Emergency cardiac surgery after a failed percutaneous coronary intervention in an interventional centre without on-site cardiac surgery

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Background. Based on experience from other countries, the Medical Centre Alkmaar was granted permission to start the first Dutch PCI programme without on-site cardiac surgery. The cardiology group of the Medical Centre Alkmaar started an off-site PCI programme in 2002 with only primary PCI in the first year and a full PCI programme from November 2003 onwards. We report the first Dutch experience with acute cardiac surgery following a failed PCI procedure in an off-site clinic.

Patients. From October 2002 until February 2007, 2500 patients were treated by PCI in the Medical Centre Alkmaar. These patients were treated for an acute myocardial infarction (33%), acute coronary syndromes (37%) or progressive angina (30%). In this first series of off-site PCI in the Netherlands, the incidence of emergency cardiac surgery following failed PCI was 0.2%. All five patients who needed emergency surgery underwent elective PCI for progressive stable coronary artery disease. No emergency surgery was needed for primary PCIs in patients with an acute myocardial infarction. All patients survived emergency surgery following failed PCI.

Conclusion. Adherence to the Dutch guidelines of interventional cardiology with protocols describing a close collaboration with cardiac surgeons and an immediate availability of rapid ground transportation are mandatory when performing off-site PCI. This series extends the current expertise of emergency surgery after failed PCI to off-site clinics. With appropriate settings, off-site PCI may not be associated with an increase in the risk of adverse events. (*Neth Heart J* 2007;15:173-7.)

Keywords: angioplasty, surgery, off-site

Percutaneous coronary interventions (PCI) were introduced by Andreas Gruntzig in 1979 and initially performed for stable angina pectoris due to a discrete lesion in a proximal coronary artery. The early experience by Gruntzig et al. demonstrated the potential success of this new therapy; however, the two well-recognised caveats were immediate vessel occlusion due to balloon-induced obstructive dissections and late restenosis. The occurrence of an obstructive dissection mandated the presence of on-site cardiac surgery in the early years after the introduction of PCI. Umans et al. reported the first Dutch results of surgery following a failed percutaneous transluminal coronary angioplasty (PTCA) in 1984 showing an incidence of 9%.^{1,2} A dramatic decline in the need for cardiac surgery as a result of an acute vessel occlusion occurred after the introduction of the intra-coronary stent by Sigwart et al.³ Zijlstra et al. reported on the role of cardiac surgery in the 1990s in the large Zwolle experience.⁴ The incidence of emergency coronary artery surgery after PCI further declined to 0.14-0.3% with increasing operator experience and improved wire, balloon and stent design.^{5,6} This improvement of PCI outcome led to an increase in PCI procedures encompassing the total spectrum of the coronary artery disease. Additionally, PCI was performed in centres without on-site cardiac surgery. Sub-

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sequently new guidelines were accepted including the possibility of performing PCI in an off-site centre. Based on experience from other countries, the Medical Centre Alkmaar was granted permission to start the first Dutch PCI programme without on-site cardiac surgery. In 2002, the cardiology group of the Medical Centre Alkmaar started an off-site PCI programme with only primary PCI in the first year and a full PCI programme from November 2003 onwards. We report the first Dutch experience with acute cardiac surgery following a failed PCI procedure in an off-site clinic.

Method

Clinical setting

The Medical Centre Alkmaar is a large community hospital with 11 cardiologists, 12 CCU and 70 ward beds and equipped with two catheterisation laboratories with a 24 hours a day, seven days a week service level. The cardiology department employs three experienced interventional cardiologists who perform >150 procedures a year. Before the start of this programme, a 0.2 function unit thorax surgeon from the VU University Medical Centre in Amsterdam (VUmc) was added to the interventional team. Weekly heart team meetings take place in both centres when indications for PCI/coronary artery bypass graft (CABG) and complications are discussed. All elective PCI patients are scheduled and discussed beforehand. Our programme fulfils the Dutch criteria for off-site PCI given the annual case load of over 650 PCIs performed by three interventional cardiologists and close cooperation with the thorax surgeons from the VUmc.

Interhospital transport

By protocol, the referring physician will contact the admitting surgeon at the VUmc to accept the patient for transfer and confirm that the appropriate higher level resources are available before the transfer occurs. The receiving surgeon is given a full description of the patient's condition. The central ambulance service will then be contacted to confirm its availability, to prepare for anticipated patient needs during transport, and to coordinate the timing of the transport. A copy of the medical records and PCI procedure, including a patient case summary and all relevant laboratory and radiographic studies, will accompany the patient. It is recommended that a minimum of two people, in addition to the vehicle operators, accompany the critically ill patient during interhospital transport. The transport team leader should be a physician or nurse able to provide advanced airway management, intra-aortic balloon pump management, intravenous therapy, dysrhythmia interpretation and treatment, and basic and advanced cardiac life support. The transportation team will contact the VUmc by phone once they are in the vicinity of the hospital to allow appropriate measures to be taken for intrahospital transfer to the receiving ward or operating theatre without delays.

