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Case Report

PERCUTANEOUS CORONARY INTERVENTION OF THE SMALL DIAGONAL BRANCH IN ACUTE MYOCARDIAL INFARCTION WITHOUT ST ELEVATION COMPLICATED BY CORONARY ARTERY PERFORATION AND CARDIAC TAMPONADE

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ABSTRACT – Introduction: Small coronary artery disease is more common in elderly patients, smokers, patients with diabetes and chronic kidney disease. Percutaneous interventions on small coronary arteries are associated with an increased risk of complications (perforation, dissection and restenosis). Coronary artery perforation treatment includes cover stents and coil placement.

Case report: A 73-year-old patient, without comorbidities, was hospitalized for acute non ST-elevation myocardial infarction. Coronary angiography showed subocclusion of the first diagonal branch (culprit lesion) while the other epicardial coronary arteries were without stenosis. Multiple predilatations of the target vessel were performed, and as it was a vessel with a diameter of less than 2 mm, no stent was placed. The final angiogram showed normal flow and good morphological result. Half an hour after the procedure, cardiac tamponade and cardiorespiratory arrest developed. Emergency pericardiocentesis was performed and after the return of spontaneous circulation, emergency recoronarography was performed. It showed perforation of the diagonal branch with contrast extravasation. Coronary coil was applied proximal to the perforation site. Perforation repair and hemodynamic stabilization were achieved.

Conclusion: Coronary artery perforation is a life-threatening complication of percutaneous coronary intervention. The risk of perforation is higher in the case of small coronary arteries; it can be presented by delayed cardiac tamponade, which requires increased supervision of the patient.

Key words: *small coronary arteries, coronary artery perforation, cardiac tamponade*

Introduction

One third of patients with symptomatic coronary artery disease have small vessel disease (SVD) (1). The definition of a small vessel varies in the literature. Depending on the source, small coronary vessels are defined as <3mm (2), <2.8mm (3, 4), <2.75mm (5), <2.5mm (6) and/or smaller in diameter. Small coronary artery disease is more common in elderly patients, smokers, patients with diabetes and chronic kidney disease (1). Percutaneous coronary intervention (PCI) on small coronary arteries is always challenging. Stent implantation is associated with an increased risk of complications such as coronary artery perforation (CAP), dissection and restenosis (3). CAP occurs in 0.1-1.45% of PCI procedures (7). The incidence of

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CAP is higher in PCI of small coronary vessels, especially during CTO interventions (up to 3%) and when using high pressure, cutting balloons and / or rotablators. In just under a quarter of cases CAP is caused by workhorse wire and the risk is increased when using hydrophilic - polymer coated guidewires (8). Perforation of large blood vessels is associated with the use of balloons of larger diameter and "high pressure" balloons. It is manifested by a dramatic clinical presentation and the rapid development of cardiac tamponade. Delayed tamponade after completion of PCI is a more common complication of PCI of small coronary arteries or if perforation is caused by coronary guidewire (9). The most used angiographic classification of CAP is Ellis's classification (Table 1) (10). Large perforations (Ellis's calcification Type III and IV) are associated with a higher incidence of emergency coronary artery bypass grafting (CABG) and a higher risk of death (11). There are several treatment options for CAP and the best treatment modality depends on both the localization of the perforation and the diameter of the perforated coronary artery. In case of hemodynamic instability caused by cardiac tamponade, emergency pericardiocentesis should be performed. Prolonged balloon inflation proximal to the perforation site, discontinuation of antiplatelet and anticoagulant therapy, use of protamine to correct clotting time, and platelet transfusion are first aid in the event of perforation. Cover stents are used for perforation of the proximal segment of the coronary artery and when the vessel diameter is > 2.8mm. For the treatment of perforation of the distal parts of the coronary arteries and small coronary vessels, coronary coils are used. They can be placed trough guide catheter or a microcatheter to the target lesion (12). Even though small coronary arteries have a relatively small supply and ischemic area, SVD may be the cause of limiting angina and significantly reduction of quality of life (1).

