Visceral Arterial Compromise During Intra-Aortic Balloon Counterpulsation Therapy

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Background—Intraaortic balloon pump (IABP) therapy is a widely used method of circulatory support. Based on frequent findings of balloon malposition with visceral arterial compromise on computerized tomographic (CT) imaging studies, we conducted a systematic review of cardiac surgical IABP patients with available CT scans to determine reasons, incidence, and clinical relevance of malposition.

Methods and Results—From January 2007 to March 2009, a total of 621 of 7756 cardiac surgical patients (8.0%) received perioperative IABP support, of whom 63 (10.1%) received a thoracoabdominal CT scan during IABP support. Proximal and distal balloon positions were analyzed. The anatomic distance from the left subclavian artery to celiac trunk and aortic transverse diameter were measured in all patients and compared with implanted balloon dimensions. Mean age was 67.1 ± 11.9 years; 33.3% were female, and height was 169 ± 9 cm. Based on radiography, proximal balloon position was correct in 96.8% but only appropriate in 38.1% based on CT. In 61 of 63 patients, compromise of at least 1 visceral artery was found: celiac trunk, 96.8%; superior mesenteric artery, 87.3%; and renal arteries, 66.7%. Left subclavian artery to celiac trunk distance was 241 ± 23 mm, and balloon length was 248 ± 17 mm and corresponded to an anatomic to balloon length mismatch in 68.2%. Spinal deformations were found in 42.9%. Laparotomy for mesenteric ischemia was required in 23.8%. Hospital mortality rate was 60.3%.

Conclusions—IABP malposition was commonly identified by CT. Reasons included incorrect proximal balloon position as well as an anatomic-to-balloon length mismatch. Thus, shorter than recommended balloon sizes and better positioning strategies had to be considered. (Circulation. 2010;122[Suppl 1]:S92–S99.)

Key Words: IABP ■ renal artery ■ visceral artery ■ visceral ischemia ■ balloon size

Intraaortic balloon pump (IABP) implantation is a commonly used form of circulatory support for patients with acute coronary syndromes as well as present or impending cardiogenic shock. The first experimental results using an inflatable latex balloon for aortic counterpulsation inserted into the descending thoracic aorta through the femoral artery were reported in 1962,1 followed by the first clinical application by Kantrowitz et al in 1968.2 Since that time, IABP technology has made significant progress leading to a widespread acceptance, with an estimated >70,000 IABP insertions annually in the United States only.3

Despite reducing left ventricular afterload and improving coronary and systemic perfusion, IABP support is also associated with lower extremity ischemia in up to 33% of surgical patients.4–7 Although smaller balloon catheters and sheathless implantation techniques could reduce this incidence significantly, limb ischemia still necessitates premature IABP removal in a considerable number of patients. Multiple studies have revealed that patients with ischemic complications have a significantly higher mortality rate.6,8,9 Therefore, careful assessment is of utmost importance to avoid ischemic complications. However, while lower extremity ischemia is relatively easy to identify by clinical examination, early detection of visceral ischemia is far more challenging that potentially leads to a high number of unrecognized patients. Moreover, acute abdominal condition in these critical patients commonly expresses only irreversibly and fatal organ damage.

By definition, severely ill patients in cardiogenic shock often have some degree of baseline visceral and/or renal ischemia. Malposition of the IABP balloon, however, may result in compromise of the visceral arteries, further exacerbating malperfusion, which is poorly tolerated by these patients. As a result, anatomic landmarks on plain chest radiography have been established to define correct proximal IABP position, and standard balloon lengths have been developed to avoid coverage of the visceral arteries during balloon inflation. The landmarks vary among institutions but...
include positioning of the radioopaque proximal tip at the lower aspect of the aortic knob or the 2nd intercostal space anteriorly.

However, despite strict adherence to these implantation guidelines, we noted frequent malposition of the IABP balloon with visceral arterial compromise on computerized tomographic (CT) scans obtained on our patients. Therefore, we conducted a systematic review of all cardiac surgical patients who underwent a CT scan during IABP support to determine the incidence, reasons, and clinical relevance of visceral arterial compromise.

Patients and Methods
From January 2007 to March 2009, a total of 621 of 7756 cardiac surgical patients (8.0%) received perioperative IABP support. All patient data, including demographics, type, and severity of heart disease, intraoperative details, type of surgery performed, the time of IABP insertion, as well as all major postoperative complications were prospectively recorded in the hospital database. Retrospective review of the database revealed 63 of 621 patients (10.1%) who underwent combined thoracic and abdominal CT imaging during IABP support and comprised our study population.

