Fast-track Cardiac Care for Adult Cardiac Surgical Patients

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GRADUATE THESIS

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List of Abbreviations

FTCA	Fast-tract Cardiac Anaesthesia
ICU	Intensive Care Unit
CABG	Coronary Artery Bypass Graft
CAD	Coronary Artery Disease
TAVR	Transcatheter Aortic Valve Replacement
MI	Myocardial Infarction
IMA	Internal Mammary Artery
RA	Radial Artery
GSV	Great Saphenous Vein
PCI	Percutaneous Coronary Intervention
LAD	Left Anterior Descending
FTF	Fast-track Failure
RBC	Red Blood Cells
BMI	Body Mass Index
LOS	Length of Stay
MeSH	Medical Subject Headings
TV	Tidal Volume
PEEP	Positive End-Expiratory Pressure
SvO_2	Central Venous Oxygen Saturation
ECG	Electrocardiogram
CXR	Chest X-ray
OR	Operating Room
PACU	Postanaesthetic Care Unit
IMC	Intermediate Care Unit
FFR	Fractional Flow Reserve
LV	Left Ventricle
LVEF	Left Ventricular Ejection Fraction
PONV	Postoperative Nausea and Vomiting
COPD	Chronic Obstructive Pulmonary Disease

Contents

Summary

Title: Fast-track Cardiac Care for Adult Cardiac Surgical Patients

Written by: María José Riera Manzano

Key words: fast-track, adult, cardiac surgical procedures, early extubation, anaesthesia

Cardiac anaesthesiology is a specialized branch of anaesthesiology focused on the care of patients undergoing heart surgery. In the late 1980s and early 1990s, the concept of fast-track cardiac anaesthesia (FTCA) began to be introduced because a search to improve recovery times and reduce cost was being carried out. After some clinical trials the benefits such as reduction in Intensive Care Unit (ICU) length of stay (LOS) and additionally, in the hospital, and improvement in patient satisfaction without compromising morbidity or mortality, were demonstrated and allowed the implementation by the early 2000s.

FTCA emerged as a response to the need for more efficient, cost-effective and patient-centered care in cardiac surgery, and includes optimized anaesthesia, early extubation and early mobilization, all of which contribute to rapid recovery. The protocol uses low-dose opioids, volatile anaesthetic agents, and short-acting neuromuscular blockers to provide quick sedation, reversal and hemodynamic stability while facilitating early extubation within 1-10 hours after surgery.

In this thesis, fast-track and conventional anaesthetic protocols are compared, highlighting FTCA's benefits, and identifying potential complications and predictors of failure while stating the extubation criteria, perioperative goals and risk factors.

In conclusion, FTCA offers significant advantages in cardiac surgery, including economic benefits from shorter hospital stays and better patient outcomes. Despite challenges and risks, careful patient selection and strict perioperative management are crucial for successful FTCA implementation. Continuous research and improvements are necessary to further enhance its effectiveness and patient care in surgery.

Sažetak

Naslov: Brza kardijalna procjena bolesnika za kardijalni zahvat

Autor: María José Riera Manzano

Ključne riječi: ubrzana skrb, odrasli, kardijalni kirurški zahvati, rano ekstubiranje, anestezija

Kardijalna anesteziologija je specijalizirana grana anesteziologije usmjerena na skrb o pacijentima podvrgnutim operacijama srca. Koncept brze kardijalne anestezije (FTCA) se počeo uvoditi krajem 1980-ih i početkom 1990-ih godina, ne bi li se skratilo vrijeme oporavka i smanjili troškovi liječenja. Kliničkim ispitivanjaima su prikazane prednosti poput smanjenja duljine boravka u jedinici intenzivnog liječenja (ICU) i dodatno, u bolnici, te poboljšanje zadovoljstva pacijenata bez utjecaja na morbiditet ili mortalitet, što je omogućilo implementaciju početkom 2000-ih.

FTCA se pojavila kao odgovor na potrebu za učinkovitijom, isplativijom i na pacijenta usmjerenom skrbi u kardijalnoj kirurgiji, a uključuje optimiziranu anesteziju, rano ekstubiranje i ranu mobilizaciju, što sve doprinosi brzom oporavku. Protokol uključuje niske doze opioida, hlapljive anestetike i kratkodjelujuće neuromuskularne blokatore kako bi se osigurala brza sedacija, povratak svijesti i hemodinamska stabilnost, omogućujući u isto vrijeme rano ekstubiranje unutar 1-10 sati nakon operacije.

U ovom radu uspoređuju se protokoli brze i konvencionalne anestezije, ističući prednosti FTCA i identificirajući potencijalne komplikacije i prediktore neuspjeha, i navodeći kriteriji za ekstubiranje, perioperativni ciljevi i čimbenici rizika.