Table 1. Modified Ellis classification of coronary perforation

TYPE I	Extra luminal crater No contrast extravasation
TYPE II	Myocardial or pericardial blush No contrast extravasation jet
TYPE III	Contrast extravasation through orifice > 1mm in diameter
TYPE IV	Perforation into anatomic cavity: left ventricle, coronary sinus…
TYPE V	Distal guidewire perforation

Case report

A 73-year-old female patient, without any known chronic comorbidities, was hospitalized at the Clinic for Cardiovascular Diseases due to acute myocardial infarction without ST elevation. At the time of admission, she was free of chest pain and without acute ischemic changes in the electrocardiogram (Figure 1).

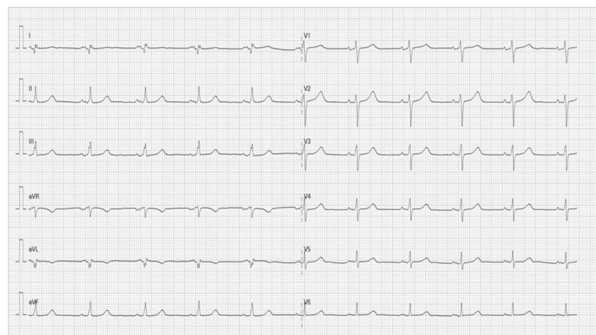

Figure 1. ECG on admission

Elevated values of cardiac enzymes were recorded in laboratory findings, with significant dynamics in the control interval (highly sensitive troponin I 782ng/L - 26403ng/L, reference interval < 34ng/L), creatine kinase (CK) 175U/L - 981U/L, reference interval 0-177U/L), elevated low-density lipo protein (LDL) cholesterol values while other laboratory findings were within the reference range interval. Echocardiography showed a left ventricle of normal size, concentrically hypertrophic, without regional loss of contractility with preserved global systolic function. The patient underwent early invasive cardiac treatment (< 24h). Dual antiplatelet therapy (DAPT) with aspirin 300mg plus ticagrelor 180mg and anticoagulation with low molecular heparin was started. Coronary angiography showed sub-occlusion of the first diagonal branch while the other coronary arteries were without hemodynamically significant stenosis (Figure 2). After workhorse guidewire (Run-through Floppy) was advanced into distal portion of diagonal branch primary percutaneous coronary intervention with multiple bal-

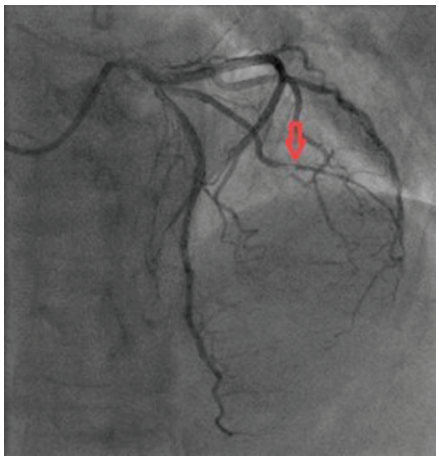

Figure 2. Coronary angiogram showing diagonal brunch (culprit lesion) sub occlusion (red arrow)

