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Incidence of Overall Bleeding in Patients Treated With Intra-Aortic Balloon Pump During Percutaneous Coronary Intervention

12-Year Milan Experience

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Objectives This study aims to report a "real-world" experience of in hospital complications and clinical outcome of a large cohort of consecutive patients who underwent percutaneous coronary intervention (PCI) with intra-aortic balloon pump counterpulsation (IABP) support, from a tertiary care center over a 12-year period.

Background The incidence of vascular complications in patients treated with PCI and IABP is expected to be higher due to simultaneous puncture of femoral arteries, larger IABP sheath size, and longer duration of IABP therapy.

Methods A total of 360 consecutive patients (mean age of 65.9 ± 11.2 years; 80.6% male) who required an IABP support during percutaneous PCI were classified into 3 groups: Urgent: 133 patients (36.9%) admitted with acute coronary syndrome in whom IABP therapy was started before urgent PCI; Emergent: 56 patients (15.6%) in whom emergent IABP insertion was required to manage hypotension during PCI; and Elective: 171 patients (47.5%) with stable angina pectoris in whom IABP was inserted before elective PCI. Overall bleeding was defined according to the newest the Bleeding Academic Research Consortium (BARC) definition criteria.

Results BARC bleeding occurred in 68 patients (19%), with the highest incidence noted in the Urgent group (31.1%), in comparison with the Emergent (26.8%) and Elective (7%) groups, $p < 0.0001$. Bleeding related to the IABP access site was 7.5%, which accounted for 82% of any access site–related bleeding. It was significantly higher in the Urgent group (12.8%) compared with the Elective (4.1%) and Emergent (5.4%) groups. At multivariate analysis, IABP treatment duration and renal impairment were the only independent predictors of BARC bleeding.

Conclusions Bleeding related to the IABP access site was significantly higher in the Urgent group and accounted for more than two-thirds of overall access site–related bleeding. IABP treatment duration and renal impairment were independent predictors of overall bleeding. (J Am Coll Cardiol Intv 2012;5:350–7) © 2012 by the American College of Cardiology Foundation

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Since the introduction of the intra-aortic balloon pump (IABP) in 1968 (1) to provide hemodynamic stability for the critically ill patient, a large volume of data has been published. In current practice, IABP support is most often required in the following clinical scenarios: 1) to provide hemodynamic support in patients admitted with cardiogenic shock (2); 2) in case of unexpected hypotension during complex percutaneous coronary intervention (PCI); and 3) electively to prevent hemodynamic deterioration during complex and high-risk PCI.

However, despite recent advances in revascularization therapy, medical therapy, and mechanical support with an IABP, in-hospital mortality rates remain high in patients with cardiogenic shock (3). The incremental increase in bleeding complications was reported to be about 3.9% in patients with acute coronary syndrome, 6.7% if glycoprotein (GP) IIb/IIIa inhibitors were used, and 18.2% when IABP was inserted (4). The incidence of vascular complications in patients treated with PCI and IABP is expected to be higher due to simultaneous puncture of femoral arteries, larger IABP sheath size, and longer duration of IABP therapy (5,6). In addition, IABP therapy during and after PCI requires the concomitant administration of antithrombin and antiplatelet agents, which increases the risk of bleeding in an already high-risk patient population. Recently, it has been reported that prophylactic usage of an IABP before high-risk PCI confers no advantage, and should be reserved only for cases associated with acute hemodynamic deterioration (7). We aim to report a "real-world" experience of in-hospital complications and clinical outcomes of a large cohort of consecutive patients who underwent PCI with IABP, from a tertiary care center over a 12-year period.

Methods

Study population. A retrospective analysis of the consecutive patients' case files of those requiring IABP support during PCI in the last 12 years in the Interventional Cardiology Unit of San Raffaele hospital in Milan was performed. Patients were classified into 3 groups according to the indication for IABP insertion: Urgent group: IABP treatment was started before urgent PCI in patients admitted with acute coronary syndrome; Emergent group: IABP inserted during PCI to manage hemodynamic acute deterioration; Elective group: IABP inserted before elective high-risk PCI in patients with stable angina pectoris (e.g., left main or multivessel disease PCI in patients with low ejection fraction, PCI in a single remaining vessel, and so on). IABP insertion was performed in the catheterization laboratory by an experienced interventional cardiologist. In each case, an 8-F IABP catheter (Datascope Corporation, Fairfield, New Jersey) was placed percutaneously from a femoral artery. When IABP was placed after PCI through the same access site, patients were excluded from the final analysis. Balloon counterpulsation was either initiated before or during PCI. The duration of IABP treatment after PCI was dependent on hemodynamic stability, and removal was at the discretion of the physician.

