International Journal of Cardiology 223 (2016) 201–211

Contents lists available at ScienceDirect

International Journal of Cardiology

journal homepage: www.elsevier.com/locate/ijcard

On- vs. off-pump coronary artery bypass grafting: A systematic review and meta-analysis

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ARTICLE INFO

Article history:
Received 14 April 2016
Received in revised form 11 August 2016
Accepted 12 August 2016
Available online 14 August 2016

Keywords:
Coronary artery bypass graft
Stroke
Off-pump
On-pump
Hospital costs

ABSTRACT

Background: To reduce complications during coronary artery bypass grafting (CABG) off-pump CABG was introduced; however, results have been mixed. The aim of this work was to conduct a systematic review and meta-analysis of off-pump vs. on-pump CABG.
Methods: To identify potential studies systematic searches were carried out using various databases. The search strategy included the key concepts of "cardiopulmonary bypass" AND "coronary artery bypass grafting" AND "off pump". This was followed by a meta-analysis investigating post-operative atrial fibrillation, myocardial infarction, ≤30 day mortality, stroke, ventilation time, intensive care unit (ICU) stay and hospital stay.
Results: Fifty four studies (59 intervention groups), totalling 16,261 participants were analysed. Off pump CABG led to a significantly lower incidence of post-operative atrial fibrillation odds ratio (OR) 0.87 (95% confidence interval [CI] 0.78 to 0.97, $p = 0.01$), but no differences in either myocardial infarction OR 0.98 (95% CI 0.82 to 1.15, $p = 0.77$) or ≤30 day mortality OR 0.85 (95% CI 0.68 to 1.06, $p = 0.16$). There was a strong trend towards a reduced incidence of stroke OR 0.77 (95% CI 0.59 to 1.00, $p = 0.05$); however this did not quite reach significance. Ventilation time mean difference (MD) −3.78 h (95% CI −4.75 to −2.82, $p < 0.00001$); ICU stay MD −0.34 days (95% CI −0.50 to −0.17, $p < 0.0001$); and hospital stay MD −0.9 days (95% CI −1.25 to −0.56, $p < 0.00001$) were all significantly shorter in the off-pump group.
Conclusions: Off-pump CABG has some benefits over on-pump CABG, particularly in relation to post-operative atrial fibrillation.

1. Introduction

The usual approach to surgical revascularisation is coronary artery bypass grafting (CABG) involving cardiopulmonary bypass (CPB). This procedure is not without risk as aortic manipulation and CPB increase the possibility of aortic damage, adverse neurologic events such as stroke, and renal damage [1]. At the micro level CPB is associated with pro-inflammatory responses such as the release of cytokines, increased production of reactive oxygen species and stimulation of the release of stress hormones [2]. Bleeding problems can lead to anaemia which is associated with acute myocardial infarction (MI) and higher 30-day mortality [2].

To reduce these complications off-pump CABG was introduced [1]. Originally developed in the 1960s, off-pump CABG became increasingly popular as tools were developed for immobilizing the myocardium (for examples see Fig. 1 in [1]). However, enthusiasm over this approach has been tempered by difficulties in accessing lateral or posterior wall vessels [1] and the surgeon's expertise and experience. In a large multi-centre study (CORONARY) off-pump CABG was associated with lower rates of postoperative blood transfusion and reoperation for bleeding but no differences in MI, stroke and new-onset renal failure at either 30 days or 1-year [3–4]. This pattern of reduced bleeding complications and new onset atrial fibrillation but no effect on MI and stroke has been repeated in other trials [5]. Because of its failure to reduce the incidence of stroke and the possible need for repeat revascularisation, off-pump CABG is not without its detractors (for example [6]).

There has been a number of meta-analyses comparing on-pump vs. off-pump, such as those by Afilalo et al. [5] and Kuss et al. [7] and the 2012 Cochrane review [8]. New studies are emerging all the time and these meta-analyses have been superseded by more recent studies [9,10]. The current meta-analysis includes more studies (and intervention groups) than that by Deppe et al. [9] and also considers resource allocation (ventilation time, ICU stay, hospital stay) which was not analysed by Kowalewski et al. [10]. In total our

