JURNAL KOMPLIKASI ANESTESI
E-ISSN 2354-6514
VOLUME 12 NOMOR 1, NOVEMBER 2024

CASE STUDY

Fast-Track Extubation In Cardiac Surgery : A Case Series

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Article Citation : Paramita Putri Hapsari, Bhirowo Yudo Pratomo, Bambang Novianto Putro. Fast-Track Extubation In Cardiac Surgery : A Case Series. Jurnal Komplikasi Anestesi 12(1)-2024.

ABSTRACT

Fast-track extubation (FTE) has been shown to reduce the incidence of prolonged mechanical ventilation, resulting in shorter hospitalization, lower morbidity, mortality, and hospital costs. We present a case series of fast-track extubation involving two females aged 31 and 33 with Atrial Septal Defect (ASD) and a 33-year-old male with Ventricular Septal Defect (VSD) scheduled for defect closure. These patients were in good clinical condition with normal biventricular function and a low probability of pulmonary hypertension. The anesthesia and surgery procedures proceeded smoothly, with cardiopulmonary bypass time < 90 minutes, aortic cross-clamp time < 60 minutes, no residual shunt, acceptable lactate and blood gas analysis, stable hemodynamic with low doses of vasoactive agents, and adequate analgesia. Following the successful execution of the fast-track extubation protocol in the operating theatre, the patients were transferred to the intensive care unit (ICU) where they received postoperative management. The total ICU length of stay was < 24 hours, demonstrating the safety and efficacy of FTE for simple cardiac procedures and favourable outcomes. This approach is aimed at accelerating patient recovery, reducing complications, and enhancing overall surgical outcomes..

Keywords : fast-track extubation, cardiac surgery, cardiac anesthesia, ICU length of stay, congenital heart disease

Introduction

Prolonged use of mechanical ventilation after open heart surgery is associated with a long duration of hospitalization, increased mortality and morbidity rates and increased hospital costs1. Fast-track extubation is intended to minimize the above impacts. Fast-track extubation after cardiac surgery is an extubation procedure carried out in less than 6 hours after the procedure is completed. This technique provides benefits for patients who meet the criteria and hospitals2. We present a case series of fast track extubation for simple cardiac surgery performed at our hospital with good results.

Case

Case 1

A 31 year old woman came with complaints of intermittent shortness of breath accompanied by easy fatigue during strenuous activity. Complaints were felt about 1 year after giving birth to the first child through spontaneous parturition. This clinical condition improved with medical therapy so that now the patient can carry out daily activities without complaints.

During pre-anesthesia evaluation, the patient's general condition was good with vital signs showing blood pressure (BP) 108/81 mmHg, regular pulse (HR) 82 times/minute, respiratory rate (RR) 18 times/minute, body temperature 36.5 °C , and peripheral oxygen saturation (SpO2) 97-98% on room air in the supine position. The patient weighs 47 kg, height 150 cm, and Body Mass Index (BMI) 20.8 kg/m2. On physical examination of the heart, it was found that the heart borders seemed widened to the caudolateral, the first heart sound was normal, the second heart sound was fixed splitting, and there was a 3/6 pansystolic murmur in the left parasternal line.

On chest X-ray examination, it was found that the heart was enlarged with a cardio-thoracic ratio (CTR) of 59%, the heart apex appeared rounded, and the heart waist disappeared. In the lung, there was perihilar haziness in both pulmonary fields with sharp right and left costophrenic sinuses (Table-1). Transesophageal echocardiography (TEE) examination revealed an atrial septal defect (septum secundum) with a diameter of 0.9-1.6 cm, left to right shunt, dilatation of the right atrium and ventricle, mild tricuspid regurgitation with a peak pressure gradient (peak PG) of 19.75 mmHg, tricuspid regurgitation Vmax (TR Vmax) 2.22 m/s, low probability of pulmonary hypertension (PH), left ventricular ejection fraction (LVEF) 58% (Simpson), and tricuspid annular plane systolic excursion (TAPSE) 28 mm. From right heart catheterization, mild PH, high flow, low resistance was obtained (Table-2). From this supporting examination, it was concluded that there was ASD Secundum, left to right shunt, with a low probability of PH.

