**Objective:** To assess the effectiveness of intra-aortic balloon counterpulsation (IABC) as adjunctive treatment in patients undergoing abdominal operations.

**Design:** Retrospective review of patient medical records to determine the incidence of mortality following abdominal surgery and the incidence of complications from IABC.

**Setting:** University-based, tertiary care hospital.

**Patients:** Sixty-eight patients who underwent an abdominal operation and IABC during the same hospitalization were divided into the following groups: Group 1, IABC initiated prior to operation to enhance perioperative cardiac function; group 2, IABC used to treat cardiogenic shock in a patient who subsequently required an operation while undergoing IABC; and group 3, IABC device inserted and removed for treatment of cardiogenic shock in a patient who subsequently required an operation within 30 days of removal of the device.

**Main Outcome Measures:** The incidence of mortality in IABC-supported patients and IABC-related complications.

**Results:** In group 1, excluding 3 patients who died following emergency operation, 26 patients underwent nonemergency procedures and had a 12% mortality rate. In group 2, 5 of 6 patients who underwent emergency operations died, whereas 3 of 4 patients who required only urgent operations survived. In group 3, 18 (62%) of 29 patients who underwent urgent or emergent operations died postoperatively. Thirteen patients experienced complications related to IABC; there were no deaths and no limbs were lost to ischemia.

**Conclusions:** This is the largest reported series looking at the utility of IABC as adjunctive treatment for patients undergoing abdominal operations. The outcome for those patients requiring emergency operations remains poor, but it is likely that more liberal use of IABC in patients with severe cardiac dysfunction who require nonemergency operations may improve patient outcome.

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**Intra-aortic Balloon Counterpulsation (IABC)** has been successfully employed as a means of improving cardiac function in patients with cardiogenic shock not responsive to inotropic therapy.1-5 Patients with compromised cardiac function undergoing major operative procedures are at great risk for postoperative mortality.6-9 Elective use of IABC in patients with preexisting cardiac dysfunction in need of major noncardiac operations may provide intraoperative hemodynamic support and reduce the risks of postoperative cardiac complications.9,10 The benefits of the use of IABC, however, need to be balanced against the inherent risks associated with its use. In addition, there is significant expense associated with the use of IABC, requiring thoughtful patient selection. Preoperative insertion of IABC devices in patients with severe left ventricular dysfunction undergoing coronary artery bypass grafting (CABG) has been shown to be cost-effective, improve survival, and reduce length of hospital stay.12,13 However, no large series yet has addressed the use of IABC as a bridge to recovery from major abdominal operations in patients with significant cardiac dysfunction. This study assessed the effectiveness of IABC as adjunctive treatment in patients undergoing a variety of abdominal procedures.

**RESULTS**

**GROUP 1**

Twenty-nine patients with compromised cardiac function underwent insertion of the IABC device to enhance cardiac function prior to undergoing their abdominal operation (Table 1). The nature and frequency of hospital stay...
PATIENTS AND METHODS

We reviewed the medical records of 98 patients who underwent an abdominal procedure and IABC during the same hospitalization between January 1984 and July 1996. Thirty patients were excluded from the study. Sixteen patients were excluded because a groin exploration following insertion of the IABC device was recognized in the database as an abdominal operation; 5 patients sustained thoracoabdominal trauma, requiring thoracic and abdominal exploration following by insertion of the IABC device; 3 patients were excluded because IABC was initiated after combined cardiac and abdominal procedures; 3 were excluded because the abdominal procedure was performed more than 30 days after the discontinuation of IABC; and 1 patient was excluded because the abdominal procedure involved harvest of a splenic artery used for CABG. The remaining 68 patient records were retrospectively reviewed.

