



## Research article

# Summary of surgical experience of an elderly patient who underwent simultaneous dual minimally invasive TA-TAVR and McKeown procedures

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## ABSTRACT

**Background:** Cases of simultaneous TA-TAVR and Mckeown dual minimally invasive surgery are very rare. A retrospective analysis of the clinical features, perioperative surgical cooperation and care of an elderly patient with esophageal cancer combined with moderate-to-severe aortic regurgitation.

**Methods:** An elderly patient with esophageal cancer combined with moderate to severe aortic valve regurgitation was admitted to the Department of Thoracic Surgery, West China Hospital, Sichuan University in September 2022. Through preoperative MDT discussion, two minimally invasive surgical options were identified and analyzed to develop personalized and standardized perioperative operating room care and surgical coordination. Informed written consent and institutional review board approval were both obtained (No. 2021-879; July 25, 2022) for the surgery and the publication of the study data.

**Results:** After a thorough preoperative MDT discussion and the development of a personalized and standardized operating room care plan, the two surgeries lasted a total of 5h 35mins with a total bleeding volume of 150 ml. The surgeries went smoothly, and the patients were sent to the ICU and transferred back to the general ward on the second day after surgery without complications.

**Conclusion:** The simultaneous performance of dual minimally invasive level IV surgery is indeed a high-risk procedure, which is a new challenge for both patients and health care workers. Standardized OR care planning and surgical coordination are also important aspects of MDT, reflecting that OR care is an indispensable role in the surgical team as well.

## 1. Background

Minimally invasive procedures in thoracic surgery and cardiac surgery have now covered most of the routine procedures [1]. Aortic regurgitation is a common valve disease, and surgical open-heart aortic valve replacement remains the treatment of choice for patients with simple aortic regurgitation. Transcatheter aortic valve placement (TAVR) is a new minimally invasive valve replacement technique, and TA-TAVR can be an effective treatment for patients at high risk or with contraindications to cardiac surgery [2,3]. With the maturation of TAVR technology and improvement of devices, the feasibility and safety of its application in elderly patients with severe

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aortic regurgitation are being explored [4]. Perioperative complications of TAVR include: injury to the arterial puncture site, arterial tree injury, and vascular closure issues; Valve release including improper positioning, impaired coronary blood supply, and valve ring rupture; Valve function including perivalvular leakage.

In recent years, minimally invasive esophageal cancer treatment has been widely used and proven in clinical practice, with a lower complication rate and death rate than traditional open-heart surgery and a better treatment effect [5]. Currently, common minimally invasive esophagectomy (MIE) includes thoraco-laparoscopic combined transabdomino-thoracic two-incision radical intrathoracic esophageal cancer anastomosis (also known as Ivor-Lewis operation), thoraco-laparoscopic combined transcervical thoraco-abdomino-three-incision radical cervical esophageal cancer anastomosis (also known as McKeown operation) and transmediastinoscopic radical esophageal cancer resection [6]. The complications of esophageal cancer surgery include bleeding, incision infection, anastomotic fistula, empyema, pulmonary complications, cardiovascular complications, chylothorax, recurrent laryngeal nerve paralysis, and gastrointestinal dysfunction.

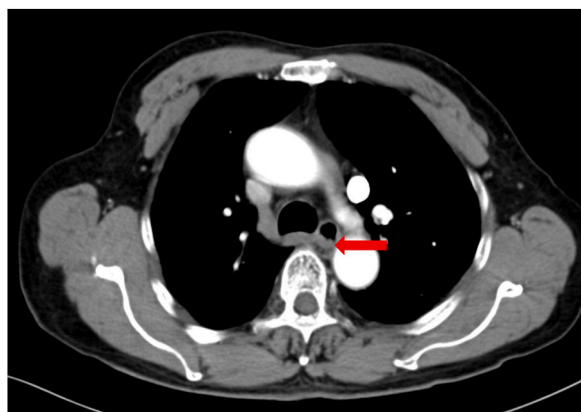
However, cases of simultaneous dual minimally invasive surgery are very rare, especially in elderly male patients. Due to the long and difficult nature of esophageal surgery, it is risky to perform esophageal surgery without cardiac surgery first. Patients may not be able to tolerate the risks of anesthesia and esophageal surgery and face the risk of heart failure, arrhythmia or even death at any time during and after surgery. If traditional open-chest valve replacement surgery is performed first, it will be very traumatic and will also face corresponding surgical risks, and the postoperative recovery and anticoagulation treatment will take longer, so it will not be possible to perform esophageal cancer surgery in a short time, and the best time for surgery may be missed. We summarize a case of an elderly patient who underwent minimally invasive radical esophageal cancer surgery combined with TA-TAVR at the same time and its related perioperative care measures to provide a reference idea and basis for more medical and nursing colleagues to face the perioperative preparation of such patients.

