# Anaesthesiologic considerations in the minimally invasive setting

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**Abstract:** Minimally invasive cardiac surgery of the mitral valve (MIMVS) has become an alternative standard of care in the majority of heart centres dedicated to valve surgery. The minimally invasive approach has gained widespread acceptance from surgeons mainly based on the superior quality of valve visibility and the avoidance of large surgical incisions. The short and mid-term results of the quality of repair and the incidence of perioperative complications are comparable or even superior to the classical open approach even in high-risk patients. From the anaesthesiologic point of view, the minimally invasive approach is more demanding and requires additional knowledge and skills compared to the classical open sternotomy approach. Therefore, a special training program and dedication of team members is required to perform these procedures with comparable low complication rates. In this review, we describe the relevant anaesthesia related topics which are part of the anaesthesia management, pre-, intra- and postoperatively.

**Keywords:** Cardiac anaesthesia; minimal invasive cardiac surgery; cardiopulmonary bypass (CPB); one-lung ventilation (OLV); mitral valve surgery; intraoperative echocardiography; transoesophageal echocardiography (TOE); team dedication

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## Introduction

During the past years, the number of patients undergoing mitral valve (MV) surgery performed via a minimally invasive approach is still increasing (1,2). The increased popularity of minimally invasive cardiac surgery of the mitral valve (MIMVS) is based on the improved quality of repair, less blood loss, decreased transfusion rates, less pain and a reduced length of stay in the hospital (3,4). Despite longer procedural times, robotic and mini patients had similar complication rates with higher repair rates and shorter length of stay metrics compared with conventional surgery (3,5). However, the robotic approach was associated with higher atrial fibrillation rates, more transfusions and longer postoperative stays compared with minimally invasive approach (5).

All MIMVS techniques share the avoidance of sternotomy and enables successful repair or replacement of the MV, with comparable short to mid-term results when compared to the classical open technique (3,6). In this number of the journal, an overview about the actual knowledge on the minimally invasive techniques will be presented.

MIMVS creates special challenges for the anaesthesia team. In this manuscript, we aim to describe the anaesthetic considerations in the field of minimal invasive MV surgery.

The manuscript is sub-divided into the relevant fields of interest throughout the perioperative period, including pre-operative evaluation, perioperative management including lung separation techniques and organ function monitoring as well pain management in the postoperative period. In summary, anaesthesia for MIMVS is comparable with cardiac anaesthesia for other complex procedures, combining the anaesthesia skills for cardiac surgical patients with skills commonly needed for thoracic surgery, like one-lung ventilation (OLV) (2).

**Table 1** Standard evaluation

| Clinical | Apparative | Laboratory |
|---|---|---|
| Careful patient history | Standard 12-lead ECG | Standard cardiac lab testing |
| Drug history incl. allergies | Standard Lab testing | Haematology |
| Physical examination | Pulmonary function test* | Renal function |
| | X-thorax | Liver function |
| | CTA | Coagulation |
| | Transthoracic echocardiography | Metabolic testing |

*, pulmonary function testing on indication. CTA, computed tomography angiography.

## Pre-operative assessment

The standard evaluation for patients undergoing MIMVS *vs.* non-MIMVS surgery is basically identical. *Table 1* gives an overview about the preoperative standard anaesthesia workup in our institution. A careful evaluation of the underlying mitral disease and the surgical repair is needed, resulting in a well described surgical plan. Despite knowledge on the MV, we routinely assess left and right ventricular function and other concomitant cardiac disorders, like coronary artery disease or patent foramen ovale. In patients with pre-existing heart rhythm disturbances, MIMVS is sometimes combined with heart rhythm surgery.

One cornerstone of MIMVS is connection of the cardiopulmonary bypass (CPB) circuit via central or, more common, the Arteria femoralis and the Vena femoralis and/or jugularis interna. Therefore, in the pre-op assessment strategy, special attendance is payed to visualization of the vascular tree, to enable peripheral cannulation of the venous and arterial system for connecting the CPB system (2). Therefore, computed tomography angiography (CTA) is necessary in all patients undergoing MIMVS. Some recent studies have demonstrated that the surgical strategy needed to be changed after performing CTA in a significant amount of patients, mainly due to inappropriate vessel size or configuration for placement of aortic and venous cannulas. It is noteworthy that on-pump MIMVS requires optimal surgical condition resulting in the need for emptying the cardiac chambers appropriately. Therefore, the need for bi-caval venous cannulation is often necessary. In our practice we therefore introduce an introducer sheath into the right vena jugularis interna to enable guidewire guided placement of a venous cannula by the surgeon.