Patients

Inclusion

From October 2002 until February 2007, 2500 patients were treated by PCI in the Medical Centre Alkmaar. These patients were treated for an acute myocardial infarction (33%), acute coronary syndromes (37%) or progressive angina (30%). Of these, 2436 patients (98%) left the catheterisation room with a patent vessel with adequate flow after the PCI procedure. Sixty-four patients left the catheterisation room with TIMI 0 or 1 flow after off-site PCI, 21 after attempted primary PCI and 43 after attempted elective PCI. Of these 64 patients, 63 were scheduled for PCI because of a total occlusion of the coronary artery to be dilated and one patient had PCI for an open vessel with normal antegrade flow. This patient is one of the patients described here who were sent for surgery.

The first patient was a 82-year-old woman who was admitted to the cardiology department for an elective percutaneous coronary intervention (PCI) for angina pectoris Canadian Cardiology Society (CCS) class III/IV due to significant one-vessel disease with stenoses in the marginal and posterolateral branch of the left circumflex coronary artery (type B2). Her cardiac history revealed a previous inferior myocardial infarction and a PCI of the circumflex coronary artery and right coronary artery. She was on triple medication. Risk factors for coronary artery disease were hypertension and hypercholesterolaemia. On admission her pulse was 64 beats/min and her blood pressure was 124/63 mmHg. Physical examination revealed no abnormalities. Her ECG demonstrated sinus rhythm 71 beats/min and a complete left bundle branch block.

A PCI with culotte stenting of the obtuse marginal branch of the right circumflex and posterolateral right circumflex was performed resulting in TIMI 3 flow. After the procedure, the patient became hypotensive. Physical examination revealed no clues, apart from a large haematoma in the right groin. The ECG showed no changes. An echocardiogram revealed 3 cm pericardial fluid and was followed by a subxiphoid pericardiocentesis. The cardiothoracic surgeon in the VUmc was consulted for transfer and emergency surgery. Upon acceptance, rapid ground transport by ambulance was arranged. On arrival to the VUmc the patient was immediately taken to the operating room for drainage of the tamponade via a sternotomy. Two small lesions in the liver, caused by the pericardiocentesis, were also treated. Coronary artery bypass grafting was not needed. The postoperative course was uncomplicated and in particular without signs of myocardial necrosis. The patient was discharged in a good condition.

The second patient was a 66-year-old man who was admitted to the cardiology department for an elective PCI because of angina pectoris CCS class III/IV and

an abnormal exercise stress test, with significant two-vessel disease with stenoses in the left anterior descending coronary artery and left circumflex coronary artery. He had a previous cardiac history of stable angina pectoris. His medication on admission was atenolol 1 x 50 mg, amlodipine 1 x 10 mg, isosorbide mononitrate 1 x 60 mg, aspirin 1 x 80 mg and simvastatin 1 x 20 mg. Risk factors for coronary artery disease were hypertension, hypercholesterolaemia, smoking and a positive family history. On admission his pulse was 56 beats/min and his blood pressure was 155/87 mmHg. Physical examination revealed no abnormalities. His ECG demonstrated sinus rhythm 55 beats/min, intermediate axis, normal conduction and no signs of ischaemia.

During the predilatation of the left anterior descending coronary artery type C lesion, a fracture of the guide wire occurred, resulting in a 2 mm piece of guide wire in the left main coronary artery. The patient was free of complaints. The ECG showed no changes. The off-site cardiothoracic surgeon in the VUmc was consulted. The decision was taken to transfer the patient to the VUmc for CABG and removal of the guidewire. On arrival the patient was admitted to the coronary care unit. Because the patient was without signs of ischaemia, the CABG was postponed until the next day. There was no rise in cardiac enzymes. A coronary artery bypass graft (left internal mammary artery-left anterior descending (LIMA-LAD), aorta-anterolateral and marginal obtuse branch) was performed. The guidewire was removed. The post-operative course was uncomplicated. The patient was discharged in a good condition.

