Cardiovascular Revascularization Medicine 17 (2016) 48–53

Contents lists available at ScienceDirect

Cardiovascular Revascularization Medicine

Coronary bypass graft perforation during percutaneous intervention☆,☆☆

Mohammed Andaleeb Chowdhury, Mujeeb Abdul Sheikh *

Department of Cardiovascular Medicine, University of Toledo, OH, USA

ARTICLE INFO

Article history:
Received 22 September 2015
Received in revised form 6 November 2015
Accepted 19 November 2015

Keywords:
CABG
Graft perforation
Covered stent

Introduction: Coronary artery bypass grafts are prone to accelerated atherosclerosis and as such graft stenosis is frequently encountered in clinical practice. Complications specific to graft- PCI include no-reflow, distal embolization, stent restenosis and thrombosis. Graft perforation during PCI is a rare coomplication of the procedure. Published literature on the predictors of perforation and management strategy remains limited to anecdotal cases.

Method: In this review we collected data on all cases of graft perforations reported in PubMed/Medline from 1987 to 2015.

Result: 37 cases of graft perforation were reported. High risk grafts for perforations included, old grafts (14 ± 7.8 years) with more than 80% luminal stenosis. Perforations were noted after use of different cardiac devices and included stent placement (30%, N=11), balloon angioplasty (36%, N=14), post-dilation with non complaint balloon (16%, N=6), guide wire perforation (1 case), post IVUS imaging (1 case) and one case after use of thrombus extraction device. Average stent diameter of 3.7 ± 0.7 mm, average balloon pressure of 15.5 ± 5 atm and 3 or more balloon inflations commonly resulted in graft perforation.

78% of cases reported class III perforation. Covered stent implantation was strongly associated with controlling acute bleed after graft perforation than prolonged balloon inflation ($p = 0.0001$). Majority of cases reported using covered stents (81%). Average stent diameter of 3.9 ± 0.7 mm, average stent length of 18.5 ± 6 mm and the average deployment pressure of 14 ± 2 atm were reported to be effective in controlling the bleed.

95% of the patients did well post procedure and with prolonged hospitalization (8 ± 4 days). 24% of cases reported cardiac tamponade causing hemodynamic compromise including 2 peri-procedural deaths.

Conclusion: Graft perforation can be effectively treated with covered stent grafts with good immediate results, short term outcome and acceptable peri-procedural risks.

1. Introduction

Coronary artery bypass graft surgery (CABG) for the treatment severe symptomatic coronary artery disease involves use of saphenous vein, radial artery or internal mamamary artery as conduits to supply blood to myocardium. Saphenous venous grafts (SVGs) are prone to degenerative atherosclerosis and eventually resulting late graft failure. Majority of symptomatic graft stenosis encountered in clinical practice are treated with percutaneous intervention (PCI) than repeat CABG to avoid risks of surgery; redo CABG has a mortality rate of 3%–7%, a peri-operative myocardial infarction rate of 3%–11% and less symptomatic benefit compared with the initial operation [1]. However, increased utilization PCI of diseased graft increases the risk of graft perforation which fortunately is a rare but a life threatening emergency. The incidence of native coronary perforation is about 0.2%–0.6% [2]. Although predictors of native artery perforation have been well studied and can result from wire, use of adjunct devices during PCI including rotational atherectomy, intravascular ultrasound, intervention on chronic total occluded vessel and calcific lesions. These adjunct devices often times avoided in vein graft interventions and hence predictors remain unknown coronary [3]. Vessel perforations can result in life threatening cardiac tamponade, extensive hemorrhage, cardiogenic shock, cardiac arrest and vessel occlusion [4]. Almost 50% of patients with perforation experience a major complication requiring emergency intervention, such as pericardiocentesis or emergent bypass surgery [5]. The current treatment strategies include prolonged balloon inflation and reversal of anticoagulation, covering the perforated area with a covered stent, placing an uncovered stent within the first stent [6], an autologous vein covered stent [7] or conservative management.

At present, the current data in literature on graft perforations are limited to a number of case reports and the predictive factors

Abbreviations: SVG, saphenous venous graft; LIMA, left internal mammary artery; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention.

☆ Conflict of interest: None.

☆☆ Disclosure: None.

* Corresponding author at: Division of Cardiovascular Medicine, University of Toledo Medical Center, 3000 Arlington Avenue, Toledo, OH 43614.
E-mail address: Mujeeb.sheikh@utoledo.edu (M.A. Sheikh).

http://dx.doi.org/10.1016/j.carrev.2015.11.004
1553-8389/

responsible for vessel perforation have not been validated. Moreover, the success rates of different treatment strategies have not been evaluated and at present no definitive guidelines state the optimum management strategy in such circumstances.

In this review we intend to identify factors contributing to graft perforations and also compare the efficacy of commonly reported management strategies.

2. Method

We performed a retrospective review of all cases of graft perforations published in PubMed/Medline from 1987 to 2015. We used the MESH words: "Graft perforation AND stent" in PubMed and included all case reports and studies pertaining to the topic. We collected a total of 25 case reports and included data from a case series involving 12 patients. Therefore, we had data on a total of 37 cases of graft perforations. We excluded studies in foreign language or those not translated into English.

We reviewed the case reports in terms of patient demographics, presenting symptoms, graft age, perforation classification, nature of the intervention resulting in perforation, the type of stents or balloons used for treatment and the short term outcomes.