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http://dx.doi.org/10.1016/j.ijcard.2016.08.250
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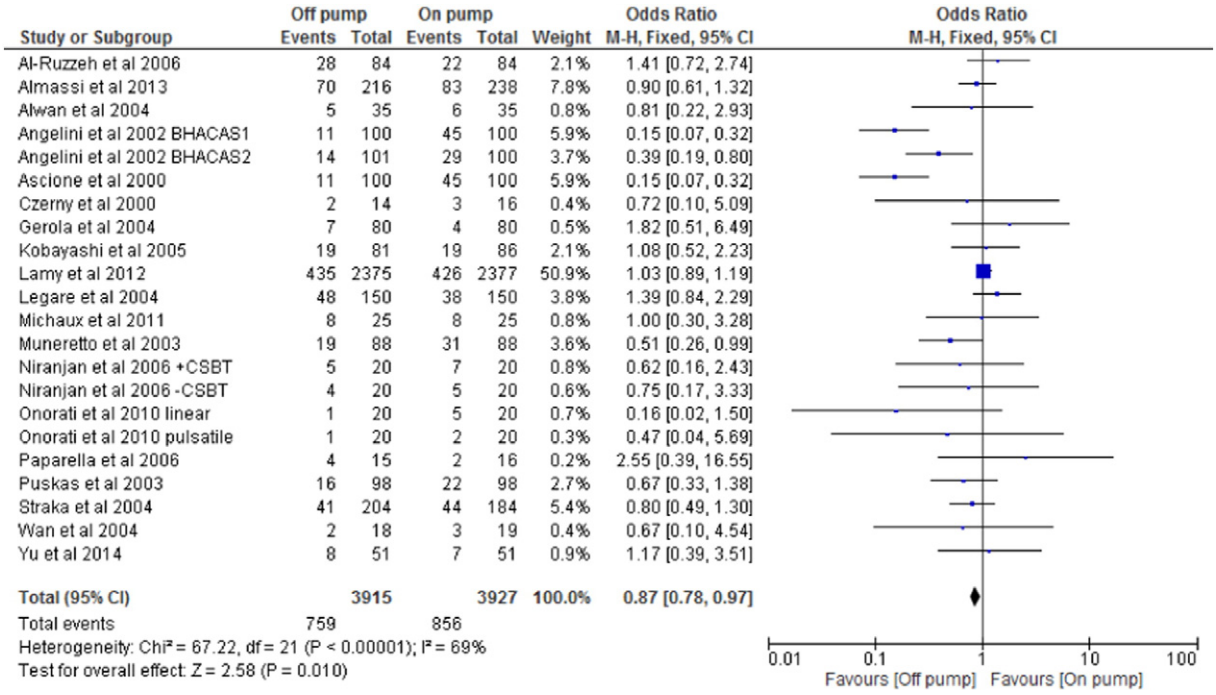

Fig. 1. Post-operative atrial fibrillation.

analyses included incidence of post-operative atrial fibrillation, incidence of myocardial infarction, mortality, incidence of stroke, ventilation time, ICU stay and hospital stay.

2. Methods

2.1. Search strategy

To identify potential studies systematic searches were carried out using the following databases: EMBASE, PubMed, Web of Science and the Cochrane Central Registry of Controlled Trials (CENTRAL). The search was supplemented by scanning the reference lists of eligible studies. The search strategy included the key concepts of "cardiopulmonary bypass" AND "coronary artery bypass grafting" AND "off pump". All identified papers were assessed independently by two reviewers. A third reviewer was consulted to resolve disputes. Searches of published papers were conducted up until January 1st, 2016.

2.2. Types of studies to be included

Only randomized controlled trials (RCTs) and their substudies where this did not involve duplication of data of off-pump vs. on-pump in patients undergoing CABG were included. There were no language restrictions. Animal studies, review papers and non-randomized controlled trials were excluded. Studies that did not have any of the desired outcome measures or participants who were treated by other modalities such as percutaneous coronary intervention were excluded. Incomplete data, or data from an already included study, were excluded. Studies that included interventions other than off-pump vs. on-pump CABG were excluded.

2.3. Participants/population

This meta-analysis analysed RCTs and their substudies where this did not involve duplication of data of both male and female adult (≥18 years) patients with coronary artery disease who were undergoing CABG using either off- or on-pump. Other treatment modalities and interventions for coronary artery disease such as percutaneous coronary intervention were excluded.

2.4. Intervention(s), exposure(s)

This meta-analysis considered all RCTs and their substudies where this did not involve duplication of data where patients with stable angina or acute coronary syndrome being treated with CABG were exposed to either on-pump or off-pump. More specifically, all RCTs and their substudies where this did not involve duplication of data where the intervention of carrying out CABG without the use of cardiopulmonary bypass were performed.

2.5. Comparator(s)/control

The studies in this analysis compared off-pump CABG with a usual care control group receiving on-pump CABG.

2.6. Search results

Our initial search found 2161 articles. Of these 2055 studies were excluded on the basis of title and abstract. 36 studies were excluded as they were not RCTs. Of the RCTs we excluded 16 studies, because they had none of the reported measures (see Supplementary Fig. S1). Fifty five studies were included in our analysis [3,11–63].

2.7. Outcome(s)

The primary outcomes analysed were: incidence of post-operative atrial fibrillation, incidence of myocardial infarction, ≤30 day mortality, incidence of stroke, ventilation time, ICU stay and length of hospital stay.

2.8. Risk of bias (quality) assessment

Risk of bias was assessed using a modification of the JADAD scale [64].

2.9. Strategy for data synthesis

Odds ratios were calculated for dichotomous data. An odds ratio (OR) is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. Mean differences were calculated for continuous data. Meta-analyses were completed for continuous data by calculating the mean difference between intervention and control groups from post-intervention data only. It is an accepted practice to only use post-intervention data for meta-analysis, but this method assumes that random allocation of participants always creates intervention groups matched at baseline for age, disease severity. All analyses were conducted using Revman 5.0 (Nordic Cochrane Centre, Denmark). A fixed effects inverse variance model was used unless heterogeneity was >75%, then a random effects model was used. Heterogeneity was quantified using the Cochrane Q test [65]. We used a 5% level of significance and 95% confidence intervals; figures were produced using Revman 5.3.

3. Results

The 54 studies (59 intervention groups) included in the analyses had an aggregate of 16,255 participants, 8156 of which had on-pump CABG and 8099 had off-pump CABG. Table 1 summarizes the characteristics of