Nursing Experience of Preoperative Prehabilitation in a Patient Undergoing Aortic Valve Replacement Surgery

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Abstract

Aortic valve stenosis (AS) has led to a continuous rise in mortality over the past two decades. AS is an insidious disease with a long latent period that can increase left ventricular afterload, thereby inducing a series of pathological remodeling processes to maintain cardiac output. Up to half of AS patients develop left ventricular hypertrophy and myocardial fibrosis, and these changes are defined as cardiac remodeling. Cardiac remodeling can occur in pressure overload associated with AS and hypertension, and also after myocardial cell loss due to myocardial infarction. Untreated severe AS patients have high mortality; once the disease progresses to a point where surgical intervention is no longer possible, survival is generally less than five years. Transcatheter aortic valve replacement (TAVR), through continuous development, is a minimally invasive therapeutic technique that delivers a prosthetic aortic valve to the aortic root via interventional catheter technology for deployment and fixation, replacing the function of the diseased aortic valve. Its safety and efficacy have been demonstrated in multiple large-scale prospective randomized controlled studies. Due to its advantages of avoiding thoracotomy, cardiac arrest, and cardiopulmonary bypass, TAVR has become an effective option for patients with severe aortic stenosis (AS) and/or aortic regurgitation (AR) who are ineligible for or at high risk for surgical intervention, and has become the gold standard treatment for elderly patients with symptomatic severe AS [**?**]. Preoperative prehabilitation refers to rehabilitation that patients undergo before surgery to enhance individual functional reserve, so that TAVR patients can better withstand the subsequent surgical stress. Studies have shown that preoperative prehabilitation for TAVR patients can reduce postoperative complication rates, shorten hospital stays, improve frailty, increase 6-minute walk test distances, and improve prognosis [**?**].

Full Text

Preamble

Title: Perioperative Prehabilitation Nursing Experience in a Patient Undergoing Aortic Valve Replacement Surgery
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Abstract

Mortality from aortic valve stenosis (AS) has continued to rise over the past two decades. AS is an insidious disease with a long latency period that increases left ventricular afterload, triggering a series of pathological remodeling processes to maintain cardiac output. Up to half of AS patients develop left ventricular hypertrophy and myocardial fibrosis, changes defined as cardiac remodeling. This remodeling can occur in response to pressure overload associated with AS and hypertension, as well as following myocardial cell loss after myocardial infarction. Untreated severe AS carries a high mortality rate, and once the disease progresses beyond surgical candidacy, survival is typically less than five years.

Transcatheter aortic valve replacement (TAVR) has evolved into a minimally invasive therapeutic technique that delivers a prosthetic aortic valve to the aortic root via interventional catheterization for fixation, replacing the function of the diseased native valve. Its safety and efficacy have been confirmed by multiple large-scale prospective randomized controlled studies. Due to advantages such as avoiding thoracotomy, cardiac arrest, and cardiopulmonary bypass, TAVR has become an effective option for patients with severe aortic stenosis (AS) and/or aortic regurgitation (AR) who are ineligible for or at high risk for surgical intervention, establishing itself as the gold standard treatment for elderly symptomatic patients with severe AS [1]. Preoperative prehabilitation refers to rehabilitation aimed at enhancing individual functional reserve before surgery, enabling TAVR patients to better withstand the subsequent surgical stress. Studies have demonstrated that preoperative prehabilitation in TAVR patients can reduce postoperative complication rates, shorten hospital stays, improve frailty, increase six-minute walk test distances, and improve prognosis [2-7].

Keywords (Chinese): Aortic stenosis (AS); Aortic valve replacement (TAVR); Cardiac rehabilitation (CR)
Keywords (English): aortic stenosis; Aortic valve replacement; Cardiac Rehabilitation

1. Clinical Data

Patient: Male, 68 years old
Chief Complaint: Recurrent chest tightness and pain for over 20 years, exac-

erbated with dyspnea for one week.