Three groups of patients were identified based on the timing and purpose of the IABC in relation to the abdominal procedure. In group 1 (n=29), IABC was initiated prior to the abdominal operation to enhance cardiac performance in patients with known cardiac dysfunction. In group 2 (n=10), IABC devices were initially inserted to treat cardiogenic shock refractory to inotropic therapy and the patients subsequently required an abdominal operation. In group 3 (n=29), IABC devices were placed for acute cardiovascular support and an abdominal procedure was performed within 30 days of IABC termination. In addition, all of the abdominal procedures were classified as elective, urgent, or emergent. An operation was defined as elective if delay in operative management was not expected to result in immediate morbidity. An urgent operation was defined as one that was delayed only until the patient’s hemodynamic state was optimized. An emergency operation was performed immediately after abdominal pathology was identified. Additionally, among the 68 patients included in this study, the complications associated with insertion of the IABC devices were reviewed. The McNemar χ² test of statistical significance (Sigmastat for Windows, Jandel Scientific, Corte Madera, Calif) was used to determine significant differences in mortality attributable to the type of operative procedure or the degree of urgency of the operation.

of the operative procedures performed are demonstrated in Table 2. Overall mortality in this group was 21%, but the mortality rate in the elective group was significantly lower (P<0.01) than either the urgent or emergent group (Figure 1). The only death in the elective group was caused by ventricular fibrillation 4 days following a right hemicolecotomy for adenocarcinoma. The 2 deaths in the urgent group were attributed to cardiac arrest 2 days after abdominal surgery for bowel ischemia. All 3 patients requiring emergent abdominal operations (open cholecystectomy for acute cholecystitis, exploratory laparotomy for colonic infarction, and a total colectomy for perforated diffuse diverticulitis disease) died despite preoperative insertion of IABC pumps; 2 patients of sepsis and 1 of an upper gastrointestinal tract hemmorhage. The degree of urgency of the operative procedure correlated significantly with mortality rate. However, the type of operation performed did not independently affect the incidence of mortality in this group of patients (McNemar χ² test).

GROUP 2

Ten patients had indwelling IABC devices when operated on for abdominal pathology (Table 1). The nature and frequency of the operative procedures performed are demonstrated in Table 2. The overall mortality rate in this group was 70% (Figure 2). In 4 patients, IABC was instituted emergently following a cardiac procedure. All 4 of these patients ultimately died. No differences in the incidence of mortality were seen based on the urgent or emergent na-

Table 1. Patient Demographics*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
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</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>29</td>
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<td>29</td>
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<tr>
<td>Age, y</td>
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<td>68.7±3.2</td>
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<td>Length of stay, d</td>
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<td>32±6</td>
<td>49±7</td>
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</tr>
<tr>
<td>F</td>
<td>6</td>
<td>2</td>
<td>6</td>
</tr>
</tbody>
</table>

*See “Patients and Methods” section for description of patient groups. Data are given as mean±SD unless otherwise indicated.

Table 2. Types of Abdominal Operations Performed With Intra-Aortic Balloon Counterpulsation Support

<table>
<thead>
<tr>
<th>Type of Operation</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory laparotomy</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Gastric procedure</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Bowel resection</td>
<td>11</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>Cholecystectomy</td>
<td>13</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

*See “Patients and Methods” section for description of patient groups.

Figure 1. Group 1. Mortality in patients undergoing intra-aortic balloon counterpulsation for cardiovascular support during abdominal operations.

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nature of the operation (McNemar $\chi^2$ test). In addition, the nature of the operative procedure performed did not affect the mortality rates (McNemar $\chi^2$ test). Four of the deaths in group 2 were attributed to sepsis and 3 to cardiopulmonary arrest. The 4 septic deaths were caused by bowel ischemia subsequent to a low blood flow state.

GROUP 3

Twenty-nine patients underwent abdominal operations within 30 days of IABC termination (Table 1). The nature and frequency of the operative procedures performed are demonstrated in Table 2. The overall mortality in this group was 62% (Figure 3). There were 17 urgent and 12 emergent operations performed, with a mortality rate of 53% and 75%, respectively ($P = .09$). Mortality in this group was attributed to cardiopulmonary arrest (n=10) or sepsis with multisystem organ failure (n=8). The nature of the operative procedure did not independently affect the incidence of mortality in this group (McNemar $\chi^2$ test).

