

Anaesthesia for off-pump coronary artery bypass grafting surgery

R Peter Alston

Abstract

Coronary artery bypass grafting (CABG) surgery may be undertaken with or without cardiopulmonary bypass (CPB) that is on- or off-pump. Although off-pump has a slightly higher mortality, it is associated with a lower incidence of short-term complications, compared with on-pump CABG surgery favouring enhanced recovery. High-dose opioid techniques of general anaesthesia should be avoided and either inhalation or total intravenous (IV) anaesthesia may be used. Monitoring should include a five-lead electrocardiograph and invasive systemic arterial pressure measurement. Effective communication between anaesthetist and surgeon is essential. Maintenance of diastolic arterial pressure (DAP) underpins prevention of myocardial ischaemia and cardiovascular collapse. Surgical positioning of the heart so as to minimize hypotension is paramount and IV fluid loading or vasoconstrictors and positive inotropes are effective. Correction of bradycardia with atropine 0.3 mg IV or epicardial pacing also helps to maintain DAP. Persisting hypotension requires intra-aortic balloon pumping or conversion to on-pump CABG surgery. As there is less blood loss, minimal requirement for cardiovascular support and earlier recovery of consciousness associated with off- compared with on-pump CABG surgery, patients may be managed in a recovery room then transferred to a high-dependency unit, thus bypassing ICU.

Keywords Cardiopulmonary bypass; coronary artery bypass grafting; coronary artery disease; epidural analgesia; general anaesthesia; hypotension; intra-operative monitoring; vasoconstrictor agents

Royal College of Anaesthetists CPD Matrix: 1I03, 2A01, 2A04, 2A05, 2E01, 2G02, 3G00

Introduction

Percutaneous coronary intervention (PCI) has become widely used to treat coronary artery disease (CAD). Notwithstanding the popularity of PCI, coronary artery bypass grafting (CABG) surgery has prognostic benefits in certain patterns of CAD and patient groups including left main and triple vessel disease especially in patients with left ventricular systolic dysfunction and diabetes mellitus. CPB was the keystone to undertaking CABG surgery. However, adverse outcomes associated with CABG surgery were long ascribed to CPB. For this reason, off-pump CABG surgery that is undertaken without CPB, regained popularity in the 1990s.

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Learning objectives

After reading this article, you should be able to:

- identify the differences in outcomes between on- and off-pump coronary artery bypass grafting (CABG) surgery
- appreciate the causes of hypotension during off-pump CABG surgery
- understand why and how to maintain diastolic arterial pressure during grafting
- compare the different anaesthetic techniques required for off-pump CABG surgery through a sternotomy and a minimally invasive direct coronary artery bypass

Possibly, this popularity may have been inappropriate as the most recent Cochrane systematic review found that off-pump has a higher mortality than on-pump CABG surgery. In addition and with the exception of atrial fibrillation, both approaches had similar incidences of serious adverse events (Table 1).¹ However, the review has important limitations that prevent its generalisation to all patients presently undergoing CABG surgery. For example in the author's unit, higher risk patients undergo off- than on-pump CABG surgery yet they have a lower mortality. Moreover, off-pump has a number of short-term advantages over on-pump CABG surgery including shorter durations of tracheal intubation, intermittent positive pressure ventilation and stay in an intensive care unit (ICU) that favour enhanced recovery. So whilst its popularity has waned, surgeons skilled in the technique will continue to use the technique. Therefore, an understanding of how to undertake anaesthesia for off-pump CABG is valuable as it poses a number of unique challenges to the anaesthetist.

Surgery

Standard technique

Like on-pump, most off-pump CABG surgery is performed through a sternotomy, but unlike on-pump, off-pump does not require cannulation of the aorta or right atrium and during CABG, systemic oxygen delivery remains dependent on the adequate functioning of the heart and lungs. Off-pump, the activated clotting time is maintained at more than 300 seconds only until completion of grafting, compared with the on-pump minimum of 450 seconds until the patient is successfully weaned from CPB. As a result, the dose of heparin for off-pump (100–150 IU/kg) is one-third to one-half of that required for on-pump CABG surgery. However, despite the risk of conversion to on-pump surgery being very low, some centres still routinely use full heparinization to allow CPB (300 IU/kg) in such an emergency.