History of Present Illness: Over 20 years ago, the patient presented with chest tightness and pain at Liwan District People's Hospital, where a cardiac murmur was auscultated and "myocardial strain" was diagnosed by the outpatient physician; medication was not taken regularly, with specific drugs unknown. More than 10 years ago, another episode of chest tightness and pain occurred at Fangcun District People's Hospital, where echocardiography was completed and "valvular heart disease" was diagnosed; the patient did not give it due attention. His usual cardiac function was NYHA Class I-II, and he could care for himself independently. Over the past three years, he experienced paroxysmal nocturnal dyspnea. One week prior to admission, chest tightness and pain worsened with dyspnea, paroxysmal nocturnal dyspnea, palpitations, dizziness, occasional cold sweats in the extremities, cough with white sticky sputum, symptoms that were pronounced with activity and poorly relieved by rest. He subsequently presented to our emergency department, where relevant examinations led to a diagnosis of "acute heart failure, suspicious for coronary artery disease observation" and he was admitted.

Symptoms on Admission: The patient was conscious but mentally fatigued, with chest tightness and pain, dyspnea, orthopnea, cough with white sticky sputum, occasional cold sweats in the extremities, decreased appetite, no lower extremity edema, normal urination, loose stools, and fair sleep. Tongue was dark red with a thin white coating, pulse was surging but weak.

Past Medical History: None
Allergy History: None
Personal History: Native-born, denied smoking history, occasional alcohol consumption, married with children.
Family History: Mother had heart disease, father had cerebral infarction, siblings have coronary artery disease.

Vital Signs on Admission: Temperature 36.5°C, Pulse 76 beats/min, Respiratory rate 20 breaths/min, Blood pressure 128/72 mmHg
Laboratory Values: Preoperative NT-proBNP on September 18 was 1885 ng/L.

Examination Results:

Preoperative Echocardiography (September 21): Severe aortic stenosis with massive regurgitation, mild mitral stenosis with massive regurgitation, segmental wall motion abnormalities, decreased left ventricular systolic and diastolic function. 2D measurement of valve orifice area was 0.98 cm^2, with thickened, calcified leaflets and restricted opening. Peak velocity: 4.8 m/s, mean transvalvular pressure gradient: 56 mmHg, EF: [value missing in original].

2. Preoperative Specialist Assessment

Preoperative blood pressure was 128/72 mmHg, heart rate 76 beats/min. The patient had chest tightness and pain, dyspnea, and orthopnea. No lower extremity edema was present. Wet rales were heard on bilateral lung auscultation. Cardiac border was enlarged to the left. A jet-like murmur was heard at the aortic auscultation area, radiating to the neck. A blowing murmur was heard at the mitral valve area, radiating to the left axilla. ASA Class: III-IV, Cardiac function NYHA Class IV.

3. Preoperative Rehabilitation Assessment

General Function: Preoperative severe aortic stenosis with NYHA Class IV cardiac function. The patient had no regular exercise habits, with activity level equivalent to office worker (metabolic equivalent 1-2 METs), belonging to the low exercise capacity population.

Cognitive Function: No impairment, good communication.

Activities of Daily Living: BADL score 75 points, indicating mild dependence.

Motor Ability Testing:
- Grip strength test: Right hand grip strength 36 kg by dynamometer
- Muscle strength assessment: Four-limb muscle strength grade 5
- Balance function assessment: 35 seconds of single-leg stance with eyes open
- Lower extremity endurance assessment: 12 repetitions in 30-second sit-to-stand test
- Cardiopulmonary endurance assessment: 125 meters in six-minute walk test

Frailty Score: Frail questionnaire score 4 points, indicating obvious frailty.
Nutritional Status: NRS assessment 0 points.
Psychological Status: Depression Self-Rating Scale score 30 points, Anxiety Self-Rating Scale score 51 points.
Sleep: Pittsburgh Sleep Quality Index: 12 points.

Surgical Procedure

Preoperative Preparation: On September 18 at 11:00, preoperative indwelling catheterization was performed.
Surgical Time: 13:40-15:55
Anesthesia: General anesthesia with endotracheal intubation; vital signs remained stable.

Operative Process: The right subclavian vein was punctured to place a vascular sheath, and a temporary pacemaker was advanced to the low septum of the right ventricle with good pacing position. After left femoral artery puncture and catheterization, a 6F sheath was retained via right femoral artery puncture. A J-tipped guidewire was inserted, the sheath was withdrawn, two

preloaded suture devices were placed, and a 9F sheath was inserted. Through the right femoral artery, the aortic valve replacement system was inserted via wire exchange. The aortic valve was successfully deployed under high-frequency temporary pacemaker stimulation. Repeat aortic angiography was satisfactory. A pigtail catheter was inserted for repeat measurement of aortic transvalvular pressure gradient at 2 mmHg. The procedure was smooth with satisfactory anesthesia. The temporary pacemaker was retained with pacing rate 50 beats/min, sensitivity 2 mV, and pacing threshold 5 mA. During the intervention, a right neck double-lumen central venous catheter was placed with 7 cm external length, with smooth return from both lumens.

