Case Reports

Acute Myocardial Infarction: Intracoronary Application of Nitroglycerin and Streptokinase

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Summary: In five patients with acute myocardial infarction, the effects of both intracoronary nitroglycerin (NTG) and subsequent intracoronary streptokinase application were evaluated. In addition, transluminal recanalization was performed in one of these patients. Injection of NTG into the infarct-related coronary artery resulted in improved distal filling of the subtotally occluded left circumflex artery in one patient, and in transient patency of the completely occluded right coronary artery in a second patient. In a third patient patency of the totally occluded left anterior descending artery (LAD) was achieved by transluminal recanalization with a guide wire. In a fourth patient with occlusion of the LAD, there was no response to intracoronary NTG and mechanical recanalization was not attempted. Subsequent intracoronary infusion of streptokinase (1,000–2,000 U/min for 15–60 min) resulted in a further and long-term reduction of narrowing at the site of acute occlusion in patients I-III and in opening of the completely occluded LAD in patient IV. Improvement of lumen was paralleled by alleviation of symptoms. In a fifth patient, in whom the LAD was subtotally occluded, the degree of coronary obstruction could not be changed by intracoronary application of NTG or by lysis. In this patient, symptoms and ECG changes improved with reduction of pathologically elevated blood pressure values. The findings suggest that myocardial infarction had been caused by thrombotic occlusion in four patients, and that spasm of the infarct vessel could have been an additional factor in two of these patients. In the fifth patient, an increase of afterload in the presence of a subtotal lesion might have caused the critical imbalance between oxygen supply and demand, resulting in cell death.

Keywords: acute myocardial infarction, streptokinase, nitroglycerin, transluminal recanalization, aortocoronary bypass surgery
Introduction

According to the classical pathologic theory, acute myocardial infarction is caused by coronary thrombosis superimposed upon high-degree atherosclerotic lesions in the majority of cases (4). Acute coronary occlusions could be recanalized permanently by perforation using guide wires and catheters (19). In the chronic stage of infarction, spontaneous increase of diameter of the recanalization canal was found (19). In medically treated infarct patients, spontaneous recanalization of the occluded vessel was found in 40% of the restudied cases (18). These observations can best be explained by endogenous lysis of thrombotic material.

On the other hand, Oliva et al. discussed spasm, superimposed on an atherosclerotic obstruction, as a possible cause of acute myocardial infarction (16). They were able to reopen occluded infarct vessels by intracoronary application of nitroglycerin (NTG).

In this study, the effects of both intracoronary NTG and subsequent intracoronary streptokinase application were evaluated in four patients. In addition, transluminal recanalization was performed in one patient.

Case Reports

Case I

A 57-year-old man had had recurrent retrosternal pain radiating into the neck, lasting for 10–15 min upon emotional stress, for the last 3 weeks prior to admission. On July 1, 1979, at 1:30 p.m., he experienced sudden excruciating chest pain associated with dyspnea, diaphoresis, nausea, and anxiety. He was admitted with these symptoms at 2:00 p.m. The patient had smoked 20 cigarettes a day for 30 years. His father and sister had died from coronary heart disease. The patient did not take any medication.

Physical examination showed a blood pressure of 140/90 mm Hg and a regular heart rate of 88/min. There were no abnormal findings. The ECG revealed acute anteroseptal infarction (Fig. 1). (CK-MB) was 6 U/l, the upper normal value being 12 U/l (25). The subsequent therapeutic and diagnostic steps are summarized in Table I. An intravenous nitroglycerin (NTG) infusion was started at a rate of 3 mg/h. Cine-coronary angiography was performed using the Judkins (9) technique. The only lesion found was a proximal occlusion of the left anterior descending artery (LAD) after the origin of a small septal and a major diagonal branch (Fig. 2a). The distal third of the LAD showed faint filling via collaterals with a lateral circumflex branch. The middle third of the LAD was not visualized. The left ventriculogram showed extensive akinesia (8), involving the anterolateral wall, the apex, and the septum. The end-diastolic volume index (EDVI) (10) was 99.4 ml/m²; the end-systolic volume index (ESVI) was 50.5 ml/m²; the ejection fraction (EF) was 49%.

