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CASE REPORT

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Difficult airway management in a patient with severe mitral and tricuspid regurgitation, rapid atrial fibrillation, and moderate pulmonary hypertension: a case report

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Abstract

Background Given the prevalence of cardiovascular disease, encountering difficult airways in this patient population is quite common. The challenge for anesthesiologists lies not only in establishing the airway but also in managing the hemodynamic instability caused by sympathetic activation during intubation. The purpose of this report is to describe the anesthetic experience of this patient with severe mitral and tricuspid regurgitation, atrial fibrillation with rapid ventricular response, and moderate pulmonary hypertension with an anticipated difficult airway.

Case presentation This case report describes intubation with fibreoptic bronchoscopy after the induction of general anesthesia in a cardiac surgical patient diagnosed with severe mitral and tricuspid regurgitation, rapid atrial fibrillation, and moderate pulmonary hypertension who underwent mitral and tricuspid valve replacements. The patient had a history of difficult intubation. Therefore, having considered that the benefits of intubation after general anesthesia induction outweighed the risks of awake intubation, the choice of fibreoptic bronchoscopy-guided intubation was performed following general anesthesia induction. No adverse events occurred throughout the proceeding.

Conclusion This case highlights the importance of considering both airway safety and maintaining hemodynamic stability when cardiac surgery patients encounter an anticipated difficult airway. Awake intubation is not the only option, and intubation after general anesthesia may be considered when the benefits are evaluated to outweigh the risks.

Keywords Mitral regurgitation, Tricuspid regurgitation, Atrial fibrillation, Pulmonary hypertension, Difficult airway, Intubation

Background

The American Heart Association Heart Disease and Stroke Statistics 2021 report forcing on the periods of 2015 to 2018 links 49.2% of adults aged between 20 years of age or older with cardiovascular disease with its prevalence steadily increasing with age [1]. For this reason, the number of patients undergoing cardiac surgery has increased significantly in the past decade. While cardiac comorbidities alone may not directly constitute an independent risk factor for difficult airway management, studies have demonstrated that the incidence of difficult

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intubation is notably higher in patients undergoing cardiac surgery compared to those undergoing noncardiac procedures [2, 3]. Hemodynamic fluctuations induced by excitement of the sympathetic-adrenal during intubation, such as tachycardia and hypertension, are undoubtedly an enormous catastrophe for patients with poor physiological reserves undergoing cardiac surgery. Increase in BP and HR by 30% and 50%, respectively, have been reported [4]. Therefore, for patients who undergo cardiac surgery with a difficult airway, the challenges faced by anaesthesiologists include not only the safe establishment of the airway but also the consideration of the pathophysiological characteristics of the patient's cardiac disease, the stability of a patient's hemodynamics, which can be life-threatening. Performing awake intubation is not the only option since local anesthetic application to the airway does not always sufficiently block the sympathetic response to intubation. Intubation after the induction of general anesthesia should be considered when its benefits outweigh the associated risks [5]. Consideration of the relevant anaesthetic management protocol is currently limited. Herein, we report our anaesthetic experience regarding a patient with severe mitral and tricuspid regurgitation, rapid atrial fibrillation, and moderate pulmonary hypertension combined with an anticipated difficult airway. Written informed consent was obtained from the patient.

Case presentation

A 60-year-old female with dyspnea and reduced exercise capacity has an American Society of Anesthesiologists (ASA) physical status III grading measuring a weight of 55 kg and height of 158 cm was admitted into the hospital. One year ago, this patient experienced chest discomfort during ordinary activity and was diagnosed with "Rheumatic Mitral Valve Disease". After repeated treatment with furosemide, spironolactone and digoxin, her symptoms did not improve. Approximately one month ago, her symptoms worsened significantly, and she was subsequently scheduled for valve replacement surgery. Her admission diagnosis had severe mitral regurgitation (MR), severe tricuspid regurgitation (TR), atrial fibrillation, and moderate pulmonary hypertension, with a New York Heart Association (NYHA) Classification III grading. Preoperative laboratory tests revealed BNP of 2387 ng/L and troponin-T of 22.9 ng/L. ECG revealed atrial fibrillation with a heart rate of 110 beats per minute. Transthoracic echocardiography (TTE) revealed severe MR and TR, moderate pulmonary hypertension, and an ejection fraction of 61% (Fig. 1). The preoperative airway assessment included Mallampati class IV, mouth opening degree of less than three horizontal fingers in width, a thyromental distance of approximately three horizontal fingers wide, and demonstrated normal neck mobility (Fig. 1). Noting previous anaesthesia experience, the patient added that her "last valve operation at another hospital had an unexpected difficult intubation", which could mask ventilation but was difficult to expose. The intubation took close to an hour using retrograde guidance, but the procedure was later postponed for intubation difficulties. Discussion with the attending anaesthetist reconfirmed that the patient could be ventilated with a mask but that intubation would be a difficult one. Ultimately, we decided to perform an oral intubation with the guidance of fibreoptic bronchoscopy after the induction of general anesthesia.