The third patient was a 63-year-old man who was admitted to the cardiology department after an antero-septal infarction treated conservatively in another hospital because of delay. He had no other previous cardiac history. His medication on admission was metoprolol tartrate 1 x 100 mg, clopidogrel 1 x 100 mg, aspirin 1 x 80 mg, fosinopril 1 x 10 mg and atorvastatin 1 x 40 mg. Risk factors for coronary artery disease were hypertension, smoking and a positive family history. On admission his pulse was 55 beats/min and his blood pressure was 110/60 mmHg. Physical examination revealed no abnormalities. His ECG demonstrated sinus rhythm 55 beats/min, left axis, Q waves in V₁ to V₃ and negative T waves in V₂ to V₆. Nuclear imaging revealed a large area of an antero-septal infarction with signs of ischaemia. A coronary angiogram showed one-vessel disease with a significant lesion in the LAD coronary artery (type C). The decision was made to perform a PCI. During the procedure a partial rupture of the LAD occurred resulting in a tamponade. Immediate subxiphoid pericardiocentesis was successfully performed. The cardiothoracic surgeon in the VUmc was consulted for transfer and emergency surgery. Upon acceptance, rapid ground transport by ambulance was arranged. On arrival to the VUmc the

patient was immediately taken to the operating room for drainage of the tamponade and CABG: LIMA-LAD, aorta-first diagonal (D1) branch of LAD. The postoperative course was uncomplicated without signs of reinfarction on echocardiography. The patient was discharged in good condition.

The fourth patient was a 68-year-old man who was admitted to the cardiology department for an elective PCI for angina pectoris NYHA class III/IV due to significant one-vessel disease with a type A stenosis in the LAD. His cardiac history revealed stable angina pectoris NYHA class II/IV. His medication on admission was clopidogrel 1 x 75 mg, metoprolol tartrate 1 x 200 mg and atorvastatin 1 x 20 mg. Risk factors for coronary artery disease were hypertension, a positive family history and hypercholesterolaemia. On admission his pulse was 76 beats/min and his blood pressure was 140/66 mmHg. Physical examination revealed no abnormalities. His ECG demonstrated sinus rhythm 60 beats/min, left axis and no signs of ischaemia.

During the introduction of the guidewire into the LAD, a dissection occurred resulting in a total occlusion of the LAD (TIMI 0 flow). An intra-aortic balloon pump was inserted immediately with relief of chest pain. Restoration of flow was not achieved despite extensive efforts. The patient remained in a stable haemodynamic condition throughout the entire procedure. The cardiothoracic surgeon in the VUmc was consulted for transfer and emergency surgery. Upon acceptance, rapid ground transport by ambulance was arranged. On arrival to the VUmc the patient was immediately taken to the operating room for coronary artery bypass grafting: LIMA-D2-LAD. At the start of the procedure, ventricular fibrillation occurred which was treated by defibrillation. The postoperative course was uncomplicated. The patient was discharged in a good condition with preserved LV function on echocardiography.

The fifth patient was a 73-year-old man who was admitted to the cardiology department for an elective PCI for angina pectoris NYHA class III/IV due to significant two-vessel disease with a type B2 stenosis in the LAD. His cardiac history revealed a previous non-ST-elevation infarction in 1994. His medication on admission was clopidogrel 1 x 75 mg and metoprolol tartrate 1 x 100 mg, aspirin 1 x 80 mg, amlodipine 1 x 10 mg and simvastatin 1 x 20 mg. Risk factors for coronary artery disease were hypertension, a positive family history and hypercholesterolaemia. On admission his pulse was 60 beats/min and his blood pressure was 145/76 mmHg. Physical examination revealed no abnormalities. His ECG demonstrated sinus rhythm 60 beats/min without signs of ischaemia.

During the introduction of the guidewire into the LAD a dissection occurred resulting in a TIMI-2 flow in the LAD with mild angina. An intra-aortic balloon pump was inserted immediately with relief of chest

pain. Restoration of flow was not attempted. The patient remained in a stable haemodynamic condition throughout the entire procedure. The patient was sent to the CCU while the cardiothoracic surgeon in the VUmc was consulted for transfer and surgery. The patient arrived at the CCU of the VUmc 61 minutes after the first call to the ambulance service and was sent to the next available operating room two hours later for CABG. The postoperative course was uncomplicated. The patient was discharged in good condition with preserved LV function.

Discussion

In this first series of off-site PCI in the Netherlands, the incidence of emergency cardiac surgery following failed PCI was 0.2%. All patients who had emergency surgery underwent elective PCI for progressive stable coronary artery disease. No emergency surgery was needed in the case of primary PCI for patients with an acute myocardial infarction. Adherence to the Dutch guidelines of interventional cardiology with protocols describing a close collaboration with cardiac surgeons and an immediate availability of rapid ground transportation are mandatory when performing off-site PCI. This series extends the current expertise of emergency surgery after failed PCI to off-site clinics. With appropriate settings, off-site PCI may not be associated with an increase in the risk of adverse events.

