Principles of cardiac anaesthesia

David Alexander

Abstract

Cardiac surgical outcomes in the UK have consistently improved despite increasing procedure complexity and 'sicker' patients. Numerous anaesthetic techniques are employed with no definitive evidence clearly demonstrating superiority of one particular technique. Patient safety is paramount and various monitoring techniques used to enhance safety and ensure effective anaesthesia are outlined. Management of bleeding, particularly in complex cases, is a major component of cardiac anaesthesia and recent developments in this area are briefly described.

Keywords Anti-fibrinolytics; bleeding and haemostasis; cardiac anaesthesia; cardiac surgery; cerebral oximetry; monitoring

Royal College of Anaesthetists CPD Matrix: 3G00

Learning objectives

After reading this article, you should be able to:

- recognize cardiac surgical outcome improvements in an increasingly complex patient cohort
- understand broad principles of delivery of cardiac anaesthesia
- be aware of monitoring modalities commonly applied to cardiac surgical patients
- understand approaches to managing bleeding and deranged haemostasis associated with cardiac surgery

Cardiac surgery in the UK

More than 30,000 cardiac surgical operations are performed each year in the UK. The Society for Cardiothoracic Surgery in Great Britain & Ireland has led the surgical specialities in audit of clinical outcomes for several decades. Annual outcome data for named individual surgeons and institutions are readily available via the Society of Cardiothoracic Surgery in Great Britain and Ireland (SCTS).[1]

The National Adult Cardiac Surgery Audit (NACSA) collects data regarding all major cardiac surgery in the UK and publishes an annual report (last published 2014).[2] It is managed by the National Institute for Cardiovascular Outcomes Research (NICOR) with clinical direction from the SCTS. The latest report shows that in-hospital mortality has fallen by 20% in the last 10 years, with overall mortality under 3% despite increasing case complexity. A further valuable resource is the Blue Book (www.bluebooks.scts.org) which is an up-to-date account of cardiac surgery, including national trends for mortality and operative risk.

Data available concerning cardiac anaesthesia or anaesthetists are limited. The value of effective teamwork is widely recognized as key to the safe delivery of specialized, invasive and highly technical healthcare procedures. As part of the cardiac surgical team, many cardiac anaesthetists encounter an ever more complex case-mix with patients identified to be at increasingly high risk.

In 2008, the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) published its report on 'Death following a first time, isolated coronary artery bypass graft'.[3] This analysis of 1045 deaths following first-time CABG aimed to investigate organizational factors impacting on surgical mortality rates. The specific 'anaesthetic question' addressed, ranked 6/13 in importance, was '*To what extent does variation in the anaesthetic process affect outcome?*' Anaesthetic questionnaires/records were available to anaesthetic assessors in 88% of cases.

This report also highlighted the importance of effective teamwork and communication amongst team members and the need for senior clinicians to be readily available throughout the perioperative period 'to ensure that complications (which occur commonly) are recognised without delay and managed appropriately'.[3] The report recognized anaesthesia induction as a critical time and reported that 'in 97% of cases a consultant was the most senior anaesthetist at induction',[3] reflecting a consultant-delivered cardiac anaesthesia service in the UK. Although elements of individual cases were examined, no comments or recommendations were made concerning the actual techniques used for cardiac anaesthesia.

Cardiac anaesthesia

Numerous cardiac anaesthetic techniques have been reported in the literature, often with institutional or favoured personal variations. As far as the author is aware, there is still no definitive evidence confirming clear superiority of a particular technique and it remains, as has been suggested in previous articles, that the choice of anaesthetic technique appears less important than the manner in which it is applied.

Induction of anaesthesia

The NCEPOD report highlighted induction as one of the most critical times during the cardiac anaesthetic process. Wide fluctuations in arterial blood pressure and heart rate may result in reduced cardiac output and impaired coronary perfusion, resulting in myocardial ischaemia and further deterioration in cardiovascular haemodynamics. Induction should be performed in a gradual and careful fashion, with knowledge of the likely adverse effects of agents used and with a view to mitigating these adverse effects in the patient's particular haemodynamic profile. Small doses of short acting vasoconstrictors (metaraminol 25–100 μg, phenylephrine 10–50 μg) are frequently administered at or soon after induction to counteract systemic vasodilatation if coronary perfusion is at risk, particularly in coronary artery disease with critical lesions (e.g. high-grade left coronary main stem) or severe aortic stenosis (with or without coronary disease).