## 2. Methods

### 2.1. Case presentation

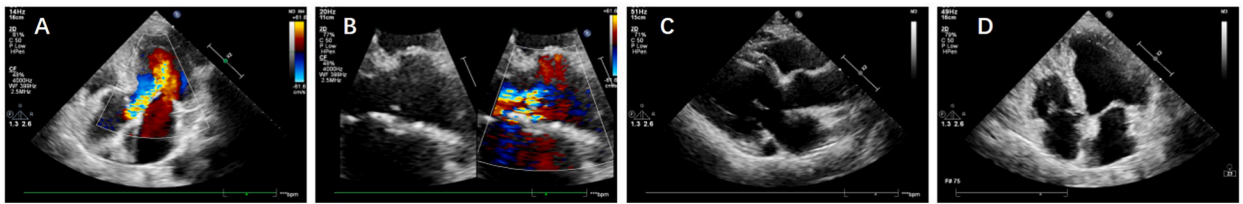
The patient was a 71 years old male. He was admitted to the hospital with a diagnosis of squamous carcinoma of the lower and middle esophagus. The patient had a history of sulfonamide allergy but no history of surgery, blood transfusion or other medical history. Informed written consent and institutional review board approval were both obtained (No. 2021-879; July 25, 2022) for the surgery and the publication of the study data.

The chest CT examination was performed and it showed the wall of the upper middle esophagus was slightly thickened, the thickest part was approximately 0.9 cm, and the local lumen was slightly narrowed (Fig. 1). Routine echocardiography revealed aortic regurgitation (moderate to severe), mitral regurgitation (mild to moderate), tricuspid regurgitation (mild), and normal left ventricular systolic function measurements in the residual left superior vena cava (Fig. 2 A, B, C, D). CT coronary angiography showed mild atherosclerosis of the coronary arteries, with soft plaques and mild luminal stenosis (25–49 %) visible in the mid-LAD wall. The patient's initial diagnosis was aortic regurgitation (severe), class III cardiac function, squamous carcinoma of the lower and middle esophagus.



**Fig. 1.** Chest CT of the case.

CT scan showing the wall of the upper middle esophagus was slightly thickened, the thickest part was approximately 0.9 cm, and the local lumen was slightly narrowed. Routine echocardiography revealed aortic regurgitation (moderate to severe), mitral regurgitation (mild to moderate), tricuspid regurgitation (mild), and normal left ventricular systolic function measurements in the residual left superior vena cava. CT coronary angiography showed mild atherosclerosis of the coronary arteries, with soft plaques and mild luminal stenosis (25–49 %) visible in the mid-LAD wall. The patient's initial diagnosis was aortic regurgitation (severe), class III cardiac function, squamous carcinoma of the lower and middle esophagus.



**Fig. 2.** Echocardiography before the surgery. Aortic valve regurgitation (moderate to severe); Mitral regurgitation (mild to moderate); Tricuspid valve regurgitation (mild).

