Beating heart coronary surgery and the 'foundation stone' evidence

Raimondo Ascione

Gianni D Angelini

COPYRIGHT MEDINEWS (CARDIOLOGY) LIMITED REPRODUCTION PROHIBITED

Over the last decade, technical improvements have made off-pump coronary artery bypass (OPCAB) surgery a routine procedure. Exposure and positioning of the three main coronary targets with minimal haemodynamic deterioration has been achieved with a combination of pericardial retraction sutures, the Trendelenburg manoeuvre, and rotation of the operating table.[1-3] Intracoronary shunts have been introduced to prevent snaring-related injury of the coronary vessels and to allow myocardial perfusion during the construction of the anastomoses.[1,4,5] Finally, excessive motion of the coronary target, a main concern as potential cause of suboptimal anastomoses, has been overcome with the introduction of either pressure or suction retractor-stabilisers.[6,7]

In the absence of recognised guidelines, the initial approach to OPCAB surgery was often left to the surgeon's 'common sense'. With the development of enabling instruments, there has been a progressive widening of OPCAB surgery application. This still varies from 0% to 100%, however, probably as a direct reflection of the phase of the learning curve reached. Nevertheless, some developed countries have shown a surprisingly slow impetus towards OPCAB surgery. Hardly any OPCAB procedures were carried out in the USA before 1995. But, by 1999, more than 11,000 (10%) coronary procedures were performed on the beating heart.[8] It is estimated that this percentage is currently 20%, with expectations that this will rise to 50% by 2005.[9,10] If these numbers are correct, OPCAB would be the most impressive clinical change in the 40-year history of coronary surgery. Furthermore this 'revolution' is taking place in the absence of recognised common guidelines. In this context a comment from a more conservative surgeon, while scanning these numbers, could potentially be: "I hope they are right!"

For almost a decade, OPCAB surgery has been audited against conventional technique by a very large number of observational and case-matched studies. The limitation in study design of the vast majority of them has generated an intellectual war of opinions, rather than facts, in the scientific community. Several prospective randomised studies have now been completed by independent groups worldwide.[7,11-22] It is hoped that the results of these will be a serious 'foundation stone' for the surgical community in the evaluation of the 'supra partes' evidence on OPCAB surgery.

Randomised studies

The largest two randomised studies report primarily on in-hospital and mid-term mortality and morbidity. The Beating Heart Against Cardioplegic Arrest Studies (BHACAS 1 and 2) report on a total population of 401 (200 off-pump) elective patients in a single centre.[7] The number of grafts per patient

(there was no coronary anatomy limitation in BHACAS 2) and in-hospital mortality did not differ between the groups. In-hospital benefit associated with OPCAB surgery included a significant reduction of chest infection, inotropic requirement, incidence of arrhythmias, total chest tube drainage and consequent transfusion requirement, intubation time, intensive care, hospital stay, and costs. A multicentre randomised trial in a cohort of 281 patients (142 off-pump) showed no difference in terms of in-hospital mortality and morbidity, but OPCAB surgery was associated with a shorter ventilation time and hospital stay, and a reduction of 41% release of CK-MB when compared to conventional technique.[11] Other randomised studies have focused on the assessment of subsystem organ function: some of these studies on the inflammatory response have all shown a minimal activation associated with OPCAB surgery as compared to conventional technique.[12-14] One has shown reduced coagulation impairment;[15] one has shown a protective effect of OPCAB surgery on renal function in elective patients,[16] as compared to conventional surgery; others have shown marked reduction of myocardial injury assessed by markers like troponin I,[17] or CK-MB serial release.[11]

Cognitive dysfunction occurs in up to 60% of patients in the first week, and may persist with an incidence of 25–30% at eight weeks post-conventional surgery with only slightly lower levels at one year.[18] Three independent prospective randomised studies and a case-matched study have focused on neurological influence of OPCAB surgery,[19-22] although with different methodology. Diegeler[19] investigated the release of serum S100 protein, cognitive dysfunction, and neurological microembolisation, our group[20] focused on S100 release and cognitive dysfunction, while van-Dijk and Taggart[21,22] focused on cognitive dysfunction alone. The results of these studies all agree in regard to the release of S100, which was markedly reduced during OPCAB surgery.[19,20] This is in keeping with the marked higher neurological microembolisation observed by Diegeler[19] in the same group. But the results of these studies conflict when we consider early cognitive dysfunction – during OPCAB surgery cognitive dysfunction was either lower[19,21] or similar[20,22] when compared to conventional surgery, although when a beneficial effect was identified, this became negligible at 12 months.[21]

Evidence on early and mid-term efficacy of OPCAB surgery are limited to two trials. The BHACAS 1 and 2 trials (29.3±7.4 and 15.7±5.5 months of follow-up respectively) showed no differences in terms of late mortality, cardiac-related events, and need for further coronary revascularisation procedure between groups.[7] These results are similar to those reported by van-Dijk at one, three, and 12 months of follow-up.[11,21]

One known limitation of prospective randomised studies is the low randomisation rate due to restricted exclusion criteria. Thus, in principle, the results may not be extended to the entire surgical population. This problem was partially addressed in the BHACAS 2 trial with a randomisation rate of 62.8%.[7] Nevertheless, in a more representative surgical population, the occurrence of post-operative complications is likely to be higher, and the postulated benefit of OPCAB surgery could be more visible. Such a hypothesis should be tested in further randomised studies, but this might lead to obvious ethical issues.

OPCAB surgery has evolved rapidly in the last few years and the use of modern exposure and stabilisation techniques have made it a routine and established procedure. Rightly or wrongly thousands of OPCAB procedures are now performed worldwide. The 'supra partes' evidence arising from the foundation stone urges the surgical community to dictate the future of this surgical technique, by agreeing appropriate guidelines on clinical, ethical, training, and economic issues.

