Original Article

Effect of Transcatheter Embolization by Autologous Fat Particles in the Treatment of Coronary Artery Perforation During Percutaneous Coronary Intervention

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Abstract

Background: Coronary artery perforation (CAP) is a rare but severe complication of percutaneous coronary intervention (PCI). The aim of our study was to evaluate the effect and safety of transcatheter embolization by autologous fat particles in the treatment of CAP.
Methods: Once the CAP was confirmed, a little autologous subcutaneous fatty tissue was obtained from the groin of the patient and then was made into 1 mm × 1 mm fat particles. The perforated vessel was embolized by fat particles via a micro-catheter. There were eight patients undergoing transcatheter embolization by autologous fat particles in the treatment of CAP during PCI in Peking University Third Hospital from February 2009 to June 2014, and the clinical data of these patients were collected and analyzed retrospectively.
Results: The lesion morphology of the patients was classified based on the American College of Cardiology/American Heart Association Task Force classification, there were one patient with Class B2 lesion and seven patients with Class C lesions (there were five patients with chronic total occlusion lesions). According to the Ellis classification of CAP, there were six patients with Class II perforations and two patients with Class III perforations. The causes of perforation included that seven patients induced by guide wire and one patient by balloon predilation. Three patients had pericardial effusion. All of the eight patients with CAP underwent transcatheter embolization by autologous fat particles. Coronary angiography confirmed that all of them were embolized successfully. There was no severe complication after the procedure. The coronary angiography of one patient at 1 week and another patient at 2 years after the embolization showed that the embolized arteries had recanalized. The median follow-up time was 20.3 months (8.8–50.2 months), the event-free survival rate was 100%.
Conclusions: Transcatheter embolization by autologous fat particles was an effective, safe, cheap, and easy way to treat the perforation of small vessels during PCI.

Key words: Autologous Fat Particles; Coronary Artery Perforation; Embolization; Percutaneous Coronary Intervention

Introduction

Coronary artery perforation (CAP) is one of the rarest, but severe complications of percutaneous coronary intervention (PCI), the reported incidence was 0.10%–3.00%.[1,2] Acute CAP might cause acute cardiac tamponade and even death if the management is not timely and correct. The management of CAP includes reversal of anticoagulation, prolonged inflation of a balloon, implantation of a covered stent graft, emergency surgical repair, and embolization of the distal vessel by some embolus. The autologous fat particles were used as embolus to embolize the acute perforated coronary in Peking University Third Hospital since February 2009. Up to now, only one report involving three cases regarding this method to treat CAP was published,[3] and there were no any data published for long time follow-up. We analyzed the clinical data of eight patients undergoing this method retrospectively in order to investigate the effect and safety of transcatheter embolization by autologous fat particles in the treatment of CAP during PCI.

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Methods

Study population

All of the patients undergoing transcatheter embolization by autologous fat particles in the treatment of CAP during PCI at Peking University Third Hospital from February 2009 to June 2014 were enrolled, and the clinical data were collected

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and analyzed retrospectively. This study was approved by the Ethics Committee of Peking University Third Hospital, and informed consent was acquired from all patients.

Coronary intervention

Selective coronary angiographies were performed for all patients according to standard Judkins techniques. The major coronary vessels included the left main (LM), left anterior descending artery (LAD), left circumflex artery (LCX), and right coronary artery (RCA). The diseased vessel was defined as luminal diameter narrowing of 50% or more in the major coronary vessels in at least two orthogonality postures of projection. According to the number of diseased vessels, the patients were divided into single-vessel disease, double vessel disease, triple-vessel disease or LM + triple-vessel disease. The lesions were divided into Type A, B1, B2, and C based on the American College of Cardiology/American Heart Association Task Force (ACC/AHA) classification.[4]

Classification of coronary artery perforation

The type of CAP was classified according to the Ellis classification:[5] Class I, extra-luminal crater without extravasation; Class II, pericardial or myocardial blushing; Class III, perforation ≥1 mm diameter with contrast streaming and cavity spilling.