The patient had routine monitoring in a supine horizontal position prior to surgery, and her baseline preinduction vital signs included a heart rate (HR) of 120 beats/minute, an arterial blood pressure (ABP) of 140/82 mm Hg, a respiratory rate of 14 breaths/minute, and an oxygen saturation of 98% on room air. The initial arterial blood gas analysis results showed unremarkable abnormal values. The plan was to perform oral intubation with the guidance of fibreoptic bronchoscopy after the induction of general anesthesia. Preparations for nasal intubation were kept ready as a necessary measure. In addition, we prepared an antagonist which was to be used once the number of intubation attempts exceeded 3 times, plus an additional attempt by a consultant, to restore spontaneous breathing and made alternative arrangements when the patient woke. We have prepared esmolol, ephedrine and epinephrine to manage potential circulatory collapse. Five anesthesia staff were involved in the procedure. An independent anesthesiologist was responsible for anesthesia induction and for preventing and managing hemodynamic instability during intubation. Another independent anesthesiologist, familiar with difficult airway management algorithms and techniques, was in charge of the intubation. Two additional anesthesiologists assisted with mask ventilation and provided general support. Adequate preoxygenation was performed for 3 min with face mask using a 6-L/min oxygen flow (adequate preoxygenation was defined as an end-tidal O_2 concentration of approximately 90%). Followed by a 60 μg of sufentanil (Yichang Renfu Pharmaceutical Co., Ltd), 50 mg of rocuronium (with prepared antagonist sugammadex [Yichang Renfu Pharmaceutical Co., Ltd]) and 6 mg of etomidate (Enhua Pharmaceutical, Jiangsu, China) were given during anaesthesia induction. After adequate mask ventilation, the team used video laryngoscope and fibreoptic bronchoscopy to complete the patient's orotracheal intubation. During the fibreoptic intubation attempts, a nasal cannula was used to provide supplemental oxygen. Due to the relaxation of the tongue muscle and the narrowing of the pharyngeal cavity,