## 2.2. Preoperative multidisciplinary discussion

After multidisciplinary team (thoracic surgery, cardiac valve team, and anesthesiology) discussions, an optimal personalized surgical plan was developed for the patient. Due to the long and difficult nature of esophageal surgery, it was risky to perform esophageal surgery without cardiac surgery first. Patients would not be able to tolerate the risks of anesthesia and esophageal surgery and faced the risk of heart failure, arrhythmia or even death at any time during and after surgery. If traditional open-chest valve replacement surgery was performed first, it would be very traumatic and would also face corresponding surgical risks, and the postoperative recovery and anticoagulation treatment would take longer, so it would not be possible to perform esophageal cancer surgery in a short time, and the best time for surgery might be missed.

After discussion among the multidisciplinary team, our specialized surgical team of cardiac surgery TAVR would plan to perform minimally invasive TA-TAVR to address the problem of aortic regurgitation first, while the surgical team of the thoracic surgery esophageal group would perform minimally invasive McKeown surgery to address the esophageal problem at the same time. In response to this surgical plan, it was customary to abstain from drinking and eating before surgery, and to conduct preoperative health education. As the patient's surgical approach was to the left and right chest, abdomen, and neck, preoperative guidance was provided to the patient to practice abdominal breathing and effective sputum expulsion methods to help with postoperative recovery. Strict aseptic operation during surgery, professional and smooth multidisciplinary surgical cooperation were the key to successful surgery, and postoperative multidisciplinary combined treatment and nursing were necessary links for postoperative rehabilitation.

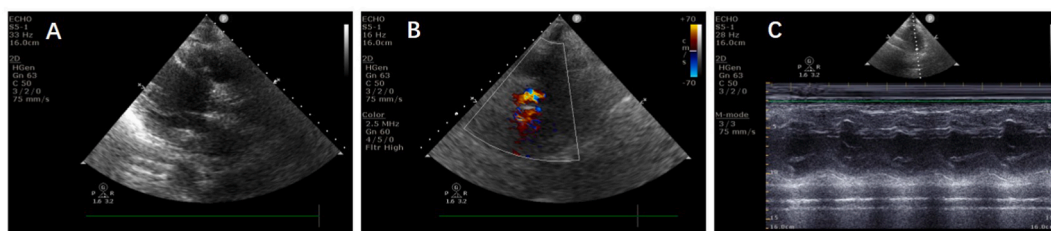
In order to prevent the occurrence of surgical site infection (SSI) in infection control, antibiotics were used 30 min to 1 h before the start of routine surgery. For surgery >3 h and intraoperative bleeding >1500 ml, antibiotics were added reasonably, and strict aseptic procedures were performed during surgery. For the risk management of perioperative bleeding, TAVR surgery involved routine peripheral venous injection of 1 mg/kg heparin for anticoagulation before the placement of the guide wire. At the end of the surgery, protamine antagonistic heparin (1:1) was used. Accurate surgical cooperation during valve placement was the key to reducing intraoperative bleeding; Artificial pneumothorax would be established during MIE surgery to free the thoracic esophagus, passing through the aortic arch, and all difficulties would be combined in the thoracic cavity. The precise operation of the chief surgeon and the control of surgical time were the key to reducing intraoperative complications.

## 2.3. Perioperative preparation

It had been reported many details which can be presented in our *Supplementary data*.

## 2.4. Postoperative follow-up

After discharge, the patient would be followed up at the cardiac and thoracic outpatient clinics once a week in the first month, twice a month in the second month, and once a month in the third month. Follow ups would be conducted every six months thereafter. Postoperative telephone follow-up had been conducted for over a year.



**Fig. 3.** Echocardiography after the surgery. Aortic valve is an artificial valve with stable valve frame and no abnormal echo attachment around the valve; The forward blood flow of the artificial Aortic valve is unobstructed, and there is no exact regurgitation around the artificial valve.