Finally, in each of the 3 groups, the patients are stratified based on the nature of their underlying cardiac disease.

| Table 3. Patient Classification Based on Predisposing Cardiac Conditions* |
|------------------|------------------|------------------|
|                  | Group 1 | Group 2 | Group 3 |
| Acute MI         | 11 (3)  | 4 (2)   | 14 (10) |
| CHF              | 11 (2)  | 1 (1)   | 8 (5)   |
| Cardiomyopathy   | 7 (1)   | 4 (3)   | 6 (2)   |
| Arrhythmia       | 0 (0)   | 1 (1)   | 1 (1)   |

*See “Patients and Methods” section for description of patient groups. Numbers in parentheses represent deaths. MI indicates myocardial infarction; CHF, congestive heart failure.

The 4 types of cardiac dysfunction identified include: (1) myocardial infarction, diagnosed at hospital admission or during the same hospitalization; (2) congestive heart failure characterized by right-sided ventricular dysfunction; (3) end-stage cardiomyopathy with biventricular dysfunction; or (4) refractory cardiac arrhythmia (Table 3).

COMPLICATIONS

Thirteen of the 68 patients included in this study suffered complications of IABC device insertion. Eleven patients had thrombosis of the femoral artery, with 2 subsequent embolizations to the great toe. All patients were treated with anticoagulant therapy and recovered without further sequelae. Another patient with femoral artery thrombosis developed thrombophlebitis requiring antibiotic therapy in addition to anticoagulants. This patient recovered fully as well. Two patients developed wound infection at the site of IABC device insertion. These patients were treated with antibiotics and wound care and recovered without further complications. There were no deaths directly caused by IABC device insertion and no limbs were lost.

COMMENT

There is a paucity of information regarding the use of IABC to support patients requiring general surgical operations. The goal of the present study was to examine the utility of IABC in patients with compromised cardiac function in need of major abdominal surgery. Intra-aortic balloon counterpulsation has been used successfully to provide circulatory support for patients in cardiogenic shock.1-5 Patients with compromised cardiac function requiring major operative intervention are at higher risk of postoperative cardiac complications than patients with normal cardiac function.5-9

Our study provides the largest reported experience with elective use of IABC in patients with significant cardiac dysfunction in need of an abdominal operation (group 1). The overall mortality rate of 21% (6/29) for this group compares favorably with that reported in patients not treated with IABC.6,9,14,15 The mortality rate is even lower (12%) among the 26 patients who had elective or urgent abdominal surgery with preoperative use of IABC. This observation sharply contrasts with the eventual outcome for the 3 patients who underwent emergent abdominal surgery, all of whom ultimately died following complicated hospital courses. Although only suggested by our data, it is quite likely that reinstitution of IABC in the group 3 patients might have decreased
the cardiac mortality seen in those patients, as 10 (34%) of 29 of these patients died of cardiac causes. Likewise, the 8 patients in this group who died of multiorgan system failure and the sequelae of a low-flow state may have benefited from IABC. Finally, when stratified for the type of underlying cardiac disease (Table 3), the incidence of mortality among the patients with recent myocardial infarction is higher among the group 3 patients as compared with the group 1 patients (P=.05, Fisher exact test), further raising the possibility of improved outcome with elective reinstitution of IABC in this subgroup of patients.

Another significant observation is made in the group of patients with an indwelling IABC device who required emergency abdominal operations. Five of 6 such patients died of cardiac complications postoperatively. The operative procedures in this group included open cholecystectomy (1, alive), total colectomy (1), exploratory laparotomy (3), and oversew of a bleeding gastric ulcer (1). In this era of cost containment, one might consider nonoperative management for this group of patients, who presumably have a grave prognosis with or without surgical intervention.