Preoperative transthoracic and/or transoesophageal echocardiography (TOE) of high quality is a prerequisite for the anaesthesia planning, as identification of potential factors contributing to prolonged CPB (4) may interplay with the chosen anaesthesia technique and also the need for different strategies with respect to blood transfusion and coping of CPB-associated coagulation disorders. In principle, MIMVS can be performed with acceptable morbidity and mortality even in patients with increased perioperative risk (1).

The knowledge of heart rhythm disorders, in particular atrial fibrillation and associated decrease in diastolic heart function is important for planning the pre-bypass period but also the strategy during weaning from CPB, however this is also of relevance for non-MIMVS procedures.

As the classical surgical approach for MIMVS is a right-sided incision into the thorax, knowledge on right thoracic pathologies or abnormalities like adhesions or other lesions is of vital importance for planning the surgical strategy.

Pulmonary function testing is routinely done in many heart centres, mainly including chest radiography and even pulmonary function testing with or without measurement of lung volumes and diffusion capacity (7). However, data on pulmonary complication risks and the predictive value of pulmonary function tests are usually extrapolated from patients undergoing non-cardiac surgery (8). There is limited evidence to suggest that any preoperative pulmonary function testing should be done before MIMVS in routine fashion (9), however some centres consider the existence of severe pulmonary dysfunction, in particular pulmonary hypertension or higher degrees of chronic obstructive pulmonary disease (COPD) as a relative contraindication, in particular if the surgical approach require the use of OLV (2). In the majority of studies and case series, patients with extensive pulmonary dysfunction are not well represented, resulting in the inability of giving strict recommendations in this subset of patients. Moreover, the value of classical pulmonary function testing (Spirometry) can be questioned as a sole parameter, as this technique is dependent on patient cooperation (10). New approaches are in favour of cardiopulmonary exercise testing (CPET) which requires at least cycle ergometry and is therefore not suitable for a number of patients undergoing MV procedures due to the high risk of acute cardiovascular decompensation (11).

**Table 2** Standard monitoring for MIMVS

| Standard monitoring | Non-invasive | Invasive |
|---|---|---|
| Transoesophageal echocardiography (TOE) | 5-lead ECG | Arterial blood pressure monitoring (ABP)[§] |
| | Pulse-oximetry | Central venous pressure (CVP) |
| | EEG-monitoring (BIS) | Pulmonary artery catheter* |

*, pulmonary artery catheter in selected patients based on right ventricular function and pulmonary artery pressure; [§], left and right radial or brachial invasive blood pressure monitoring when using an endoclamp. BIS, bispectral index; EEG, electroencephalogram. MIMVS, minimally invasive cardiac surgery of the mitral valve.

## The team

It seems of importance to create a dedicated "mitral team", from the anaesthesia department, in particular when starting such a program. Anaesthesiologists dedicated to MIMVS should be experienced echocardiographers, including both 2D but also 3D echocardiography knowledge. Moreover, it seems useful if they are involved in the preoperative decision making, in particular with respect to the topic of vascular access. In the majority of centres, OLV is part of the surgical requires requiring profound knowledge with the institution of OLV and different lung separation techniques including use of double lumen tubes and bronchus blocking techniques.

Moreover, the internal quality control of the program should be done in close collaboration of cardiac surgeon (leader), cardiac anaesthesiologist, cardiologist and other supporting specialists like perfusionists and operating theatre assistants (12). It seems nearly impossible to create big scale scientific evidence for an outcome relevant effects of a dedicated team approach, however, circumstantial evidence and a couple of small-scale studies in the field of crew resource management are available, demonstrating the added values of such an approach (13).

## Anaesthesia technique and intraoperative management

Most commonly, general anaesthesia (GA) using a balanced opioid—hypnotic technique is used. Whereas some centres prefer the use of total intravenous anaesthesia (TIVA), others use volatile anaesthetics as part of the anaesthetic regimen. To date, only small studies are available describing the benefit of one of these two techniques, therefore the choice is mainly based on local guidelines than overall scientific evidence (2). Recently, Moscarelli *et al.* compared sevoflurane and propofol based anaesthesia management in a case series of 62 patients in randomized fashion. In this study, the authors do not find a difference between both regimen (14).

Monitoring depth of anaesthesia is performed by routine EEG, or EEG derived parameters like bispectral index (BIS), entropy or narcotrend depending on centre preference. Nowadays, avoiding of "too deep" anaesthesia becomes a relevant topic of interest. There is considerable evidence that extremely deep anaesthesia levels may result in an increased incidence of neurocognitive dysfunction and potentially also a higher rate of renal dysfunction.

