Emergency reinstitution of cardiopulmonary bypass following cardiac surgery: outcome justifies the cost

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Abstract

Objective: Crash back on bypass (crash-BOB) is occasionally required in the resuscitation of patients developing life-threatening complications following cardiac surgery. This study aims to determine the incidence, aetiology and cost-effectiveness of such intervention.

Methods: Retrospective review of all crash-BOB patients over 5.5 years at one hospital.

Results: The incidence of crash-BOB was 0.8% and occurred at a mean of 7 h post-operatively (range 1 h–20 days). Pre-operative Parsonnet scores were similar to the overall population of patients undergoing surgery in our institution (mean score 10; range 0–45). The original cardiac operations were coronary revascularization (39), valve surgery (12) and others (4). Indications for crash-BOB were cardiac arrest (23), bleeding (20), hypotension (7), ischaemia (1) and others (4). Of the 55 patients, 20 died on the operating table. Of the remaining 35, a further 12 died in hospital. Overall survival was therefore 42%. Where crash-BOB was for bleeding, 17 of 20 patients (85%) survived to leave theatre, of whom 11 patients (55%) left hospital alive. In the 35 non-bleeders, only 18 (51%) survived crash-BOB and 12 (34%) left hospital alive. Sixteen patients required a second period of aortic cross-clamping of whom 13 (81%) survived to leave theatre, and 11 (69%) left hospital alive. Conversely, of nine patients in whom no specific diagnosis was found during crash-BOB, only two (22%) survived the procedure and none survived to hospital discharge. Multiple logistic regression identified pre-operative Parsonnet score (P = 0.045) and the need for aortic cross-clamping to deal with an identified surgical problem (P = 0.03) as significant predictors of hospital survival. Indication for crash-BOB (bleeder/non-bleeder) failed to reach significance (P = 0.08). Age, sex, intra-aortic balloon pump use at the primary procedure, and time following the primary procedure to crash-BOB were not identified as predictors of hospital survival. Of the 23 hospital survivors, three patients suffered a stroke post-operatively and made a good functional recovery prior to discharge. Two patients developed sternal wound dehiscence requiring surgical rewiring. At follow-up (mean 3 years, range 1–6 years), 19 patients were in NYHA class I and four were in class II. Crash-BOB patients required an average of 8 extra intensive care days and 2 extra ward days. The total cost of these resources was £164 900 (including theatre time, cardiopulmonary bypass and intra-aortic balloon pump use). This was equivalent to £7170 per life saved.

Conclusions: Crash-BOB occurred in 0.8% of cases and was associated with a survival to discharge of 42%, and a justifiable cost of only £7170 per life saved. Establishing an accurate diagnosis for the cause of clinical deterioration resulting in crash-BOB intervention was important, and the need for a further period of aortic cross-clamping did not preclude a favourable outcome. © 2000 Elsevier Science B.V. All rights reserved.

Keywords: Emergency; Cardiopulmonary bypass; Cardiac surgery

1. Introduction

Modern cardiac surgical practice has proven to be highly effective in terms of increased survival, improved capacity for work and better quality of life in all age groups. Although surgical mortality and morbidity is low, crash back on bypass (crash-BOB) is sometimes required for the resuscitation of patients who develop life-threatening post-operative complications. Whether or not such an aggressive approach to the management of these complications is a worthwhile clinical endeavour is not currently known. Furthermore, crash-BOB procedures are perceived to be extremely high-cost interventions, with a considerable resource demand. These issues have not been investigated in the world literature to date. They are, however, important in an era where the cost of health care is very closely scrutinized. The aims of the present study were to determine the incidence, aetiology and cost-effectiveness of crash-BOB procedures in our institution.

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2. Methods

Patients undergoing crash-BOB procedures between April 1995 and October 1998 were retrospectively identified from data that had been prospectively collected in the hospital database, and from records held by the perfusion department. Only patients who had undergone crash-BOB as a second procedure, independent of the primary operation (i.e. after sternal closure and admission to the intensive care area) were included in the study.