Our retrospective study did not allow us to identify all of the patients with preexisting cardiac dysfunction in need of major abdominal operations. Some of these patients might have gone on to recover from their operation without ever needing IABC or, conversely, many such patients might have suffered fatal cardiac events postoperatively without the use of IABC. Therefore, an accurate comparison of outcome between the 2 groups is not possible, considering the design of our study. Dietl et al13 addressed this issue in a group of patients undergoing elective CABG. Their retrospective evaluation included all of the patients who underwent CABG during the study period. Among the patients classified as New York Heart Association class III and IV, those who underwent elective IABC had a much lower morbidity and mortality.13

The advantages of IABC in patients with significantly compromised cardiac function have to be balanced against the complications and costs associated with insertion of the IABC devices. Of the 68 general surgical patients who underwent IABC device placement during our study period, 13 suffered complications. Eleven of these complications were thromboembolic in nature and 2 were wound infections. Major limb ischemia occurred in 2 patients with thrombosis. Both cases were treated successfully without further complications. In addition, no patients died directly as a result of intra-aortic balloon placement. These results are comparable to those reported previously.1,16 We attribute the high incidence of thromboembolic events in our patients to our avoidance of anticoagulant therapy in the immediate postoperative period. We now employ a much more liberal approach to systemic anticoagulation in patients with indwelling IABC devices.

Our study was not designed to address the cost-effectiveness of IABC. However, Dietl and colleagues13 reported significant cost benefits in patients undergoing IABC prior to CABG in patients with New York Heart Association class III or IV classification. An accurate cost comparison in patients undergoing abdominal operations would require either a prospective study or a retrospective study that would include all of the patients with significant heart disease undergoing an abdominal operation with or without perioperative IABC. Our study excluded all patients who did not undergo IABC.

In conclusion, we believe that more liberal use of IABC in patients with severe cardiac dysfunction who require elective and urgent abdominal operations may improve patient outcome. However, in critically ill patients requiring emergency operations with compromised cardiac function requiring IABC for hemodynamic support, the outlook remains grave.


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REFERENCES


Jorge L. Rodriguez, MD, Minneapolis, Minn: Dr Shayani and colleagues have presented 2 very important points. The first one is that patients who require intra-abdominal exploration while on intra-aortic balloon counterpulsation (IABC) for cardiogenic shock and all of those patients who were treated for cardiogenic shock with IABC and then required an emergent operation really do poorly, with mortality rates of 70% and 62%, respectively. Second, in contrast, patients with compromised cardiac function who are supported with IABC prior to their exploratory laparotomy had a mortality rate of 21%. If you ex-
tend the subgroup analysis to those who had elective placement of an IABC device and elective operation, the mortality rate dropped to 12%.

For this society and its membership to be able to utilize these take-home concepts, I would like the authors to clarify certain points. First, in group 1 patients, patients who had undergone placement of an IABC device before intra-abdominal exploration, what were the trigger points that led to the placement of the IABC device? In other words, what were the cardiac function parameters that led to the placement of the IABC device, and what were the cardiac function parameters that led to the removal of the pump? How long was the IABC device maintained, and what other tools were utilized to maintain cardiac function?

In groups 2 and 3, the mortality was high. Could the authors define the population who expired in the context of cardiac function? Are there predictable cardiac function parameters that are associated with mortality? Can we identify or pre-identify a set of factors that could avoid a futile process?

Third, the patients who had intra-abdominal exploration following the discontinuation of IABC had a mortality rate of 62%. Would they state that with replacement they would have done better? Have the authors performed analysis regarding the cardiac function parameters at 2 different time points, and were there any differences in this?

Last, this is an important observation. I think one realizes that as America “grays,” we as general surgeons or surgical intensivists will be facing many more patients with compromised cardiac function who will require elective operative intervention. How do the authors plan to identify the need to incorporate IABC into the management algorithm of patients with compromised cardiac function who require intraperitoneal exploration?

James A. Madura, MD, Indianapolis, Ind: I am pleased to be asked to discuss this interesting paper. However, I must say that initially I felt insecure that in Indiana we have not been using IABC, and I polled our cardiovascular surgeons, perfusionists, as well as similar people at our sister institutions in central Indiana and found out that we are not alone. Then I did a quick literature search and found that the Loyola experience is truly unique. Most reports in the past 20 years have been anecdotal and not comparable to this paper with 68 patients.