The patient underwent general anesthesia with invasive monitoring. Anesthesia induction using Midazolam 3 mg, Sufentanil 15 mcg, Rokuronium 25 mg with volatile gas Desflurane 3-6 vol%. The mechanical ventilation mode used is Pressure Synchronized Intermittent Mandatory Ventilation-Volume Guaranteed (PSIMV-VG) with a tidal volume of 375 cc, respiratory rate 12 times/minute, Positive End-Expiratory Pressure (PEEP) 3-5 mmHg, fraction of inspired oxygen (FiO2) 50%. During the surgery, the analgesia was given Morphine 10-20 mcg/kg/minute, Paracetamol 1 gram, and the muscle relaxant Rocuronium intermittently. The patient had the atrial septal defect closed with a patch. Hemodynamics during surgery were monitored to be stable with systolic BP 79-110

mmHg, diastolic BP 49-70 mmHg, HR 70-93 times/minute, SpO2 99-100%. TEE examination after the defect closure procedure showed no residual ASD and LVEF was 60%. After weaning from the cardiopulmonary bypass machine, hemodynamics was stable with the support of vasoactive Dobutamine 4 mcg/kg/minute. The duration of use of the cardiopulmonary bypass machine was 44 minutes, the duration of aortic cross clamping was 27 minutes, and the duration of ischemia was 40 minutes (Table-3). The blood gas and lactate analysis values were quite optimal with hemoglobin levels of 8 grams/dL (Table-4). The patient is then given a Packed Red Cells (PRC) transfusion to optimize hemoglobin levels.

Before closure of the sternum, the patient begins to spontaneously gradually until he is able to use continuous positive airway pressure (CPAP) ventilation mode with an FiO2 of 50%. After skin closure is complete, the anesthetic gas is stopped and waited until the patient is conscious, able to carry out commands, tidal volume > 6 ml/kg, SpO2 > 95% with FiO2 50%, no arrhythmias, normal body temperature, and adequate analgesia, then the patient is conscious extubation. Respiratory, hemodynamic and clinical monitoring of the patient continues after extubation. After the post-extubation condition is stable, the patient is then transferred to the ICU to receive the necessary post-operative management.

Case 2

A 33 year old woman with a diagnosis of an atrial septal defect was planned for defect closure surgery. Currently the patient is receiving medical therapy and is in good clinical condition without restrictions on daily physical activity. When examining vital signs, BP was 118/82 mmHg, regular HR 80 times/minute, RR 18 times/minute, body temperature 36.5 °C, and SpO2 97-100% in room air in the supine position. The patient weighs 56 kg, height 156 cm, and Body Mass Index (BMI) 24.2 kg/m2. On physical examination of the heart, it was found that the heart borders seemed widened to the caudolateral, the first heart sound was normal, the second heart sound was wide fixed splitting, and there was a 3/6 pansystolic murmur in the left parasternal line.

Chest x-ray examination revealed an enlarged cast with a cardio-thoracic ratio (CTR) of 62%, perihilar haziness was visible in both pulmonary fields (Table-1). TEE examination revealed an atrial septal defect (septum secundum) with a diameter of 1.8 cm, left to right shunt, Qp : Qs = 3.25, dilatation of the right atrium and ventricle, mild tricuspid regurgitation, LVEF 75% (Simpson), and TAPSE 32 mm. From right heart catheterization, PH was mild, high flow, low resistance, mean pulmonary artery pressure (mPAP) 21 mmHg, pulmonary vascular resistance/systemic vascular resistance (PVR/SVR) 0.01, pulmonary artery resistance index (PARi) 0.11 (Table-2). From the supporting examination, it was concluded that there was ASD Secundum, left to right shunt, and mild PH.