loon dilatations with a semi-compliant balloon Traveler 2.5/12 mm was done. After dilatation, bifurcation of the diagonal branch with second branch was shown. The true culprit lesion was the branch of diagonal artery, which was initially occluded. Guidewire was than repositioned to distal part of culprit vessel and again balloon dilatations with smaller semi-compliant balloon (Traveler 2.0/12mm) were performed. There were no residual stenosis on the control angiogram, and as it was a thrombotic incident in the vessel with a diameter of less than 2 mm, there was no indication for stent implantation. The final angiogram, with workhorse guidewire still in the branch of diagonal artery, showed normal flow and morphological result (Figure 3). Use of the drug-coated balloon was considered. Due to very small diameter of culprit vessel, good angiographic result after balloon dilatation and that patient is free of chest pain with no ischemic ECG changes and no regional wall motion abnormalities on echocardiogram simple percutaneous balloon dilatation was the chosen strategy. The patient was transferred to the Department of Intensive Cardiac Care for observation. Forty-five minutes after the procedure, the general condition of the patient suddenly deteriorated. Hypotension and tachycardia developed. Despite bolus administration of crystalloid solutions and inotropic support with norepinephrine infusion, there was further progression of hypotension and finally, cardiorespiratory arrest occurred within few minutes. Resuscitation was started, the patient was endotracheal intubated and mechanical ventilation was initiated. Emergency cardiac ultrasound done at the patient's bedside, showed 25 mm pericardial effusion in front of the right ventricle with collapse of right ventricle in diastole and right atrium in systole (Figure 4). Under ultrasound control, emer-

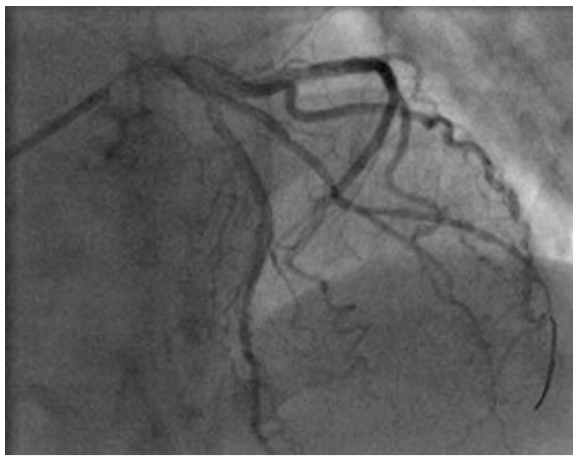

Figure 3. Final angiogram showing normal flow and morphological result

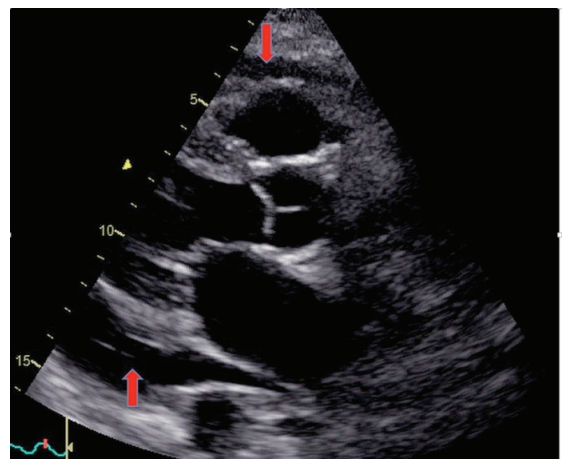

Figure 4. Pericardial effusion

gency pericardiocentesis was performed. In total, 450 ml of hemorrhagic effusion was evacuated. After pericardiocentesis, spontaneous circulation was restored. Immediate blood transfusion was given. Emergency coronary angiography was performed again, showing perforation of the diagonal branch with extravasation of contrast into the pericardium (Fig. 5). Because the site of perforation was in the branch of diagonal artery were balloon dilatation was not performed the presumed mechanism is distal guide wire perforation. An extended balloon inflation with semi-compliant balloon Ryujin 2.5/10mm was performed immediate-