Peak systolic left ventricular pressure (PLV) was 145 mm Hg; left ventricular end-diastolic pressure (PLVED) was 26 mm Hg prior to angiography.

**Intracoronary NTG.** After diagnostic angiography, 0.450 mg of NTG were injected over a period of 30 s into the left main coronary artery (LCA), using the technique described by Oliva (16). Control injections of contrast media immediately after NTG application and 3 min later showed no changes in the LAD obstruction.

**Transluminal Recanalization.** Recanalization (19) of the LAD occlusion was performed at 4:25 p.m. A Teflon-coated 0.32-inch guide wire (USCI) was passed through the lesion (Fig. 2b). Upon subsequent control injection, the middle third of the LAD showed delayed antegrade filling via a thin recanalization canal (Fig. 2c).

**Intracoronary Streptokinase.** Immediately after control angiography, a bolus of streptokinase (20,000 U dissolved in 8 ml of normal saline solution) was injected into the LCA. Next, streptokinase was continuously infused into the LCA via the Judkins catheter at a rate of 2,000 U/min for 50 min. Before streptokinase infusion, prednisolone (250 mg) and meclastin (2.7 mg) had been given intravenously. Control

![ECG chest leads before acute angiography (pre rec.), after restoration of blood flow by transluminal recanalization and intracoronary streptokinase application (post rec.), and after aortocoronary bypass surgery (post op.)](https://example.com/fig1.png)
Fig. 2 Case 1: left coronary artery, RAO projection. (a) Acute occlusion of the left anterior descending artery (LAD); (b) guide wire advanced beyond occlusion; (c) control injection after guide wire recanalization; (d) control injection after intracoronary application of streptokinase; (e) postoperative control angiogram showing recanalization canal patent and wash-out at site of bypass anastomosis; (f) graft to the LAD.
angiography performed thereafter revealed definite improvement of lumen at the site of the recanalized obstruction. There was complete filling of the LAD without any delay (Fig. 2d). There were no complications during the procedure. The chest pain subsided completely within minutes after initiation of streptokinase infusion. The EGG taken immediately after completion of streptokinase therapy showed decrease of ST-elevations (Fig. 1). Fibrinogen did not decrease (Table II). After completion of the laboratory procedure, an i.v. heparin infusion (1,000 U/h) was started. The i.v. NTG infusion was maintained until surgery. The patient remained asymptomatic. CK-MB peaked at 11:00 p.m., reaching 88 U/l. The following day, ventricular fibrillation occurred suddenly at 11:00 a.m. Immediate defibrillation was successful. The control ECG did not show any changes. The patient remained free of symptoms. That afternoon, a saphenous vein graft to the LDA was constructed. Upon intraoperative inspection, there were no signs of myocardial infarction. Control angiography performed after 2 weeks showed a patent LAD graft (Fig. 2f) and an 85% lesion of the LAD at the site of acute obstruction (Fig. 2e). Left ventricular function had improved. There was only anterolateral hypokinesia. EDVI had decreased to 63.6 ml/m², ESVI had decreased to 25.5 ml/m², and EF had increased to 60%.

Table I Sequence of diagnostic and therapeutic procedures in three patients with acute myocardial infarction

| Procedure                                      | Case
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1. nitroglycerin infusion (1.5–6 mg/h)</td>
<td>I</td>
</tr>
<tr>
<td>2. informed consent</td>
<td>I</td>
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<tr>
<td>3. premedication: diazepam (10 mg orally)</td>
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<tr>
<td>heparin (10,000 U IV bolus)</td>
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<tr>
<td>4. diagnostic coronary angiography</td>
<td>I</td>
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<tr>
<td>5. intracoronary nitroglycerin (0.15–0.45 mg)</td>
<td>I</td>
</tr>
<tr>
<td>control angiograms</td>
<td>I</td>
</tr>
<tr>
<td>6. transluminal recanalization (case I only)</td>
<td>I</td>
</tr>
<tr>
<td>7. intracoronary streptokinase (after prednosolone, 250 mg IV, and meclastin, 2.7 mg IV)</td>
<td>I</td>
</tr>
<tr>
<td>bolus (10,000–20,000 U)</td>
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</tr>
<tr>
<td>infusion (1,000–2,000 U/h for 15–60 min)</td>
<td>I</td>
</tr>
<tr>
<td>control angiogram</td>
<td>I</td>
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<tr>
<td>8. heparin infusion (~1,000 U/h)</td>
<td>I</td>
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<tr>
<td>9. aortocoronary bypass surgery</td>
<td>I</td>
</tr>
<tr>
<td></td>
<td>II</td>
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<tr>
<td></td>
<td>III</td>
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</table>