Postoperative Course: The endotracheal tube was removed and the patient was transferred to ICU for monitoring.

Postoperative Echocardiography: After transfemoral aortic valve replacement, there was mild-to-moderate paravalvular leakage of the aortic bioprosthetic valve, mild mitral stenosis with mild-to-moderate regurgitation, segmental wall motion abnormalities, and decreased left ventricular systolic and diastolic function. EF: 45%. Peak velocity of prosthetic aortic valve was approximately 2.2 m/s, mean transvalvular pressure gradient 10 mmHg. Paravalvular leakage was observed during diastole, accounting for approximately 10% of the valve circumference.

Postoperative Nursing Care

(1) Local Vascular Complications and Nursing Care

On September 19, the physician removed the elastic bandage from the right femoral artery in the ward. On September 21, ultrasound of the mass showed: puncture site of right femoral artery with petechiae and ecchymosis, palpable mass measuring 5 cm × 2 cm, hard in consistency with fair mobility and mild tenderness. The following nursing measures were implemented:

1.1 Wound Observation: The puncture site was monitored for bleeding and hematoma, as well as skin temperature, color, and dorsalis pedis pulse of both lower extremities. The patient had no bleeding at the surgical site, minimal hematoma, thigh circumference 56 cm, cool skin temperature in the lower extremities, normal color, and weak dorsalis pedis pulse. Shift-to-shift handover was performed diligently, with immediate notification of the physician for compression bandaging if bleeding was observed.

1.2 Condition Monitoring: Vital signs were closely monitored. If the patient developed decreased blood pressure, restlessness, and complained of abdominal or back pain, the possibility of retroperitoneal hemorrhage was considered. During bedside compression by the physician, nurses observed for vagal reflex. After re-compression, passive massage and ankle pump exercises were provided to prevent lower extremity thrombosis.

Outcome: The patient had no bleeding at the surgical site, minimal hematoma,

thigh circumference 54 cm, warm skin temperature in the lower extremities, normal color, and good dorsalis pedis pulse. On September 26, petechiae and ecchymosis at the right femoral artery puncture site had decreased compared with previous, the palpable mass was smaller, with no obvious tenderness. Ultrasound showed a regular tubular hyperechoic area from distal external iliac artery to common femoral artery, approximately 30 mm in length, pulsating with the pulse. VAS pain score was 3 points. The patient did not develop lower extremity thrombosis.

(2) Rehabilitation Training and Implementation

2.1 Preoperative Early Rehabilitation Intervention

Based on comprehensive rehabilitation assessment results, an individualized prehabilitation plan was formulated to improve physical fitness, adjust psychological status, ameliorate frailty, enhance exercise tolerance and surgical tolerance, and encourage active participation in postoperative early exercise rehabilitation. Corresponding rehabilitation assessments were performed, and under the premise of patient tolerance, low-intensity training was guided by rehabilitation therapists. Patients were also instructed in postoperative positioning management and bedside rehabilitation training.

Specific rehabilitation content included: After removal of immobilization from the puncture site limb (preoperative 1-2 days), exercise rehabilitation was initiated at 1 METs in sitting or assisted sitting position, with position changes every 2 hours. The rehabilitation exercise prescription included: patients wore cardiac monitors, blood pressure cuffs, and pulse oximetry devices. Exercises consisted of: (1) seated ankle pump training; (2) upper extremity muscle strength training; (3) lower extremity muscle strength training; (4) bedside cycling training; (5) ACBT breathing training. Activities included bed and bedside mobility, self-feeding with partial assistance. Borg Rating of Perceived Exertion was 8-10 points. Vital signs were recorded before exercise. The protocol ensured no exercise contraindications occurred, such as new-onset arrhythmia or ECG ST-T changes.