Zaključno, FTCA nudi značajne prednosti u kardijalnoj kirurgiji, uključujući ekonomske koristi od kraćeg boravka u bolnici i bolje ishode za pacijente. Unatoč izazovima i rizicima, pažljiv odabir pacijenata i strogo definirano perioperativno zbrinjavanje ključni su za uspješnu implementaciju FTCA. Kontinuirano istraživanje i unapređenja nužni su za daljnje poboljšanje njegove učinkovitosti i skrbi za pacijente tijekom operacije.

1. Introduction

Cardiac surgery is an essential intervention for patients with various heart conditions, offering a potential return to a better quality of life but often accompanied by significant postoperative challenges. That is why, throughout the years, patient care has evolved in the search for new techniques and improvements for post-surgery recovery.

Since 1990, a new approach in the field of anaesthesiology known as fast-track has been implemented (1). This technique may decrease perioperative morbidity, shorten the length of stay (LOS) in the hospital, and improve patient satisfaction without compromising safety.

The concept of fast-track cardiac anaesthesia (FTCA) encompasses a multidisciplinary approach that includes optimized anaesthesia, early extubation, and early mobilization. These elements work together to support rapid recovery while preserving patient comfort and safety. One of the primary goals of fast-track protocols is to reduce the LOS in the Intensive Care Unit (ICU). This effort aims to reduce the risk of problems associated with ICU, such as infections, and to facilitate a quicker discharge and transfer to general wards (2).

This anaesthetic protocol is based on low-dose opioids, volatile agents, and short-acting neuromuscular blockers to achieve rapid sedation reversal and hemodynamic stability, while allowing early extubation of the patient (1–3).

This thesis aims to explore different aspects of coronary artery bypass graft surgery (CABG) and valve replacement surgeries, focusing on the implementation and outcomes of FTCA. By examining the indications, techniques, and complications associated with these cardiac procedures, this review seeks to provide a comprehensive understanding of how FTCA can enhance surgical outcomes and patient recovery.

Comparative studies between fast-track and non-fast-track patients offer insights into the benefits and potential limitations of fast-track cardiac care. By examining various outcomes, such as ICU and hospital LOS, and the incidence of postoperative nausea and vomiting (PONV), this thesis aims to provide a comprehensive evaluation of fast-track protocols. The findings can inform clinical practice, guiding healthcare professionals in optimizing perioperative care for adult cardiac surgical patients.

In this thesis, the aim is to assess the advantages and complications of FTCA, evaluate its impact on patient morbidity and mortality rates, analyse the cost-effectiveness in cardiac surgical care, identify risk factors and patient eligibility, and examine perioperative goals and extubation criteria.

Through comprehensive analysis and evidence-based recommendations, this thesis seeks to summarize the advancements in the field of cardiac anaesthesia in the context of modern healthcare challenges.

2. Methodology

A systematic and comprehensive literature search has been conducted across PubMed and the Cochrane Library. The search strategy incorporated a combination of keywords, MeSH terms, and Boolean operators. On PubMed, the search query was as follows: ((Fast-track) AND ("Cardiac Surgical Procedures" [Mesh])) AND ("Adult" [Mesh]) AND ("Length of Stay" [Mesh] OR "Postoperative Complications" [Mesh]). The results were then filtered by Publication Date: from 2010 to 2024 and by Text Availability: Full Text, sorted by relevance, yielding a total of 61 results.

In the Cochrane Library, the search strategy is depicted in Appendix 1, resulting in 79 matches. These results were further limited to the time frame from 2010 to 2024, resulting in 2 Cochrane Reviews and 39 Trials that matched the criteria, which were then sorted by relevancy.

The selection criteria were based on the relevance and adequacy of the topic. The following keywords and MeSH terms were chosen for specific reasons: "Fast-track" to identify articles discussing this protocol, "Cardiac Surgical Procedures" to ensure the search focused on publications related to cardiac surgery, "Adult" to limit the search to the adult population, and "Postoperative Complications" and "Length of Stay" to emphasize the impact of the protocol on hospital and ICU stays and post-surgical complications.

Different Boolean operators were used to refine the search. "AND" was employed to combine various concepts, ensuring that all retrieved studies included all the required terms. "OR" was used to find studies addressing either or both of the specified outcomes.

Regarding applied filters, articles published between 2010 and 2024 were included to focus on the most current research related to fast-track guidelines. Additionally, only articles with full-text availability were included to ensure access to complete study data and findings.

These rigorous search and selection processes aim to provide a comprehensive overview of the current literature on fast-track cardiac care for adult cardiac surgical patients, offering valuable insights into this field.