Method of transcatheter embolization by autologous fat particles in the treatment of coronary artery perforation

After the location and classification of the perforation was confirmed, the guide wire was adjusted into the distal of perforated artery, a micro-catheter or an over-the wire balloon catheter was advanced to the location 10–15 mm proximal to the perforation along the guide wire. Then, the 1–2 pieces of autologous subcutaneous fatty tissue, about 3 mm of diameter, was obtained from the abdomen or the groin where the femoral artery was punctured, and then the fatty tissue was cut by scissors into fat particles which diameter was about 0.5–1.0 mm. The 3–5 pieces of fat particles were put carefully at the front of an 1 ml injector which containing 2:1 diluted contrast agent, then the fat particles were slowly injected through the micro-catheter or over-the wire balloon catheter to the perforated artery. If angiography through guide catheter showed that there still had contrast agent leakage, the embolization would be performed repeatedly. If there did not have any contrast agent leakage shown by angiography through guide catheter, the micro-catheter would be pulled back 20–30 mm, then angiography would be performed once more through the micro-catheter, the embolization would be considered as success if there still had no contrast agent leakage.

Management of cardiac tamponade

If cardiac tamponade was present, pericardiocentesis would be performed to draw the blood out of the pericardial cavity, and a 6F pigtail catheter would be placed for constant drainage. The pigtail catheter would be pulled out after 24 h if no fluid was drained out.

Anticoagulation and antiplatelet strategies

All patients were treated with aspirin 100 mg/d, clopidogrel 300 mg, and heparin 100 IU/kg bolus injection before the beginning of PCI. After the perforation of the vessel, the heparin did not need to be neutralized during the procedure, and would not be used after the procedure. The dual-antiplatelet drugs including aspirin and clopidogrel would be used continuously on the next day after the procedure as routine.

Clinical follow-up

The clinical data were obtained from inpatient observations, outpatient clinic visits, and telephone interviews. Symptoms of all patients were observed carefully after the procedure. Blood routine test, creatine kinase-MB (CK-MB), and troponin I (TnI) were detected at 6 h, 24 h, and 48 h after the procedure. Electrocardiogram (ECG) was recorded immediately, 2 h, 24 h, and 48 h after the procedure. Echocardiogram (echo) was performed during the procedure and 24 h after the procedure. All patients were followed up every month after discharge, major adverse cardiovascular events (MACE) were recorded which including cardiac death, recurrent myocardial infarction, stent thrombosis, stent restenosis, and target vessel re-PCI.

Statistical analysis

Data analysis was performed using the SPSS 19.0 software package (SPSS Inc., Chicago, IL, USA). Descriptive statistics was presented as mean ± standard deviation (SD) or median (interquartile range) for continuous variables and as frequencies (percentages) for categorical variables.

Results

Clinical features and coronary angiography characteristics of the patients

A total of 5303 PCI procedures were performed between February 2009 and June 2014 at Peking University Third Hospital, and CAP occurred in 15 patients (0.28%), eight of them were treated with the transcatheter embolization by autologous fat particles. There were five males and three females, and the average age was 65.9 ± 7.9 years (range 53–74 years).

The clinical features and coronary angiography characteristics of eight patients undergoing autologous fat particles embolization were shown in Table 1. Among these eight patients, there were five patients with unstable angina pectoris, two with non-ST-elevation myocardial infarction (NSTEMI) and one with ST-elevation myocardial infarction (STEMI). According to the number of diseased vessels, there were one patient with LM + triple-vessel disease, four patients with triple-vessel disease, and three patients with double-vessel disease. The lesion morphology was classified based on the ACC/AHA classification, there were one patient with Type B2 lesion and seven patients with Type C lesions, and there were five patients with chronic total occlusion (CTO) lesions among them. The perforations were located at the distal of LAD or its branch (four cases), the

Table 1: Clinical features and coronary angiography characteristics of the patients underwent transcatheter embolization by autologous fat particles