### 3. Results

The patient underwent dual minimally invasive TA-TAVR and Mckeown under general anesthesia at the same time for a high-risk procedure in the thoracic cavity adjacent to a vital organ. With the cooperation of the TAVR team, minimally invasive esophageal surgery team, anesthesiologists, and operating room nursing team, a double minimally invasive TA-TAVR, combined thoracic-laparoscopic cervical anastomosis for radical resection of esophageal cancer, pleural adhesion branding, thoracic duct ligation, bilateral laryngeal recurrent nerve exploration, and pyloroplasty were completed under general anesthesia over 6 h at the same time. The patient was safely transferred to the thoracic ICU for specialized treatment after surgery and was transferred back to the thoracic surgery ward on the third postoperative day for continued treatment. The patient recovered smoothly without surgical complications, ate normally, had normal cardiac ultrasound function, valve structure and position (Fig. 3 A, B, C), and was discharged on the 10th postoperative day. During the follow-up process, we used patient reported outcomes (PRO), which is a report that directly reflects a patient's assessment of their own health status, to understand the self-reported symptoms, quality of life impact, and treatment experience/satisfaction of patient. The patient reported occasional wound pain, but it did not affect daily life, and was relatively satisfied with the surgery.

### 4. Discussion

TAVR surgery is different from conventional open heart surgery, with relatively fewer contraindications, and is the best choice for many patients with limited basic conditions. In recent years, with the continuous development of TAVR surgery, its trauma is small, the surgical time is short, the recovery is fast, and the entire perioperative period has been optimized. This simultaneous double minimally invasive surgery clearly demonstrates that TAVR surgery can protect MIE surgery, quickly solve and reduce the risks of heart valve problems to patients and esophageal tube surgery. Reduced the pain and economic burden of patients, further controlled the deterioration of the disease, and brought new hope to patients and their families.

The safety and feasibility of MIE alone has been widely demonstrated clinically, but patients with combined severe aortic regurgitation are rare. Given the rarity of the procedure, a qualified OR nurse with strong technical expertise was arranged to participate in the MDT discussion. By participating in the preoperative multidisciplinary discussion, we understand the surgical plan, surgical priorities and difficulties, and through preoperative visits, the surgeon's preferences, and develop a standard personalized OR care plan and contingency plan. In combination with our mature TAVR emergency plan [7,8]: (1) the attending surgeon initiates the emergency plan and establishes vascular access by emergency transit open-chest or transfemoral; (2) the anesthesia team stabilizes circulation and directs resuscitation; (3) the OR nurse initiates the emergency plan in the nursing plan, takes inventory of supplies, follows the rhythm of the attending surgeon, and cooperates with the surgery right; (4) the traveling nurse calls for extracorporeal circulation (perfusionist must be on standby in the operating room); (5) the team moves away from the C-arm, radiology imaging equipment, and other instruments on the side of the operating table; (6) the cardiologist on the right side of the patient immediately starts CPR; (7) the surgeon moves to the right side of the patient for emergency chest opening; (8) the perfusionist prepares the extracorporeal circulation machine and immediately moves to the side of the operating table; (9) the handwashing nurse prepares the arterial cannula; (10) the primary surgeon is responsible for exposing the (10) The main surgeon is responsible for exposing the heart and giving heparin orders, and the assistant assists in completing intubation and connecting the tubing; (11) Start extracorporeal circulation.

As showed in our patient, a 71-year-old male, underwent dual minimally invasive TA-TAVR and Mckeown under general anesthesia at the same time for a high-risk procedure in the thoracic cavity adjacent to a vital organ. With the cooperation of the TAVR team, minimally invasive esophageal surgery team, anesthesiologists, and operating room nursing team, a double minimally invasive TA-TAVR, combined thoracic-laparoscopic cervical anastomosis for radical resection of esophageal cancer, pleural adhesion branding, thoracic duct ligation, bilateral laryngeal recurrent nerve exploration, and pyloroplasty were completed under general anesthesia over 6 h at the same time [9–11]. The patient was safely transferred to the thoracic ICU for specialized treatment after surgery and was transferred back to the thoracic surgery ward on the third postoperative day for continued treatment. The patient recovered smoothly without surgical complications, ate normally, had normal cardiac ultrasound function, valve structure and position, and was discharged on the 10th postoperative day. During the follow-up process, we used patient reported outcomes (PRO), which is a report that directly reflects a patient's assessment of their own health status, to understand the self-reported symptoms, quality of life impact, and treatment experience/satisfaction of patient. The patient reported occasional wound pain, but it did not affect daily life, and was relatively satisfied with the surgery.