Clinical indications for CT scan were suspected acute abdominal condition (n=44), pulmonary embolism (n=15), or exclusion of acute aortic dissection (n=4). IABP balloon size was chosen according to the patient’s height and was in accordance with manufacturer recommendations (Datascope Corp, Fairfield, NJ; Arrow International, Everett, Mass). For intraoperatively as well as for preoperatively implanted IABPs, the balloon position was controlled by intraoperative transesophageal echocardiography. However, because displacement or slipping could not be fully excluded during transfer to the ICU, the IABP position was controlled immediately after arrival at the ICU by chest radiography and repositioned as indicated. For further controls as well as for all postoperative IABP insertions, the balloon position was routinely based on chest radiographic assessment.

Postoperative acute renal injury was defined as a requirement for new onset of continuous veno-venous hemofiltration. Stroke was defined as transient or persisting postoperative hemiparesis or neurological dysfunction with morphological substrate confirmed by CT or MRI. MACCE was defined as all major cerebrovascular and cardiac events including all-cause mortality.

CT Protocol and Image Analysis
All scans were performed on a 64-row multidetector CT (Brilliance 64, Philips Medical Systems, Cleveland, Ohio) in helical mode. Patients were examined in supine position and during brief apnea. After creating planning scans and intravenous injection of 100 mL nonionic iodinated contrast medium (Iopromide, 370 mg iodine per mL, Ultravist 370, Schering, Berlin, Germany) with a flow rate of 4.5 mL/s, the scan was started by bolus tracking measurement in the left atrium at a threshold of 150 Hounsfield units (HU) in cranio-caudal direction. A collimation of 64×0.625 mm at a rotation time of 0.5 seconds (Pitch 1.17) was used. Tube current and voltage were 200 mAs/slice and 120 kV, respectively. Images were reconstructed at a slice thickness of 0.8 mm without overlap using a soft tissue reconstruction algorithm (Standard B). All CT imaging before processing and analyses was performed on a commercially available medical workstation (Philips Extended Brilliance Workspace V 3.5.0.2254, CT Viewer, Philips Medical Systems, Best, The Netherlands). Length measurements were obtained from oblique sagittal view or, if necessary, from curved multiplanar reconstruction. Diameter measurements were performed orthogonally to the vessel path.

The proximal and distal balloon tip position was identified and recorded, in relation to the location of all visceral arteries. Proximal
Table 1. Implanted IABP Balloon Sizes and Dimensions (According to Manufacturer Information) and Number of Implants

<table>
<thead>
<tr>
<th>Balloon</th>
<th>Balloon</th>
<th>Balloon</th>
<th>Recommended</th>
<th>Patients,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume, mL</td>
<td>Length, mm</td>
<td>Diameter, mm</td>
<td>Patient Height, cm</td>
<td>n</td>
</tr>
<tr>
<td>Datascope</td>
<td>25</td>
<td>165</td>
<td>15</td>
<td>152</td>
</tr>
<tr>
<td>34</td>
<td>221</td>
<td>15</td>
<td>152–162</td>
<td>14</td>
</tr>
<tr>
<td>40</td>
<td>258</td>
<td>15</td>
<td>162–183</td>
<td>29</td>
</tr>
<tr>
<td>50</td>
<td>&gt;183</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arrow</td>
<td>30</td>
<td>230</td>
<td>13.9</td>
<td>&lt;162</td>
</tr>
<tr>
<td>40</td>
<td>260</td>
<td>15</td>
<td>162–182</td>
<td>15</td>
</tr>
<tr>
<td>50</td>
<td>260</td>
<td>16</td>
<td>&gt;182</td>
<td>0</td>
</tr>
</tbody>
</table>

balloon tip position was considered as appropriate when positioned 10 to 40 mm distal to the origin of the left subclavian artery (10 mm margin each to recommended distance of 20 to 30 mm). Appropriate position was compared with the latest horizontal chest radiographic findings. A correct position was defined as location of the radioopaque tip at the lower margin of the aortic knob, as visualized on anteroposterior chest radiography.

Anatomic distances from the left subclavian artery to the celiac trunk (SA-TC) and from subclavian artery to proximal balloon tip were measured in all patients and compared with the length of the implanted balloon (Figure 1). Anatomic mismatch was considered when SA-TC distance was shorter than the particular balloon length. Furthermore, transverse aortic diameter at the diaphragmatic level was measured and compared to the inflated diameter of each particular balloon. A residual lumen of ≥5 mm was considered to be flow relevant.