The patient was installed with an invasive monitoring device and underwent general anesthesia with induction of Midazolam 4 mg, Sufentanil 20 mcg, Rocuronium 30 mg and volatile gas Desflurane 3-6 vol%. The mechanical ventilation mode used is PSIMV-VG with a tidal volume of 450 cc, respiratory rate 12 times/minute, PEEP 3-5 mmHg, FiO2 50%. During the surgery, the analgesia was given Morphine 10-20 mcg/kg/minute, Paracetamol 1 gram, and the muscle relaxant Rocuronium intermittently. The patient had the atrial septal defect closed with a patch. Hemodynamics during surgery

were quite stable with systolic BP 80-130 mmHg, diastolic BP 60-85 mmHg, HR 75-95 times/minute, SpO2 98-100%. TEE examination after the defect closure procedure showed no residual ASD, LVEF 60%, and TAPSE 22 mm. After weaning from the cardiopulmonary bypass machine, hemodynamics was stable with the support of vasoactive Dobutamine 3 mcg/kg/minute. The duration of use of the cardiopulmonary bypass machine was 45 minutes, the duration of aortic cross clamping was 24 minutes, and the duration of ischemia was 21 minutes (Table-3). Blood gas and lactate analysis values were still within normal limits with hemoglobin levels of 8.5 grams/dL (Table-4). The patient also received a PRC transfusion to increase the hemoglobin level.

The patient begins to spontaneously gradually until he is able to use CPAP ventilation mode with an FiO2 of 50%. After skin closure is complete, the anesthetic gas is stopped and waited until the patient is conscious, able to carry out commands, tidal volume > 6 ml/kg, SpO2 > 95% with FiO2 50%, no arrhythmias, normal body temperature, and adequate analgesia, then the patient is conscious extubation. We continue to monitor the patient's respiratory, hemodynamic and clinical patterns after extubation. After the post-extubation condition is stable, the patient is then transferred to the ICU to receive the necessary post-operative management.

Case 3

A 33 year old man came with complaints of shortness of breath and easy fatigue when doing strenuous activities for 2 years. The patient received medical therapy and is currently in good clinical condition and without complaints.

During the pre-anesthesia evaluation, the patient's general condition was good with vital signs showing BP 119/65 mmHg, regular HR 73 times/minute, RR 18 times/minute, body temperature 36.5 °C, and SpO2 97-100% in room air with the position supination. The patient weighs 63 kg, height 167 cm, and Body Mass Index (BMI) 22.6 kg/m2. On physical examination of the heart, it was found that the heart borders were normal, heart sounds I-II were normal, and there was a 3/6 pansystolic murmur in the left parasternal line.

On chest x-ray examination, the heart and lungs did not show any abnormalities (Table-1). Transthoracic echocardiography (TTE) examination revealed a ventricular septal defect (VSD) with a diameter of 0.8 cm (Qp:Qs = 3.52), left to right shunt, mild tricuspid regurgitation with vena contracta 0.2 cm, tricuspid regurgitation Vmax (TR Vmax) 1.56 m/ s, mild mitral regurgitation with vena contracta 0.2 cm, mild aortic regurgitation with pressure half time (PHT) 563 msec, LVEF 62% (Simpson), and TAPSE 19 mm. From right heart catheterization, subarterial doubly committed (SADC) VSD was obtained, mild PH, high flow, low resistance (Table-2). From the supporting examination, it was concluded that there was a SADC VSD, left to right shunt, and low probability of PH.

The patient underwent general anesthesia and invasive monitoring was installed. During induction of anesthesia, Midazolam 4 mg, Sufentanil 20 mcg, Rocuronium 35 mg and volatile gas Desflurane 4-6 vol% were given. The mechanical ventilation mode used is PSIMV-VG with a tidal volume of 450 cc, respiratory rate 12 times/minute, PEEP 3-5 mmHg, FiO2 50%. During the surgery, the analgesia was given Morphine 10-20 mcg/kg/minute, Paracetamol 1 gram, and the paralytic Rocuronium intermittently. The patient had the ventricular septal defect closed with a patch. Hemodynamics during surgery were quite

stable with systolic BP 80-130 mmHg, diastolic BP 50-90 mmHg, HR 80-95 times/minute, SpO2 98-100%. TEE examination after the defect closure procedure showed no residual VSD and LVEF was 63%. After weaning from the cardiopulmonary bypass machine, hemodynamics was stable with the support of vasoactive Dobutamine 5 mcg/kg/minute. The duration of use of the cardiopulmonary bypass machine was 67 minutes, the duration of aortic cross clamping was 53 minutes, and the duration of ischemia was 49 minutes (Table-3). The blood gas and lactate analysis values were quite optimal with hemoglobin levels of 8.8 grams/dL (Table-4). The patient then received a PRC transfusion to optimize hemoglobin levels.