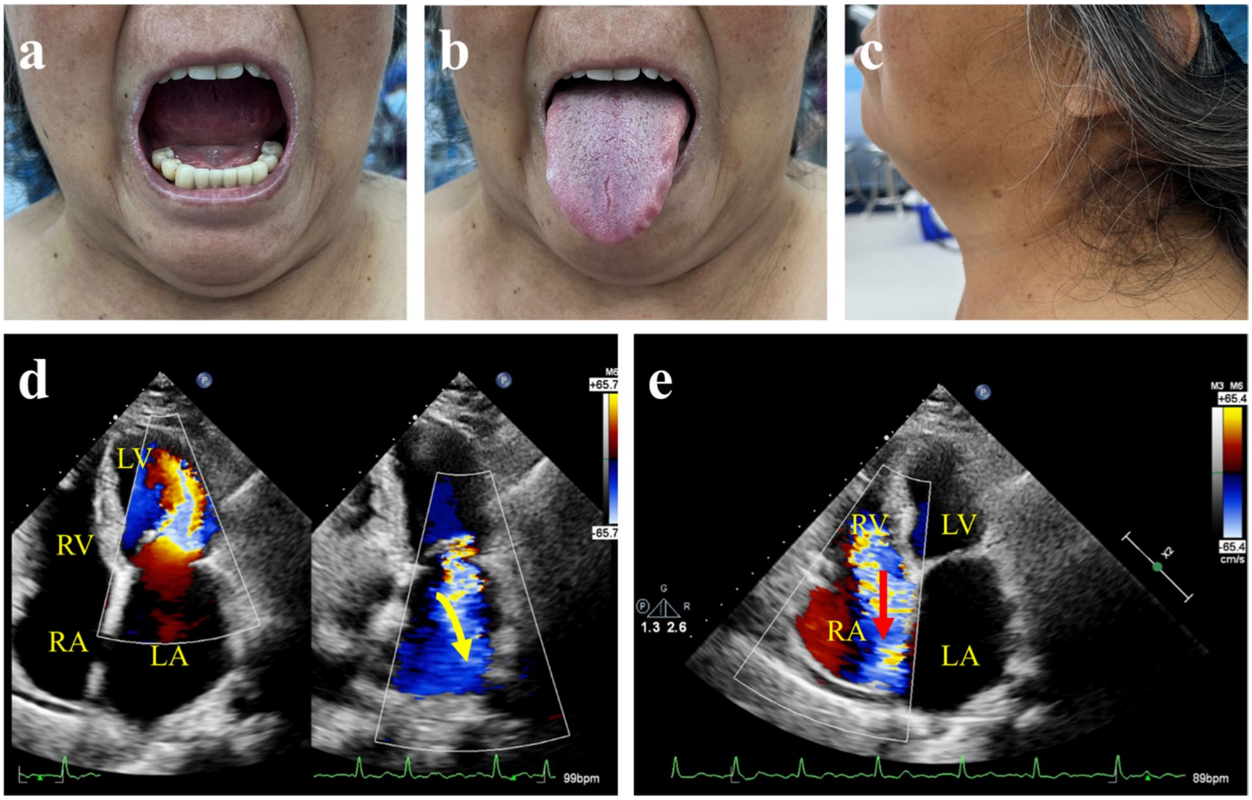

Fig. 1 **a** Restricted mouth opening; **b** Mallampati class IV grading; **c** Normal neck mobility; **d**, **e** Findings of the preoperative transthoracic echocardiography; LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle; The yellow arrows indicate the mitral valve regurgitation; The red arrows indicate the tricuspid valve regurgitation

exposing the glottis through oral intubation proved challenging. After two unsuccessful attempts, we decided to switch to nasal intubation. Subsequently, a standard cuffed endotracheal tube with an internal diameter of 6.5 mm was successfully inserted via nasal intubation in the first attempt, guided by fibreoptic bronchoscopy. Throughout the intubation process, the patient's hemodynamic was relatively stable, her heart rate increased to 140 beats/min, her blood pressure fluctuated between 100–140 and 63–80 mmHg, and her SpO_2 sat between 99 to 100% (Fig. 2). The arterial blood gas analysis results after intubation also showed unremarkable abnormal values. The patient had stable vital signs throughout the operation. After the surgery, the patient was immediately transferred to the intensive care unit for continued treatment. On the following day, after a satisfactory evaluation (Glasgow Coma Scale score of E4VTM6: an eye (4) verbal (Tube) and motor (6) response; completed a spontaneous breathing trial by using pressure support ventilation mode with pressure support 10 cm H_2O, PEEP 10 cm H_2O and Fraction of inspiration O_2: 35%; Rapid Shallow Breathing Index 50 breaths/min/L; voluntary cough peak flow 60L/min) by the anaesthesiologists, attending physician and respiratory therapist, the endotracheal catheter was removed with the help of fibreoptic bronchoscopy and airway exchange catheter. The patient returned to the general ward and was discharged ten days after surgery with no complications. The patient and the attending family members were informed of the patient's difficult airway and is now documented in her medical records for future treatment reference.

Discussion and conclusion

Many guidelines suggest that when a difficult airway is anticipated, an awake intubation should be performed to reduce the risk of complications associated with airway manipulation under general anesthesia [6–8]. However, in our case, the decision to perform intubation after general anesthesia induction rather than awake intubation was influenced by the patient's complex cardiovascular condition, including severe mitral and tricuspid regurgitation, rapid atrial fibrillation, and moderate pulmonary hypertension. During the process of awake intubation, a patient's level of anxiety, inadequate surface anesthesia quantity, or mispositioning of the endotracheal tube can induce coughing that frequently leads to