All patients received anticoagulation therapy during the PCI procedure, and subsequent therapy was determined by the clinical status and physician discretion. Most patients (98.3%) received dual antiplatelet therapy (aspirin 325 mg/day and either the thienopyridine ticlopidine 250 mg twice a day, or clopidogrel 300- or 600-mg loading dose followed by 75 mg/day as maintenance therapy).

Study endpoints. The study endpoints were the incidence of in-hospital complications, such as: 1) bleeding and limb ischemia; 2) death from any cause; and 3) a combined endpoint of complications 1 and 2.

Definitions. Death from any cause was defined as any in-hospital death during treatment with, or after, removal of the IABP. Cardiogenic shock was defined as a systolic blood pressure lower than 90 mm Hg secondary to cardiac dysfunction with the clinical signs of hypoperfusion (oliguria, cold extremities, altered mental status). Acute coronary syndrome was defined as unstable angina pectoris or acute myocardial infarction (ST-segment elevation myocardial infarction or non–ST-segment elevation myocardial infarction as defined by an elevation in serum creatine kinase of >3 times the upper limit of the normal laboratory value).

Abbreviations and Acronyms

BARC = Bleeding Academic Research Consortium
CI = confidence interval
EF = ejection fraction
GP = glycoprotein
IABP = intra-aortic balloon pump
IQR = interquartile range
OR = odds ratio
PCI = percutaneous coronary intervention

Overall bleeding was defined according to the newest Bleeding Academic Research Consortium (BARC) definition criteria (8). Bleeding was then classified as access site or nonaccess site bleeding. Bleeding at the access site was defined by the presence of hemorrhage at the femoral artery puncture site either for IABP or for PCI; nonaccess site bleeding was defined as the presence of a lesion in the gastrointestinal, genitourinary tract (e.g., stomach ulcer, melena, macrohematuria), or where the cause could not be identified. Limb ischemia was defined as thrombosis associated with IABP treatment, requiring removal of the IABP and surgical intervention. The combined endpoint included a composite of death, bleeding, and limb ischemia. All events were recorded from baseline (the day of IABP insertion) until discharge from the hospital.

Statistical analysis. Continuous results are reported as mean ± SD or as the median and interquartile range (IQR) (range from 25th to the 75th percentile) where appropriate. Categorical data are presented as counts and percentages. The Kolmogorov-Smirnov test was applied to test whether the

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Table 1. Baseline Clinical Characteristics

	Overall (n = 360)	Urgent Group (n = 133)	Emergent Group (n = 56)	Elective Group (n = 171)	p Value
Age, yrs	65.9 ± 11.2 [30–94]	65.1 ± 12	66.5 ± 9.9	66.3 ± 10.7	0.605
Male	290 (80.6)	96 (72.7)	45 (80.4)	148 (86.5)	0.011
Weight, kg	76.4 ± 13.3	73.8 ± 12.7	76.2 ± 13.3	77.6 ± 11.4	0.054
Previous revascularization	128 (35.6)	28 (21.2)	25 (45.5)	73 (42.7)	<0.0001
Previous myocardial infarction	182 (50.7)	38 (28.8)	37 (66.1)	106 (62.4)	<0.0001
Previous stroke	25 (7)	11 (8.4)	1 (1.8)	13 (7.7)	0.250
Peripheral vascular disease	79 (22.1)	26 (20)	10 (17.9)	43 (25.4)	0.375
Diabetes	126 (35.4)	42 (32)	18 (32.7)	66 (38.6)	0.472
Cardiogenic shock	99 (27.5)	99 (74.4)	–	–	–
Acute coronary syndrome	143 (39.7)	133 (100)	10 (17.9)	–	<0.0001
Stable angina pectoris	217 (60.3)	–	46 (82.1)	171 (100)	<0.0001
Creatinine, mg/dl	1.3 ± 0.96	1.41 ± 1.14	1.23 ± 0.9	1.23 ± 0.8	0.241
Renal impairment*	82 (23.2)	40 (30.2)	11 (19.6)	31 (18.1)	0.013
INR	1.15 ± 0.32	1.27 ± 0.44	1.14 ± 0.33	1.06 ± 0.14	<0.0001
Hb, g/dl	13.6 ± 1.9	13.3 ± 2.1	13.6 ± 1.8	13.9 ± 1.8	0.022
Ejection fraction, %	37.7 ± 13.2	32.4 ± 10.4	42.8 ± 12.3	40 ± 13.9	<0.0001