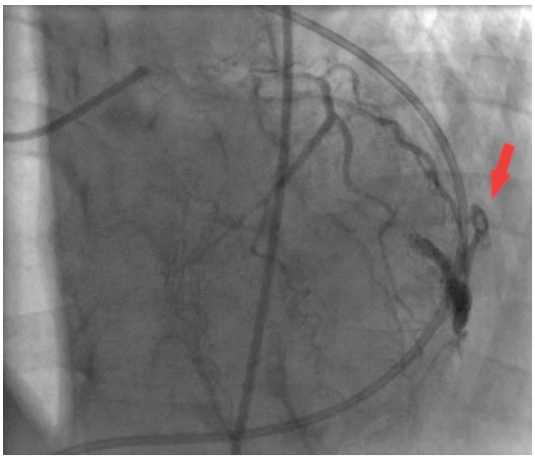

Figure 5. Coronary artery perforation (Ellis`s type III) (red arrow)

ly at perforation site and proximal to perforation site. For reversal of anticoagulant effect of heparin, protamine sulphate was applied. Despite initial treatment, extravasation cessation was not achieved, so coronary coil (Terumo Azur 3.0 / 8mm) through micro catheter (Finecross) was applied proximally to the perforation site (Fig. 6). Perforation repair was achieved, and

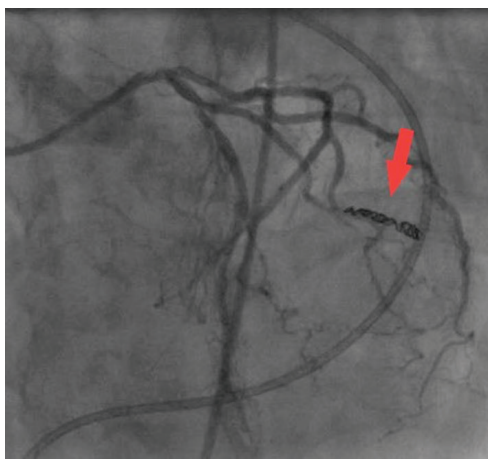

Figure 6. Coronary coil (Terumo Azur 3.0 / 8mm) proximally to the perforation site in diagonal branch

the patient was stabilized hemodynamically. Intensive cardiac care treatment and invasive monitoring of vital functions were continued within next hours. The vasopressor support was gradually discontinued, and the patient was extubated after 36 h. Ticagrelor was changed to clopidogrel, and dual antiplatelet therapy with acetylsalicylic acid and clopidogrel was continued throughout hospitalization. Control laboratory findings showed an increase in CK values post procedurally (maximal value 1512U / l) while systolic function of the left ventricle remained preserved with only mild hypo contractility of the lateral wall. Total of 710ml of pericardial effusion was evacuated within 3 days. On the third day of hospitalization, due to the development of acute renal insufficiency and oliguria, treatment with continuous venous-venous hemodiafiltration was performed for 48 hours, followed by gradual recovery of renal function and spontaneous diuresis. On the 16th day of hospitalization, due to new onset pericarditic chest pain, control echocardiography was performed, and it showed a new collection of 23 mm of pericardial effusion with signs of threatening cardiac tamponade. Once more pericardiocentesis was done and 650ml of hemorrhagic effusion was evacuated. The believed mechanism of pericardial effusion was iatrogenic pericarditis due to inflammation reaction to accumulation of blood and debris from tissue damage. Treatment with ibuprofen and colchicine was continued. In total, evacuated pericardial effusion volume was 1360 ml. Complete resolution of pericardial effusion was confirmed, and the patient was discharged after 20 days of hospitalization.

Discussion

The risk of complications associated with PCI of small coronary arteries and the results of ISCHEMIA trial that did not show a significant difference in cardiovascular events and mortality in initially invasive strategy compared to optimal drug therapy in patients with stable coronary artery disease and moderate to significant ischemia (13), provide evidence that a less aggressive strategy for treating chronic coronary artery disease is more favourable.