In-hospital data included patient demographics, perioperative information and clinical outcome. Pre-operative risk stratification was carried out using the Parsonnet score [1]. Operative information from the database was supplemented by a retrospective review of individual patient case notes. Long-term follow-up was undertaken by telephone interview of the patient or the general practitioner. Functional ability was recorded using the New York Heart Association (NYHA) classification.

The chi-squared and Fisher’s exact tests were used to compare nominal variables, and the Mann–Whitney test was used for continuous data. Stepwise regression analysis was undertaken with hospital survival as the dependent variable. Eight independent variables were evaluated: age, sex, Parsonnet score, intra-aortic balloon pump (IABP) use following primary procedure and crash-BOB, indication group (bleeding versus non-bleeding), need for further aortic cross-clamping and findings at crash-BOB (definite diagnosis versus no definite diagnosis). Data are expressed as mean ± standard deviation. A P-value of less than 0.05 was regarded as statistically significant.

3. Results

During the 5.5-year period of the study, 55 of 6882 patients (0.8%, 44 males, mean age 65 ± 12 (SD) years) underwent crash-BOB procedures at a mean of 7 h postoperatively (range 1 h to 20 days). Preoperative Parsonnet scores were similar to the overall population of patients undergoing surgery in our institution (mean score 10; range 0–45). The original cardiac operations were coronary revascularization (39), valve surgery (12) and others (4). Indications for crash-BOB were cardiac arrest (23), bleeding (20), hypotension (7), ischaemia (1) and others (4). Of the 55 patients, 20 died on the operating table. Of the remaining 35, a further 12 died in hospital. Overall survival was therefore 42%. Where crash-BOB was for bleeding, 17 of 20 patients (85%) survived to leave theatre, of whom 11 patients (55%) left hospital alive. In the 35 non-bleeders, only 18 (51%) survived crash-BOB and 12 (34%) left hospital alive. The difference in hospital survival between bleeders and non-bleeders was not statistically different at univariate level (P = 0.134). Parsonnet score was lower in those who survived to hospital discharge (7.8 ± 5.4 vs. 12.0 ± 8.3; P = 0.01). Fourteen patients were treated with crash-BOB for a life-threatening complication which developed on the low dependency ward. Six of these survived to hospital discharge. Procedures performed during crash-BOB are shown in Table 1. Sixteen patients required a second period of aortic cross-clamping of whom 13 (81%) survived to leave theatre, and 11 (69%) left hospital alive. Conversely, of nine patients in whom no diagnosis was found during crash-BOB, only two (22%) survived the procedure and none survived to hospital discharge. The absence of a clear diagnosis on crash-BOB was therefore strongly associated with a poor outcome (P = 0.007).

Results of the multiple logistic regression analysis are shown in Table 2. Higher pre-operative Parsonnet score and the need for aortic cross-clamping to rectify an identified surgical problem were found to be statistically significant predictors of survival to hospital discharge. There was a trend towards better survival by indication (bleeder versus non-bleeder) but this was not statistically significant (P = 0.08).

The incidence of important morbidity in the 23 hospital survivors is shown in Table 3. All patients who suffered a stroke post-operatively made a good functional recovery.
Intensive care unit.

crash-BOB did not influence survival. was the finding that time between primary surgery and hospital survival, as may be expected. Of particular interest was the identification and correction of a surgical primary predictor of hospital survival. These observations suggest the requirement at crash-BOB was found to be a significant predictor of a successful outcome following crash-BOB.

Conversely, the need for a second period of aortic cross-clamping did not preclude a good clinical outcome; indeed, aortic cross-clamp did not preclude a favourable outcome. Thus, to include the cost of medical staff that were already on call, or building costs that had already been covered in the charge costs of non-emergency operations would have considerably increased the calculated costs of crash-BOB, without actually having been a true expense of the procedure. We therefore chose to use only the variable costs of items necessary for the performance of a crash-BOB operation. Using these items, the total cost of crash-BOB in the 55 patients was less than £165 000. In other words, the cost of crash-BOB per life saved was less than £7200, an amount similar to the charge costs of coronary revascularization in our institution. We believe that the favourable clinical outcome of crash-BOB justifies this cost.

