Frequency of Abrupt Vessel Closure and Side Branch Occlusion After Percutaneous Coronary Intervention in a 6.5-Year Period (1994 to 2000) at a Single Medical Center

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The aims of this study were to analyze the contemporary trends in the changing incidence of abrupt vessel closure (AVC) after percutaneous coronary intervention (PCI), to determine the impact of intracoronary stenting and glycoprotein IIb/IIIa inhibitors (GPIs) on complication rates and etiologies, and to determine the incidence of side branch occlusion (SBO) as the etiology of AVC in the stent era. Additionally, the evaluation of intracoronary stenting and glycoprotein IIb/IIIa inhibitors (GPIs) on complication rates and etiologies, and to determine the incidence of side branch occlusion (SBO) as the etiology of AVC in the stent era. We evaluated trends in the etiology and clinical outcomes of AVC at a single large academic referral center over a 6.5-year period. The objectives of this study were the following: (1) to analyze the contemporary trends in the changing incidence of AVC after PCI, (2) to determine the impact of intracoronary stenting and GPI on complication rates and etiologies, and (3) to determine the incidence of side branch occlusion (SBO) as the etiology of AVC in the stent era.

Abrupt vessel closure (AVC) is the dramatic complication of percutaneous coronary intervention (PCI) that leads to major adverse consequences, including myocardial infarction, emergency bypass surgery, and death.1,2 The timely recognition and proper management of AVC significantly reduces the incidence of these adverse events. Additionally, the emergence of coronary stenting and glycoprotein IIb/IIIa inhibitors (GPIs)3,4 has substantially decreased the incidence of AVC and facilitated its treatment. We evaluated trends in the etiology and clinical outcomes of AVC at a single large academic referral center over a 6.5-year period. The objectives of this study were the following: (1) to analyze the contemporary trends in the changing incidence of AVC after PCI, (2) to determine the impact of intracoronary stenting and GPI on complication rates and etiologies, and (3) to determine the incidence of side branch occlusion (SBO) as the etiology of AVC in the stent era.

METHODS

Patient population: A prospectively collected, dedicated interventional cardiology database was developed on site that collected over 800 data elements using a PARADOX platform (Borland International, Scotts Valley, California). The data elements were designed to be compatible with the American College of Cardiology-National Cardiovascular Database Registry and Society of Cardiac Angiography and Interventions databases, as well as collecting numerous additional data elements. A definition dictionary serves as a guide for all technical descriptors. All data are entered by the interventional attending and cardiac fellow who review the output routinely as this information is used to produce the catheterization report. Data collected by nurses from the catheterization laboratory for quality assurance purposes are entered into the database. Additionally, the results of the monthly laboratory Quality Assurance meeting are also reviewed, ensuring that all data on patients with evident complications have been analyzed. To ensure data quality, a research nurse annually screens about 10% of all procedures at random, and evaluates all cases where any complication is identified with the patient’s
At Rush-Presbyterian-St. Luke's Medical Center from April 7, 1994 to December 31, 2000, 3,300 PCIs were performed. All cases were recorded in the database without exclusions. To identify all patients who may have had AVC, the database was queried for any periprocedural complication. Using this method, 103 patients with AVC, defined as total luminal occlusion with Thrombolysis In Myocardial Infarction (TIMI) 0 flow angiographically at the target lesion site or side branch, were identified. AVC of a previously totally occluded artery was defined as closure after attainment of TIMI 3 flow during an initially successful dilation. All records and/or case images were reviewed to independently confirm the occurrence, to be absolutely certain that all identified cases had AVC.

**Clinical and procedural end points:** The clinical and procedural variables collected included the incidence and site of AVC, the use of intracoronary stents, the use of GPI, the rate of emergency coronary artery bypass graft surgery, and the incidence of SBO as the etiology of AVC. Each variable collected was also referenced to an annual period. Other clinical variables collected and analyzed included demographic characteristics such as age, gender, history of myocardial infarction, and diabetes mellitus. The clinical setting of the PCI included acute ST-segment elevation myocardial infarction, unstable angina, non-Q-wave myocardial infarction, or chronic stable angina. The various presentations of AVC analyzed included severe and prolonged angina, significant electrocardiographic changes (1 mm of ST-segment elevation or depression), hemodynamic instability (systolic blood pressure <80 mm Hg unresponsive to crystalloid infusion or need for intravenous vasopressor agents), and/or cardiac arrest. The hospital location of initial presentation of AVC included the catheterization laboratory, holding area, or coronary care unit.