Case number	Gender	Age (years)	Diagnosis	Number of diseased vessels	Degree of target vessel stenosis (%)	Morphologic types of target vessel	Location of CAP	Cause of CAP	Diameter of perforated vessel (mm)	Ellis classification of CAP
1	Male	63	UAP	Triple-vessel	100	Type C; CTO	LCX	Balloon predilation	1.5	III
2	Male	72	UAP	LM + triple-vessel	80	Type C	LAD	Guidewire	<1	II
3	Male	64	UAP	Triple-vessel	75	Type B2	LAD	Guidewire	<1	II
4	Female	74	NSTEMI	Triple-vessel	100	Type C; CTO	PDA	Guidewire	<1	II
5	Female	57	NSTEMI	Triple-vessel	100	Type C; CTO	PL	Guidewire	<1	II
6	Female	71	UAP	Double-vessel	100	Type C; CTO	S1	Guidewire	<1	III
7	Male	53	UAP	Double-vessel	100	Type C; CTO	PL	Guidewire	<1	II
8	Male	73	STEMI	Double-vessel	90	Type C	LAD	Guidewire	<1	II

CAP: Coronary artery perforation; UAP: Unstable angina pectoris; NSTEMI: Non-ST-elevation myocardial infarction; STEMI: ST-elevation myocardial infarction; CTO: Chronic total occlusion; LM: Left main; LAD: Left anterior descending artery; LCX: Left circumflex artery; PDA: Posterior descending artery; PL: Posterior branch of left ventricle; S1: Septal 1.

distal of LCX (one case) and the distal of RCA (three cases). The diameters of the perforated arteries were all <1 mm except for 1.5 mm of diameter in one patient. The CAP was classified according to the Ellis classification, and there were six patients with Class II perforations and two patients with Class III perforations. The causes of perforation included that seven patients induced by guide wire and one patient induced by balloon predilation.

Efficiency of transcatheter embolization by autologous fat particles in the treatment of coronary artery perforation

Among the eight CAP patients, seven patients received embolization by autologous fat particles directly, and one patient received this treatment after the failure of prolonged low-pressure inflation of the balloon. The coronary angiography immediately after embolization showed that all of CAP in these patients were embolized successfully, the success rate was 100% [Figure 1].

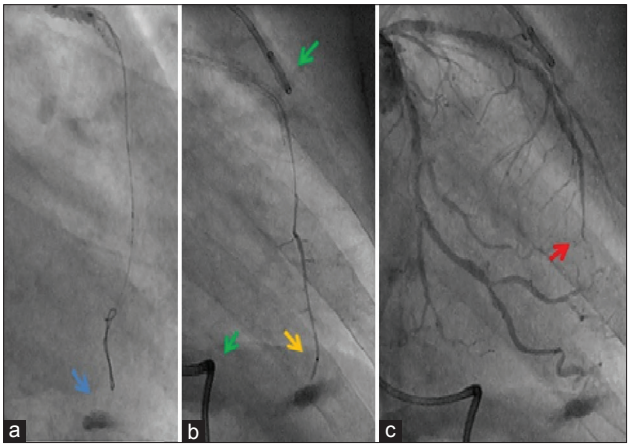

Figure 1: Type II perforation at distal left anterior descending artery (LAD), which was induced by guide wire and resulted in cardiac tamponade, was treated with transcatheter embolization by autologous fat particles successfully. (a) Guide wire induced distal LAD perforation and contrast agent extravasate to pericardial cavity (blue arrow). (b) Perforation caused cardiac tamponade and a pigtail catheter (green arrow) was placed for pericardial drainage, the distal end of a micro-catheter (yellow arrow) was advanced to the proximal of perforation. (c) Distal LAD was embolized successfully (red arrow).