When closing the sternum, the patient begins to spontaneously gradually until he is able to use CPAP ventilation mode with an FiO2 of 50%. After skin closure is complete, the anesthetic gas is stopped and waited until the patient is conscious, able to carry out commands, tidal volume > 6 ml/kg, SpO2 > 95% with FiO2 50%, no arrhythmias, normal body temperature, and adequate analgesia, then the patient is conscious extubation. After the patient was assessed as stable with good respiratory, hemodynamic and clinical patterns, the patient was then transferred to the ICU for post-operative management.

Dicussion

Fast-track extubation is widely recognized in various cardiac surgery centers as a safe and effective technique2. However, this technique cannot yet be considered a "new standard" as a whole because each cardiac surgery center has its own considerations such as patient population, surgical complexity, protocols at each institution and the preferences of the cardiac surgeon himself. In general, the fast-track extubation technique is widely applied because it is useful in reducing postoperative complications, improving patient outcomes, and optimizing the use of existing resources. Although fast-track extubation has many benefits, the important thing to emphasize is that not all patients or all cardiac surgical procedures are worthy of fast-track extubation. This technique also has potential complications such as respiratory distress, possible reintubation or readmission to the intensive care unit3. This feasibility assessment is individualistic and is crucial in determining the expediency of using this technique for particular cases.

Some cardiac surgical procedures that can be performed quickly are cases where the patient has a low postoperative risk. For example, in cases of closure of simple atrial or ventricular septal defects, coronary artery bypass grafting (CABG), minimally invasive heart surgery (MICS), and off pump CABG (OPCAB)4. The case series at our hospital are cases of simple cardiac surgery, namely closure of atrial (2 cases) and ventricular (1 case) septal defects in adult patients. In adult patients with congenital abnormalities, there is indeed one potential problem of concern, namely pulmonary hypertension, but based on the results of echocardiography and catheterization, it was found that our patients had a low risk of pulmonary hypertension, good clinical condition with a higher metabolic equivalent of tasks score (MET score). of 4, as well as normal biventricular function. Based on the above, these three cases are ideal candidates for fast-track extubation.

Fast-track extubation in cardiac surgery is defined as removal of the endotracheal tube in less than 6 hours after surgery, provided the patient meets the criteria for readiness for early extubation2. This is in contrast to conventional techniques where patients will

still be given mechanical ventilation support for at least 24 hours while in the intensive care unit (ICU) even though the cardiac surgical procedure being undertaken is in the simple category. The advantages of using mechanical ventilation include stable oxygenation due to always maintaining airway patency, continuous respiratory control in patients who are unable to maintain adequate ventilation, and easing the work of the left ventricle in patients with low cardiac output syndrome after cardiac surgery. . However, prolonged use of mechanical ventilation also has disadvantages, including increasing the risk of infection (ventilator-acquired pneumonia), barotrauma, respiratory muscle weakness, increasing the length of time in the ICU, which will increase hospital costs, and dependency on ventilators, which can slow down recovery and rehabilitation process 5. To minimize complications due to prolonged use of mechanical ventilation, fast-track extubation can be an option for patients who meet the criteria.

There are three things that are taken into consideration when carrying out fast-track extubation, namely matters related to the patient, surgery and metabolic conditions. The ideal patient condition for early extubation requires adequate oxygenation and ventilation, stable hemodynamics, good neuromuscular function and patient awareness, inspiratory effort, cough reflex and fluid adequacy (Table-5)3,6–8. Regarding surgery, there are factors that influence it, namely the duration of the operation, the duration of using a cardiopulmonary bypass machine (CPB), and the duration of aortic cross clamping9. There is a significant correlation between the duration of the CPB machine and short aortic cross-clamping with the success rate of fast-track extubation in cardiac surgery. The short duration of the CPB machine will reduce blood exposure to foreign surfaces which is a trigger factor for systemic inflammation, so this will reduce post-operative complications and speed up recovery. The short duration of aortic cross-clamping represents a quicker surgical technique and reduces the duration of cardiac ischemia time and this also contributes to accelerated recovery and weaning from the ventilator10. In the three patients above, hemodynamics were monitored to be stable using low dose vasoactive support. Apart from that, the duration of the cardiopulmonary bypass machine and aortic cross clamp is also relatively short (CPB machine duration < 90 minutes, aortic cross clamp duration < 60 minutes). Meanwhile, regarding metabolic factors, the things of concern are lactate values, hemoglobin levels and blood gas analysis.