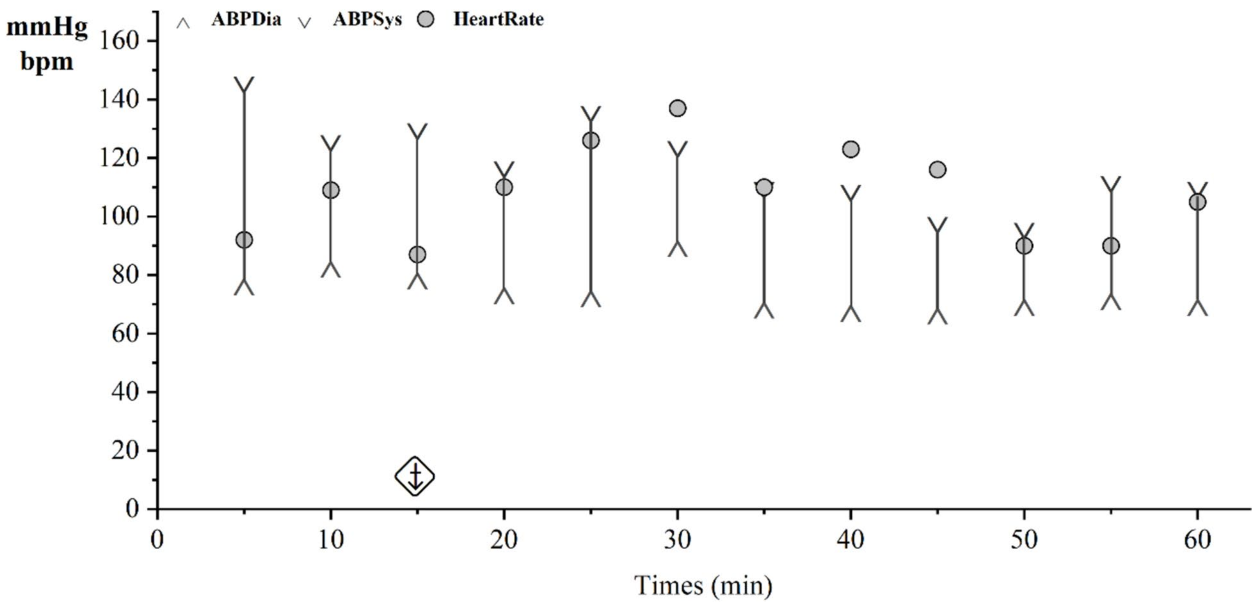

Fig. 2 Patient's vitals during fibreoptic intubation; heart rate marked in circles with arterial blood pressure marked by solid lines

hemodynamic changes, such as hypertension and tachycardia. These hemodynamic shifts are particularly detrimental in patients with MR [9, 10]. Hypertension can increase total peripheral vascular resistance, obstructing left ventricular outflow and exacerbating MR, which in turn increases left atrial pressure. The subsequent rise in left atrial pressure can lead to pulmonary congestion and, in severe cases, left heart failure. Although tachycardia can partially mitigate the impact of MR by preventing left ventricular dilation and aggravating regurgitation, in this patient, rapid atrial fibrillation with a high ventricular rate can cause an ineffective atrial filling, reducing left ventricular filling and cardiac output. This scenario can result in heart failure or cardiogenic shock [11]. Furthermore, during spontaneous respiration, the reduction in pleural pressure can promote venous return, increasing right ventricular preload and stroke volume [12, 13]. However, under positive pressure ventilation similar to its use in general anesthesia, airway pressure increases pleural pressure, impedes venous return and reduces right ventricular preload, which can further compromise right-ventricular function [12, 13]. These considerations make awake intubation challenging, especially when managing the patient's hemodynamic stability. Another critical factor is that the use of sedatives to improve patient comfort during awake intubation can lead to respiratory depression, with a reported incidence of up to 21% [14]. Respiratory depression can result in hypoxia, carbon dioxide retention, and pulmonary vasoconstriction, all of which worsen pulmonary hypertension. Additionally, severe coughing or airway manipulation during awake intubation can trigger bronchospasm, further increasing pulmonary vascular resistance and possibly leading to a pulmonary hypertensive crisis, which can escalate to right heart failure [15]. Given these risks, intubation after general anesthesia induction was favoured to ensure the patient's comfort and hemodynamic stability. The use of general anesthesia allowed a controlled ventilation environment, with the ability to manage airway pressure, heart rate, and blood pressure that reduces the risks associated with airway manipulation. Additionally, general anesthesia ensured the patient was completely relaxed, reducing the likelihood of coughing and airway reflexes that could induce detrimental hemodynamic fluctuations.