*Table 2* shows the standard monitoring for MIMVS in our institution. Perioperative monitoring is based on ECG, continuous pulse oximetry ($SaO_2$), invasive arterial blood pressure measurement and central venous pressure. In some centres, invasive cardiac output measurements are performed as standard of care whereas others do not. There is no data available demonstrating the benefit of routine use of the pulmonary artery catheter (PAC) in cardiac surgical patients, therefore a patient centered approach dependent on individual patient related risk factors is used in our institution. The use of 2D/3D TOE is mandatory during MIMVS, as both careful evaluation pre- and post-repair are needed for a successful procedure. TOE results should be documented in standardized fashion. In our institution we prefer to follow the actual American Society of Echocardiography (ASE) and Society of Cardiovascular Anesthesiologists (SCA) guidelines on perioperative echocardiography (15).

Basically, anaesthesia technique and monitoring do not differ significantly between MIMVS and other complex cardiac surgical procedures. When using the endoclamp approach, invasive arterial pressure measurement is performed simultaneously via the right and left radial artery. Both measures are needed to verify the correct position of the endoclamp balloon in the ascending aorta (5).

Ventilation and pulmonary management are based on the intermittent use of OLV during the procedure. Usually, intubation is performed using either a double lumen tube or a conventional tube combined with a bronchus blocker.

 

Both techniques are well known from thoracic surgery and can be used safely in experienced hands (16). Both techniques require the use of bronchoscopic control to verify adequate positioning of the tube and the respective blocker. During MIMVS, the right lung needs to collapse to enable optimal visualization of the heart after right thoracic incision. When preferring a technique based on the use of a bronchus blocker, the anatomy of the right bronchial system is crucial as anatomic variations can lead to difficulties in placing the blocking balloon. Management of periods of desaturation during OLV needs adequate treatment in accordance with standard guidelines. OLV is not strictly mandatory as a number of centres use standard intubation and an intermittent halt of ventilation in their patients, however in our own experience the likeliness of insufficient OLV resulting in severe hypoxemia is quite low and can be treated appropriately in the vast majority of patients.

## Haemodynamic management in the perioperative period

In general, the haemodynamic management of patients undergoing MIMVS differs not substantially from those after open procedures. However, the prolonged CPB times can lead to an increased need of vasoactive and positive inotropic support in particular during weaning and after separation from bypass (2).

Patients with MV disease sometimes present with disturbed right ventricular function, enlarged atria and pulmonary hypertension. In this subgroup of patients, the use of inotropic support and reduction of right ventricular afterload is crucial for successful weaning from CPB. In recent literature, both the use of beta-mimetic support (e.g., Dobutamine), phosphodiesterase (PDE) inhibitors (e.g., Milrinone) and even the combination of positive inotropic agents and vasodilators is described and needs to be tailored to the individual patient. Therefore, evaluation of cardiac function by TOE is a prerequisite when preparing the patient for weaning from CPB. Again, adequate monitoring via TOE is of substantial value for the monitoring of myocardial contractility and volume status after separation from CPB. The use of ECMO in case of otherwise untreatable cardiac failure has been described and should be available in centres dealing with this patient population.

## Pain management

Still, the use of parenteral opioids forms the basis of adequate pain management in patients undergoing MIMVS (2). The multimodal treatment program can be expanded, by adding an intercostal blockade intraoperatively or by placing wound catheters during the surgical procedure, enabling postoperative administration of local anaesthetics. In a recent study, Zhan *et al.* investigated the effects of GA alone or in combination with thoracic intercostal blockade on the perioperative morbidity including cytokine response. The authors detected a significant decrease in cytokine release associated with earlier extubation in the group of patients with a combination of intercoastal blockade and GA (17). However, only 15 patients per group were included, so it seems useful to evaluate these preliminary results in a study of appropriate power. Neuburger and colleagues also observed a reduction in postoperative pain scores when comparing GA alone with a combination of intercostal blockade and GA in a group of 60 patients undergoing robotic MV surgery (18). In their study, extubation in the operating theatre was possible in 90% of patients, independent from the anaesthesia technique, however satisfaction was higher in patients receiving both, intercostal blockade and GA. Therefore, it can be summarized that the combination of intercostal blockade and GA is promising and most likely able to reduce postoperative pain scores, facilitates early extubation and has some effects on the amount of opioids in the perioperative period. However, there are no adequately powered randomized controlled trials about the superiority of this approach, compared to the standard technique. Given the increased interest in early recovery after surgery programs, it seems appropriate to discuss the current approach of using long acting opioids as a basis for pain management in cardiac surgical patients. It merits further investigation to study the effects of multimodal pain management schemes in this subset of patients.