3. Results

3.1. Baseline characteristics

37 cases of graft perforation were reported in literature from 1987 to 2015; 11% (n = 4) reported left internal mammary artery (LIMA) graft perforation and 89% (n = 33) reported saphenous venous graft (SVG) perforation. Average age of the patients was 69 years ± 9.5 years with a male: female ratio of 3:1. Majority of patients underwent PCI for unstable angina (35%, n = 10 out of 29) and stable angina (31%, n = 9 out of 29), non ST elevation myocardial infarction (24%, n = 7 out of 29) and ST elevation myocardial infarction (11%, n = 3 out of 29). The average time from CABG to the time patient develops symptomatic graft stenosis was 14 ± 7.8 years for SVG and around 4 days for LIMA grafts. There were not enough data to compare the influence of co-morbid conditions such hypertension, diabetes or kidney disease on graft perforations.

3.2. Angiogram findings

Commonly reported perforated vessels were grafts to right coronary artery (RCA) (29%, n = 7 out of 24) and left anterior descending artery (LAD) (25%, n = 6 out of 24). These vessels commonly had severe stenosis, usually more than 80% (83%, n = 15 out of 18) in the mid-portion of the graft (61%, n = 11 out of 18). Moreover, patients with reported graft perforations were seen to have extensive coronary artery disease since majority of them already had 3 or more co-existing grafts (n = 67%, n = 10 out of 15).

3.3. Procedure

Perforations were most commonly seen after stent placement (30%, n = 11) and after pre-dilation with balloon followed by stent placement (21%, n = 8). Among balloon angioplasty; which included a case of cutting balloon angioplasty (16%, n = 6) and post-dilation with balloon after stent placement (16%, n = 6). There were 2 cases of perforation from catheter placement (5%); one of which was after trans-luminal thrombus extraction catheter device insertion. In addition, there was one case of guide wire perforation (3%), one case following diagnostic angiogram (3%), and another following intravascular ultrasonography (3%) (Fig. 1) (Table 1).

Graft perforation was most commonly associated with stents with an average diameter of 3.7 ± 0.7 mm, an average length of 17.5 ± 7 mm and an average deployment pressure of 14 ± 3 atm (atmospheres). No association between the type of stent and perforation could be established. The average size of balloons involved in perforation was 3.18 ± 0.8 mm and the average inflation pressure was reported to be 15.5 ± 5 atm. Repeated balloon dilation was another common cause of perforation and the risk increased after three or more dilations. Again there was no clear association between the type of balloon and graft perforations.

3.4. Graft perforation

The majority of patients had Ellis class III perforation [2] (78%, n = 28 out of 36) including 6 cases of class III with cavity spilling, 19% (n = 7 out of 36) reported Ellis Class II perforation and 3% (n = 1 out of 36) reported Ellis Class I perforation.

3.5. Management

The reported management strategy (Fig. 2) for graft perforation included stent implantation (n = 19, 54%), prolonged balloon inflation followed by stent implantation (n = 7, 20%), conservative management (n = 5, 14%), prolonged balloon inflation only (n = 2, 6%) and surgery (n = 2, 6%) (Fig. 2) (Table 1).

Post perforation prolonged balloon dilation was the most common initial strategy (n = 9); the average pressure applied was 6 ± 2 atmospheres and the average duration pressure was applied for was 22.5 ± 21 minutes. However, only 2 cases reported successful control of the bleed; therefore prolonged balloon inflation had a success rate of 22% (n = 2 out of 9), while stent implantation controlled the bleed in 96% of the cases (n = 25 out of 26). Therefore, stent implantation was strongly associated with successful control of bleed after graft perforation compared to prolonged balloon inflation (p = 0.0001).

Majority of cases reported using covered stents (81%, n = 21 out of 26), 3 cases reported using regular stents (11%) and 2 cases reported using mounted stents (8%). The stent dimensions mainly depended diameter of graft; the average stent diameter was 3.9 ± 0.7 mm, the average stent length was 18.5 ± 6 mm and the average deployment pressure was 14 ± 2 atm. Jomed covered stent graft (Jomed International AB, Helsingborg, Sweden) was the most common covered stent used in the management of perforations, only one case reported using Symbiot covered stent (Boston Scientific, Natick, MA).

Reversal of anticoagulation was attempted as an adjuvant therapy and its use depended more on the operator's preference. 10 cases reported using protamine, 1 case reported using dextran and 1 case reported using Bivalirudin. No cases of heparin use were reported.

3.6. Outcome

Out of the 37 cases of reported graft perforation only 2 cases of death were reported. Therefore, in our review graft perforation had a mortality rate of 5.4%. Hemodynamic compromise due to cardiac tamponade was reported in 9 patients (24%) out of which 2 patients needed surgery, 2 patients were treated with stent implantation, 2 patients were treated conservatively, 2 patients died and only 1 patient had pericardiocentesis. 3 cases of pericardial effusion (8%) were reported out of which 2 cases had localized pericardial effusion. One of the localized pericardial effusion required surgery while the other one was managed conservatively. The remaining case of pericardial effusion underwent pericardiocentesis.

Majority of patients survived after graft perforation (95%) and were eventually discharged. Average time to discharge after perforation was 8 ± 4 days. *A case series reported follow up details on 7 patients, which showed total occlusion of the treated SVG graft in 5 patients and significant restenosis in 2 patients.*