An increase in lactate values and less than optimal blood gas analysis indicate inadequate tissue perfusion10. In the three cases above, the blood gas analysis values were still within the normal range, but post-CPB lactate values showed levels of more than 2 mmol/L. This could be due to hemodilution conditions during use of the CPB machine resulting in anemia. Anemia causes a decrease in oxygen transport capacity, causing tissue hypoxia. When tissues do not receive adequate oxygen, tissue metabolism will change to anaerobic metabolism with the final product being lactate. In the case above, post-CPB hemoglobin levels were found to be in the range of 8 g/dL, so packed red cells (PRC) were transfused with a target hemoglobin in the range of 10 g/dL. Because the cases carried out are not cases of cyanotic congenital heart disease, the hemoglobin target does not need to be high (in cases of cyanotic congenital heart disease, the postoperative Hb target is 14-16 g/dL). Monitoring of hemoglobin levels

must be carried out during the postoperative period as a benchmark for the need for blood transfusions and the adequacy of oxygen transport capabilities6.

Although the various parameters above are important to pay attention to, we must consider these parameters together with other clinical factors, such as hemodynamic stability, respiratory function, and overall clinical status before making the decision to extubate 9,11. The three patients above had good hemodynamic stability with the support of low doses of vasoactive agents, analgesia was given continuously, during the anesthesia induction process or weaning from the CPB machine there were no heart rhythm disturbances, the patients were not hypothermic, lung function was also good with bronchovascular patterns which is still normal so this is in accordance with the diagnosis of low probability of pulmonary hypertension. The existing anemia condition is treated with PRC transfusion so that at the end of the operation optimal hemoglobin levels can be obtained.

Based on the clinical characteristics of these three patients, we decided to perform fast-track extubation in the operating room. Extubation is carried out after the patient is fully conscious, able to follow commands, with adequate ventilation criteria. Indeed, until now there is no scoring system to determine the appropriateness of extubation in patients, especially for on table extubation. We therefore adopted a fast tract cardiac anesthesia algorithm to guide the evaluation of the hemodynamic course during surgery and the determination of early extubation (Figure-1)11. This algorithm can guide fast track cardiac anesthesia to avoid complications of reintubation or intensive care readmission.

After extubation in the operating room, hemodynamic and respiratory monitoring still needs to be carried out for some time until the patient's condition is stable for transfer to the ICU. In the ICU, patients receive post-operative management and close clinical monitoring including echocardiography evaluation (hemoecho). This is aimed at optimizing conditions, early detection if there are post-operative problems such as bleeding that requires repeat transfusion or respiratory problems that require definitive action, as well as determining the suitability of therapy to the patient's needs. During the postoperative period, the patient's clinical and hemodynamic condition was monitored to be stable so that the patient could be transferred from the ICU in less than 24 hours.

Conclusion

Fast-track extubation is a safe and effective option in simple cardiac surgery cases. The criteria for fast-track extubation include good clinical and respiratory conditions, stable hemodynamics and no complications during surgery. The benefits of fast-track extubation include a shorter patient recovery period, reduced risk of ventilator-related complications, and reduced length of stay in the ICU. However, it should be emphasized that not all patients are candidates for fast-track extubation so that appropriate patient selection, adherence to protocols, and good postoperative management in the ICU are determinants of the success and safety of this technique. Therefore, it is necessary to refine patient selection criteria and optimize perioperative strategies in accordance with the Enhanced Recovery After Cardiac Surgery (ERACS) protocol to improve cardiac surgical services in Indonesia.