3. Cardiac Procedures

3.1. Coronary Artery Bypass Grafting

Coronary Artery Bypass Grafting is a cardiac revascularization technique used to treat significant and symptomatic stenosis found on coronary artery or its branches. This condition is called coronary artery disease (CAD), and is caused by atherosclerosis, that consists of lipid accumulation, cholesterol and/or calcium within the intima layer of the arterial wall, leading to intraluminal plaque formation and subsequent decrease in blood supply to the myocardium. A diminished blood supply results in a mismatch between myocardial oxygen demand and supply, which presents as an acute retrosternal chest pain (angina), a cardinal sign of CAD. Patients may be asymptomatic or present with stable or unstable angina depending on the degree of arterial diameter diminished by the plaque. It can lead to severe ischemia further causing myocardial infarction (MI) (4–6). In Figure 1, revascularization procedure is shown.

The surgical procedure entails revascularization, wherein a bypass is created to avoid the blocked or narrowed section harvesting healthy blood vessel from alternative anatomical sites, to restore the flow to the heart muscle and relieve the symptoms. An arterial (internal mammary artery (IMA), radial artery (RA)) or venous (great saphenous vein (GSV)) autograph is used to bypass the stenosed segment and restore blood supply to the myocardium's ischemic regions. The patient's anatomy and the location of the blocked arteries determine the kind and placement of the graft. Left IMA is typically grafted to the left anterior descending (LAD) artery, while the other conduits are often used for the other occluded arteries (7–10).

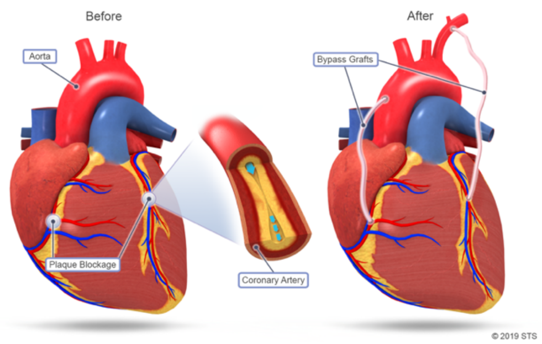

Figure 1: Diagram showing CAD (before CABG) on the left and revascularization done on CABG (after) on the right. Obtained from The Society of Thoracic Surgeons (5).

In Table 1, 2018 ESC/EACTS guidelines for Class 1 revascularization indications in patients with stable angina or silent ischaemia are shown:

Left main disease with stenosis >50%
Proximal LAD stenosis >50%
Two- or three-vessel disease with stenosis >50% with impaired LV function (LVEF ≤35%)
Large area of ischemia detected by functional testing (>10% LV) or abnormal invasive FFR (<0.75)
Single remaining patent coronary artery with stenosis >50%
Haemodynamically significant coronary stenosis (FFR ≤0.80 or >90% stenosis in a major coronary vessel) in the presence of limiting angina or angina equivalent, with insufficient response to optimized medical therapy

Table 1: Indications for revascularization, either PCI or CABG. FFR: Fractional Flow Reserve. LAD: Left Anterior Descending Coronary Artery. LV: Left Ventricle. LVEF: Left Ventricular Ejection Fraction. Obtained from 2018 ESC/EACTS Guidelines (11).

Generally, CABG is indicated when there is a high-grade blockage in any of the major coronary arteries and/or percutaneous coronary intervention (PCI) has failed to destroy the blockage (6). The technique that is most advised for the patient based on their features is determined using Table 1 and the scores from STS, SYNTAX, and EuroSCORE II, which provide information regarding the surgical risk and the complexity of CAD. The STS score or EuroSCORE II, evaluate in-hospital or 30-day mortality as well as in-hospital morbidity following CABG. The SYNTAX score is used to evaluate the long-term risk of death and morbidity following PCI, as well as the anatomical complexity of CAD (11).

The procedure is contraindicated when the patient refuses to undergo the surgery, when the coronary arteries are incompatible with grafting and in the absence of viable myocardium to graft (6).

CABG may be performed either via on-pump CABG, the traditional heart-lung bypass machine executes the work while allowing the heart to be completely at rest, due to the administration of cardioplegia, a solution made of potassium and other electrolytes to induce cardiac arrest, and the whole body to receive blood supply during the operation, and once the grafts are placed, the pump is turned off and the heart slowly turns to beat to normal, or via off-pump CABG, that avoids extracorporeal circulation, so the heart is still beating during the surgery (5,7,10,12).

Complications, include stroke, wound infection, graft failure or occlusion, renal failure, myocardial dysfunction, postoperative cardiac tamponade with cardiogenic shock, postoperative arrythmias, postpericardiotomy syndrome, which is an autoimmune febrile pericarditis or pleuritis that may occur 1-6 weeks following the procedure, and death (4,6). They are dependent on co-morbidities as advanced age, diabetes, obesity, chronic obstructive pulmonary disease (COPD), etc (6,7).

3.2. Valve Replacement Surgery

The heart is a muscle-based organ situated in the middle mediastinum. It is divided into four chambers: two atria and two ventricles. The systemic circulation supplies deoxygenated blood to the right heart, which is composed of the right atrium and the right ventricle, the latter one being the responsible to send the blood into the pulmonary trunk. On the opposite side, the left heart made of the left atrium and the left ventricle, receives oxygen-rich blood from the pulmonary circulation and pumps it into the aorta, where it enters the systemic circulation and supplies the body and its organs with oxygen (13,14).