The release of the "2022 American Society of Anesthesiologists Practice Guidelines for Management of the Difficult Airway", emphasizes the importance of developing a difficult airway management strategy, whilst also updating the recommended equipment for managing both standard and advanced difficult airway procedures. The guidelines also advocate for the administration of supplemental oxygen before and during the process of difficult airway management, including the extubation period. Furthermore, the 2022 ASA guidelines provide non-invasive and invasive alternatives for difficult airway management and emphasise the importance of time restraints, as well as limiting the number of attempts using different devices and techniques. Notably, the guidelines offer more robust recommendations for extubation in difficult airway cases and present new algorithms and infographics for managing both adult and paediatric difficult airway cases. These updates significantly enhance the practical applicability and ease of implementation of the guidelines in clinical settings. New recommendations have also been made regarding the strategy for managing anticipated difficult intubation [5]. It is suggested to first rule out whether the patient has concurrent face mask or supraglottic airway difficulties, whether there is a high risk of aspiration, whether the patient is able to tolerate short periods of respiratory arrest and hypoxia, and whether it is anticipated that establishing an emergency invasive airway will be difficult; if any of the above situations exist, awake intubation should be implemented. If all are denied, for cooperative patients, although intubation after general anesthesia induction is not recommended, when the benefits of intubation after general anesthesia induction are comprehensively assessed to outweigh the risks, intubation after general anesthesia induction can be considered, but the number of attempts with any technique class should be limited to 3 by the provider managing the airway, with 1 additional attempt by secondary airway provider. It is also recommended to choose familiar airway handling methods. In addition, given the challenge of managing hemodynamics and myocardial oxygenation while concomitantly managing a difficult airway, Patel et al. suggest that in patients with an anticipated difficult airway, two anesthesia providers are to be available to allow for each assigned provider to be solely responsible for either (a) managing preinduction hemodynamics or (b) airway management. If the provider managing the airway fails to successfully intubate the trachea, they may either postpone the case or intubation until additional resources are available. If mask ventilation is not adequate (cannot intubate, cannot ventilate scenario), an emergency invasive airway access should be prepared. Meanwhile, providers may attempt alternate approaches as those preparations are being made [5]. Figure 3 summarizes the key steps of difficult intubation management in cardiac surgery. The format presented is a combined representation of the 2022 Difficult Airway Consensus [5] guideline and our intuitional experience as a high-volume cardiac surgical center.

During the anaesthetic induction and when formulating the intubation strategy for this patient, consideration of the patient not having the aforementioned situations of being awake intubated, the hemodynamic changes caused by intubation was weighed, and the benefits and risks to the patient was considered. Thus, the decision to use fiberoptic bronchoscopy-guided intubation after general anesthesia induction was chosen. Fibreoptic bronchoscopy allows for superior airway visualization, especially in patients with difficult airways and/or anatomical distortions. This method provides flexibility and precise manipulation of the endotracheal tube, minimizing trauma to the airway structures and reducing the risk of adverse hemodynamic responses [16]. The success rate of fibreoptic bronchoscopy intubation varies with the number of attempts and studies indicating a first-attempt success rate of 85–95% in anticipated difficult airways