COPYRIGHT MEDINEWS (CARDIOLOGY) LIMITED REPRODUCTION PROHIBITED

References

1. Watters MPR, Ascione R, Ryder IG, Ciulli F, Pitsis AA, Angelini GD. Haemodynamic changes during beating heart coronary surgery with the "Bristol technique". *Eur J Cardiothorac Surg* 2001;**19**:34-40.
2. Geskes GG, Dekker AL, Van der Veen FH *et al*. The enabler right ventricular circulatory support system for beating heart coronary artery bypass graft surgery. *Ann Thorac Surg* 1999;**68**:1558-61.
3. Grundeman PF, Borst C, Verlaan CWJ, Meijburg H, Moues CM, Jansen EWL. Exposure of circumflex branches in the tilted, beating porcine heart: echocardiographic evidence of right ventricular deformation and the effect of right or left bypass. *J Thorac Cardiovasc Surg* 1999;**118**: 316-23.
4. Malkowski M, Kramer CM, Parvizi ST *et al*. Transient ischemia does not limit subsequent ischemic regional dysfunction in humans: a transesophageal echocardiographic study during minimally invasive coronary artery bypass surgery. *J Am Coll Cardiol* 1998;**31**:1035-9.
5. Lucchetti, V, Capasso F, Caputo M *et al*. Intracoronary shunt prevents left ventricular function impairment during beating heart coronary revascularization. *Eur J Cardiothorac Surg* 1999;**15**:255-9.
6. Pym J. Off pump arterial grafting:125 cases using the Medtronic-Utrecht Octopus. *Eur J Cardiothorac Surg* 1999;**16**:S88-S94.
7. Angelini GD, Taylor FC, Reeves BC, Ascione R. Early and midterm outcome after off-pump and on-pump surgery in Beating Heart Against Cardioplegic Arrest Studies (BHACAS 1 and 2): a pooled analysis of two randomised controlled trials. *Lancet* 2002;**359**:1194-9.
8. Cleveland JC, Shroyer LW, Chen AY *et al*. Off-pump coronary artery bypass grafting decreases risk-adjusted mortality and morbidity. *Ann Thorac Surg* 2001;**72**:1282-9.
9. Mark DB, Newman NF. Protecting the brain in coronary artery bypass graft surgery. *JAMA* 2002;**287**:1448-50.
10. Shennib HA. A renaissance in cardiovascular surgery: endovascular and device-based revascularisation. *Ann Thorac Surg* 2001;**72**:993-4.
11. van Dijk D, Nierich AP, Jansen WL *et al*. Early outcome after off-pump versus on-pump coronary bypass surgery. Results from a randomised study. *Circulation* 2001;**104**:1761-6.
12. Matata BM, Sosnowski AW, Galinanes M. Off-pump bypass graft operation significantly reduces oxidative stress and inflammation. *Ann Thorac Surg* 2000;**69**:785-91.
13. Diegeler A, Doll N, Rauch T *et al*. Humoral immune response during coronary artery bypass grafting: A comparison of limited approach, "off-pump" technique and conventional cardiopulmonary bypass. *Circulation* 2000;**102**(suppl 3):III95-100.
14. Ascione R, Lloyd CT, Underwood MJ *et al*. Inflammatory response after coronary revascularisation with or without cardiopulmonary bypass. *Ann Thorac Surg* 2000;**69**:1198-204.

15. Ascione R, Williams S, Lloyd CT *et al*. Reduced post-operative blood loss and transfusion requirement after beating-heart coronary operations: a prospective randomised study. *J Thorac Cardiovasc Surg* 2001;**121**:689-96.
16. Ascione R, Lloyd CT, Underwood MJ, Gomes WJ, Angelini GD. On pump versus off pump coronary revascularisation: evaluation of renal function. *Ann Thorac Surg* 1999;**68**:493-8.
17. Ascione R, Lloyd CT, Gomes WJ, Caputo M, Bryan AJ, Angelini GD. Beating versus arrested heart revascularisation: evaluation of myocardial function in a prospective randomised study. *Eur J Cardiothorac Surg* 1999;**15**:685-90.
18. Smith PLC. The cerebral consequences of coronary artery bypass surgery. *J Roy Coll Surg (Engl)* 1988;**70**:212-16.
19. Diegeler A, Hirsch R, Schneider F *et al*. Neuromonitoring and neurocognitive outcome in off-pump versus conventional coronary bypass operation. *Ann Thorac Surg* 2000;**69**:1162-6.
20. Lloyd CT, Ascione R, Underwood MJ *et al*. Serum S-100 protein release and neuropsychologic outcome during coronary revascularisation on the beating heart: a prospective randomised study. *J Thorac Cardiovasc Surg* 2000;**119**:148-54.
21. van-Dijk D, Jansen EW, Hijman R *et al*. Cognitive outcome after off-pump and on-pump coronary artery bypass surgery. A randomised trial. *JAMA* 2002;**287**:1405-12.
22. Taggart DP, Browne SM, Halligan PW, Wade DT. Is CPB still the cause of cognitive dysfunction after cardiac operations? *J Thorac Cardiovasc Surg* 1999;**118**:414-20.

Raimondo Ascione
Consultant Senior Lecturer in Cardiac Surgery
Gianni D Angelini
British Heart Foundation Professor of Cardiac Surgery
Bristol Heart Institute, Bristol Royal Infirmary, Bristol, BS2 8HW.
Correspondence to: Dr R Ascione (email: R.Ascione@bristol.ac.uk)
Br J Cardiol 2003;**10**:87–9

COPYRIGHT MEDINEWS (CARDIOLOGY) LIMITED REPRODUCTION PROHIBITED