The PHANOM trial showed that an angiographic assessment of the significance of small coronary artery stenosis alone was not sufficient and only 30% of stenosis were found to be functionally significant using functional flow reserve analysis (FFR) (4). Numerous studies have compared different percutaneous treatment options for SVD. Balloon angioplasty (POBA) is still a valid treatment option particularly for very small coronary arteries (<2 mm) (4). Funatsu et. al. published a multicenter, prospective, randomized controlled trial on efficacy and safety of using paclitaxel-coated balloon (PCB) to treat small vessel disease. Total of one hundred and thirty-five patients were randomized into

a PCB group and plain balloon angioplasty (POBA) group and follow-up was 24 weeks. The results failed to show superiority of PCB compared with POBA in terms of differences in target vessel failure. On the other hand, target lesion revascularization (TRL) was slightly lower, late lumen loss was significantly lower and late lumen enlargement was more frequently observed in the PCB group compared with POBA (16). One single centre randomized clinical trial included 80 patients with an indication for PCI on small coronary arteries. Patients were presented with stable or unstable angina pectoris, while patients with acute myocardial infarction were excluded. Trial failed to demonstrate the non-inferiority of paclitaxel-coated balloons, compared with the second-generation drug eluting stents (DES) for the treatment of small vessel disease, in terms of angiographic and clinical restenosis (5). The opposite findings were observed in the Swedish Coronary Angiography and Angioplasty Registry (SCAAR) that aimed to investigate the outcomes of patients with SVD undergoing PCI. This was an observational, nationwide, multicenter study that included 14,788 patients, median follow-up time was 1,095 days. Results showed that the drug coated balloon (DCB) treatment was associated with a double risk for restenosis compared with DES, but the risk of target lesion thrombosis, myocardial infarction and all-cause mortality was not significantly different among the study groups (14). These results were comparable with a BASKET-SMALL 2 multicenter, open-label, randomized trial that showed non-inferiority of angioplasty with DCB versus implantation of a second-generation DES in coronary vessels < 3 mm in diameter (2). The PICCOLETO II trial sought to compare the performance of a novel drug-coated balloon with an everolimus-eluting stent in patients with SVD. Total of 232 patients were enrolled, and the results showed that late lumen loss was significantly lower in the DCB group (0.04 vs. 0.17 mm; $p < 0.001$ for noninferiority; $p = 0.03$ for superiority), but no difference was found in the per cent diameter stenosis and minimal lumen diameter after 6 months. After 12 months, there was no significant difference in MACE (17). Current data supports the use of DCB in SVD, as it has been shown that DCB compared to DES have a similar efficacy and safety. Use of DCB could be an option in our patient, but due to diameter of targeted vessel < 2mm and no elastic recoil or dissection was observed after POBA no further actions were taken. There is no clear consensus in the available literature on the optimal percutaneous management of small coronary arteries that are the culprit lesions in acute coronary syndrome due to increased risk of PCI related complications. Single-centre, retrospective analysis of prospective PCI database reported an incidence, clinical characteristics and management of iatrogenic coronary perforation based on 11 years of experience. During the study period 0.71% of all procedures were complicated by CAP. Guidewire exit caused CAP in 61.5% of cases and among those, only 1.1% were treated with cover stents (12). The incidence of CAP was 0.56% according to retrospective analysis of the Manchester Heart Center PCI database. Risk factors were female sex, older age, calcification, use of cutting balloons, atherectomy and treatment of chronic total occlusion. Increased risk of death was associated with non-elective procedure and pericardial drain insertion (11). In a retrospective analysis of 17,972 patients, who underwent PCI in Sapporo Cardio Vascular Clinic, Japan, 110 CAP were identified and treated with coil embolization. The degree of myocardial damage and systolic function was evaluated. Most of the patients underwent PCI for stable angina pectoris. In 88.2% of patients, the guidewire exit was the cause of perforation. Creatin kinase (CK) elevation was observed in patients with perforation types III and IV, and no elevation of CK in case of distal guidewire perforation. Systolic function of left ventricle tended to decrease in patients with types I, III, and IV CP and was not changed in case of distal guidewire perforation (15). In our case, the elevation of CK levels was documented after coronary coil embolization and no reduction of ejection fraction was observed. Treatment options for CAP include coils, autologous subcutaneous adipose tissue, thrombin, clotted autologous blood and cover stents. Covered stents are bail-out treatment of CAP when located in the proximal vessel segments with a diameter ≥2.75 mm. Coils are permanent metallic, wired structured agents delivered through normal guide catheters or through generally used for CAPs in more distal and smaller calibre segments. Autologous blood clots and fat embolization are used mostly for distal perforations. They are universally available and biocompatible in every patient (12.) In terms of dual antiplatelet therapy (DAPT), the European guidelines recommend DAPT for at least 12 months in acute coronary syndrome and for at least 6 months in