Table 1. Thoracic X-ray Image

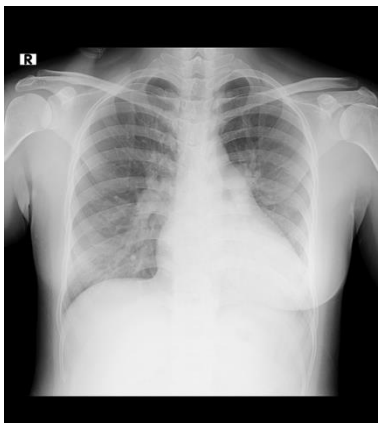
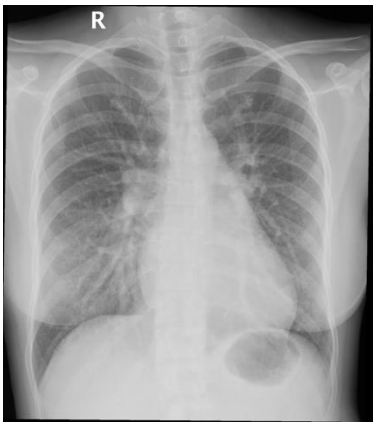
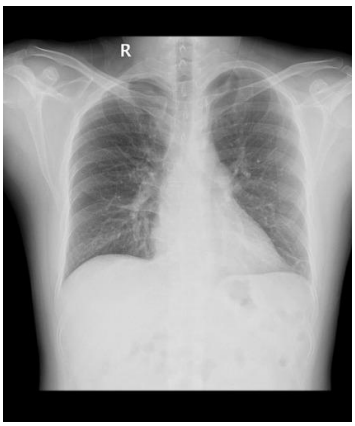
Case 1	Case 2	Case 3
		
Interpretation: in the three chest x-ray images, the bronchovascular pattern of the lungs is still visible to the lateral side, the lungs also do not appear oligemic, so this supports the condition of low probability of pulmonary hypertension.		

Table 2. Results of Right Heart Catheterization

	MAP (mmHg)	mPAP (mmHg)	PARi (WU/m2)	PVR/SVR	FR	Conclusion
Case 1	104	26	1.61	0.08	2.2	**PH Mild, HFLR**
Case 2	81	21	0.12	0.01	15.1	**PH Mild, HFLR**
Case 3	113	32	1.7	0.1	1.5	**PH Mild, HFLR**

MAP : *mean arterial pressure*, mPAP : *mean pulmonary artery pressure*, PARi : *pulmonary artery resistance index*, PVR : *pulmonary vascular resistance*, SVR : *systemic vascular resistance*, FR : *flow ratio*, PH : *pulmonary hypertension*, HFLR : *high flow low resistance*

Table 3. Duration of CPB Machine, Aortic Cross Clamp, Ischemic, ICU, and Hospitalization

	CPB Machine Duration (minute)	Aortic Cross Clamp Duration (minutes)	Duration Ischemic (minute)	ICU Duration (hour)	Duration Hospitalization (day)
Case 1	44	27	24	18	6
Case 2	45	24	21	18	6
Case 3	67	53	49	16	6

CPB : *cardiopulmonary bypass*, ICU : *intensive care unit*

Table 4. Post-CPB Blood Gas Analysis Results

	pH	pCO_2 (mmHg)	pO_2 (mmHg)	SaO_2 (%)	P/F rasio	Lactate (mmol/L)	Hb (g/dL)
Case 1	7.35	32.8	179	100	358	4.3	8.0

Case 2	7.42	30	105	99	210	2.1	8.5
Case 3	7.33	41.6	217	100	434	5.5	8.8

CPB : *cardiopulmonary bypass*; samples were taken with inspired oxygen fraction 50%

Table 5. Fast-Track Extubation Criteria [3,6–8]

Criteria	Explanation
Adequate Oxygenation	PaO_2 > 80 mmHg dengan FiO_2 < 0.5 SpO_2 > 92% pada FiO_2 < 0.5 dengan PEEP < 8 cm H_2O
Adequate Ventilation	pH 7.35 – 7.45 $PaCO_2$ < 50 mmHg RR < 25 kali per menit PEEP < 8 cm H_2O Volume tidal > 6 cc/kg
Stable Hemodynamics	Blood pressure and heart rate are stable There were no significant arrhythmias Cardiac Output is sufficient
Neuromuscular Function	Ability to carry out orders, cooperation, there is inspired effort
Extubation Awareness and Readiness	The ability to maintain airway patency, the presence of a cough reflex Opens eyes spontaneously and responsively
Fluid Balance	Urine production is sufficient There are no signs of excess/lack of fluid
Thoracic X-ray Image	There are no abnormalities in the lungs (e.g. areas of consolidation, effusion) Lung fields are clean