On second and third readings of the manuscript, however, I felt as though I had been given only one potato chip. There is more that I needed to know to see if this is a technique that we, as well as everyone else, should be using more freely. Conversely, I wondered if the Loyola group was a little quick on the trigger for insertion of an IABC. In order to convince our cardiologists and cardiovascular surgeons to get busy, I need more information.

What are your criteria currently for insertion of an IABC for a noncardiac case? Who makes the decision or the request—you, the cardiologist, or the cardiovascular surgeon?

I know this is a retrospective study, but do you have a cohort of similar patients operated on without a balloon? If so, how were they managed perioperatively and what was their respective mortality?

I divided your 3 groups basically into 2: the urgent and emergent cases in all 3 of your groups had a mortality rate of 63% (31/49), which is not unexpected in patients with severe cardiac decompensation. However, the elective group had only 1 death in 19 patients. What was the cardiac status in these patients? Did they have irreparable cardiac lesions? Were they pre- or post-CABG? Did they have recent myocardial infarctions or valvular disease? Were they awaiting cardiac surgery or heart transplantation? In regard to the general surgical conditions in these individuals, it seems that most of the cholecystectomies were in this favorable group. Were there any bowel resections for obstruction, ischemia or other emergent reasons? Were any of the operations done for neoplasms?

Finally, Dr Pickleman, have you developed an algorithm you can share with us for these patients with severe cardiac disease and coexisting noncardiac general surgical problems?

Raymond J. Joehl, MD, Chicago, Ill: I have 3 questions. To continue emphasis from a previous paper this morning on surgery at the end of life, how many of your patients had advance directives or living wills? Second, how many patients with severe cardiac dysfunction and abdominal catastrophe were evaluated and did not have an operation? Third, other than having emergency operations, which patients can you select for a no-treatment group based on this analysis?

Dr Pickleman: Clearly we anticipated these questions because this is a retrospective analysis, and the shortcomings of this study is that we don’t have a control group. The control group of course are the patients with severe cardiac dysfunction who did not undergo insertion of a balloon pump and did have abdominal surgery, and we do not know the number of that group and we do not know their outcome.

Loyola is a unique institution. We do more than 1200 openheart procedures yearly plus cardiac and lung transplantation, and therefore that explains perhaps why this is the largest reported series of the use of balloon pumps. Our cardiologists, to paraphrase Dr Madura, are a bit quick on the trigger because we have seen over the years many patients succumb to cardiac dysfunction following elective and urgent abdominal operations. So the question was posed, who selects the use of the balloon? Usually it’s the cardiologist, but many of the surgeons like to operate with the balloon in place because we have seen good outcomes with the balloon. This is not science and there’s surely no standard protocol at our institution for this.

How do we know which patients in whom to institute the balloon? A patient who has had a recent myocardial infarction, a patient with a documented decreased ejection fraction, and patients who have unstable angina. Whether or not they have had prior heart surgery, these are the patients who we would consider for prophylactic insertion.

There was a question regarding the reasons for bowel resections. Virtually all bowel resections were for low-flow ischemic states. There were also several patients who had lower gastrointestinal tract hemorrhage and required operation for that.

I agree with Dr Rodriguez. We haven’t proven our hypothesis. This is something we are still taking on faith. We wanted to get this data analyzed so that perhaps we could come up with a better algorithm as to which patients should have a balloon inserted preoperatively.

Dr Joehl asked about advance directives. I have no information on that.

When we looked at the deaths in all groups, groups 1, 2, and 3, every death was cardiac. Now many of these deaths were listed as septic, but the septic deaths were basically the effects of low flow and that’s cardiac. So every one of our patients died a cardiac death, and that is why we feel that it may be beneficial to prophylactically insert balloon pumps in any patient with a demonstrated decreased ejection fraction, unstable angina, or a recent myocardial infarction. We would hope that we would be able to demonstrate in the future that this will improve patient outcome, but as of right now of course it is just a hypothesis.