Data Analysis

Continuous variables are expressed as mean±SD or median plus range in variables missing normal distribution. Normal distribution was tested by the 1-sample Kolmogorov-Smirnov test. Categorical data are given as proportions throughout the manuscript. Correlation of body height and SA-CT distance was performed and the Pearson product-moment correlation coefficient was given. All statistical analyses were performed using 17.0 SPSS software package.

All authors had full access to the data and take full responsibility for its integrity. They read and agree to the manuscript as written. The study was approved by the local ethics committee and study design, anonymous data acquisition, as well as data publication were approved according to the Declaration of Helsinki.

Results

Implanted balloon dimensions and the number of patients receiving the implants are presented in Table 1. According to the manufacturer guidelines and recommendations based on body height, all patients received an appropriate balloon size ranging from 30 to 40 mL. The majority of the patients (44/63, 69.8%) received a 40-mL balloon, with a corresponding balloon length of 258 mm (Datascope) or 260 mm (Arrow) and diameter of 15 mm.

Patient characteristics and procedural details are presented in Tables 2 and 3, respectively. The mean age was 67.1±11.9 years (range, 37.9 to 85.7 years), 33.3% were female, and average height was 169±9 cm. Preoperative cardionic shock was present in 36.6% of the patients before surgery, with only 17.4% of the patients undergoing preoperative IABP implantation. In a total of 34 of 63 patients (53.9%), CABG was performed as an isolated or combined procedure, with complete revascularization achieved in 85.3%. In 47.6% of the patients, IABP was implanted after surgery. CT scan was performed 2 days (range, 0 to 12 days) after IABP implantation.

Table 2. Patient Baseline Characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>67.1±11.9</td>
</tr>
<tr>
<td>Female, %</td>
<td>33.3</td>
</tr>
<tr>
<td>Height, cm</td>
<td>169±9</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>76.4±14.0</td>
</tr>
<tr>
<td>Body mass index</td>
<td>26.6±4.4</td>
</tr>
<tr>
<td>Diabetes, %</td>
<td>49.2</td>
</tr>
<tr>
<td>Arterial hypertension, %</td>
<td>71.4</td>
</tr>
<tr>
<td>COPD, %</td>
<td>20.6</td>
</tr>
<tr>
<td>Renal insufficiency, %</td>
<td>41.2</td>
</tr>
<tr>
<td>Peripheral vascular disease, %</td>
<td>12.7</td>
</tr>
<tr>
<td>Atrial fibrilation, %</td>
<td>30.2</td>
</tr>
<tr>
<td>AMI within 12 h prior op, %</td>
<td>22.2</td>
</tr>
<tr>
<td>s/p PCI, %</td>
<td>28.6</td>
</tr>
<tr>
<td>Ejection fraction, %</td>
<td>39.9±18.1</td>
</tr>
<tr>
<td>Log EuroScore</td>
<td>18.0 (2.3–85.8)</td>
</tr>
</tbody>
</table>

Table 3. Procedural Details and IABP Insertion

<table>
<thead>
<tr>
<th>Cardiac procedures</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isolated CABG, %</td>
<td>30.2</td>
</tr>
<tr>
<td>Isolated AV surgery, %</td>
<td>12.7</td>
</tr>
<tr>
<td>Isolated MV surgery, %</td>
<td>7.9</td>
</tr>
<tr>
<td>Combined CABG+AV surgery, %</td>
<td>7.9</td>
</tr>
<tr>
<td>Combined CABG+MV surgery, %</td>
<td>6.3</td>
</tr>
<tr>
<td>Double valve surgery+AVB, %</td>
<td>27.0</td>
</tr>
<tr>
<td>Other combinations, %</td>
<td>7.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Procedure times</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total procedural time, min</td>
<td>249±115</td>
</tr>
<tr>
<td>CPB use, %</td>
<td>87.3</td>
</tr>
<tr>
<td>CPB time, min*</td>
<td>162±83</td>
</tr>
<tr>
<td>Cardiopulotic arrest, %</td>
<td>76.4</td>
</tr>
<tr>
<td>Cross-clamp time, min*</td>
<td>90±40</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IABP implantation</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preop, %</td>
<td>17.4</td>
</tr>
<tr>
<td>Intrap, %</td>
<td>34.9</td>
</tr>
<tr>
<td>Postop, %</td>
<td>47.6</td>
</tr>
</tbody>
</table>

AV indicates aortic valve; CABG, coronary artery bypass grafting; CPB, cardiopulmonary bypass; and MV, mitral valve.