Values are mean ± SD [nterquartile range], n (%), or mean ± SD. *Renal impairment was defined by a serum creatinine concentration of ≥1.4 mg/dl.
Hb = hemoglobin; INR = International Normalized Ratio.

data were not normally distributed. Demographic, clinical, and procedural variables were compared between patients with and without complications using the Student *t* test, chi-square, or Fisher exact tests when appropriate. Fisher exact test was used when any expected cell count was <5 (not resulting from missing rows or columns in a larger table): for parametric data, the 1-way analysis of variance was used to test the hypothesis that multiple continuous results comparison are equal (more than 2 groups analysis). The Kruskal-Wallis test was used as the nonparametric alternative to analysis of variance. Levene's test was used to test homogeneity of variance, and the Bonferroni test was performed as post-hoc range test. Multivariable logistic regression analysis was performed to assess the independent association between potential risk factors and occurrence of overall in-hospital bleeding. Variables that appeared imbalanced by univariate analysis in patients with and without complications, indicated by p value <0.1 were included in the multivariable model. To avoid overfitting, the number of independent variables entered into the final multivariable model was limited to a maximum of 1 for every 10 events. Results of the logistic regression model are presented as the odds ratio (OR) and the 95% confidence interval (CI). The discrimination and calibration ability of the final multivariable logistic model was assessed by means of the C-statistic and the Hosmer-Lemeshow

Table 2. IABP-Related Procedural Characteristics

	Total Population (N = 360)	Urgent Group (n = 133)	Emergent Group (n = 56)	Elective Group (n = 171)	p Value
IABP treatment, h	3.0 (2.0–22.5)	24 (8–48)	9 (2.25–23.75)	2 (2)	<0.0001
Removal of IABP immediately after PCI	179 (49.9)	14 (10.5)	15 (26.8)	150 (87.7)	<0.0001
Closure devices	14 (3.9)	—	2 (3.6)	12 (7)	0.007
Thienopyridine	354 (98.3)	130 (97.7)	55 (98.2)	169 (99.4)	0.451
GP IIb/IIIa receptor inhibitors	199 (55.3)	95 (71.4)	34 (60.7)	70 (40.9)	<0.0001
Heparin	286 (79.4%)	83 (62.4)	43 (76.8)	160 (93.6)	<0.0001
Low-molecular-weight heparin	10 (2.8)	7 (29.3)	1 (1.8)	2 (1.2)	0.093
Bivalirudin	15 (4.2)	4 (3)	4 (7.1)	7 (4.1)	0.432
Dicumarol	5 (1.5)	3 (2.3)	1 (1.8)	1 (0.6)	0.441
Thrombolytic drug	6 (1.7)	4 (3)	2 (3.6)	—	0.611
No antithrombin agent	49 (13.6)	39 (29.3)	8 (14.3)	2 (1.2)	<0.0001
In-hospital stay, days	5 (2–11)	9 (5–15.5)	6 (4–12)	3 (2–5)	<0.0001

Values are median (interquartile range) or n (%).
GP = glycoprotein; IABP = intra-aortic balloon pump; PCI = percutaneous coronary intervention.

Table 3. Clinical Endpoints

	Total Population (N = 360)	Urgent Group (n = 133)	Emergent Group (n = 56)	Elective Group (n = 171)	p Value
Death	46 (12.8)	40 (30.1)	5 (8.9)	1 (0.6)	<0.0001
BARC bleeding	68 (19.0)	41 (30.8)	15 (26.8)	12 (7.0)	<0.0001
Access site bleeding	33 (9.2)	21 (15.8)	3 (5.4)	9 (5.3)	0.04
IABP access site bleeding	27 (7.5)	17 (12.8)	3 (5.4)	7 (4.1)	0.014
PCI access site bleeding	11 (3.1)	6 (4.5)	1 (1.8)	4 (2.3)	0.461
Nonaccess site bleeding	41 (11.4)	26 (19.5)	12 (21.4)	3 (1.8)	<0.0001
Blood transfusion	36 (10.0)	25 (18.8)	6 (10.7)	5 (2.9)	<0.0001
Limb ischemia	7 (1.9)	6 (4.5)	—	1 (0.6)	0.025
Combined endpoint	104 (29.1)	71 (53.4)	19 (33.9)	14 (8.2)	<0.0001

Values are n (%).
BARC = Bleeding Academic Research Consortium; other abbreviations as in Table 2.

statistic. A 2-sided p value <0.05 was considered significant. Calculations were performed with SPSS version 16.0 (IBM, Armonk, New York).