Specific exercises were: (1) Ankle pump training: 1 set of 36 repetitions, 4 sets daily; (2) Upper extremity training: grip ring 4 sets of 36 repetitions + elastic band 4 sets of 36 repetitions (front and back stretches with both hands) + 0.5 kg dumbbell 4 sets of 36 repetitions (overhead raise, forward reach, lateral raise); (3) Lower extremity bed training: straight leg raise 4 sets of 36 repetitions; (4) Bed cycling training: 10 minutes per session, 2 sessions daily; (5) ACBT breathing training (at least 4 sets daily): 5 breath controls (pursed-lip breathing) + 10 deep breaths (hold 2-3 seconds then exhale with diaphragmatic breathing) + 1 forced huff and 1 cough.

2.2 Postoperative TAVR Rehabilitation

TAVR patients without abnormalities in catheter position or function should

begin early exercise rehabilitation as soon as possible after full evaluation by the attending physician confirms tolerance and safety. Early initiation of exercise rehabilitation should simultaneously meet the following clinical indicators: (1) Mean arterial pressure (MAP) 60-100 mmHg (1 mmHg = 0.133 kPa); (2) Systolic blood pressure (SBP) 90-180 mmHg; (3) Oxygen saturation (SpO_2) $ $88% (at rest without oxygen); (4) Resting heart rate 60-130 beats/min.

Specific rehabilitation content was implemented in phases: In the postoperative ICU rehabilitation phase (postoperative days 1-2), exercises at 1 METs in supine position included ankle pumps, upper extremity muscle training, lower extremity muscle training, and ACBT training, with position changes every 2 hours. In the postoperative general ward rehabilitation phase (postoperative days 2-3), exercises progressed to 1-2 METs in semi-recumbent or assisted sitting position, adding seated ankle pumps, upper and lower extremity muscle training, balance training, and ACBT training. As patients advanced, they progressed to 2-3 METs with assisted standing, then independent standing and indoor activities. Throughout all phases, patients wore cardiac monitors, portable blood pressure cuffs, and pulse oximetry. Borg scores progressed from 8-10 to 12-13 points as activity increased. Safety measures included ensuring puncture site fixation, patent supportive tubes and monitoring systems, and patient tolerance for progressive exercises such as stretching and stair climbing.

The exercise protocol included: (1) Ankle pump training (supine/seated): 1 set of 36 repetitions, 4 sets daily; (2) Upper extremity training (with optional 0.5 kg dumbbells): grip ring 4 sets of 36 repetitions + elastic band 4 sets of 36 repetitions (front/back stretches) + 0.5 kg dumbbell raises 4 sets of 36 repetitions (overhead, forward, lateral); (3) Lower extremity training (with optional 0.5 kg dumbbells): straight leg raise 4 sets of 36 repetitions; (4) Cycling training (supine/seated): 10 minutes per session, 2 sessions daily; (5) ACBT breathing training (at least 4 sets daily): 5 breath controls (pursed-lip) + 10 deep breaths (hold 2-3 seconds then exhale with diaphragmatic breathing) + 1 forced huff and 1 cough; (6) Walking distance: 10-25 meters, 2-4 times daily; (7) Balance training: single-leg stance with eyes open, 4-8 sets of 1-2 minutes each (under bedside nursing supervision); (8) Stretching training: limb, shoulder/back/leg stretches for 3-5 minutes; (9) Stair climbing training: 20 steps per floor, 1-2 floors per session.

2.3 Rehabilitation Nursing Protocol

Rehabilitation nursing staff must strictly follow the "assessment-exercise-reassessment" operational protocol for critically ill patients during postoperative exercise rehabilitation in TAVR patients. Patient-reported exertion (Borg score) should be emphasized, with close observation of hemodynamic and respiratory status. If patients fail to meet early rehabilitation criteria or demonstrate intolerance, exercise must be terminated immediately, vital signs closely monitored, and changes reported to the attending physician.

(3) Paravalvular Leak Complication and Nursing Care

3.1 Postoperative bedside echocardiography was used to evaluate aortic valve position, structure, function, degree of paravalvular leak, and cardiac function.

3.2 Hemodynamic changes and oxygen saturation were observed, along with mental status, presence of pallor, and temperature elevation. Hemoglobin, urinalysis, and B-type natriuretic peptide were monitored. The patient remained conscious with stable vital signs and no fever. On September 21, hemoglobin was 112 g/L, urinalysis was normal, and NT-proBNP was 1001 ng/L.