The atria and the ventricles are separated by atrioventricular valves, and the semilunar valves divide the ventricles from the arterial outflow tracts. In total, the heart has 4 valves: tricuspid, pulmonary, mitral valve and aortic valve. The heart's anatomy is shown in Figure 2.

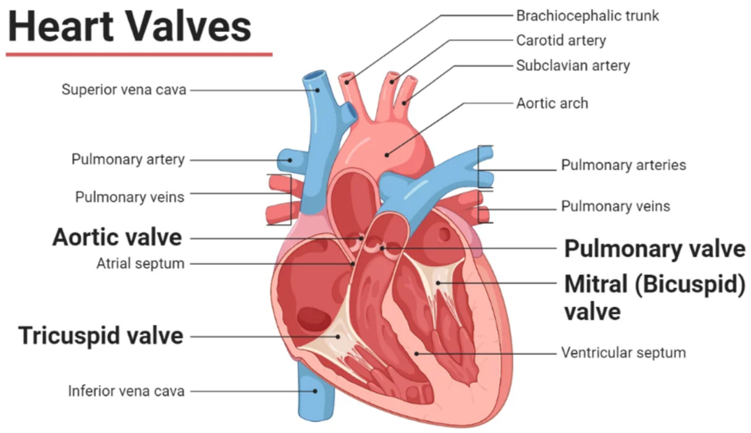

Figure 2: The heart's anatomy and its valve's location. Obtained from Heart Valves: Types, Structure, Functions, Diseases (15).

Heart valves may become damaged or diseased requiring repair or replacement. The diseases can be congenital or acquired, with common types including stenosis meaning narrowing of the valve opening, causing an outflow obstruction, and regurgitation meaning it fails to close, allowing backflow. These malfunctions disrupt the normal flow of blood through the heart, leading to angina pectoris, dyspnoea, palpitations, fatigue, and in severe cases, to heart failure (13,14).

Once diagnosed and classified according to severity, the proper management is discussed. Regularly, requires surgical intervention when the disease is advanced or symptomatic. Surgical treatment options include valve repair and valve replacement. Repair involves procedures to reconstruct the valve such as annuloplasty, which consist of attaching a ring device to the outside of the valve opening allowing the function and the shape to be reestablished, leaflet repair that involves a clip device and valvuloplasty, which is performed in stenotic valves to separate the calcified or fused leaflets. Finally, replacement is done by substitution with either a mechanical or a biological prosthetic valve. Selection of the prosthetic valve is based on patient characteristics such as age, risk of bleeding, ability to take anticoagulants and presence of comorbidities (13).

Apart from surgery, new minimal invasive techniques, such as transcatheter aortic valve replacement (TAVR), have been implemented because of the reduction in surgical risks and recovery times, making it suitable for high-risk patients who might not be candidates for open-heart surgery (13,16).

As for complications of valve replacement, there can be a patient-prosthesis mismatch when the implanted valve has a functional area that is insufficient to suit the patient's cardiac needs, leading to left ventricular hypertrophy and further development of arrhythmias and MI, which can increase mortality. Additionally, prosthetic valve thrombosis is another complication, associated more with mechanical valves, because often arises from insufficient anticoagulatory therapy, which is administered as a life-long treatment for those patients. Other challenges include valve dysfunction, heart failure, pericarditis, bleeding and stroke, among others (13).

4. Fast-track in Cardiac Surgery

Fast-track cardiac anaesthesia is defined as a modified anaesthetic technique with the primary goal of early extubation of the patient to reduce the stay in the ICU to less than 24 hours (1,2,17), and consequently, in the hospital. The administration of smaller opioid doses, use of volatile agents and short-acting neuromuscular blockers provides shorter sedation, thereby shortening the extubation time (12), which is performed within 1 to 6 hours (18), even though some studies also consider extubations done up to 8 to 10 hours (2,19). This protocol, compared to the conventional approach that entails longer sedation and extubation occurring within 12-22 hours, aims to promote swift recovery while maintaining the efficacy and safety standards inherent in the conventional method (18).

Furthermore, some studies define fast-track as a protocol where patients bypass the ICU and are treated in postanaesthetic care unit (PACU) instead. Successful care is achieved when the patient is discharged without needing ICU admission or readmission to higher dependency areas during their stay (20) aiming to streamline the recovery process.

Although some drugs may be more expensive, early extubation, shorter stays in the ICU and early hospital discharge had positive economic effects, which is one of the reasons why there is a need to find different anaesthetic techniques (1).

Interventions can be done by administering low-dose opioid-based general anaesthesia, using a time-directed extubation protocol or both (2).