Safety of transcatheter embolization by autologous fat particles in the treatment of coronary artery perforation

The clinical features after the procedure of the patients were shown in Table 2. Pericardial effusion was presented in three patients. The pericardial effusion of one patient did not induce cardiac tamponade and was observed without further treatment except for embolization of the vessel. The CAP of the other two patients had not been found immediately after the stents were implanted; several hours later, the patients presented cardiac tamponade, coronary angiography was performed once more and showed that there was contrast leakage from the distal of interventional artery, then perforated vessels were embolized, and the blood in pericardial cavity was drained and autologously transfused through the sheath.

Hemoglobin was decreased after the procedure in four patients, the decline ranged from 9 g/L to 26 g/L, and no one was cell-saver or allogeneic blood transfused. CK-MB was slightly elevated in five patients compared with the baseline level before the PCI, the extents of elevations were all <3 times the upper limit of normal. TnI of all the eight patients were increased compared with the baseline level before the PCI, the average level was 0.410 ng/ml (0.225–1.321 ng/ml). ECG of eight patients presented varying degrees of changes, including transient T wave inversion, ST segment depression or elevation. Among these eight patients, no new onset of regional wall motion abnormality (RWMA) was found by echo after the procedure.

Long-term follow-up of the patients with transcatheter embolization by autologous fat particles

Among these eight patients, there were two patients undergoing coronary angiography once more after the embolization, including one at one week later for planed PCI of other coronary artery (Case 4) and another at two years

Table 2: Clinical features after the procedure of the patients undergoing transcatheter embolization by autologous fat particles

Case number	Pericardial effusion (ml)	HGB decrease	CK-MB elevation	TnI elevation	ECG change	New onset of RWMA
1	Few	Yes	Yes	Yes	ST segment depression	No
2	No	No	Yes	Yes	T wave inversion	No
3	430	Yes	Yes	Yes	ST segment elevation	No
4	No	No	No	Yes	ST segment elevation	No
5	No	Yes	No	Yes	ST segment depression	No
6	No	Yes	Yes	Yes	T wave inversion	No
7	No	No	No	Yes	T wave inversion	No
8	800	Yes	Yes	Yes	ST segment elevation	No

HGB: Hemoglobin; CK-MB: Creatine kinase-MB; TnI: Troponin I; ECG: Electrocardiogram; RWMA: Regional wall motion abnormality.

later for untypical chest pain (Case 2), respectively, which showed that the fat particles injected into the coronary had been absorbed totally, and the embolized arteries had already been recanalized, and there were no contrast agent leakage anymore [Figure 2]. The other six patients did not undergo coronary angiography again after the embolization.

All of the eight patients were discharged, and the length of stay was not prolonged, oral drugs were used as routine manner. All patients were followed-up, the median follow-up time was 20.3 (8.8, 50.2) months (range from 5.5 months to 71.0 months). There was no MACE, and the event-free survival rate was 100%.

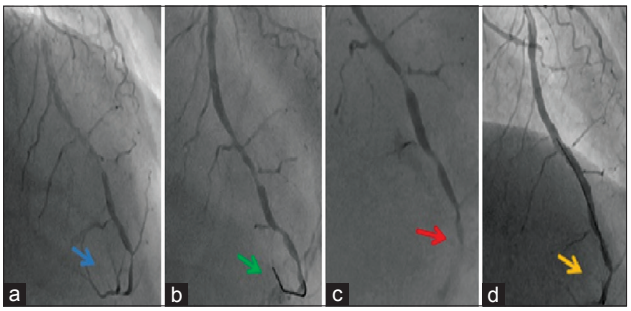

Figure 2: Type II perforation at distal left anterior descending artery (LAD) was embolized by autologous fat particles successfully, and the coronary angiography preformed 2 years later showed that the embolized distal LAD had already been recanalized; (a) Distal LAD was normal before the percutaneous coronary intervention (blue arrow); (b) Type II perforation of distal LAD induced by guide wire (green arrow); (c) Distal LAD was embolized successfully by autologous fat particles (red arrow); (d) Two years later, the embolized distal LAD had already been recanalized (yellow arrow).

