Physician	1. Implementation of routine follow-up plans for study participants; 2. Standardized collection and organization of clinical data; 3. Assisting with informed consent communication, document signing, and archiving of ethics-related files; 4. Assisting in performing medical procedures; 5. Study data entry, preliminary statistical analysis, and timely reporting of data anomalies or study bottlenecks.	Yes
Tao Liu	Postgraduate Student in Cardiovascular Medicine	Serving as the data manager, assisting with data entry, document management, and other related tasks.	Yes

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