**Statistical analysis:** Data are presented as mean ± SD. Linear regression analysis was used to determine the significance of increasing or decreasing trends over time. Pearson’s correlation was used to determine the correlation (r value) between 2 separate trends over time. A p value of <0.05 was considered statistically significant.

**RESULTS**

**Clinical profile:** A total of 103 patients (3.12%) with AVC were identified of 3,300 total PCI cases over a 6.5-year period at this institution. The mean age of patients...
patients who experienced AVC was 64 ± 11 years; 66% were men, 37% had a prior myocardial infarction, and 36% had diabetes, which is not statistically different from the patients who did not have AVC. In patients who experienced AVC, PCI was performed in the clinical setting of acute ST-segment elevation myocardial infarction (16%), unstable angina (56%), and chronic stable angina (28%). AVC occurred in the catheterization laboratory during the procedure (80%), holding area (3%), and coronary care unit (17%). Clinical manifestations of AVC included severe angina (54%), electrocardiographic changes (24%), hypotension (23%), and cardiac arrest (8%).

Annual incidence: Coronary stenting was utilized in 1,231 of the total 3,300 PCIs (37.3%) over the 6.5-year period. There was a significant increase in the use of coronary stents from 0.4% in 1994 to 56.8% in 2000 (Figure 1). Linear regression analysis over this time frame documented a steadily decreasing incidence of AVC from 5.9% in 1994 to 1.1% in 2000 (−0.76 per year, 95% confidence interval −0.99 to 0.52, p <0.001) (Figure 2). Further analysis using Pearson’s correlation showed that the decreasing incidence of AVC was strongly and inversely correlated with the percentage of stents placed over this time period (r = −0.94, p <0.001) (Figure 3).

There was a significant increase in the utilization of GPI of approximately 6% per year from 1994 to 2000 (95% confidence interval 2.4 to 9.4, p = 0.009) (Figure 4). In addition, the increased use of GPI correlated with the decrease in AVC over this same time period (r = −0.90, p = 0.015) by linear regression analysis (Figure 5).

Emergency coronary artery bypass surgery was performed in 23 of the total 3,300 PCIs (0.8%) and in 22.3% of AVC cases (23 of 103). The percentage of bypass surgery remained stable over 6 years (0.77 ± 0.28%/year), and was not correlated with either the use of coronary stenting (r = −0.606, p = 0.2019) or the incidence of AVC (r = 0.582, p = 0.2256) (Table 1).

The absolute rates of SBO did not change over the observed time period, although as a proportion of total AVC, SBO increased from 0% in 1994 to 28% in 2000 (Table 2). This increase in percentage of SBO as etiology of AVC was strongly correlated with the increased use of stenting (r = 0.85, p = 0.015) (Figure 6), using Pearson’s correlation. The in-hospital adverse outcomes associated with patients with SBO included 2 patients with non-Q-wave myocardial infarction (10%). There were no deaths or urgent coronary artery bypass graft surgery in patients with SBO.

**DISCUSSION**

Overall, stenting was utilized in 32.6% of coronary interventions at a rate that has steadily increased from <1% to approximately 60% from 1994 to 2000. This is similar in magnitude to the increasing use of intracoronary stents seen in most medical centers in the United States. The incidence of AVC in this study has decreased linearly over the same time period from 5.9% to 1.1%, and this decrease is strongly correlated with the increased utilization of stenting (r = −0.94, p <0.001) by linear regression analysis. Intracoronary stents have been demonstrated in several trials to be the most effective means of managing established or
threatened AVC with angiographic success rates of ≥90%. The decrease in AVC in current interventional practice may thus in part be a result of the early stent deployment when dissections are first identified, but before the development of acute or threatened closure. One recent trial involving a large number of patients in Canada showed an improved clinical outcome with the widespread use of intracoronary stenting. Other studies have demonstrated a decrease in the frequency of failed interventions requiring urgent surgery with the advent of intracoronary stenting. Although these earlier studies provide valuable information on the impact of stents on subsequent complications, they predate the widespread use of GPI, and provide limited insight into the prevalence of SBO as an etiology of AVC.