Discussion

Studies have reported the incidence of CAP was ranging from 0.10% to 3.00%,[1,2] which was similar to the incidence of our center (0.28%). Many risk factors, including patient-related risk factors and procedure-related risk factors, are associated with the occurrence of CAP. Risk increases with the complexity of the lesions, including small vessel size, angulated calcified Type B2 and Type C lesions, long (>10 mm), eccentric lesions, and CTO.[5-7] Older age and previous coronary artery bypass graft also increase the risk.[5,8,9] Patients with diabetes, hypertension, and chronic renal failure are at increased risk because of the increased risk of calcification.[8] Although in some studies, females are thought to be more prone to perforation due to their smaller vessels,[10] but data from other studies have found no association between sex and CAP.[2] Many complex techniques and special instruments may increase the risk of CAP. CAP may occur with the use of guiding catheters, guide wires, oversized balloon/stents, cutting balloons, rotablator, intravascular ultrasound catheters, debulking techniques, or following balloon rupture.[7,11,12] Stiffer or hydrophilic-coated guide wires also increase the risk of perforation.[1,13] Kiernan *et al*.[1] reported that the incidence of CAP among 14,281 PCIs was 0.48%, and 65% of CAP were due to manipulation of guide wires, among which 37% occur in distal coronary arteries,[14] this was similar to the data of our center.

The management of CAP is depended on the size of perforation, the degree of contrast agent leakage and the hemodynamics of the patient. Prolonged, low-pressure inflation of a balloon for 5–15 min is the most common way to treat CAP and prevent cardiac tamponade. The other methods to treat CAP include covered stent implantation, embolization and emergency surgical repair. Embolization therapies used in selected cases include coil embolization, thrombogenic particles including polyvinyl alcohol, gel foam, thrombin, embolic agents like N-butyl cyanoacrylate glue, and autologous blood clot.[15-18] Oda *et al*.[3] have reported three cases using subcutaneous tissue to successfully embolize the CAP after the failure of prolonged inflation of the balloon. Our center began to use the fat particles made by autologous fatty tissue of the patients as embolus to embolize the perforated distal vessels during PCI since 2009, eight patients had been embolized successfully. According to the meta-analysis, the pooled mortality rates were 0.30%, 0.40%, and 21.20% for patients with Ellis Class I, II, and III CAP, respectively.[2] There were six patients with Ellis Class II CAP and two patients with Class III CAP in this study, and there was no death or surgical repair, and even no CM-MB significant elevation or new onset of RWMA. Hence, transcatheter embolization by autologous fat particles is very effective and safe in the treatment of CAP.

In our experience, the characteristics of transcatheter embolization by autologous fat particles in the treatment

of small vessel perforation including: (1) Easy to perform, no learning curve, and all experienced PCI operators could perform independently; (2) Instrument was simple, the only instrument needed was a micro-catheter or an over-the wire balloon catheter, so, usually did not increase the operation cost additionally; (3) Fatty tissue could be obtained quickly, when the trans-femoral PCI was performed, fatty tissue could be extracted from the incision site of the femoral region, where a sheath had been inserted; when the trans-radial PCI was performed, fatty tissue could be extracted from the subcutaneous of the abdomen after the skin was dissected for about 2 mm; (4) The heparin did not need to be neutralized during the procedure, which reduce the risk of acute stent thrombosis; (5) Along with the healing of the perforation, the fat particles injected into the artery could be absorbed and the embolized artery would be recanalized. It is worth noting that if there was collateral circulation at the distal of the perforated artery, contralateral coronary angiography should be performed to confirm if there still has contrast agent leakage, the distal of contralateral collateral vessel could be embolized by the same way if necessary.

In summary, CAP is a kind of rare, but severe complication of PCI, which might cause cardiac tamponade and even death. Transcatheter embolization by autologous fat particles is an effective and safe method to treat CAP of distal small vessel caused by guide wire, and could be performed easily and quickly by PCI operators. Promotion of this method might improve the prognosis of patients with CAP. But the sample size of our study was very small, which might cause bias. The more accurate large sample study should be performed in the future to further investigate the effect and safety of this method.

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