*Only for patients who had this event.
In a total of 61 patients (96.8%), the IABP balloon position was distal to the origin of the celiac trunk (95% confidence interval, 92.4 to 101.3). The IABP balloon also compromised the superior mesenteric artery and renal arteries in 87.3% and 66.6% of the patients, respectively (Figure 2). Potential reasons for this significant malposition were divided into an anatomic length mismatch of the SA-TC distance with the particular balloon length (anatomic-to-device length mismatch) and an inappropriate (too low) proximal balloon tip positioning. With respect to the former reason, anatomic distance measurements between the left subclavian artery and the origin of the celiac trunk are presented in Table 4. An anatomic-to-device length mismatch was evident in 68.2% of the patients, with a mean SA-TC distance of 241 ± 23 mm and implanted balloon length of 248 ± 17 mm. There was a significant relation between patient height and length of the subclavian artery-to–celiac-trunk segment (Figure 3). The Pearson correlation coefficient was 0.369 (P = 0.003) indicating, of note, only a limited degree of linear dependence between the variables.

By transverse diameter measurements, the residual perfused lumen during balloon inflation was 9.4 ± 3.2 mm and was found to be <5 mm in 6.3% of all patients (Table 4).

On the basis of chest radiography, proximal balloon tip position was correct in 96.8% but appropriate in only 38.1% of the patients based on CT evaluation (Table 5). The mean distance from left subclavian artery to proximal balloon tip was 50.2 ± 25.5 mm, with a position more than 40 mm distal to the subclavian artery origin in 60.3% of the patients (Figure 4).

CT signs of bowel ischemia were evident in 39.7% of the patients, whereas liver and renal hypoperfusion were found in 10 and 11 patients, respectively. There was evidence of spinal deformations, including sintering of vertebral bodies, in 42.9%. CT scan excluded acute aortic dissection and pulmonary embolism in all patients.

Clinically, IABP support was required for a median of 144 hours (range, 10 to 720 hours). No evidence of paraplegia or spinal cord ischemia was found in any of the patients. During the hospital stay, renal replacement therapy was required in 82.5% of the patients. Laparotomy for mesenteric ischemia was performed in 15 patients (23.8%) after a median 10 days after IABP implantation (range, 2 to 43 days), with IABP in place in 66.7%. Hospital mortality in this subset of high-risk patients was 60.3%, with bowel ischemia as the primary cause of death in 8 patients.

**Table 4. Anatomic Versus Balloon Longitudinal and Transverse Dimensions**

<table>
<thead>
<tr>
<th>Longitudinal dimension</th>
<th>Subclavian artery to celiac trunk distance, mm</th>
<th>240.7 ± 22.6 (195–307)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subclavian artery to celiac trunk distance, mm</td>
<td>240.7 ± 22.6 (195–307)</td>
<td></td>
</tr>
<tr>
<td>Aortic arch to celiac trunk distance, mm</td>
<td>215.6 ± 20.9 (176–270)</td>
<td></td>
</tr>
<tr>
<td>IABP balloon length, mm</td>
<td>248.0 ± 16.5 (221–260)</td>
<td></td>
</tr>
<tr>
<td>Anatomic length mismatch, %</td>
<td>68.2</td>
<td></td>
</tr>
<tr>
<td>Transverse diameter</td>
<td>Thoracoabdominal aortic diameter, mm</td>
<td>24.3 ± 3.2 (18.2–31.1)</td>
</tr>
<tr>
<td>IABP balloon transverse diameter, mm</td>
<td>14.9 ± 0.3 (13.9–15.0)</td>
<td></td>
</tr>
<tr>
<td>Difference in transverse diameter, mm</td>
<td>9.4 ± 3.2 (3.2–16.1)</td>
<td></td>
</tr>
<tr>
<td>Residual aortic lumen &lt;10 mm, %</td>
<td>58.7%</td>
<td></td>
</tr>
<tr>
<td>Residual aortic lumen &lt;5 mm (= flow relevant), %</td>
<td>6.3%</td>
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</table>

**Figure 2.** Transversal CT scan of the abdominal aorta at the level of origin of celiac trunk (a) and renal arteries (b) demonstrating compromise by IABP balloon.