stable coronary artery disease without high bleeding risk. Shorter duration of DAPT duration is considered in case of high bleeding risk (18). Metanalysis that compared prolonged (≥12 months) versus short (≤6 months) DAPT duration after DES implantation included 9 trials and DAPT study. The DAPT study and ISAR-SAFE trial are double blind placebo-controlled trials, while the other 8 are open-label design. Acute coronary syndrome was the initial presentation in 23-74% of patients. Result showed that short DAPT duration was associated with lower bleeding risk without a significant increase in ischemic risk (19). In our patient DAPT with less potent P2Y12 inhibitor, clopidogrel plus acetylsalicylic acid was recommended after hospital treatment and is planned to be continued for 12 months according to the current European guidelines.

Conclusion

Dealing with SVD is challenging due to the increased risk of complications that may be fatal. True significance of SVD can be overestimated when using only angiographic assessment, so a routine additional functional assessment with FFR or instantaneous wave-free ratio should be considered. We are still lacking large size, randomized, double-blinded, multicentre trials on percutaneous treatment options (POBA vs. DES vs. DCB) in terms of efficacy and safety in small vessel coronary artery disease, especially in acute coronary syndromes.

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Sažetak

PERKUTANA KORONARNA INTERVENCIJA NA MALOJ DIJAGONALNOJ ARTERIJI U AKUTNOM INFARKTU MIOKARDA BEZ ST ELEVACIJE KOMPLICIRANA PERFORACIJOM I SRČANOM TAMPONADOM

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Uvod: Bolest malih koronarnih arterija je češća u bolesnika starije životne dobi, pušača, bolesnika sa šećernom bolesti i kroničnom bubrežnom insuficijencijom. Perkutana intervencija na malim koronarnim arterijama je povezana s povećanim rizikom od komplikacija (perforacija, disekcija i restenoza). Liječenje perforacije koronarne arterije uključuje postavljanje pokrovnih stentova i koronarnih zavojnica.

Prikaz slučaja: 73-godišnja pacijentica, bez kroničnih komorbiditeta, hospitalizirana je zbog akutnog infarkta miokarda bez ST elevacije. Koronarografija je prikazala subokluziju prve dijagonalne grane (odgovorna lezija) dok su ostale epikardijane koronarne arterije bile bez stenoza. Učinjene su višestruke predilatacije odgovorne lezije, a kako se radilo o žili dijametra manjeg od 2mm nije postavljena potpornica. Na završnom angiogramu je prikazan uredan protok i morofološki rezutat. Pola sata nakon procedure dolazi do razvoja tamponade srca i kardiorespiratornog aresta. Učinjena hitna perikardiocenteza, a po povratu spontane cirkulacije i žurna rekoronarografija kojom se prikazala perforacija ogranka dijagonalne grane s ekstravazacijom kontrasta. Proksimalno od mjesta perforacije primijenjen je koronarni coil, postignuta je sanacija perforacije i hemodinamska stabilizacija.

Zaključak: Perforacija koronarnih arterija je životno ugrožavajuća komplikacija perkutane koronarne intervencije. Rizik perforacije je veći u slučaju malih koronarnih arterija, može se prezentirati odgođenom tamponadom srca zbog čega je potreban pojačani nadzor bolesnika.

Ključne riječi: *male koronarne arterije, perforacija koronarne arterije, tamponada srca*