Results

Between January 1998 and July 2010, 360 of 18,813 patients who underwent PCI required IABP support (0.2%). Of these, 133 patients (36.9%) required IABP insertion for an urgent indication, 56 (15.6%) for an emergent indication, and the remaining 171 (47.5%) for an elective indication. Baseline clinical characteristics are shown in Table 1. Cardiogenic shock was present in most patients in the Urgent group (74.4%). Renal impairment and a lower left ventricular ejection fraction (EF) were more common in the Urgent group (30.2%; EF: 32.4 ± 10.4%, respectively) than in the Emergent (19.6%; EF: 42.8 ± 12.3%) and Elective (18.1%; EF: 40 ± 13.9%) groups, p = 0.013. IABP-related procedural characteristics are shown in Table 2. IABP treatment duration was significantly longer in patients with cardiogenic shock in the Urgent group (median 27 h; IQR: 2 to 472 h) compared with the Emergent (median 9 h; IQR: 2.25 to 23.75 h) and Elective (median 2 h; IQR: 2 to 2 h) groups, p < 0.0001. In 49 (13.6%) of 360 patients, no antithrombin agent for IABP-related treatment was given. The high risk of bleeding or on-going bleeding was a cause to discontinue antithrombin agents in 21 of 49 patients (42.9%): 18 patients (13.5%) in the Urgent group, 2 (3.6%) in the Emergent group, and 1 (0.6%) in the Elective group; p < 0.0001. A GP IIb/IIIa receptor inhibitor was used more frequently in the Urgent group (71.4%) than in the Emergent (60.7%) or Elective (41%) groups, p < 0.0001.

Clinical endpoints. Clinical endpoints are summarized in Table 3 and Figure 1.

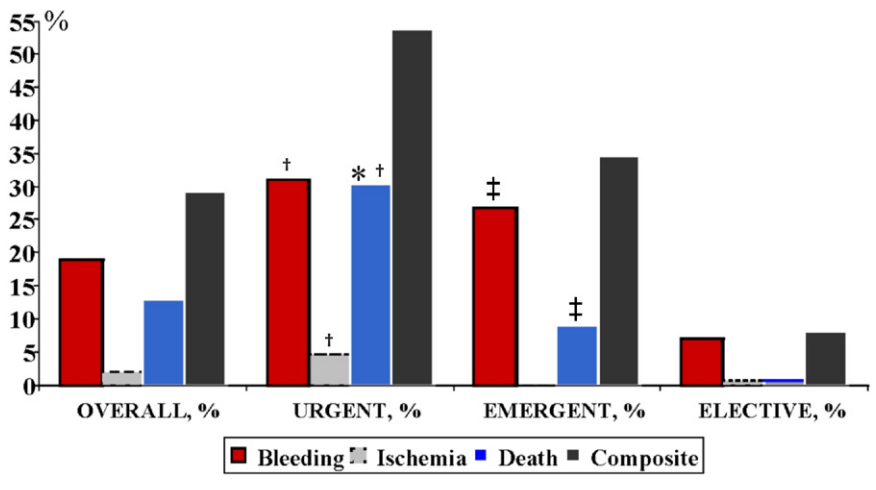

Figure 1. Clinical Outcome

*p = 0.013, Urgent versus Emergent group; †p = 0.046, Urgent versus Elective; and ‡p = 0.001, Emergent versus Elective group.

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Bleeding events. BARC bleeding occurred in 68 patients (19%): type 3a bleeding in 37 cases (10.3%); type 3b in 29 (8.1%); type 5a in 1 (0.3%); and type 5b in 1 case (0.3%). The highest incidence was noted in the Urgent (30.8%) and Emergent (26.8%) groups compared with the Elective group (7%), $p < 0.0001$, (Table 3, Fig. 1); 33.3% of patients with cardiogenic shock had a bleeding complication (33 of 99 patients), which accounted for 80.5% of all bleeding events in the Urgent group.

Access site–related bleeding was noted in 33 patients (9.2%): 21 in the Urgent (15.8%), 3 in the Emergent (5.4%), and 9 in the Elective (5.3%) group (p value reported in Table 3). Of these 33 patients, pseudoaneurysm at the access site occurred in 7 patients, 1 of which required acute surgical intervention. In 1 patient, an arteriovenous fistula was noted, and elective surgical repair was planned.