David Alexander *FRCA is Consultant in Cardiothoracic Anaesthesia at The Royal Brompton and Harefield NHS Foundation Trust, UK.* *Conflicts of interest: none declared.*

The choice of induction agent appears to be less important than the speed of injection and overall dose, with the possible exception of ketamine, which is not routinely used for cardiac anaesthesia. Some practitioners advocate a moderate dose of opioid (fentanyl 2.5–5 μg/kg, alfentanil 50–100 μg/kg or remifentanil 1 μg/kg) followed by an induction dose of induction agent given slowly via large bore peripheral IV access. Others prefer a higher dose opioid (e.g. fentanyl 20–40 μg/kg) supplemented with a modest dose of induction agent, titrated to loss of the lash reflex. Both approaches are appropriate and confer cardiac stability with a smooth induction. Very high-dose opioid techniques (e.g. fentanyl 50–100 μg/kg or similar) following pre-treatment with a benzodiazepine are popular in North America and are occasionally employed in the UK.

The main induction agents used are propofol, etomidate and thiopentone. Pre-treatment with an opioid and/or benzodiazepine should allow reduction of the overall induction dose. The most important effects of each of the drugs are detailed in Table 1.

Muscle relaxant and intubation

Most non-depolarizing muscle relaxants have been used safely and effectively in cardiac surgery. Atracurium is less favoured due to its short duration of action and hypotension that may result from histamine release. Pancuronium is widely used due to long duration of action, and confers some advantage through its sympathomimetic and vagolytic actions. The resultant tachycardia may be undesirable in a patient with aortic stenosis or with coronary artery disease who is intolerant of β-blockers. Patients established on β-blockade rarely develop troublesome tachycardia following pancuronium. Vecuronium and rocuronium are equally effective and do not cause tachycardia but may require repeated dosing, especially after separation from cardiopulmonary bypass. They may result in bradycardia, especially when given shortly after fentanyl or remifentanil. Common agents used for muscle relaxation are detailed in Table 2.

Intubation with an oral, cuffed endotracheal tube is the usual method of securing the airway. Lung isolation may be required for some cases where thoracoscopic surgery is employed — usually minimally invasive techniques which may proceed to cardiopulmonary bypass if required. This can be achieved with a left-sided double-lumen endo-bronchial tube, although this usually necessitates a tube change on completion of the case to facilitate postoperative ventilation. Bronchial blockers may also be used, ensuring only one endotracheal intubation is required.

Antibiotic prophylaxis

Antibiotic prophylaxis is recommended for cardiac surgery and the responsibility for administration usually lies with the anaesthetist. The Scottish Intercollegiate Guidelines Network 2008 guidelines are informative, widely used and based on best available evidence at the time, plus recommended best practice based on the clinical experience of the guideline development group.[4] These recommend that for cardiac surgery intravenous prophylactic antibiotics should be given 30 minutes or earlier before the skin is incised and duration should not be more than 48 hours. The choice of antibiotic should take into account local resistance patterns and if β-lactam antibiotics are first-line agents, an alternative should be recommended for patients with allergy to penicillins or cephalosporins. Current recommendations at the authors' institution are for CABG IV cefuroxime 1.5 g at induction, 750 mg at sternal closure and 8-hourly for a total of four doses. In addition, for valve surgery, teicoplanin 400 mg IV is added 12-hourly for three doses then daily until major indwelling catheters are removed. Penicillin/cephalosporin-allergic patients receive teicoplanin plus gentamicin 2 mg/kg ideal body weight as single induction dose (continued for valves as per aminoglycoside protocol).

Maintenance

There are three phases in the maintenance of cardiac anaesthesia which can each be managed with a single or multiple methods. These are the pre-bypass, bypass and post-bypass phases of the case. Anaesthesia for cardiac surgery without cardiopulmonary bypass is considered in another article in this issue. The aim throughout is to maintain anaesthesia whilst balancing myocardial oxygen delivery and demand and minimizing ischaemic risk. Volatile agents and intravenous agents have both been used effectively to maintain anaesthesia throughout the phases. Total intravenous anaesthesia affords cardiovascular stability and reduces the risk of awareness by maintaining reasonably constant

Induction agents in cardiac anaesthesia

Drug	Cardiovascular effects	Pharmacokinetics special considerations
Thiopentone	Cardiac depression → reduced cardiac output preserved or increased SVR and HR	Slow hepatic metabolism
Propofol	Reduced cardiac output as MAP reduced from significant fall in SVR	Rapid metabolism through redistribution. Suitable for infusion
Etomidate	Minimal cardiac output change with minor changes to HR (increase) and SVR (decrease)	Rapid metabolism via esterases. Adrenal suppression even after single dose. Pain on injection
Ketamine	Increase in cardiac output with increased HR and SVR	Not suitable in ischaemic heart disease but may maintain cardiac stability in tamponade/pericardial restrictive disease

HR, heart rate; MAP, mean arterial pressure; SVR, systemic vascular resistance.

Table 1