Table II Clotting factors before (A), immediately after (B), and 12 h after (C) streptokinase therapy

<table>
<thead>
<tr>
<th></th>
<th>Fibrinogen (mg%)</th>
<th>Thromboplastin time (%)</th>
<th>Thrombin time</th>
<th>Partial Thrombin time</th>
<th>Fibrin Monomer Complexes (g%)</th>
<th>Plasminogen (mg%)</th>
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<tbody>
<tr>
<td>Case I</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>480</td>
<td>17</td>
<td>5 min</td>
<td>5 min</td>
<td>1%</td>
<td>14.3</td>
</tr>
<tr>
<td>B</td>
<td>480</td>
<td>20</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>11.7</td>
</tr>
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<td>C</td>
<td>450</td>
<td>98</td>
<td>56 s</td>
<td>72 s</td>
<td>neg.</td>
<td>12.0</td>
</tr>
<tr>
<td>Case II</td>
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<td></td>
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<td></td>
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</tr>
<tr>
<td>A</td>
<td>740</td>
<td>28</td>
<td>5 min</td>
<td>5 min</td>
<td>0.5%</td>
<td>18.4</td>
</tr>
<tr>
<td>B</td>
<td>660</td>
<td>28</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>16.1</td>
</tr>
<tr>
<td>C</td>
<td>700</td>
<td>72</td>
<td>66 s</td>
<td>81 s</td>
<td>0.2%</td>
<td>15.9</td>
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<td></td>
<td></td>
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<tr>
<td>A</td>
<td>440</td>
<td>52</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>17.4</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>72</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
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<td>C</td>
<td>470</td>
<td>84</td>
<td>96.1 s</td>
<td>86 s</td>
<td>neg.</td>
<td>16.1</td>
</tr>
<tr>
<td>Case IV</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>540</td>
<td>45</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>14.5</td>
</tr>
<tr>
<td>B</td>
<td>520</td>
<td>45</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>13.2</td>
</tr>
<tr>
<td>C</td>
<td>480</td>
<td>76</td>
<td>88 s</td>
<td>82 s</td>
<td>neg.</td>
<td>13.8</td>
</tr>
<tr>
<td>Case V</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>370</td>
<td>31</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>14.7</td>
</tr>
<tr>
<td>B</td>
<td>400</td>
<td>36</td>
<td>5 min</td>
<td>5 min</td>
<td>neg.</td>
<td>13.0</td>
</tr>
<tr>
<td>C</td>
<td>400</td>
<td>78</td>
<td>76 s</td>
<td>84 s</td>
<td>neg.</td>
<td>12.4</td>
</tr>
</tbody>
</table>
Case II

A 56-year-old man, cigarette smoking his only risk factor, was free of symptoms until July 13, 1979. Starting at 12:10 p.m., he experienced sudden severe chest pain with dyspnea and diaphoresis. Shortly thereafter, he lost consciousness for a few minutes. Chest pain continued until hospital admission at 1:00 p.m. Clinical examination was not remarkable. Blood pressure was 100/80 mm Hg and the pulse rate of 76/min was regular. The ECG showed acute inferior infarction (Fig. 3) and first-degree atrioventricular (AV) block. CK-MB was 5 U/l. Coronary angiography was performed with the Sones technique (23). NTG was infused i.v. at a rate of 1.5–3 mg/h throughout the study and for the next 2.5 days.

The LAD was found to have two proximal 60% lesions and minor diffuse distal narrowing. The first major lateral branch of the circumflex artery showed a proximal lesion of 80%; the posterolateral branch was narrowed by about 85% at its origin. The dominant right coronary artery (RCA) was completely occluded shortly before the bifurcation (Fig. 4a). The inferobasal segment of the left ventricle was hypokinetic. EVDI was 69 ml/m², ESVI was 36 ml/m², and EF was 48%. PLV was 100 mm Hg, and PLVED was 3 mm Hg.