IABP access site–related bleeding was noted in 27 patients (7.5%) and accounted for 82% of overall bleeding at the access site (Fig. 2). The highest incidence of IABP-related bleeding occurred in patients in the Urgent group (12.8%) compared with the Elective (4.1%, p = 0.005) and Emergent (5.4%, p = NS) groups (Fig. 3). The lowest incidence occurred in the Elective group when the IABP was removed immediately after the PCI procedure (3.5%).

Of the 68 patients with a bleeding complication, 36 required blood transfusion (52.9%). Blood transfusion was required for bleeding in 69.7% of patients with cardiogenic shock and in 33.3% in the presence of access site–related bleeding. The incidence of bleeding at the IABP access site requiring blood transfusion was 6.8% in the Urgent group and 1.8% in the Elective group.

All acute vascular thrombosis requiring vascular surgery occurred at the IABP access site (n = 7, 1.9%). Most of these (85.7%) involved Urgent patients.

Death. Forty-six patients (12.8%) died during the hospital stay after a median of 5.5 days (IQR: 2 to 16.25 days) (Table 3, Fig. 1). The incidence of death was higher in the Urgent (30.3%) compared with the Emergent (9.1%) and Elective (0.6%) groups, $p < 0.0001$. The highest incidence of death occurred in patients admitted with cardiogenic shock

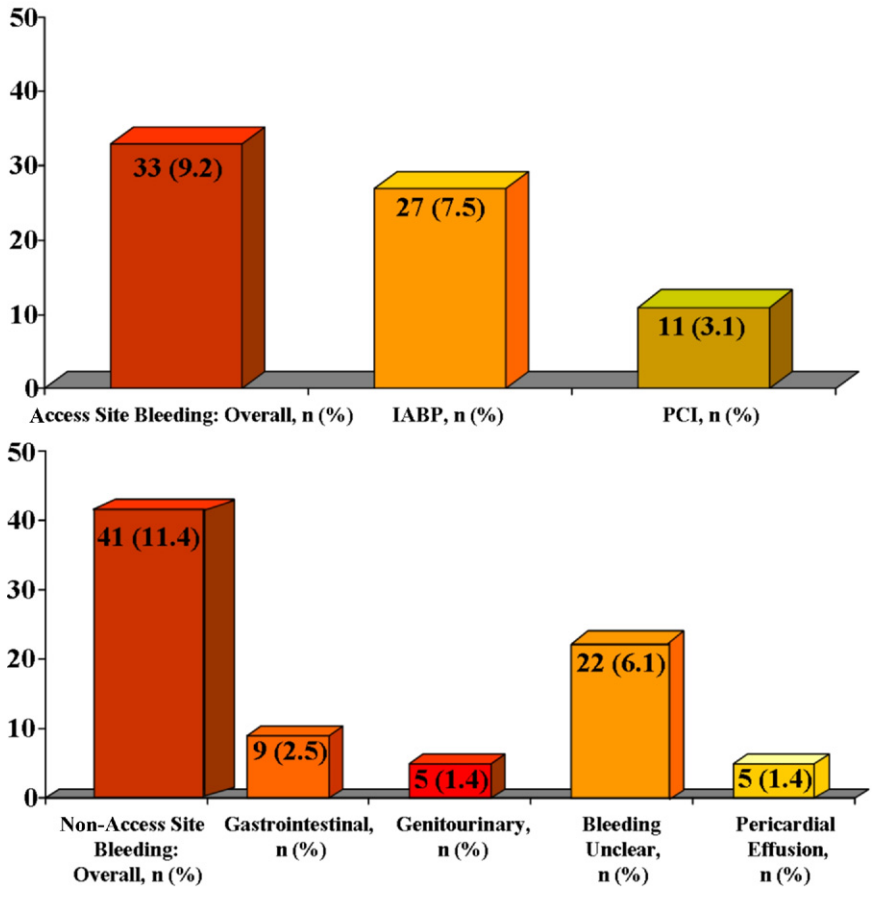

Figure 2. BARC Bleeding Events Related to the Access and Nonaccess Sites

BARC = Bleeding Academic Research Consortium; IABP = intra-aortic balloon pump; PCI = percutaneous coronary intervention.