In conclusion, crash-BOB occurred in 0.8% of cases and was associated with a survival to discharge of 42%, and a justifiable cost of only £7170 per life saved. Establishing an accurate diagnosis for the cause of clinical deterioration resulting in crash-BOB intervention was important, and the need for a further period of aortic cross-clamping did not preclude a favourable outcome.

Table 4

Financial implications of crash-BOB procedures using variable cost-based data

<table>
<thead>
<tr>
<th>Unit of cost*</th>
<th>Rate</th>
<th>Cost (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra CPB and theatre use</td>
<td>£700 × 55</td>
<td>38500</td>
</tr>
<tr>
<td>Extra IABP use</td>
<td>£800 × 26</td>
<td>20800</td>
</tr>
<tr>
<td>Extra ICU stay (mean 8 days)</td>
<td>£220 × 8 × 55</td>
<td>96800</td>
</tr>
<tr>
<td>Extra ward stay (mean 2 days)</td>
<td>£80 × 2 × 55</td>
<td>8800</td>
</tr>
<tr>
<td>Total cost of crash-BOB</td>
<td>–</td>
<td>164900</td>
</tr>
<tr>
<td>Total cost per life saved (n = 23)</td>
<td>–</td>
<td>7170</td>
</tr>
</tbody>
</table>

* CPB, Cardiopulmonary bypass; IABP, Intra-aortic balloon pump; ICU, Intensive care unit.

prior to discharge. Two patients developed sternal wound dehiscence requiring surgical intervention.

All patients were alive at a mean of 3 years post-operatively (range 1–6 years). Nineteen were in NYHA class I and the remainder were in class II.

Crash-BOB patients required an average of 8 extra intensive care days and 2 extra ward days. The total cost of these resources was £164 900 (including theatre time, cardiopulmonary bypass (CPB) and IABP use; see Table 4). This was equivalent to £7170 per life saved.

4. Discussion

The sight of a team of cardiothoracic surgeons with their hands in an open chest on the ward can be frightening even to the experienced observer. The precise value of such aggressive intervention has not been investigated previously, and the present study has attempted to provide an initial appraisal of this procedure in our institution.

Crash-BOB occurred infrequently and was associated with a 42% salvage rate at hospital discharge. We believe that this is a highly satisfactory outcome considering that all 55 patients would invariably have died without intervention. Although bleeders tended to do better than non-bleeders, this was not statistically significant. The surgical findings at crash-BOB had a greater clinical impact on the likelihood of hospital survival: all patients in whom no cause for clinical deterioration was found at crash-BOB eventually died. Conversely, the need for a second period of aortic cross-clamping did not preclude a good clinical outcome; indeed, the majority of these patients did well. Aortic cross-clamp requirement at crash-BOB was found to be a significant predictor of hospital survival. These observations suggest that the identification and correction of a surgical primary cause of clinical deterioration is crucial in predicting a successful outcome following crash-BOB.

Parsonnet score was lower in those that survived to hospital discharge, and was found to be a significant predictor of hospital survival, as may be expected. Of particular interest was the finding that time between primary surgery and crash-BOB did not influence survival.

In the 23 hospital survivors morbidity was low and long-term functional outcome was good, providing further justification for the clinical value of crash-BOB intervention.