Intracoronary NTG. Three minutes after injection of 0.150 mg of NTG into the RCA, there was prompt antegrade filling of the distal segments. At the site of previous obstruction, there was a subtotal occlusion (Fig. 4b). Immediately after the control angiogram, ECG leads II and III, which were continuously registered, showed a transient decrease of ST-elevation lasting about 2 min. There was no change of symptoms. Eight minutes after intracoronary NTG, second-degree AV block occurred, heart rate dropped to 45/min, blood pressure started to decrease, and chest pain increased. These changes reversed immediately after application of atropine (1 mg i.v.). Complete relief of pain was achieved by i.v. injection of pentazocine (30 mg). Ventricular fibrillation occurred when a transvenous pacemaker was advanced into the right ventricle. Sinus rhythm was restored by defibrillation and slow i.v. application of propofenon (70 mg). Since the patient remained stable, the RCA was visualized again 50 min after the first intracoronary injection of NTG. The vessel was found to be completely obstructed (Fig. 4c). Repeat intracoronary injection of NTG (0.150 mg) once more resulted in filling of the distal RCA with subtotal occlusion at the site of the acute obstruction.

Intracoronary Streptokinase. Treatment with intracoronary streptokinase was begun 3.5 min after NTG injection with a bolus of 20,000 U. Continuous infusion of streptokinase (1,500 U/min) was given via the Sones catheter into the RCA for 50 min. Control angiograms after 30 and 50 min revealed increasing diameter at the site of previous obstruction (Fig. 4d). During infusion of streptokinase, there was a progressive decrease of ST-elevation, which accelerated after each injection of contrast media (Fig. 3). At the end of streptokinase therapy, fibrinogen had not dropped (Table II). Parenteral heparin was continued with a dose of 1,000 U/h for 12 days followed by long-term anticoagulation. Peak CK-MB was 79 U/l at 3:00 a.m. that night.

On July 30, 1979 the patient woke up at 4:00 a.m. with severe angina pectoris, relieved by NTG (0.4 mg sublingually). Repeat angiography performed the same morning did not show substantial changes of coronary artery morphology (Fig. 4e). EDVI had increased to 96 ml/m² and ESVI was 35 ml/m². EF had increased to 64%. The suggestion to undergo bypass surgery was accepted by the patient, but the operation was delayed at his request.

Fig. 3 Case II: ECG leads II and III before second application of NTG (0.15 mg) into the occluded RCA; 4 min after intracoronary NTG and immediately before intracoronary streptokinase infusion; after 30 and 50 min of intracoronary streptokinase infusion.
Fig. 4 Case II: right coronary artery, LAO projection. (a) Acute occlusion; (b) 3 min after intracoronary application of NTG (0.3 mg); (c) 40 min after intracoronary application of NTG and reocclusion; (d) after 50 min of intracoronary infusion of streptokinase; (e) control angiogram 17 d later.
Case III

A 47-year-old man who had smoked 25 cigarettes a day for more than 20 years was in excellent health until August 6, 1979, when he was admitted because of severe chest pain radiating into both arms. The pain had started suddenly at 12:15 p.m. and was associated with shortness of breath, weakness, and numbness of the hands. On admission to the hospital at 1:15 p.m. blood pressure was 100/80 mm Hg and the pulse was 48 and regular. The ECG showed ST-elevations in II, III, and AVF, a broad R-wave of 0.04 s in V1 and V2, and ST-depression in V1–V4. Cardiac enzymes were normal. Coronary angiography, performed with the Sones technique (23), showed a proximal subtotal left circumflex lesion with delayed, incomplete filling of the distal segments (Fig. 5a). The posterolateral segment of the left ventricle was akinetic and the apex was hypokinetic. EDVI was 84 ml/m², ESVI was 33 ml/m², EF was 61%, PLV was 100 mm Hg, and PLVED was 16 mm Hg.

Intravenous NTG was started at a rate of 3 mg/h at the beginning of coronary angiography and maintained for the next 2 days. During the study the ST-elevations reverted to normal; symptoms did not change.