6.1 Postoperative Rehabilitation Assessment

General Function: Postoperative cardiac function NYHA Class III. After rehabilitation training, metabolic equivalent was 2-3 METs. The patient remained in the low exercise capacity population, preparing for continued outpatient Phase II rehabilitation.

Cognitive Function: No impairment, good communication.
Activities of Daily Living: BADL score 90 points, mild dependence.

Motor Ability Testing:
- Grip strength test: Right hand grip strength 42 kg by dynamometer
- Muscle strength assessment: Four-limb muscle strength grade 5
- Balance function assessment: 45 seconds of single-leg stance with eyes open
- Lower extremity endurance assessment: 15 repetitions in 30-second sit-to-stand test
- Cardiopulmonary endurance assessment: 366 meters in six-minute walk test

Frailty Score: Frail questionnaire score 2 points.
Nutritional Status: NRS assessment 0 points.
Psychological Status: Depression Self-Rating Scale score 22 points, Anxiety Self-Rating Scale score 35 points.
Sleep: Pittsburgh Sleep Quality Index: 7 points.

6.2 Outpatient Follow-up and Phase II Rehabilitation

Based on postoperative rehabilitation assessment in TAVR patients, a multidisciplinary team of physicians, rehabilitation therapists, and nurses collaboratively developed a Phase II rehabilitation plan after discharge. Cardiopulmonary exercise testing for evaluation must confirm good healing of the femoral artery puncture wound before assessment. Patients with poor wound healing should defer exercise testing. Corresponding rehabilitation protocols were selected based on postoperative mental status, disease condition, and fitness level.

Currently, the safety and efficacy of TAVR have been widely recognized clinically. Postoperative patients require long-term disease control, subsequent

pharmacotherapy, exercise rehabilitation, and self-health management. Multiple studies have demonstrated that postoperative exercise rehabilitation in TAVR patients can effectively improve exercise capacity, muscle strength, respiratory function, and quality of life. Active implementation of preoperative prehabilitation and early inpatient rehabilitation can reduce the incidence of various complications such as pulmonary infection, acquired sarcopenia, and lower extremity deep vein thrombosis, facilitating shorter hospital stays and rapid recovery of independent social functioning. Related exercise rehabilitation reports have been published domestically and internationally. Research by Yu Zikai et al. [8-11] showed that comprehensive assessment results in TAVR patients have certain correlations with cardiac rehabilitation outcomes, suggesting that healthcare professionals can evaluate rehabilitation effectiveness through comprehensive assessment results. Based on the summarized evidence, continuous dynamic comprehensive assessment is recommended for TAVR patients. Preoperative assessment of baseline conditions and postoperative evaluation of exercise tolerance and disease stability should be performed, with careful exclusion of contraindications before rehabilitation and accurate identification of initiation and suspension criteria during exercise to ensure patient safety and avoid adverse events.

TAVR involves multiple vascular access procedures and intraoperative heparin use, resulting in relatively high incidence of vascular complications, including puncture site bleeding, hematoma, and iatrogenic injury bleeding along the catheter path [12-16]. Preoperative evaluation and selection of appropriate surgical approach based on imaging data, along with standardized intraoperative procedures, are important measures to reduce vascular complications. Enhanced nursing observation and shift-to-shift handover facilitate early problem detection and timely physician notification.

Paravalvular leak is one of the main complications after TAVR, related to the pathoanatomy of aortic valve disease, TAVR surgical principles, device types, and implantation methods. Preoperative comprehensive evaluation based on imaging data and selection of appropriate TAVR valve type and size are important measures to reduce paravalvular leak. This is primarily because prosthetic valves rely on radial support force from the stent for active anchoring and apposition to the native annulus or supra-annular structures rather than surgical suturing. Generally, small paravalvular leaks cause minimal hemodynamic changes and have little impact on overall cardiac function. Severe paravalvular leak can cause complications such as heart failure, hemolysis, and infective endocarditis, requiring reoperation [17-20]. In this patient, postoperative echocardiography showed paravalvular leakage during diastole accounting for approximately 10% of the valve circumference. Clinical symptoms were mild, consistent with mild paravalvular leak, which was managed conservatively.

8 References

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Note: Figure translations are in progress. See original paper for figures.