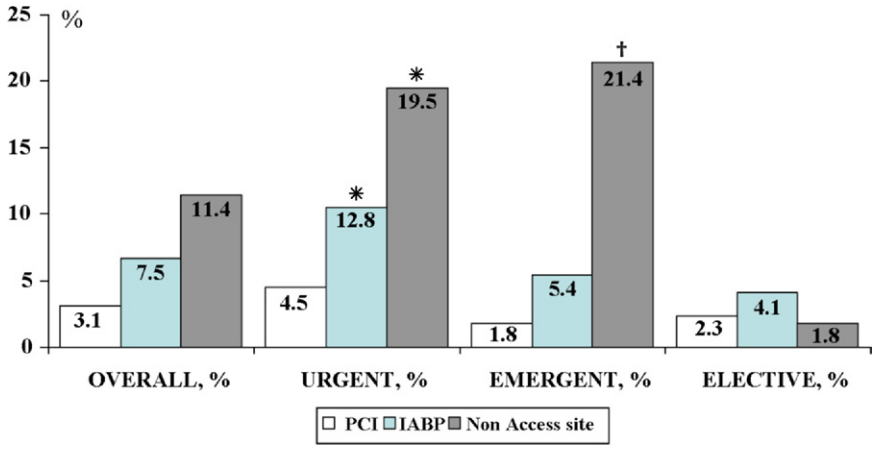

Figure 3. BARC Bleeding According to Location

*p = 0.005, Urgent versus Elective group; †p = 0.0001, Emergent versus Elective group. Abbreviations as in Figure 2.

(36.4%). Death caused by complications related to arterial access occurred in 6 patients (1.7%): acute thrombosis of the IABP access site artery was noted in 3 patients and of both iliac arteries in 1 patient; retroperitoneal bleeding caused by insertion of an extracorporeal membrane oxygenator occurred in 1 patient; amputation of the limb below the knee occurred at 1 month post-IABP removal in 1 patient. All these patients presented with cardiogenic shock.

Combined endpoint. The combined endpoint was detected in 104 patients (29.1%) and was significantly higher in the Urgent group (53.8%) compared with the Emergent (34.5%) and Elective (8.2%) groups, $p < 0.0001$.

Predictors of BARC bleeding. Multivariate logistic regression analysis (Table 4) revealed that independent predictors of BARC bleeding were IABP treatment duration (adjusted OR: 1.015/h; 95% CI: 1.005 to 1.024; $p = 0.002$) and renal impairment (adjusted OR: 1.893; 95% CI: 1.004 to 3.573; $p = 0.049$). Having an IABP inserted electively was found to be a negative predictor of BARC bleeding (adjusted OR: 0.273; 95% CI: 0.115 to 0.648; $p = 0.003$).

Discussion

The principal findings of this study are: 1) the incidence of overall bleeding, limb ischemia, and mortality in patients requiring IABP support before or during PCI was 19%, 1.9%, and 12.8%, respectively; 2) IABP access site–related bleeding occurred in 7.5% of patients, with the highest

Table 4. Predictors of BARC Bleeding

	Present (n = 68)	Not Present (n = 292)	Univariate OR (95% CI)	p Value	Multivariate OR (95% CI)	p Value
Age, yrs	67.2 ± 10.5	65.6 ± 11.3	1.012 (0.988–1.037)	0.321		
Male*	49 (72.1)	241 (82.5)	0.546 (0.297–1.004)	0.052	0.656 (0.301–1.429)	0.289
Weight, kg	73.4 ± 11.9	76.7 ± 12.3	0.977 (0.954–1.001)	0.060		
Previous myocardial infarction	27 (40.3)	155 (53.1)	0.597 (0.348–1.023)	0.061		
Previous revascularization	21 (30.9)	107 (36.6)	0.773 (0.438–1.362)	0.371		
Diabetes	20 (29.4)	106 (37)	0.723 (0.407–1.284)	0.267		
IABP treatment, h	23.5 (4.6–49.5)	2 (2–15)	1.017 (1.010–1.025)	<0.0001	1.010 (1.003–1.018)	0.007
Left ventricular ejection fraction, %	35.6 ± 12.7	38.2 ± 13	0.985 (0.964–1.007)	0.177		
Urgent group	41 (60.3)	92 (31.5)	3.301 (1.914–5.693)	<0.0001	0.851 (0.406–1.784)	0.669
Emergent group	15 (22.1)	41 (14)	1.733 (0.894–3.357)	0.100		
Elective group	12 (17.6)	159 (54.5)	0.179 (0.092–0.348)	<0.0001	0.273 (0.115–0.648)	0.003
Hb, g/dl	13.4 ± 2.2	13.7 ± 1.8	0.915 (0.797–1.050)	0.205		
Renal impairment	24 (35.3)	58 (20)	2.201 (1.239–3.909)	0.006	1.893 (1.004–3.573)	0.049
GP IIb/IIIa inhibitors	49 (72.1)	150 (51)	2.441 (1.371–4.349)	0.002	1.675 (0.894–3.138)	0.107

Values are mean ± SD, n (%), or median (interquartile range). On multivariate analysis, the Hosmer-Lemeshow goodness of fit test p = 0.746; C-statistic = 0.755. *n = 290.
CI = confidence interval; OR = odds ratio; other abbreviations as in Tables 1, 2, and 3.