A potential disadvantage of crash-BOB originates from concerns over the rising costs of medical intervention in the face of limited resources and increasing demand for cardiac surgical procedures. These issues pose a major challenge for individuals involved in the funding, management and delivery of healthcare. As a result, high-cost interventions such as crash-BOB should be closely evaluated. Whilst it was relatively easy in this study to determine the clinical outcome of crash-BOB, the assessment of its cost implications was more difficult. Inclusion of capital costs was felt to be an incorrect representation of the real costs of crash-BOB, because many of these resources were already in place. Thus, to include the cost of medical staff that were already on call, or building costs that had already been covered in the charge costs of non-emergency operations would have considerably increased the calculated costs of crash-BOB, without actually having been a true expense of the procedure. We therefore chose to use only the variable costs of items necessary for the performance of a crash-BOB operation. Using these items, the total cost of crash-BOB in the 55 patients was less than £165 000. In other words, the cost of crash-BOB per life saved was less than £7200, an amount similar to the charge costs of coronary revascularization in our institution. We believe that the favourable clinical outcome of crash-BOB justifies this cost.

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Reference


Appendix A. Conference discussion

Dr M. Murtra (Barcelona, Spain): Could you tell us, regarding the nine patients that died and you didn’t actually cause of death whether you performed post-mortem examination?

Mr Birdi: All patients who die within 24 h of surgery in our institution have post-mortem information. We don’t have that postmortem information, but it’s very interesting, and we will be collecting that in due course.

Dr Murtra: Right. Because early in the sessions, on the first day there was a very interesting paper that showed that, for instance, in one case the postoperative theory for cause of death was bleeding complications from the abdomen or intestinal complications.

Mr Birdi: Well, there were some intra-abdominal complications. But a lot of these complications were not recorded as bleeding complications, they were patients who had myocardial dysfunction as a result of acidosis.
All the patients who were recorded as having bled, actually did bleed, and they bled into the pericardium. And there were various causes of bleeding from a distal anastomosis, a proximal anastomosis, bleeding from a dissected aorta, and so forth.

Dr H. Aebert (Regensburg, Germany): How did you go on bypass? Did you always open the chest in the operating room? Or did you, for example, sometimes use the femoral vessels or go on bypass in the intensive care unit?

Mr Birdi: All patients in this study had their sternum re-opened. Now, this was either performed in theatre, or in the intensive care unit or it was performed on the ward. We have done a separate audit of cardiac arrest, that is no-output cardiac arrest, in our institution, on the recovery ward, that is not the ITU and not in theatre, and the results of that audit are being analyzed. In this particular study, 14 patients either arrested or had life-threatening complications on the ward, all of whom went on to crash-BOB, and we were able to resuscitate and save six patients, all of whom are now alive and well. So in our institution we are looking at this in some more detail. We are just wondering whether a scoop-and-run policy for all patients on the ward who arrest and do not respond to immediate effective resuscitation should be transferred to our theatre, heparinized and placed onto bypass, so that an accurate diagnosis for the cause of their deterioration can be made. And it would be interesting to see what the results of this intervention would be.

Dr M. Turina (Zurich, Switzerland): It’s very interesting information and encouraging. It parallels our experience. What is the proportion of IMA patients in this material? A very common occurrence, in spite of all claims to the contrary, with the IMA patient and the hypertrophied left ventricle, is that the patient might crash due to a drop in blood pressure or some arrhythmia in the hours after surgery. We have all observed such patients and it is very easy to treat them, especially with minimally invasive techniques, inserting an additional vein graft. This is really a low-risk procedure if the patient is not brain-damaged due to prolonged resuscitation. What was your proportion of patients with this particular disorder? And the second question is, why do you cross-clamp if you have a simple coronary artery problem on the distal anastomosis which nowadays can be very well fixed with the beating-heart technique?

Mr Birdi: It’s very difficult to answer the second question because this is a retrospective study and I wasn’t there at the time for a lot of these.

With respect to the first question, I presume you’re talking about internal mammary artery spasm. And I don’t know the exact figures. I have a list of all the patients in my wallet over there. I couldn’t present it here because there are just so many numbers. But a considerable proportion of those suffered internal mammary artery spasm or what was believed to be internal mammary artery spasm. The majority of those were effectively dealt with in the first instance with revascularization. And this involved the use of a vein distally to the LAD. But not all of them survived to hospital discharge.