## Conclusions

Minimal invasive cardiac surgery is the actual standard of care in surgical treatment of MV disorders. Nowadays, a couple of treatment options with and without the use of CPB are used in clinical practice requiring excellent knowledge of the procedures from the anaesthesia team. Anaesthesia for minimal invasive MV procedures is a challenging sub-type of cardiac anaesthesia. Basically, anaesthesia for these operations require excellent echocardiography knowledge combined with experience in the management of lung ventilation together with overall knowledge in the management of

complex patients undergoing cardiac surgery. The fact that the decision-making is mainly based on TOE and invasive monitoring results in a dedicated team approach, requiring adequate communication and transfer of information skills from all team members. This may be of greater importance for the success of such a program than the individual anaesthesia technique.

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## References

1. Moscarelli M, Fattouch K, Casula R, et al. What Is the Role of Minimally Invasive Mitral Valve Surgery in High-Risk Patients? A Meta-Analysis of Observational Studies. Ann Thorac Surg 2016;101:981-9.
2. Vernick W, Atluri P. Robotic and minimally invasive cardiac surgery. Anesthesiol Clin 2013;31:299-320.
3. Hawkins RB, Mehaffey JH, Mullen MG, et al. A propensity matched analysis of robotic, minimally invasive, and conventional mitral valve surgery. Heart 2018;104:1970-5.
4. Mkalaluh S, Szczechowicz M, Dib B, et al. Early and long-term results of minimally invasive mitral valve surgery through a right mini-thoracotomy approach: a retrospective propensity-score matched analysis. PeerJ 2018;6:e4810.
5. Chitwood WR Jr. Robotic mitral valve surgery: overview, methodology, results, and perspective. Ann Cardiothorac Surg 2016;5:544-55.
6. Atluri P, Stetson RL, Hung G, et al. Minimally invasive mitral valve surgery is associated with equivalent cost and shorter hospital stay when compared with traditional sternotomy. J Thorac Cardiovasc Surg 2016;151:385-8.
7. Kim TH, Lee JS, Lee SW, Oh YM. Pulmonary complications after abdominal surgery in patients with mild-to-moderate chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis 2016;11:2785-96.
8. Diaz-Fuentes G, Hashmi HR, Venkatram S. Perioperative Evaluation of Patients with Pulmonary Conditions Undergoing Non-Cardiothoracic Surgery. Health Serv Insights 2016;9:9-23.
9. Reeves T, Bates S, Sharp T, et al. Cardiopulmonary exercise testing (CPET) in the United Kingdom-a national survey of the structure, conduct, interpretation and funding. Perioper Med (Lond) 2018;7:2. Erratum in: Correction to: Cardiopulmonary exercise testing (CPET) in the United Kingdom-a national survey of the structure, conduct, interpretation and funding. [Perioper Med (Lond) 2018].
10. Ad N, Henry L, Halpin L, et al. The use of spirometry testing prior to cardiac surgery may impact the Society of Thoracic Surgeons risk prediction score: a prospective study in a cohort of patients at high risk for chronic lung disease. J Thorac Cardiovasc Surg 2010;139:686-91.
11. Richardson K, Levett DZH, Jack S, et al. Fit for surgery? Perspectives on preoperative exercise testing and training. Br J Anaesth 2017;119:i34-43.
12. Hawkins RB, Ailawadi G. Institutional or individual experience matters in minimally invasive valve surgery. J Thorac Cardiovasc Surg 2016;152:1477-8.
13. Marvil P, Tribble C. Lessons from Crew Resource Management for Cardiac Surgeons. Heart Surg Forum 2017;20:E077-81.
14. Moscarelli M, Terrasini N, Nunziata A, et al. A Trial of Two Anesthetic Regimes for Minimally Invasive Mitral Valve Repair. J Cardiothorac Vasc Anesth 2018;32:2562-9.

15. Hahn RT, Abraham T, Adams MS, et al. Guidelines for performing a comprehensive transesophageal echocardiographic examination: recommendations from the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. Anesth Analg 2014;118:21-68.
16. Kim HY, Baek SH, Je HG, et al. Comparison of the single-lumen endotracheal tube and double-lumen endobronchial tube used in minimally invasive cardiac surgery for the fast track protocol. J Thorac Dis 2016;8:778-83.
17. Zhan Y, Chen G, Huang J, et al. Effect of intercostal nerve block combined with general anesthesia on the stress response in patients undergoing minimally invasive mitral valve surgery. Exp Ther Med 2017;14:3259-64.
18. Neuburger PJ, Ngai JY, Chacon MM, et al. A Prospective Randomized Study of Paravertebral Blockade in Patients Undergoing Robotic Mitral Valve Repair. J Cardiothorac Vasc Anesth 2015;29:930-6.

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