Intracoronary NTG. Immediately after injection of NTG (0.300 mg) into the LCA, there was prompt complete filling of the distal circumflex segments, which persisted throughout the control period of 30 min (Fig. 5b). Shortly after injection of NTG chest pain began to subside; after 5 min the patient was asymptomatic. During the subsequent 30-min control period the patient had two episodes of minor chest discomfort,

Fig. 5 Case III: left coronary artery, RAO projection. (a) Subtotal occlusion of the left circumflex artery (Cx) with delayed incomplete distal filling; (b) 6 min after intracoronary application of NTG (0.3 mg) showing complete Cx filling; (c) 30 min after completion of intracoronary streptokinase infusion showing improvement of lumen; (d) control angiogram 14 d later.
each lasting for less than 5 min and not associated with ECG changes.

**Intracoronary Streptokinase.** Application of intracoronary streptokinase was begun 30 min after NTG injection with a bolus of 10,000 U, followed by continuous infusion of 1,000 U/min for 15 min. Control angiography immediately after completion of streptokinase application did not show any changes; however, 30 min later there was marked luminal improvement with reduction of the lesion to about 60% (Fig. 5c).

Peak CK-MB was 77 U/l; the follow-up ECG showed a strictly posterior infarction. The patient remained asymptomatic. Control angiography performed 2 weeks later showed the 60% circumflex lesion unchanged (Fig. 5d). Posterolateral wall motion was normal and the apical segment was hypokinetic. EDVI was 107 ml/m2, ESVI was 45 ml/m2, and EF was 58%.

**Case IV**

A 57-year-old female was free of cardiac symptoms until August 30, 1979, when she awoke at 1:00 a.m. with severe left chest pain radiating into the left arm and back. The pain was unrelieved at the time of hospital admission 3.5 h later. The patient had a history of diabetes mellitus (treated by glibenclamide, 2.5 mg p.o., since 1970) and of hypertension (treated by an unknown drug since 1966). Her mother had died from a stroke. On physical examination, moderate obesity was noted. Blood pressure was 170/100 mm Hg and the pulse rate was 68 with occasional extra beats. The ECG showed left anterior hemiblock and ST-elevations of 1–10 mm in V1–V5 with reciprocal changes in the inferior leads. Cardiac enzymes were normal. NTG was infused at a rate of 3 mg/h. Coronary angiography, performed by the Sones technique, showed a proximal occlusion of the LAD. There were no collaterals. The circumflex lateral branch was stenosed by 70%. The anterolateral, apical, and septal segments of the left ventricle were akinetic. EDVI was 70.4 ml/m2, ESVI was 37 ml/m2, and EF was 44.5%. PLV was 145 mm Hg and PLVED was 20 mm Hg. The patient complained of moderate pain during the study.

**Intracoronary NTG.** Injection of NTG (0.3 mg) into the LCA did not result in any changes of coronary artery filling or of symptoms.

**Intracoronary Streptokinase.** Intracoronary application of streptokinase was begun at 6:05 a.m., 6 min after NTG injection, with a bolus of 10,000 U followed by infusion of 100,000 U over a period of 1 h. After 15 min of streptokinase infusion, multifocal ventricular extrasystoles occurred; they subsided without treatment within 5 min. There were no changes in pressure. A control injection of contrast media into the LCA after 17 min revealed patency of the previously occluded LAD with prompt, complete antegrade filling. About 5 min after the onset of the arrhythmia the patient spontaneously noted that she was completely free of pain. Control angiography after 1 h of streptokinase infusion showed a proximal LAD lesion of about 90% and diffuse narrowing of the distal third of the vessel. PLV was 130 mm Hg and PLVED was 7 mm Hg at the end of streptokinase application. The ECG showed persistent left anterior hemiblock, the ST-elevations were reduced to 2–5 mm in V1–V4, and the R-wave was lost in V5. The patient was transferred to the intensive care unit in good condition. A further follow-up was not available at the time of submission of this paper.