It has been reported [3] that TA-TAVI reduces the risk of peripheral vascular injury and atherosclerotic plaque dislodgement by the delivery system and is a new minimally invasive, non-extracorporeal procedure for the treatment of aortic valve lesions performed mainly in elderly patients with high-risk surgical risks through a small left thoracic incision with direct visualization of the valve implantation via the apical introducer. Valve selection is also critical to the success of the procedure, and it has been reported in the literature [4] that both the J-Valve and Jenavalve valve stents contain external anchors to assist in intraoperative positioning of the annulus, as well as clamping of autologous leaflet tissue to increase longitudinal support, improving the feasibility and safety of TAVR applications in AR patients. However, a growing number of studies are guiding case selection, surgical planning, and perioperative approaches to TAVR. In contrast, there is a lack of evidence to describe the standards of intraoperative and postoperative care [12].

The TA-TAVR technique at our institution was initiated in March 2013 and has constituted a solid teamwork model since then, and the team leader is constantly exploring and updating the surgical technique with his members [13,14]. This procedure is not only demanding for surgeons and anesthesia, but also difficult for intraoperative nursing cooperation because it operates on the apex of the heart, and nurses play an irreplaceable and important role in TAVR surgery [15], which is also a new challenge for OR nurses. Our

operating room nurses have passed the national systematic X-ray training and examination, and the training of professional instrumentation and valve loading, and after many years of surgical cooperation, we have continuously summed up our experience to improve and update the standardized nursing cooperation in TAVR surgery, which is highly recognized by surgeons, and the 2021 ESC valve management guidelines also point out that professional nursing staff is a reflection of the soft power of the heart team [16].

Esophageal cancer is the seventh most common cancer and the sixth most common cause of death worldwide [17–20]. In 2018, esophageal cancer ranked 5th and 4th in incidence and death rates of malignant tumors in China, respectively [21]. McKeown procedure is the current mainstream surgical approach for minimally invasive esophageal cancer surgery due to its relatively simple operation and good safety [22,23]. McKeown procedure is a three-incision MIE via right chest-upper abdomen-left neck + esophageal reconstruction, which is extensive, long, difficult, and has many postoperative complications, and the operating room nurses should be familiar with thoracic and abdominal anatomy, surgical methods and steps, and have rich experience in surgical coordination [24].

The McKeown procedure is a total lumpectomy, and this technique is quite mature in our thoracic surgery department, and the operating room nursing team has a standardized procedure for surgical coordination. We actively establish a tumor-free zone during the procedure to reduce the risk of lymph node metastasis. It has been reported in the literature [24] that because the esophageal anatomy has certain special features, the transverse and longitudinal lymphatic pathways in the submucosa and intrinsic muscular layer of the esophagus constitute the unique lymphatic network of the esophagus, which has no clear pattern of lymph node metastasis and becomes jumpy, even for patients with early-stage esophageal cancer, so lymph node metastasis is one of the reasons for the poor prognosis of patients with esophageal cancer. It is also a major difficulty for the surgeon in charge when freeing the tissue and lymph nodes adjacent to the aortic arch and near the heart after the patient's TAVR. During esophagogastric anastomosis, i.e., GI reconstruction, lubricating the filament used for anastomosis and reducing the cutting of the thread and tissue is also one of the measures to prevent anastomotic fistula, and some studies have shown [23] that anastomotic leakage not only affects the immediate prognosis but also is closely related to the long-term postoperative quality of life of patients, and this step is the core and key to esophageal cancer surgery.