FiO_2 : fraction of inspired oxygen, PEEP : *positive end-expiratory pressure*

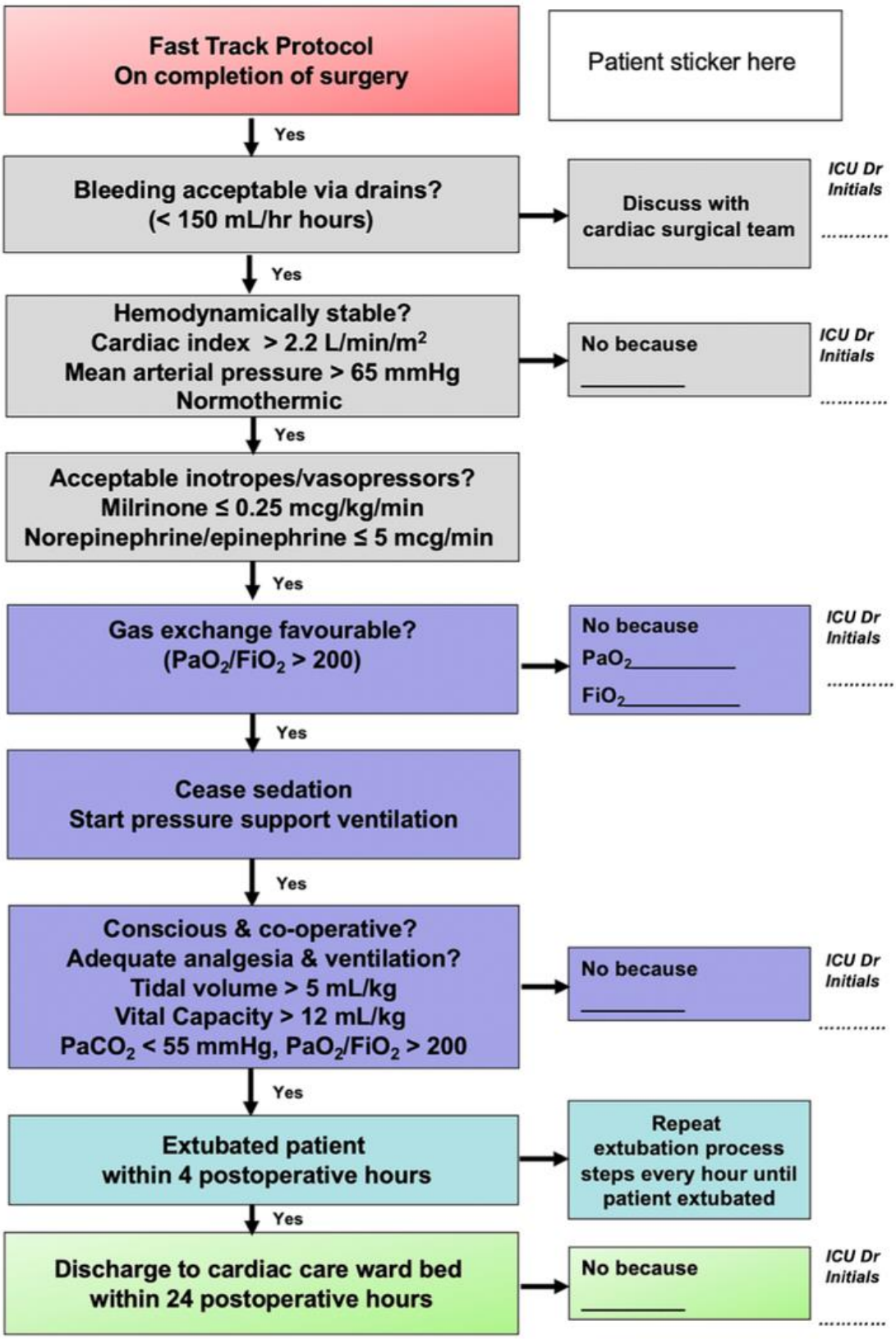


Figure 1. Fast-Track Protocol in Cardiac Surgery[11]

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