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incidence noted in the Urgent group (12.8%); 3) the highest complication rate occurred in the Urgent group (53.4%) and was mainly driven by the presence of cardiogenic shock; and 4) IABP treatment duration and renal impairment were the only independent predictors of overall bleeding.

The present study shows that the frequency of overall bleeding in patients with IABP undergoing PCI was higher in the presence of acute coronary syndrome (30.8%, Urgent group) and after emergent IABP placement to treat hypotension occurring during PCI (26.8%). The 30.8% incidence of bleeding in Urgent patients is consistent with previous reports, which showed overall bleeding rates of 23% to 27% (9–11). However, it is higher than that reported in the GRACE registry (Global Registry of Acute Coronary Events), where the incidence of bleeding was only 18.2% in patients with acute coronary syndrome requiring IABP support (4). This discrepancy may be related to differences in patient's clinical characteristics and to the way in which bleeding was defined. We observed that the incidence of overall bleeding was significantly higher after emergency IABP insertion compared with elective insertion (26.8% vs. 7%, respectively), most likely related to the greater use of GP IIb/IIIa agents (60.7% vs. 40.9%, respectively) and longer duration of IABP support (median 9 vs. 2 h, respectively). It is also noteworthy that bleeding at nonaccess sites contributed significantly to this difference (21.4% at nonaccess sites compared with only 1.8% at access sites). The fact that the Elective group was a negative predictor for overall bleeding complications might be explained by a number of clinical and procedural characteristics: lower usage of GP IIb/IIIa agents; fewer patients with renal impairment; and the early removal of the IABP immediately after PCI in 87% of patients. The present study found 2 significant independent predictors for overall bleeding: 1) renal impairment (OR: 1.893), which again is consistent with reports in the literature (12); and 2) the duration of IABP treatment (OR: 1.010). IABP treatment requires continuous systemic anticoagulation, which can potentially increase the risk of vascular complications, especially if required for >48 h (13).

In contrast to the previous data reported by Cohen et al. (14), we did not find that peripheral vascular disease was an independent predictor for overall bleeding complications. This discrepancy is most likely related to differences in patient selection (>50% of our patients were treated for stable angina instead of myocardial infarction) and in the definitions used for vascular complications and bleeding between the 2 studies.

This study provides additional and important information on the relationship between IABP use and the risk of bleeding, in the spectrum of IABP utilization during PCI procedures. The highest bleeding rate at the IABP access site occurred in the Urgent group (12.8%) in whom the median duration of treatment was 24 h. Not surprisingly, the lowest incidence of IABP access site bleeding occurred in patients in the Elective group (3.5%), where the IABP was removed immediately after PCI.

In our patient cohort, the occurrence of access site–related death was low (1.4%). We found that limb ischemia caused by IABP insertion in the presence of cardiogenic shock, and requiring surgical intervention, impacted significantly on hospital survival. Indeed, it has previously been reported that although limb ischemia following IABP use is an uncommon complication, occurring with an incidence of 0.5% to 5% (14,15), it has an adverse effect on overall prognosis (16). Again, consistent with previous reports (12), the highest incidence of in-hospital death in our study occurred in patients with cardiogenic shock (36.4%). Furthermore, the mortality rate in patients with cardiogenic shock occurring unexpectedly during PCI remains high, at 9.1%, in our study. With mortality reported at up to 29% in other studies (17), this should be considered a malignant scenario.

Several important aspects can be considered to reduce the rate of bleeding complications in patients requiring IABP support during PCI procedures. Certainly, the modification of intraprocedural pharmacotherapy by, for example, replacing unfractionated heparin with newer direct thrombin inhibitors, such as bivalarudin, and by reducing the excessive, and often unnecessary, use of GP IIb/IIIa inhibitors would be an important first step.

In current clinical practice, hemodynamic support provided by IABP remains effective and competitive with other left ventricular assist devices. A previous meta-analysis of controlled trials revealed that in patients with cardiogenic shock, superior hemodynamic improvement can be achieved with percutaneous assist devices than with IABP counterpulsation. However, this advantage did not translate into improved 30-day survival, and patients treated with a percutaneous left ventricular assist device tended to have a higher incidence of leg ischemia and device-related bleeding in comparison with IABP (17).