**Discussion**

In the nearly 50 years since the pioneering work of Moulopoulos and Kantrowitz, intraaortic balloon counterpulsation has become a standard assist device of circulatory support for medical and surgical patients. The salutary effects are achieved through a significant reduction of left ventricular afterload and augmentation of coronary and systemic perfusion. Achieving optimal outcomes requires strict adherence to implantation guidelines, a clinical protocol for monitoring of ischemia, and ongoing radiological surveillance to ensure proper balloon position. Despite strict adherence to this protocol, malposition of the IABP balloon detected by CT imaging resulted in visceral artery compromise in up to 97% of patients in our study. Furthermore, nearly 90% of patients had compromise of 2 vessels (TC+ superior mesenteric artery) and nearly 70% had compromise of 3 visceral vessels (TC+ superior mesenteric artery+ renal artery). Even with correct balloon selection and appropriate proximal positioning, the balloon was anatomically too long in nearly 70% of the patients, which we refer to as an anatomic-to-device length mismatch. Furthermore, mismatch with visceral vascular compromise was clinically significant, as evidenced by the need for laparotomy for bowel ischemia in nearly 25%, renal replacement therapy in over 80%, and an overall hospital mortality rate of 60%.
IABP-related vascular complications have been reported in multiple prior studies, with an incidence of 8.7% to 33%.4–12 The spectrum ranges from access site or lower extremity ischemic complications to aortic dissection, vessel perforation, as well as visceral or cerebral ischemia. Arafa et al5 reported major vascular complications in 41 of 509 patients, with the majority (n = 38) having lower extremity ischemia. Meharwal et al12 reported a variety of vascular complications including false aneurysm at the site of catheter insertion, catheterized limb ischemia, ilioaortic dissection, arterial perforation, and renal or abdominal organ ischemia. These complications are poorly tolerated in the critically ill cardiac surgical patient with a low output state and marginal reserve. As a result, multiple strategies have been used to prevent or reduce the incidence of such complications. These include the use of smaller catheters, a sheathless implantation technique, avoiding IABP implantation in patients with heavily calcified aortas, daily roentgenographic examination to confirm balloon position, and serial clinical and laboratory examination for early detection of ischemia.3,6,13–15 Indeed, visceral ischemia in these patients is often multifactorial and can be related to the underlying malperfusion of the low-output state, shower of atheroembolic debris from the aorta, or mechanical obstruction of branch aortic vessels. In contrast to lower extremity ischemia, where careful clinical assessment can lead to early diagnosis and intervention to prevent limb loss, avoiding visceral ischemic complications is predicated on identifying compromise of visceral vessels. The present study demonstrates that such compromise is nearly universal when using standard implantation and positioning criteria and reliance on chest radiography to determine accurate balloon position or clinical examination to detect visceral ischemia can provide a false sense of security.

Regarding the role of imaging for IABP patients, we found that chest radiography alone provides an inaccurate assessment of proximal balloon position. Clearly, additional imaging is required and may involve CT or transesophageal echocardiography. CT is a useful modality to detect not only balloon position but also thoracic aortic calcification. Particularly in elderly patients with clinical coronary artery disease, identification of a heavily calcified aorta would help determine whether IABP is feasible. A recent study by Kim et al16 showed that the aortic knob, which is well established as a radiographic landmark for accurate balloon position, is less useful as marker than a point 2 cm above the carina. Using this point on CT to delineate the proximal landing zone for the balloon enabled accurate positioning of the balloon tip 1.5 to 3.5 cm distal to the left subclavian artery in 95.3% of the patients. However, CT imaging typically requires transport of a critically ill patient out of the ICU setting, with its attendant risks. The use of transesophageal echocardiography, in con-

Table 5. Proximal Balloon Tip in Chest Radiographic Examination Versus Chest CT Scan

| Correct balloon position in chest radiography, % | 96.8 |
| Subclavian artery to proximal balloon tip distance, mm | 50.2 \pm 25.5 (9.7–129) |
| Proximal balloon tip <10 mm distal to subclavian artery, % | 1.6 |
| Proximal balloon tip 10 to 40 mm distal to subclavian artery, % | 38.1 |
| Proximal balloon tip >40 mm distal to subclavian artery, % | 60.3 |
differences. Careful survey of the CT scans revealed aortic length which is influenced by age, sex, and ethnic varying correlation between height and thoracoabdominal with an even higher renal artery compromise. In our current analysis, we basically could confirm these findings was especially common in patients of small stature. In our results of the Benchmark counterpulsation outcomes reg-