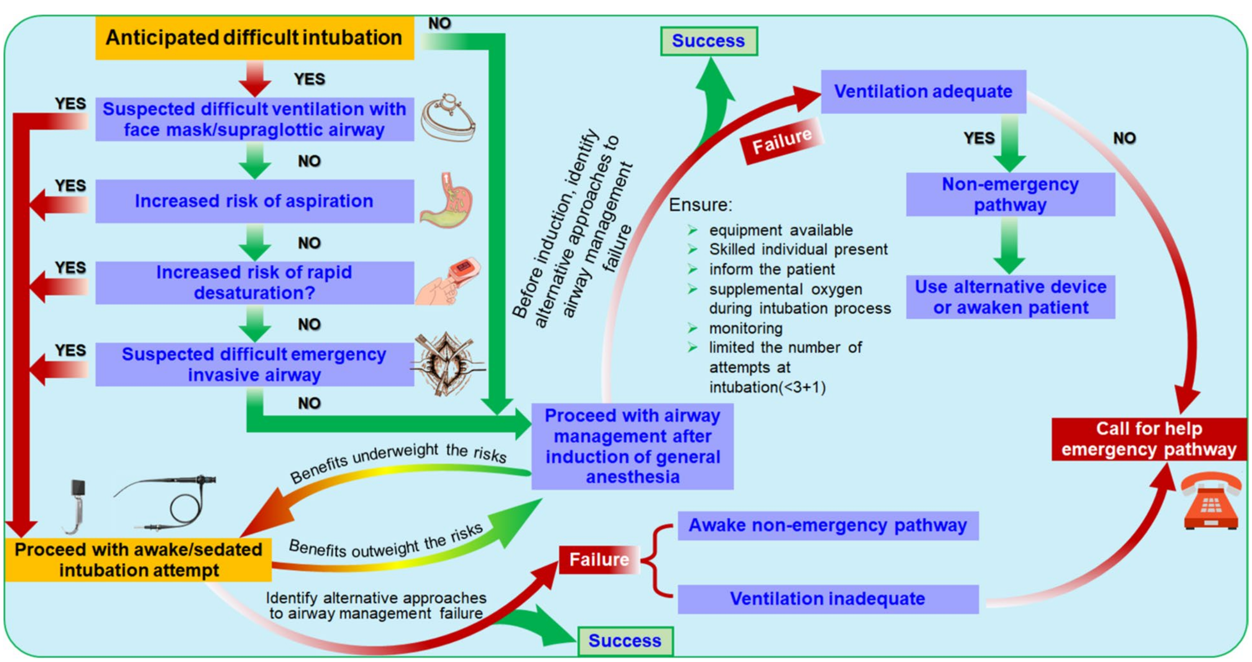

Fig. 3 Anticipated difficult airway infographic: cardiac surgical patient example

[17, 18]. Unlike video-assisted laryngoscopy, which is excellent for visualizing the glottis, may be less effective in patients with limited neck mobility or anatomical obstructions, while fibreoptic bronchoscopy offers greater flexibility in navigating around airway distortions. Additionally, techniques such as direct laryngoscopy, which can cause significant cardiovascular stress, were considered but was deemed unsuitable for this patient. The ability to perform fiberoptic bronchoscopy with precise control and minimal hemodynamic disturbance made it the most suitable technique for securing the airway in this case. Propofol, sufentanil, and rocuronium were used as anaesthetic induction drugs. The effects of propofol and sufentanil can be easily controlled. Due to the lack of data on catecholamine levels, although the increase in heart rate after intubation was limited, there is no definitive evidence of suppressed sympathetic activity. In addition, we chose rocuronium, a muscle relaxant known for its rapid onset and quick reversibility. The reason for choosing an effective muscle relaxant was so it can provide better exposure conditions for the glottis. Additionally, esmolol, ephedrine, and epinephrine was prepared to manage potential circulatory collapse during intubation, taking into account the patient's complex cardiovascular status. Esmolol had been chosen for its rapid onset and short half-life to control heart rate and reduce sympathetic activation, particularly in response to the stress of intubation [19, 20]. Ephedrine was available to support blood pressure in case of hypotension, as it acts as a potent vasopressor by increasing systemic vascular resistance [21]. Epinephrine was on hand to manage severe bradycardia or cardiovascular collapse, providing both inotropic and vasopressor support when needed [22]. Meanwhile, single intubation technique may be difficult considering the size of the patient's tongue. We adopted a combination technique (video laryngoscopy combined with bronchoscopy), and past observational studies have shown that the success rate of combination technique intubation with expected difficult airways can reach 80–90% [23]. In the operation, there were two anesthesiologists each being responsible for the patient's (a) anesthetic induction and manage the hemodynamic, and (b) intubation. Although oral intubation is the preferred intubation route, for patients with a relatively large tongue, nasal intubation is also an alternative which was why nasal preparation was also performed in advance. In addition, limiting the number of attempts at tracheal intubation or supraglottic airway placement helps to avoid potential injury and complications [5]. A reasonable approach may be to limit attempts with airway techniques (i.e., face mask, supraglottic airway, tracheal tube) to three, with one additional attempt by a consultant [5]. Thus, an antagonist was prepared once the number of intubation attempts exceeded 3 + 1 to restore spontaneous breathing and performed awake intubation, adhering to the principle of "oxygenation first."