With respect to the second question, I agree with you entirely that one may wish to avoid an extra period of cross-clamping, put the patient on bypass, stabilize and deal with whatever complications you can deal with without rendering the heart ischaemic once more. But it’s interesting also then to see that the results of this study don’t actually suggest that cross-clamping was a deleterious mechanism to outcome. I think what would be more deleterious is not being able to make the accurate diagnosis as to the cause of the deterioration. But clearly this work needs to be looked at in more detail, perhaps as a prospective study.

Mr A. Anyanwua (Middlesex, UK): Can you tell me what proportion of patients that had a cardiac arrest in your unit actually went back on bypass?

Mr Birdi: If we’re talking about cardiac arrest with no output, the only data I can give you at this present time is the 14 patients who were on the ward, some of whom suffered a no-output cardiac arrest, all of whom were put onto bypass, six of whom survived to hospital discharge. Now, in a year we would expect perhaps five patients per year on our recovery ward to have some form of no-output cardiac arrest. That’s been the estimated figure. I don’t know the exact number. So over this period of time you would expect there to be perhaps 25 or 27. Some of those patients presumably then were put onto bypass, but I can’t tell you that for sure.

Mr Anyanwua: You don’t have data on the patients that arrested but were not put on bypass?

Mr Birdi: Yes. But not in these data.

Mr Anyanwua: I think the problem is you’ve suggested that this is a more cost-effective means of treating cardiac arrest and you can’t really say that unless you’ve got a comparative group. Because it might be that some of these 55 patients would have survived without going on bypass. A lot of patients that have bleeding and crash do not necessarily need cardiopulmonary bypass. And you can’t really say, from a point of economics, that it’s more cost-effective unless you directly make a comparison with patients who had a cardiac arrest in similar situations in which you used an alternative strategy.

Mr Birdi: I’m not sure whether you missed my conclusion slide, but in my conclusion I don’t state that cardiac arrest will benefit from crash-BOB. My conclusion is the group of patients are a heterogeneous group; not all of them had no-output cardiac arrest, and some of them were bleeders. But in that group of patients, all of whom required some form of intervention to save their life, we found that the cost implications were justifiable.

What we are interested in at our institution is to look at specifically these patients that you are talking about, the patients who suffer no-output cardiac arrest. We don’t have data for that. We don’t know whether the cost implications of treating those patients is justified. And that is the sort of work that we would like to think about carrying out in our institution. So I’m sorry, no, my conclusion is not based on that group of patients but on the basis of the heterogeneous group of patients here who we believed would not have survived without some kind of aggressive intervention.

Mr Anyanwua: So you believe none of these patients would have survived if you hadn’t gone on bypass?

Mr Birdi: No, undoubtedly, none of these patients would have survived without intervention.

Mr J.R.L. Hamilton (Newcastle-upon-Tyne, UK): How long does it take to get a bypass pump set up in your unit?

Mr Birdi: Well, the only limiting factor would be the perfusionist. And we believe that that is a limiting factor. And we’d be looking at something like 15 min before, or 20 min at the most, before he could arrive in the institution. And you’ve seen the time between surgery and crash-BOB intervention. I don’t actually know what the timing was between arrest with no output and cardiopulmonary bypass. It would be interesting to see what that is. But clearly that is an issue. And in our institution at the present time we would probably only be able to do that as quickly as 30–40 min.

Dr Murtra: I would like to ask you if in the group of bleeding patients, did you have any patients with cardiac rupture? Because in our experience, among these patients that bleed because of cardiac rupture, the results are terrible. Unfortunately, we have a lot of very old patients, and normally the cardiac rupture after mitral valve replacement is a really tough complication and most of these patients die, whatever you do.

Mr Birdi: None of the patients had cardiac rupture related to mitral valve surgery. I have a list, I wish I could have put on the board here, but the writing would have been too small for the people in the back to see clearly, but none of the patients were cardiac rupture.