Our data revealed a slightly lower overall rate of AVC (3.12%) compared with past studies (4.2% to 8.3%) performed from 1988 to the early 1990s, which is likely due in large part to improved equipment, operator skill, and adjunctive therapy. Importantly, this decrease occurred despite the increasing complexity of coronary lesions seen at our institution. The annual increase in the use GPI of 6% per year from 1995 to 2000 also probably contributed to the decreased rate of acute vessel occlusion (r = −0.90). Activation of the platelet glycoprotein receptor is the final common pathway for platelet aggregation and represents the crucial step in arterial thrombus formation, and inhibition of this pathway with potent GPI has been shown to improve subsequent cardiac events in a variety of interventional settings. Our findings are consistent with previous trials that have demonstrated that GPI use significantly reduces the risk of ischemic complications during low- and high-risk PCIs.

An important observation from our study is that SBO accounted for an increasing percentage of AVC over this same time period. Thus, incidence of SBO, when viewed as a percentage of AVC, has shown an increasing trend over time from 9% in 1995 to 28% of AVC in 2000; this increase is positively correlated with the increased use of stenting (r = 0.85, p = 0.015). These data suggest that the greater use of intracoronary stents coupled with the increasing complexity of coronary interventions, including treatment of bifurcation lesions, may partly explain the increased incidence of SBO as the etiology of AVC seen in our study. This observation has important clinical implications, because if other studies confirm this trend, that an increasing percentage of AVC is due to SBO in the stent era, then future efforts should be directed at side branch vessel protection and preservation. It remains to be seen whether the newer intracoronary stents and devices with improved side branch access will have a favorable impact on the incidence of SBO as the etiology of AVC over time. An alternative, and not necessarily mutually exclusive, explanation for the increasing percentage of AVC due to SBO in the stent era may be that this trend may be mainly a function of the decreasing incidence of AVC during this same 6.5-year time period. Indeed, there appeared to be no increase in the absolute rates of SBO over time, although this may have been due in part to lack of statistical power. Furthermore, the absolute annual incidence of SBO in our study was extremely low. Although this may be related to case selection, this more likely reflects the

<table>
<thead>
<tr>
<th>Year</th>
<th>AVC (n = 103)</th>
<th>Urgent Surgery (n = 23)</th>
<th>Stents (n = 1,231)</th>
<th>Total PCI (n = 3,300)</th>
</tr>
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<tr>
<td>1994</td>
<td>13 (5.9%)</td>
<td>2 (0.9%)</td>
<td>1 (0.4%)</td>
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<tr>
<td>1995</td>
<td>23 (5.2%)</td>
<td>4 (0.6%)</td>
<td>59 (13.5%)</td>
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<tr>
<td>1996</td>
<td>15 (3.3%)</td>
<td>4 (0.8%)</td>
<td>110 (24.3%)</td>
<td>452</td>
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<tr>
<td>1997</td>
<td>18 (3.9%)</td>
<td>5 (1.1%)</td>
<td>162 (35.9)</td>
<td>451</td>
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<tr>
<td>1998</td>
<td>16 (2.9%)</td>
<td>5 (0.9%)</td>
<td>204 (37.1%)</td>
<td>550</td>
</tr>
<tr>
<td>1999</td>
<td>11 (2.0%)</td>
<td>2 (0.3%)</td>
<td>329 (60%)</td>
<td>547</td>
</tr>
<tr>
<td>2000</td>
<td>7 (1.1%)</td>
<td>1 (0.1%)</td>
<td>366 (56.8%)</td>
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<table>
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<tr>
<th>Year</th>
<th>SBO (n = 20)</th>
<th>AVC (n = 103)</th>
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<td>1994</td>
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</tr>
<tr>
<td>1995</td>
<td>2 (9%)</td>
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<td>1999</td>
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<td>11</td>
</tr>
<tr>
<td>2000</td>
<td>2 (28%)</td>
<td>7</td>
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</table>

FIGURE 5. Relation of increased use of GPIs and AVC over time.
limitations inherent in database access of events. To be certain that all patients experiencing transient or established AVC, at the target site or in a side branch, were identified correctly, 16 variables were selected in the database to identify such patients. Although an attempt was made to identify every case of AVC and SBO using this method, the possibility of under-reporting of events cannot entirely be ruled out. Alternatively, the low rate of AVC seen in the present study may also be related in part to our de novo interpretation of events. To foundating effects, and other variables may have influenced our results. The generalizability of our findings is another potential limitation of our study, because it was a single center experiment. Finally, retrospective studies, even using a prospectively collected database, cannot totally eliminate selection and observer bias, and may account, to some degree, for our findings.

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