It is worth mentioning that successful intubation does not mean that the patient's "difficult airway" has come to an end. Close attention is often only given to patients with difficult airways during intubation, and lessons on how to avoid catastrophic events during extubation is often overlooked and underemphasized. Extubation failure rates have been reported to be between 0.1% and 0.45% in adults in operating rooms and between 2 and 25% for adults in the intensive care unit, and major airway complications after extubation, such as intubation failure, account for approximately 1/3 of reported anesthesia-related cases [24]. Therefore, to minimize the occurrence of peri-extubation period complications, a plan should be mapped in advance. To this end, the 2022 Difficult Airway Guidelines also propose that a plan for difficult airway extubation and subsequent airway management strategies be made in advance before extubation, and whether the patient meets the conditions for extubation should be assessed to ensure that experienced personnel are able to assist with extubation, and that a decision for choosing an appropriate time and place for extubation can be evaluated. Furthermore, the assigned anaesthetist should have the ability to assess the risks and benefits of tracheostomy, to assess the risks and benefits of awake extubation and extubation before awakening from anesthesia, to assess the clinical factors that may lead to insufficient ventilation after the patient's extubation, and to assess the feasibility of using an airway exchange catheter or supraglottic tool for a short period as provision for guiding reintubation and to provide oxygen to the patient throughout the extubation process [5]. On top of this, neuromuscular blocking drugs should be fully reversed, with verification using a nerve stimulator before extubation. Respiratory depressant medications, such as opioids, should be administered judiciously. That's why, in this particular case, after sufficient assessment with Glasgow Coma Scale score, spontaneous breathing trial, Rapid Shallow Breathing Index and voluntary cough peak flow (which was recommend by the guideline consensus) [5, 25] by anesthesiologists, intensive care providers, and respiratory therapists, an airway exchange catheter was used through the tube under the guidance of fibreoptic bronchoscopy and the tracheal tube was removed. The patient continued to inhale oxygen throughout the operation.

In summary, managing a difficult airway in cardiac patients requires a multifaceted approach, prioritizing both the safety of establishing the airway and the potential hemodynamic impact of intubation. In cases where the patient does not have an increased risk of aspiration or cannot tolerate even brief periods of respiratory arrest, and when emergency invasive airway rescue might be challenging, the decision to perform intubation after general anesthesia induction should be made carefully. The benefits and risks of intubation in these patients must be weighed, with a preference for using well-established and familiar techniques. When it is determined that the benefits outweigh the risks, intubation after general anesthesia induction can be considered appropriate. Additionally, regardless of whether awake intubation or intubation after anesthesia induction is chosen, it is critical to adhere to the principle of using familiar techniques to limit complications. The number of attempts should be restricted to a maximum of three attempts, with an additional attempt reserved for emergency alternatives. This highlights the importance of having alternative intubation strategies at-the-ready, including supraglottic airway management, should the initial attempts fail. These strategies and principles create a greater implication for the training of clinicians in difficult airway management, particularly for those looking after cardiac patients. Emphasizes on mastering familiar and safe techniques should be highly focused when conducting training programs, with an aim for trainees to recognize the hemodynamic implications of airway management, and the ability to prepare for difficult or failed intubation scenarios, including identification of emergency alternatives on conclusion of the program. In future cases, these lessons learned can improve patient safety and outcome, ensuring that clinicians are well-prepared for the unique challenges posed by difficult airways in cardiac patients.

Abbreviations

ASA	American Society of Anaesthesiologists
MR	Mitral regurgitation
TR	Severe tricuspid regurgitation
NYHA	New York Heart Association
TTE	Transthoracic echocardiography
HR	Heart rate
ABP	Arterial blood pressure

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Authors' contributions
Y.X and XX.L provided anaesthesia care to the patient, acquired the patient consent, and drafted and revised the manuscript; J.C, and LX.L reviewed and revised the manuscript. Y.X and XX.L reviewed and revised the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets are available from the corresponding author on request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Written informed consent was obtained from the patient for publication of this case report.

Competing interests
The authors declare no competing interests.

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