4.1. Anaesthetic Protocol

The anaesthetic agents are chosen in order to confer hemodynamic stability, early extubation, myocardial protection, while preserving the four basic mechanisms of anaesthesiology, which are: analgesia, amnesia, muscle paralysis and sedation. Taking that into account, different dosages but same principle is applied. Butterworth et al. state that for induction, 0.5-1.5 mg/kg propofol or 0.1-0.3 mg/kg etomidate is used, sedation follows with 0.05 mg/kg midazolam, and for maintainance, 25-30 μg/kg/min propofol is used or 1.5-2.0 μg/mL via TCI (1). Fentanyl and sufentanil do not exceed 15 and 5 μg/kg, respectively, and are combined with volatile agents to reduce the sympathetic response to stimulation and preserve anaesthesia. Moreover, morphine or hydromorphone may be administered toward the end of cardiopulmonary bypass with smaller doses of fentanyl or sufentanil. Additionally, Wong et al. and Myles state that low-dose opioid technique uses ≤ 20 μg/kg fentanyl or equivalent while conventional is defined by the use of high-dose meaning ≥ 20 μg/kg fentanyl or equivalent (2,17).

The reason behind using low-dose opioid-based anaesthesia is because it has been proven that high doses suppress hormonal and metabolic stress responses to surgery, but may lead to respiratory depression, cumulative effects and longer ventilation times (2). Furthermore, research has demonstrated that opting for opioid-free anaesthesia over opioid-based lowers postoperative opioid consumption and PONV (1). In Table 2, the early extubation dosage guidelines for opioids are shown.

Opioid	Loading Dose (μg/kg)	Maintenance Infusion	Boluses (μg/kg)
Fentanyl	1-5	1-3 μg/kg/h	0.5-1
Sufentanil	0.25-1.25	0.25-0.75 μg/kg/h	0.125-0.25
Remifentanil	0.5-1	0.1-1 μg/kg/min	0.25-1

Table 2: Opioid dosing compatible with early extubation after cardiac surgery. Obtained from Morgan & Mikhail's Clinical Anesthesiology (1).

In the early 1990s, benzodiazepines were added to the treatment because this approach boosts amnesia, reduces the amount of opioids needed, and reduces ICU LOS (21).

Short-acting neuromuscular blocking agents have replaced pancuronium because this enables a quicker ICU discharge and extubation. Additionally, inhalation anaesthetics are routinely used because they protect the myocardium against ischemia. Evidence indicates that this approach elicits a protective cellular response, which explains the shift from using a high-opioid anaesthetic to FT (12).

4.2. Risk Factors

The risk factors for fast-track failure after cardiac surgery can be categorized into those contributing to primary failure and secondary failure. Primary failure, which occurs during the transition from the PACU to the ICU, is influenced by several factors. Patients over the age of 70 are at higher risk, as are female patients. The duration of the surgery and the length of the cross-clamp time are critical procedural factors that can lead to complications. Additionally, a higher EuroSCORE and the presence of diabetes significantly increase the risk of primary failure (20,22).

Secondary failure, which occurs when patients are transferred from the intermediate care unit (IMC) or the ward back to the ICU, is associated with different risk factors. Renal impairment and COPD are major clinical contributors. Peripheral vascular disease and a history of MI also increase the likelihood of secondary failure. Furthermore, the duration of bypass time during surgery is a significant procedural risk factor for this type of failure (20,22).

Moreover, effective pain management is crucial, as inadequate control can impede recovery, increase stress responses, and elevate the risk of complications such as infections or poor wound healing. PONV also has significant challenges, as they can delay recovery by preventing adequate nutrition intake. As well, delayed mobilization can result in life-threatening conditions, such as pulmonary embolism, which will prolong hospitalization and compromise healing and hospital discharge (3).

When considering the broader spectrum of risk factors for fast-track failure, age and gender emerge as common elements influencing both primary and secondary failures. Clinical conditions such as unstable angina, preoperative diuretic use, and the preoperative need for a balloon pump are pertinent to both categories, with excessive bleeding, inotropic use, and atrial arrhythmia further exacerbating the risk of complications. This comprehensive understanding highlights the multifaceted nature of fast-track failure risk factors, encompassing patient demographics, clinical history, and procedural details (20,22).

4.3. Eligibility of the Patient

The eligibility criteria for FTCA has varied before and after 2018 (22). Prior to 2018, the criteria included patients aged between 18 and 80 years old who were schedule for either single-valve surgery or single CABG. Additionally, candidates needed to have a body mass index (BMI) of less than 40kg/m^2, a LVEF greater than 30%, and serum creatinine levels below 2g/dL. From 2018 onwards, the criteria were adjusted to include patients with a EuroSCORE II of less than 3.0%, those aged over 16 years, and maintaining the requirement for a BMI of less than 40kg/m^2.