Clinical setting

Off-site PCI programmes started in the mid-1990s in Europe and have been followed in the US in recent years. A variety of clinical settings have been described ranging from low- to high-volume hospitals. The study by Wharton describes the experience with primary angioplasty for high-risk acute myocardial infarction performed by experienced interventionalists at hospitals with no cardiac surgery on-site.⁷ The requirements for the clinical setting included an experienced interventionalist who performed elective interventions in a surgical centre, an experienced team on a 24 hours a day, seven days a week call schedule, a well-equipped cath lab facility and written transfer protocols. Ting recently reported the clinical outcomes in 1007 elective PCI and primary PCI in a community hospital without on-site cardiac surgery compared with those at a centre with on-site cardiac surgery.⁸ Their clinical setting also encompassed a high-volume cath lab, one to three experienced interventionalists and written transfer protocols.

The clinical settings of off-site PCI in Europe differ per country but are well defined in the various guidelines and include comparable clinical settings as described earlier.⁹⁻¹²

Wenberget al. showed that high-volume teaching hospitals with off-site PCI programmes have comparable outcomes to on-site high-volume centres with regard to in-hospital and 30-day mortality in both elective and primary PCI.¹³ Given these observations,

the initial Dutch experience with off-site PCI was obtained in a high-volume PCI centre. Thus, our single centre experience with emergency surgery after failed PCI should be interpreted in the context of our setting. The prerequisites of the programmes are as follows: three highly experienced interventionalists with an annual case load of >650 procedures including >150 primary PCIs in close collaboration with cardiac surgeons from the heart centre at a distance of 43 km. We demonstrated that such a caseload and the close collaboration can result in excellent cardiac care, also for patients in need of emergency surgery. Despite the large caseload, we needed to send five out of 2500 patients for surgery and could rely on an efficient and professional critical pathway towards off-site surgery. All patients survived surgery without signs of myocardial infarction and with good LV function on echocardiography.

Interhospital transfer

Patient outcomes depend to a large extent on the technology and expertise of the personnel available within each healthcare facility. When services are needed that exceed the available resources, a patient will ideally be transferred to a facility that has the required resources. A decision to transfer a patient is the responsibility of the attending physician at the referring institution. Once this decision has been made, the transfer is effected as soon as possible. When needed, resuscitation and stabilisation will begin before the transfer, realising that complete stabilisation may only be possible at the receiving facility. The necessary measures to stabilise the patient should be taken expeditiously. Once a patient experiences complications during PCI, immediate access to intra-cath lab echocardiography (n=2) and intra-aortic balloon pumping (n=2) is mandatory. The need for a second cardiologist at such times, who can consult the surgeon, is obvious and should be part of the protocol. Direct access to the ambulance service by an internal telephone line and direct contact with the heart centre through multiple telephone lines allow efficient communication. A direct image connection is not yet available. With

Figure 1. Timelines in patients who were directly transferred from the catheterisation laboratory to the operating room. T0=occurrence of the complication, T1=consultation with thoracic surgeon, T2=request for ground transportation, T3=patient leaves the catheterisation suite, T4=patient arrives at the operation suite.

these protocols, the lines of communication are short and the time to making decisions on interhospital transfers was a few minutes (figure 1). Subsequently, the ground transportation team was rapidly available and the transfer of patients in need of emergency surgery was performed in an efficient and safe manner. We were able to comply with the international standards with respect to timelines using these protocols.⁹⁻¹²

Off-site angioplasty, hospital and operator volumes

A clear relation has been shown between both operator and hospital volume of performing PCIs and outcome of the procedures.¹⁴⁻¹⁹ However, in the earlier reports on hospital numbers, the minimum number of all PCIs needed to guarantee an acceptable mortality was 160 to 200 per year per hospital.^{14,15} In another registry on 446 hospitals in the US, PCI had a lower mortality than thrombolysis as a treatment for acute myocardial infarction when performed in a hospital with a case load of 17 or more.¹⁶ Only recently Hannan reported on the New York PCI reporting system.¹⁷ It was clearly shown that hospital volume should be more than 400 to be on the safe side as far as mortality, same day CABG and same stay CABG are concerned. Morice also came to a minimum yearly hospital number of 400 PCIs in her abstract on a French registry of almost 38,000 PCIs.¹⁸ There are no reports, so far, originating from the Netherlands on this subject, but it is very plausible that the numbers from Hannan's and Morice's papers are also applicable to the Dutch situation. Under these conditions, we were able to develop an off-site programme which allows feasible and effective elective and primary PCIs for patients with coronary artery disease. Numerous studies have indeed confirmed the relationship between these volumes and clinical outcomes. The current data from our off-site programme confirm the outcomes described the NIRMI registry from the high-volume centres.

Conclusion

The initial Dutch experience on off-site PCI shows that emergency surgery for failed PCI occurs with an incidence of 0.2% in high-volume centres. Interhospital transport of such patients can be performed effectively without an excess of mortality. With appropriate settings, off-site PCI may not be associated with an increase in the risk of adverse events. ■

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