After the operation, we promptly organized the whole perioperative process and techniques. Two surgeries were performed on the same day in different operating rooms, which is rare in our hospital. The duration of surgical anesthesia was 8h, the duration of TAVR surgery was 1h15, and the duration of esophageal cancer surgery was 4h20, and the duration of the whole surgery was 5h35, and the articulation of surgery was 2h25, which seemed to be less than perfect. Due to the specificity of the surgical bed in the hybrid operating room and the special position of the esophageal surgery, we had to change the operating room, which was one of the factors affecting the surgical articulation and also increased the risk of patient transfer, highlighting that the improvement of the DSA surgical bed is a new technology that we need to overcome. This surgery was performed immediately after TAVR, which was a relatively more difficult and risky surgery for the thoracic surgeon to complete the radical esophageal cancer surgery in as short a time as possible, so precise surgical coordination was especially important. Together with the fact that the originally planned operation time would be prolonged when chest atresia was seen after entering the chest cavity, these were all tests for the team.

According to literatures review, there is currently no concurrent double minimally invasive TAVR and MIE procedures. Due to the poor financial situation and advanced age of most families with esophageal cancer, the process from discovery to diagnosis to surgery is lengthy, and the disease continues to worsen. Some patients may exhibit positive signs that were not previously taken seriously during preoperative examinations upon admission. The cost of open chest surgery for heart valve replacement is high, and many patients with esophageal cancer and heart valve disease may give up treatment due to family economic reasons. If a patient undergoes open heart aortic valve replacement surgery under extracorporeal circulation first, this surgical method will cause great trauma, high risk, and long postoperative recovery time for the patient. Due to the fact that esophageal cancer patients must undergo surgery or the best time for surgery upon diagnosis, if open heart surgery is performed first, the best or only treatment opportunity will be missed. If esophageal cancer surgery is performed first, the probability of cardiac arrest during surgery is high; In order to strive for the best surgical opportunity for esophageal cancer, the MDT discussed and decided to perform dual minimally invasive surgery simultaneously. The refined management process of perioperative medical care integration is the key to the ultimate success of the surgery.

There are several limitations in this case. The MIE surgery was performed in two positions: left lateral position and supine position. However, due to the limitations of the hybrid operating room in our hospital, the thoracic lateral position cannot be placed. The entire surgical process is completed in two operating rooms. When changing the operating room, the patient needs to be transferred from the hybrid operating bed to the pusher bed, and then to the regular operating room for another bed. This process may seem normal, but for postoperative cardiac patients, this risk needs to be considered.

## 5. Conclusion

It is rare for elderly patients to undergo dual minimally invasive surgery with TAVR and McKeown at the same time, which are both intra-thoracic vital organ surgeries and are a challenge to the team and hospital equipment and facilities, and both types of surgeries are among the new technological developments in each specialty. Secondly, the significance of a MDT before surgery is to provide more comprehensive and targeted diagnosis and treatment plans, bringing together experts from different fields to participate in case analysis and discussion. By integrating professional knowledge and experience from various disciplines, MDT can complement each other and jointly serve patients. For complex and rare case just like ours, MDT has special significance. These types of case often go beyond the scope of treatment in a single discipline and require comprehensive judgment from multiple perspectives and levels. In MDT discussions, experts from various fields can fully leverage their professional advantages based on the specific situation of the case and provide reasonable diagnosis and treatment suggestions. This comprehensive team collaboration can greatly improve the diagnosis and treatment level of rare cases, providing patients with better treatment outcomes. In addition, for operating room nurses, they

should actively participate in the development of new technologies, constantly summarize, share and innovate their professionalism, be patient-centered, optimize the surgical process, achieve true medical and nursing integration, and continuously improve surgical medical technology. To reflect the important and indispensable role of operating room nurses in the surgical team.

#### Availability of data and materials

All data for this study are publicly available and are ready for the public from database of hospital.

#### Competing interests

The authors have no conflicts of interest to declare.

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#### Consent for publication

All the authors consent to publish the paper.

#### CRedit authorship contribution statement

**Chunmei He:** Writing – original draft. **Chen Wang:** Methodology, Formal analysis, Data curation. **Qian Yang:** Software, Project administration, Formal analysis. **Xuehua Tu:** Project administration, Methodology. **Cheng Shen:** Writing – review & editing, Supervision, Resources, Investigation.

#### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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#### Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2024.e30577>.

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