As we and others could demonstrate, there is only a varying correlation between height and thoracoabdominal aortic length which is influenced by age, sex, and ethnic differences. Careful survey of the CT scans revealed senile degeneration and sintering of the vertebral bodies in 43% of the patients, which may be contributory to shrinkage of the thoracolumbar backbone and shortening of the longitudinal aortic axis, respectively. Thus, patient height alone appears to be not sufficient to guide for balloon sizing and to avoid anatomic-to-device length mismatch.

beside diastolic hypoperfusion, atherosclerotic embolic debris caused by mechanical interaction between the balloon and the aortic wall may be related to visceral ischemia. Karalis et al studied the prevalence, significance, and embolic potential of intraaortic atherosclerotic debris as detected in 556 patients by transesophageal echocardiography, with 11 of 36 (31%) patients with debris sustaining an embolic event.

With respect to hospital mortality, the incidence of 60% in our series is exceedingly high, but these patients represent only the subset of all IABP patients who required CT scanning. Patients who did not require CT scanning were likely to be healthier and therefore this mortality rate is not representative of the general IABP patient population. Nevertheless, the all-cause in-hospital mortality of patients receiving IABP support remains high and potentially includes a high number of patients with unrecognized visceral organ ischemia. Cohen et al published results of the Benchmark counterpulsation outcomes registry, a prospective registry of all IABP patients at multiple
participating institutions worldwide. They reported an overall mortality rate of 21% in >22,000 patients. This is comparable to our 34.7% overall mortality rate in patients receiving IABP support, when considering that mortality rate strongly depends on the liberality of indication and timing of support.

Limitations

Limitations of the study are the retrospective study design and the restriction to severely ill patients in the IABP population. The cause of our high abdominal and renal complication rate may be a consequence of the IABP malposition but also of the cardiogenic shock substrate in the most of these patients and of requiring vasoconstrictive medication. A prospective analysis of less severely compromised patients should be pursued. However, this study was not designed to report outcomes of IABP support in cardiac surgery patients but rather to report the surprisingly high incidence of anatomic balloon malposition, based on our routine practice and to investigate the underlying reasons. Because IABP-related visceral vascular compromise occurred in nearly all patients, it was not possible to determine whether the incidence of bowel obstruction for mesenteric ischemia and renal failure were statistically significantly different from patients without visceral vascular compromise. However, the overall clinical incidence of mesenteric ischemia, laparotomy, acute renal failure, and mortality in our study population was high. Notably, hospital mortality was considerably higher with this cohort than the overall 34.7% found for our entire IABP patient population during the study period. Because multiple laboratory parameters were abnormal in these critically ill patients suspected of having acute mesenteric ischemia, pulmonary embolism, or aortic dissection, only morphological but not clinical findings can be generalized to the average IABP patient population. In this context, for patients demonstrating signs of distal organ ischemia, our data suggest that earlier CT imaging or abdominal ultrasound or reevaluation of the need for ongoing IABP support may improve clinical outcomes.

Conclusion

In conclusion, intraaortic counterpulsation balloons can mechanically obstruct visceral arterial branches when the balloon is incorrectly positioned, or despite correct position when the balloons are too long for the patient’s body (anatomic-to-device length mismatch). Both events occur frequently in routine practice and can induce diastolic vascular obstruction or debris embolization. Furthermore, too large balloons result in obstructions of distal flow and may further compromise the visceral circulation. CT scan is a helpful tool for detecting low position and to exclude other vascular or organ complications. It may also reveal spine malformations as one reason for an anatomic-to-balloon length mismatch in an aging population. Transesophageal echocardiography may be a better option to gauge accurate proximal balloon tip location than chest radiography, can assess aortic atherosclerosis, and can be performed without transporting the patient out of the ICU. Further work is now needed to clarify the true incidence of balloon malpositioning, to quantify the visceral artery flow reduction, and to redefine anatomic landmarks, particularly in patients with a foreshortened spine. Until such studies are available, we change our IABP strategy (1) to use the smallest suitable balloon size, especially in older patients, (2) to more restrictively consider a prophylactic indication for IABP support, (3) to remove IABP or at least start to reduce augmentation mode as early as possible, and (4) to carefully examine patients for abdominal symptoms and consider early CT scan in patients requiring IABP but demonstrate increasing serum lactate values.

Disclosures
None.

References


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