**Case V**

A 57-year-old man was admitted to the hospital at 9:30 a.m. on June 22, 1979 because of recurrent episodes of severe chest pain at rest which lasted for hours. These episodes were not relieved by NTG (0.8 mg sublingually) and isosorbide dinitrate (80 mg/day). These symptoms first occurred 1 week prior to admission. The patient was a cigarette smoker who had a history of hypertension with systolic values up to 220 mm Hg and a type IV hyperlipoproteinemia. For the last 3 years he suffered from intermittent claudication with pain in the left calf after 250 m. His father had died from a stroke. On admission, the patient had severe chest pain which had started 30 min previously. Blood pressure was 180/120 mm Hg and the pulse rate was 104/min and regular. Left popliteal, dorsalis pedis, and tibialis posterior pulses were not palpable. The ECG showed acute anteroseptal myocardial infarction with ST-elevation in V2–V4 and lack of R-progression in V2 and V3. An ECG, registered by his physician the day before, had been normal. CK-MB, serum glutamyl oxaloacetic transaminase, aHBDH, and lactate dehydrogenase were normal. NTG was infused at a rate of 6 mg/h throughout coronary angiography, which was performed by the Sones technique. In addition to the usual premedications, beta-blockade (pindolol, 0.4 mg i.v.) was applied. Angiography revealed a proximal subtotal lesion of the LAD after the first septal and diagonal branch and 50% narrowing in the middle segment of the dominant RCA. The anterolateral, apical, and septal segments of the left ventricle were akinetic. EDVI was 112 ml/m2, ESVI was 63 ml/m2, and EF was 44%.

At the beginning of the study, PLV was 145 mm Hg and LVEDP was 28 mm Hg. Aortic pressure decreased continuously from 145/100 to 125/80 mm Hg during the study. This was paralleled by a decrease of symptoms. At the end of the diagnostic study, and prior to intracoronary injection of drugs, the patient was asymptomatic.

**Intracoronary NTG.** Immediately after application of NTG (0.3 mg) into the LCA and 3 min later, there was no change of the LCA lesion.

**Intracoronary Streptokinase.** Intracoronary application of streptokinase was begun with a bolus of 10,000 U 15 min after intracoronary injection of NTG. Subsequently, the lytic agent was infused at a dose of 1,000 U/min via the Sones catheter into the LCA for 60 min. There was no change of the angiographic findings after this treatment. The ECG registered before transfer to the coronary care unit showed reversal of the ST-elevations. Peak CK-MB was 37 U/l at 11:00 p.m. that night. Three days later another episode of AP, associated with a rise of ST-segments in V4 and V5 and preceded by an increase of blood pressure to 150/100 mm Hg.
Hg, occurred. This could be controlled by increasing the dosage of parenteral NTG. A repeat angiogram performed the next morning, immediately prior to aortocoronary bypass surgery, did not show any changes of LCA anatomy. A graft to the LAD was constructed. Upon intraoperative inspection the entire anterior wall was slightly cyanotic and hypo- to akinetic.

Follow-up angiography performed on July 10, 1979 showed the subtotal LAD lesion to be unchanged. The LAD graft was patent. Akinesia was no longer present. There was hypokinesis of the anterolateral wall and the septum. EDVI had decreased to 99 ml/m², ESVI had decreased to 42 ml/m², and EF had increased to 58%.

Discussion

Thrombolytic therapy has been tried by many investigators in acute myocardial infarction; however, systemic application was used in most studies (1, 5, 7, 17, 20, 21) and the results were not controlled by coronary angiography. Some investigators discuss a beneficial effect of systemic streptokinase therapy by alteration of the rheological properties of the blood (6) and by lysis of microthrombi in the border zone of infarction since recanalization of the infarct vessel by systemic thrombolysis (22) probably occurs too slowly to salvage jeopardized myocardium (3). Studies evaluating the effects of systemic fibrinolysis upon mortality and clinical course report conflicting results (1, 5, 7, 17, 20, 21). All investigators found a significant incidence of hemorrhagic complications.

By local application of smaller amounts of the lytic agent the local concentration of the drug can be increased; streptokinase resistance (13) need not be considered while the likelihood of systemic side effects is decreased. The efficiency of local arterial fibrinolysis in man was demonstrated by Köstering et al. (11). By injecting streptokinase (20,000 U every 5 min) into the thrombosed artery of Scriber shunts, he restored blood flow within 30–40 min. Verstraete et al. (24) and Lopacić et al. (15) reported that there was only a minor decrease in the level of fibrinogen in patients who received a streptokinase dosage of 250,000 U within 30 min. In our patients, intraarterial infusion of 1,000–2,000 U/min of streptokinase for 15–60 min also resulted in only a minimal decrease of fibrinogen and plasminogen. Prolongation of partial thromboplastin time, thrombin time, and thromboplastin time was attributable to heparin therapy. Operability of the patients was not impaired at any time by local fibrinolysis.