Patients were excluded if they had specific conditions or severe comorbidities such as arrhythmia, hypertension of 180 mmHg or higher, diabetes mellitus, recent MI or severe respiratory disease (3,23). Patients with history of difficulty airway management or those needing prolonged mechanical ventilation were not eligible (3). Additionally, those who had undergone previous complicated cardiac surgeries or were expected to have significant postoperative complications, as well as patients who required prolonged cardiopulmonary bypass time exceeding 150 minutes were excluded (3,24).

4.4. Perioperative Goals

The perioperative goals are stated in Table 3.

Preoperative education
Same-day admission whenever possible
Anaesthetic technique tailored to early extubation
Effective postoperative analgesia
Flexibility in the use of recovery areas
Protocol-driven care
Early mobilization
Early ICU and hospital discharge
Follow-up after hospital discharge
Interdisciplinary continuous quality improvement strategies

Table 3: Perioperative Goals of FT Management. Obtained from Kaplan's Essentials of Cardiac Anesthesia for Cardiac Surgery (12).

4.5. Criteria for Extubation

The criteria for extubation are shown in Table 4.

Full consciousness with no neurologic deficit
Adequate reversal of neuromuscular blockade w/ completely recovered motor function

Hemodynamically stable on minimal inotropic support
Bleeding <100 mL/h
Core temperature > 36 ºC
Arterial blood gas: $PO_2 \geq 100$ mmHg, $PCO_2 \leq 40$ mmHg on $F_IO_2 < 0.5$
Spontaneous respiratory rate 10-16 breaths/min
Sufficient TV on ventilator support (P.S. 8 cmH_2O and PEEP 5 cmH_2O)
Normal serum lactate (0.5-1.0 mmol/L)
pH between 7.34-7.45
Normal urine output (0.5-1.3 ml/kg/h)
Normal SvO_2 (60-80%)
No new ECG and CXR changes

Table 4: Criteria used for early extubation in patients who underwent fast-track anaesthesia protocol. TV: Tidal Volume. PEEP: Positive End-Expiratory Pressure. SvO_2: Central Venous Oxygen Saturation. ECG: Electrocardiogram. CXR: Chest X-ray. (12,20,23)

4.6. Advantages

According to Wong et al., the implementation of FT protocols offers several significant benefits (2). Firstly, there is a reduction in the LOS in both ICU and hospital altogether. The goal of FTCA is to shorten patients' hospital stays by accelerating their recovery. Secondly, these protocols are cost-effective. FTCA are a financially viable method of providing cardiac surgery care since they shorten hospital stays and the related medical expenses.

Further advantages are highlighted by Waseem et al., which notes that FTCA is associated with no mortality and no morbidity (20). This indicates that patients undergoing FTCA experience no increase in death rates or complications. Additionally, the reduced cost to healthcare associated with FT protocols underscores their economic benefits, further supporting their cost-effectiveness in cardiac surgical care (21).

In correlation with previous findings, Salhiyyah et al. underscores the positive impact of fast-track protocols on patient outcomes and the economic aspect of cardiac surgery (25). While it may not directly reduce hospital stay, it effectively reduces ICU stay, thereby contributing to cost-effectiveness. This observation suggests that FT protocols optimize patient recovery without compromising on the quality of care, ensuring that the resources invested in cardiac surgery yield favourable outcomes while minimizing financial burden on healthcare systems.

The benefits of implementing FTCA extend beyond the realms of reduced hospital stay and cost-effectiveness, as supported by research findings. In alignment with previous discussions, Haanschoten et al. highlights additional advantages associated with FTCA (24).

According to this source, FTCA contributes to improved cardiac function among patients undergoing cardiac surgery. This enhancement in cardiac function signifies the effectiveness in promoting better cardiovascular health outcomes. Furthermore, FTCA is shown to enhance patient comfort, emphasizing the importance of patient-centered care in the surgical setting.

Moreover, the cited research underscores a reduction in respiratory complications associated. This reduction not only signifies improved postoperative respiratory function but also reflects a decrease in potential complications, such as respiratory depression that is related to high-dose opioid anaesthetic therapy (3), thereby enhancing patient safety and overall surgical outcomes.

Better patient comfort and early mobilization are achieved by effective pain management, both of which have a positive impact on the healing process. This improved pain treatment also leads to enhanced patient satisfaction. Patients experience shorter hospital stays, faster recoveries and reduced discomfort, all of which contribute to higher levels of well-being (26).

FTCA also promotes the efficient use of medical resources. Faster patient turnover in high-dependency units facilitates better resource allocation for healthcare and enhances patient flow through the hospital. This optimization is crucial in maintaining a smooth and effective healthcare system (24).

Furthermore, a high success rate has been shown by PACU protocol in relation to FTCA. This procedure benefits an extensive number of patients without requiring additional ICU stay, with an efficiency and safety success rate of 84%. The excellent success rate in cardiac anaesthesia demonstrates the dependability and efficiency of FTCA (24).