This study is retrospective, single-center analysis; thus, bias and confounding factors could not be eliminated. However, this study reflects a large single-center report on the "real-world" use of IABP during PCI procedures and may be helpful to evaluate the risk of bleeding and highlight the importance of newer and safer pharmacological and device strategies in this cohort of patients.

Conclusions

This study shows that in patients who required IABP support during PCI, bleeding related to IABP access site occurred in 7.5% of patients and accounted for more than two-thirds of access site–related bleeding. IABP treatment duration and the presence of renal impairment were independent predictors of overall bleeding.

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REFERENCES

1. Kantrowitz A, Tjonneland S, Freed PS, Phillips SJ, Butner AN, Sherman JL. Initial clinical experience with intraaortic balloon pumping in cardiogenic shock. JAMA 1968;203:113–8.
2. Antman EM, Anbe DT, Armstrong PW, et al. ACC/AHA guidelines for the management of patients with ST-elevation myocardial infarction: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the 1999 guidelines for the management of patients with acute myocardial infarction). J Am Coll Cardiol 2004;44:E1–211.
3. Babaev A, Frederick PD, Pasta DJ, et al. Trends in management and outcomes of patients with acute myocardial infarction complicated by cardiogenic shock. JAMA 2005;294:448–54.
4. Moscucci M, Fox KA, Cannon CP, et al. Predictors of major bleeding in acute coronary syndromes: the Global Registry of Acute Coronary Events (GRACE). Eur Heart J 2003;24:1815–23.
5. Patel JJ, Kopisyansky C, Boston B, Kuretu ML, McBride R, Cohen M. Prospective evaluation of complications associated with percutaneous intraaortic balloon counterpulsation. Am J Cardiol 1995;76:1205–7.
6. Sjauw KD, Engström AE, Vis MM, et al. A systematic review and meta-analysis of intra-aortic balloon pump therapy in ST-elevation myocardial infarction: should we change the guidelines? Eur Heart J 2009;30:459–68.
7. Perera D, Stables R, Thomas M, et al. Elective intra-aortic balloon counterpulsation during high-risk percutaneous coronary intervention: a randomized controlled trial. JAMA 2010;304:867–74.
8. Mehran R, Rao SV, Bhatt DL, et al. Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the Bleeding Academic Research Consortium. Circulation 2011;123:2736–47.
9. Vales L, Kanei Y, Ephrem G, Misra D. Intra-aortic balloon pump use and outcomes with current therapies. J Invasive Cardiol 2011;23:116–9.
10. Abdel-Wahab M, Saad M, Kynast J, et al. Comparison of hospital mortality with intra-aortic balloon counterpulsation insertion before versus after primary percutaneous coronary intervention for cardiogenic shock complicating acute myocardial infarction. Am J Cardiol 2010;105:967–71.
11. Rao SV, O'Grady K, Pieper KS, et al. Impact of bleeding severity on clinical outcomes among patients with acute coronary syndromes. Am J Cardiol 2005;96:1200–6.
12. Fuchs S, Kornowski R, Teplitsky I, et al. Major bleeding complicating contemporary primary percutaneous coronary interventions-incidence, predictors, and prognostic implications. Cardiovasc Revasc Med 2009;10:88–93.
13. Scholz KH, Ragab S, von zur Mühlen F, et al. Complications of intra-aortic balloon counterpulsation. The role of catheter size and duration of support in a multivariate analysis of risk. Eur Heart J 1998;19:458–65.
14. Cohen M, Dawson MS, Kopistansky C, McBride R. Sex and other predictors of intra-aortic balloon counterpulsation-related complications: prospective study of 1119 consecutive patients. Am Heart J 2000;139:282–7.
15. Dick P, Mlekusch W, Delle-Karth G, Nikfardjam M, Schillinger M, Heinz G. Decreasing incidence of critical limb ischemia after intra-aortic balloon pump counterpulsation. Angiology 2009;60:235–41.
16. Sirbu H, Busch T, Aleksic I, Friedrich M, Dalichau H. Ischaemic complications with intra-aortic balloon counter-pulsation: incidence and management. Cardiovasc Surg 2000;8:66–71.
17. Cheng JM, den Uil CA, Hoeks SE, et al. Percutaneous left ventricular assist devices vs. intra-aortic balloon pump counterpulsation for treatment of cardiogenic shock: a meta-analysis of controlled trials. Eur Heart J 2009;30:2102–8.

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