Intracoronary Streptokinase

Increase of the concentration of the fibrinolytic agent in the occluded coronary artery was first attempted by Boucek et al. in 1960 (2). In patients with acute myocardial infarction, the investigators infused the drug into the root of the aorta. Kordenat et al. performed intracoronary lysis by infusion of lytic enzymes through a coronary catheter in dogs (13). Recanalization of experimentally induced thrombi was achieved within 15 min. In the present study, intracoronary lysis was performed for the first time in man, and recanalization of a completely occluded LAD was also seen after 15 min (case IV). In two of the three patients with initially complete occlusion of the infarct vessel, the conditions for thrombolysis were probably improved by therapeutic interventions which preceded the application of streptokinase; antegrade flow was brought about by passing a guide wire through the occlusion in case I, and by intracoronary application of NTG in case II. In cases III and V, the infarct vessel was not totally obstructed. Antegrade flow guaranteed that the fibrinolytic agent reached the site of obstruction, penetrated thrombotic material, and facilitated removal of fibrin monomer complexes. Short-term intracoronary lysis for 15–60 min resulted in marked improvement of lumen at the site of obstruction and improved distal filling in cases I–III. During control angiography 2–3 weeks later, the recanalized vessels were found to be patent. The recanalization lumina at the site of previous obstruction were unchanged.

Pathophysiologic Implications

Injection of NTG into the infarct-related coronary artery resulted in transient patency of the occluded RCA in case II and in improved distal filling of the subtotally occluded left circumflex artery in case III. Intracoronary NTG had no effect upon the degree of obstruction or quality of distal filling in the three patients with total and subtotal LAD lesions. Oliva suggested a positive response to intracoronary NTG as evidence of "spasm" of the infarct vessel (16). However, reopening of the infarct vessel and improvement of flow might be attributable to an increase in caliber of the large conductive vessels, which is known to follow the administration of nitrates (14).

Intracoronary infusion of streptokinase resulted in marked additional and long-term improvement of lumen at the site of the infarct lesion in both patients who responded to NTG and in case I, in whom the occlusion had been perforated with a guide wire. In case IV a complete occlusion was recanalized by local application of streptokinase. These findings imply that thrombotic material, containing a significant amount of fibrin, was present at the site of acute obstruction in these three patients. From a therapeutic point of view it is important to note that lysis of thrombotic material resulted in more marked luminal improvement than intracoronary application of NTG, and that recanalization of an occluded vessel could be achieved by local lysis alone within 15 min.

The cause-effect relationships between coronary artery occlusion and acute myocardial infarction are disputed. Some investigators suggest that coronary artery occlusion is a consequence rather than a cause of acute myocardial infarction (4). In two of our patients, restoration of blood flow through the occluded vessel was paralleled by a decrease of ST-elevations, in four it was paralleled by symptomatic improvement. These findings suggest that recanalization of the occluded coronary artery resulted in improvement of perfu-
In case V, the degree of coronary obstruction could not be changed by intracoronary application of NTG or by lysis. Pathogenetic factors other than thrombosis or spasm must be discussed. A decrease of symptoms coincided with pharmacologic reduction of pathologically elevated arterial blood pressure values. In this patient, an increase of afterload in the presence of a subtotal lesion might have caused the critical imbalance between oxygen supply and demand resulting in cell death.

During their hospital course, three of the patients showed signs of instability: prolonged episodes of AP at rest occurred in cases II and III, and ventricular fibrillation occurred on the 1st day after recanalization in case I. Since this was not associated with reocclusion of the infarct vessel as shown by control angiography, instability was most likely attributable to persistent high-degree narrowing of the infarct vessel. Permanent stability was achieved by aortocoronary bypass surgery in cases I and V. Grafts to the infarct vessel were constructed in both patients. Upon intraoperative inspection, there were no signs of infarction or ischemia in case I; in case V there were signs of ischemia but no evidence of transmural necrosis.

References

15. Lopacius S, Ziemski JM, Latallo ZS: Changes in blood clotting and fibrinolytic system during intermittent streptokinase therapy. Akt Prob Angiol 37, 87 (1978)