4.7. Complications

Hendrikx et al. explores various complications that arise when fast-track care fails, which can have significant implications for patient outcomes (22). Pneumonia, a common complication, is an infection of the lungs that can severely impact breathing and overall recovery. Atrial fibrillation, another frequent issue, involves an irregular and often rapid heart rate that can lead to poor blood flow and increased risk of stroke. Delirium, characterized by acute confusion and disorientation, can occur due to the stress of surgery and prolonged hospital stays, negatively affecting cognitive recovery.

Long-term mortality is a serious concern, as failure of fast-track care can contribute to increased death rates over time due to various complications and weakened health. There is also a higher incidence of coronary revascularization, which means patients may need additional procedures to restore blood flow to the heart, indicating ongoing or recurrent issues with heart function. Cardiac tamponade, a critical condition where fluid accumulates around the heart, compressing it and impairing its ability to pump blood effectively, can arise and require immediate intervention (22).

Despite preventive measures, some patients may still experience PONV (3). Hijazi states that the risk factors for occurrence are linked to young age, females, nonsmokers, with previous history of motion sickness or PONV, and with the use of certain anaesthetics applied. As postoperative care, metoclopramide 10 mg IV is administered as first line antiemetic, and if it were ineffective, ondansetron 4 mg IV is used as second line antiemetic (26).

Bleeding, which may lead to the need for surgical reintervention is another severe complication, indicating that initial surgical procedures may not have successfully controlled the bleeding, leading to further surgery to manage the issue. Sepsis, a life-threatening response to infection, can develop when infections like pneumonia or surgical site infections spread, causing systemic inflammation and organ failure (22).

Moreover, patients who are extubated in the OR may experience an increased occurrence of reintubation and postoperative complications, such as respiratory depression caused by residual narcosis (27). These complications highlight the importance of effective fast-track care and the need for careful monitoring and management of patients who do not follow the expected recovery path (22,27). Wong et al. state that complications were not different between FTCA and conventional care groups, which further contribute to the implementation of this new anaesthetic technique (2).

4.8. Failure

Unforeseen transfers of the selected fast-track patient to the ICU were referred as fast-track failure (FTF) and are shown in Figure 3. Primary FTF patients were those who were moved straight from the PACU to the ICU; secondary FTF patients were those who were relocated from the ward or IMC to the ICU (20). On the contrary, fast-track is successful when the patient follows the green line illustrated in Figure 3, which means that from the OR is moved to the PACU, then IMC and finally to the ward.

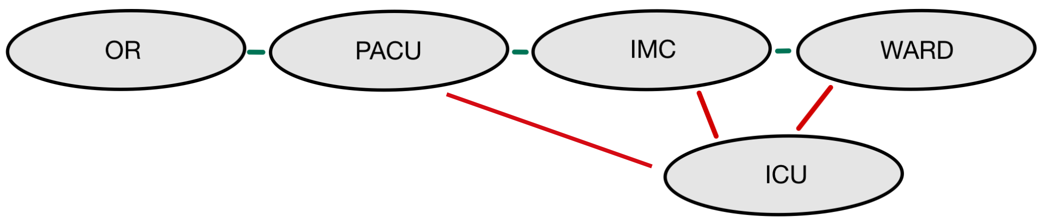

Figure 3: Flow chart showing fast-track failure. Green line: successful fast-track. Red line: fast-track failure. OR: Operating Room. PACU: Postanaesthetic Care Unit. IMC: Intermediate Care Unit. ICU: Intensive Care Unit. Obtained from Fast-track practice in cardiac surgery: results and predictors of outcome (24).

The indications for transferring the patients from PACU to IMC are shown in Table 5.

Fully awake and alert, with no neurologic deficit
Hemodynamically stable, without inotropic support
Acceptable blood gas analysis (PaO_2 > 90 mmHg and $PaCO_2$ < 46 mmHg, SpO_2 > 96% on O_2 flow 2-6 L/min)
Urinary output > 0.5 mL/kg/h
No significant bleeding (< 50 mL/h)
Normal serum lactate, SvO_2, cardiac enzymes and CXR

Table 5: Criteria for transfer of patients from PACU to IMC. Obtained from Independent Risk Factors for Fast-Track Failure Using a Predefined Fast-Track Protocol in Preselected Cardiac Surgery Patients (20).

Additionally, to be able to be transferred to the ordinary ward, the patient should have a stable rhythm and be able to mobilize independently.

According Hendrikx et al. the following factors contribute to the failure of fast-track protocols: EuroSCORE II or higher, and the transfusion of blood products (22).

EuroSCORE II is a risk model used to predict the likelihood of mortality in patients undergoing cardiac surgery (28). An overall risk assessment is provided by the updated version of the original EuroSCORE, which takes into account several patient-specific variables such age, medical history, and type of heart surgery. Higher EuroSCORE II values are associated with increased risk of complications and mortality, which may have a negative impact on the efficacy of fast-track recovery strategies.