Requiring minimal displacement of the heart, the left internal mammary artery (LIMA) can be anastomosed to the left anterior descending (LAD) coronary artery with minimal haemodynamic disturbance. For this reason and because the LAD supplies a large myocardial territory, this anastomosis is usually undertaken first. By contrast, access to the coronary arteries on the posterior and inferior surfaces requires the heart to be elevated by retracting the pericardium and using a sling or a suction device such as a Starfish Heart Positioner™ (Medtronic, Minneapolis, MN, USA) to suspend the heart (Figure 1b). Surgical access

Adverse events from off- and on-pump coronary artery bypass grafting surgery

Serious adverse event	n	Risk ratio	95% Confidence intervals	I ²
Mortality	10,324	1.24	1.01, 1.53	0%
Mortality (low risk of bias)	4950	1.35	1.07, 1.70	0%
Myocardial infarction	8547	1.00	0.79, 1.26	0%
Stroke	9044	0.76	0.54, 1.06	0%
Atrial fibrillation	3392	0.78	0.63, 0.96	67%
Renal insufficiency	4806	0.86	0.62, 1.20	0%
Coronary re-intervention	5214	1.25	0.94, 1.65	0%

Based on the Cochrane systematic review and meta-analyses.¹ Compared to off-, on-pump coronary artery bypass grafting (CABG) surgery has as lower mortality. The incidence of atrial fibrillation is significantly lower in off-than on-pump CABG surgery but the heterogeneity is high so limiting interpretation of the finding. All other important adverse outcomes from CABG surgery are not significantly different if undertaken on- or off-pump. Where coronary re-intervention is percutaneous coronary intervention or CABG surgery, I² is the percentage of total variance across trials, that is due to heterogeneity rather than chance.

Table 1

to these coronary arteries is facilitated by steep Trendelenberg positioning that may beneficially maintain systemic venous return but disguise hypovolaemia.

The Octopus 3 Tissue Stabilizer™ (Medtronic) can be used to fix the target coronary artery, stabilizing the anastomotic site so as to facilitate grafting (Figure 1a). Blood flow can then be controlled using a suture applied around the coronary artery proximal to the anastomosis site. Once opened, a shunt with an outside diameter of 1–2 mm is inserted into the coronary artery so reducing bleeding into the surgical field, and allowing some blood flow to the myocardium distal to the grafting site. The shunt is removed just prior to completion of the anastomosis. During anastomosis, blood is cleared from the surgical field by using a jet of carbon dioxide gas directed through an intravenous (IV) cannula or by a commercial device that sprays a fine mist of salinated carbon dioxide gas.

When radial artery or venous grafts are used, the proximal ends are usually anastomosed to the ascending aorta after application of a side-clamp to the ascending aorta. However, if

the ascending aorta is heavily atherosclerotic (porcelain aorta), they can be anastomosed to the LIMA so avoiding side-clamping and reducing the risk of aortic disruption or systemic embolization of atheromatous plaques.

Minimally invasive direct coronary artery bypass (MIDCAB)

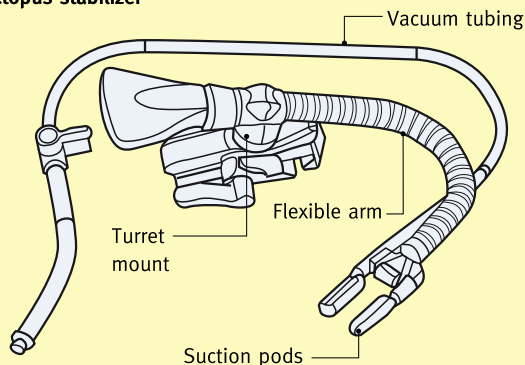
Although the majority of off-pump CABG surgery is performed through a sternotomy, isolated disease of the LAD coronary artery can be surgically undertaken through a small left thoracotomy by anastomosing the LIMA to the LAD coronary artery.

Contraindications to off-pump CABG surgery

Small-diameter, extensively calcified or intra-myocardial vessels and diffuse patterns of coronary artery disease (CAD) are all relative contraindications to undertaking CABG surgery off-pump. However, unstable angina, left main CAD and/or severe left ventricular dysfunction can usually be managed by preoperative insertion of an intra-aortic balloon pump (IABP).

Mechanical anastomotic stabilizer

a Octopus stabilizer



b Star-Fish

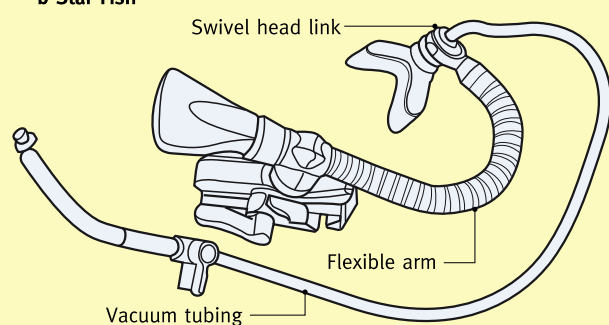


Figure 1 (a) The Octopus® Tissue Stabilizer is placed on the myocardium to stabilize the coronary artery by a combination of suction and pressure, and so facilitating surgical anastomosis. (b) The Starfish Heart Positioner™ is attached to the apex of the heart to suspend the heart enabling surgical access to the coronary arteries on the inferior and posterior surfaces of the heart. Both devices are mounted on the sternal retractor.

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