The transfusion of blood products refers to the administration of blood components, such as red blood cells (RBC), platelets, or plasma, to patients during or after surgery. In order to control blood loss or address deficits in blood components, this procedure is frequently required. Transfusions may, however, be linked to side effects, including infections, immunological responses, and increased inflammation, all of which can impede healing and make fast-track procedures that aim to accelerate postoperative recovery ineffective.

4.9. Predictors of Failure

Predictors of failure in FTCA, as outlined by Haanschoten et al., include several key patient characteristics (24). Older age is a prominent predictor, with increased age correlating with a higher likelihood of failure. Hypertension is another significant predictor, as patients with high blood pressure face greater risks during the postoperative period. Renal dysfunction also plays a crucial role, with impaired kidney function contributing to adverse outcomes. Additionally, a LVEF of <35% is a strong predictor of failure indicating that patients with reduced heart function are prone to complications and unsuccessful FT recovery.

Supporting these findings, Youssefi et al. list predictors of failure as reduced renal function, hypertension, age, EuroSCORE, cardiopulmonary bypass time, first lactate or base deficit after surgery and cross-clamp time (29). A multivariate analysis showed that the strongest predictor of failure was glomerular filtration rate <65 mL/min/BSA. And the median length of hospital stay was longer for the failed group, emphasizing the significance of these predictors in influencing patient outcomes.

5. Conclusion

Significant advantages of FTCA in cardiac surgery include shorter LOS in hospitals and ICUs, increased cost-effectiveness, and better patient outcomes.

Shorter ICU and hospital stay result in lower medical costs, which is one way that FTCA's economic benefits are demonstrated (2,25). Numerous studies have shown that patients undergoing FTCA do not have higher rates of mortality nor morbidity (20), which further supports the cost-effective of this procedure. Patients spend less time in high-dependency units, which makes it possible to allocate medical resources more efficiently, thereby enhancing patient flow and optimizing the overall healthcare system.

In terms of clinical outcomes, FTCA improves postoperative respiratory and cardiac function and lowers problems like respiratory depression that are frequently associated with high-dose opioid anaesthetic medication (3). These improvements not only enhance patient safety but also promote quicker recoveries and higher levels of patient satisfaction. FTCA procedures that successfully manage pain result in early mobilization and decreased discomfort, which promote a more pleasant and rapid healing process.

However, we also need to acknowledge the challenges and complications associated with FTCA. FTF can occur due to factors such as advanced age, hypertension, renal dysfunction, and higher EuroSCORE II values (20). The need for blood product transfusions during or after surgery, which can lead to infections and increased inflammation, also has significant risks (22). The identification of these predictors and complications highlights the importance of careful patient selection and strict perioperative management to ensure the success of FTCA protocols.

The criteria for patient eligibility and perioperative goals outlined in this thesis provide a comprehensive foundation for implementing FTCA. These criteria make sure that only suitable candidates are selected, thereby increasing the possibility of successful results.

In conclusion, the use of FTCA protocols offers an opportunity for progress in the treatment of cardiac surgical patients. Although there are challenges and risks, the overall benefit associated with FTCA make it a useful strategy in contemporary cardiac anaesthesia. Further investigation and ongoing improvements will increase its effectiveness, leading to better healthcare delivery and patient experiences in cardiac surgery.

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8. Appendices

Appendix 1. Search strategy for CENTRAL, *The Cochrane Library*.

#1 MeSH descriptor: [Cardiac Surgical Procedures] explode all trees

#2 MeSH descriptor: [Adult] explode all trees

#3 MeSH descriptor: [Airway Extubation] explode all trees

#4 fast near track

#5 (#3 OR #4)

#6 (#1 AND #2 AND #5)

9. Biography

María José Riera Manzano is currently a medical student at the University of Zagreb, Croatia. She completed her primary and secondary education in Barcelona, Spain, where she also undertook the International Baccalaureate (IB) program. María José is fluent in Catalan, Spanish, English, and German.

María José's primary research interests lie in cardiac surgery, with a focus on improving patient care and satisfaction. Her dedication to this field is evident through her extensive clinical experience, including rotations in various medical departments across Croatia and Catalonia. She has actively participated in several surgeries as a third surgeon, gaining hands-on experience in procedures such as valve replacement surgery, lung transplant, CABG, sternotomy and suturing.

In addition to her academic and clinical pursuits, María José has been a committed volunteer with organizations like the Red Cross. Her involvement in various medical-related activities and initiatives aimed at helping minorities reflects her passion for community service and healthcare.

Looking ahead, María José aims to specialize in cardiac surgery in Germany. She aspires to become an empathetic, knowledgeable, and independent doctor, dedicated to advancing the field of cardiac surgery and enhancing patient outcomes.