Complications of Selective Percutaneous Transfemoral Coronary Arteriography and their Prevention

A Review of 445 Consecutive Examinations

By GERALD S. GREEN, M.D., C. MALCOLM MCKINNON, M.D., JOSEF RÖSCH, M.D., AND MELVIN P. JUDKINS, M.D.

SUMMARY
Complications encountered during a typical 12-month period of routine work with the Judkins percutaneous transfemoral method of selective coronary arteriography are reviewed. In 445 examinations, 20 complications (16 local and four cardiac) occurred. Local complications included nine delayed hemorrhages, five thromboses of femoral arteries, and two peripheral emboli. Cardiac complications included one ventricular fibrillation, one significant bradyarrhythmia, and two myocardial infarctions. Causes of individual complications are analyzed and means for their prevention discussed. Guidelines of the procedure are proposed to minimize the complications of selective coronary arteriography. Emphasis is placed on patient evaluation, preparation for the procedure, and meticulous examination technique.

Additional Indexing Words:
Myocardial infarction 
Femoral artery thrombosis
Hemorrhage 
Ventricular fibrillation

SELECTIVE coronary arteriography has become an integral part of the evaluation of patients with myocardial ischemia and is now being performed with increasing frequency. Despite the wide application of this procedure, there is little reported information about the morbidity, mortality, and risks of the procedure.1-5 This report reviews complications encountered during a typical period of 12 months' routine work with the Judkins percutaneous transfemoral method,6 7 and includes an analysis of their causes and means for their prevention.

Methods
Between July 1, 1969 and June 30, 1970, 445 selective coronary examinations were performed in 413 patients. Thirty-two patients had two examinations—before and after saphenous vein bypass graft surgery. Two hundred and seventy-six patients were examined on an inpatient basis and 137 as outpatients. The outpatients remained in our recovery room for approximately 6 hours after the procedure before being sent home or to another hospital. About two thirds of the procedures were done by trainees with staff supervision. Clinically, the patients, who ranged in age from 18 to 74 years, had preinfarction or postinfarction angina, chest pain of unknown etiology, aortic valvular disease, or intractable heart failure.

Preparation
The patient's status was completely reviewed beforehand by the angiographer, with special attention directed to iodine allergies, to drugs
being taken, especially Coumadin, to the heart rate, premature ventricular contractions, bundle-branch blocks, and to the serum potassium and prothrombin levels. Patients on Coumadin were usually taken off medication 2 days prior to the procedure and examined when the prothrombin time had risen to greater than 30% of normal.8 A temporary transvenous ventricular pacemaker was placed prior to the procedure in patients who had persistent bradycardia (heart rate less than 60) not responding to intravenous atropine, second- or third-degree atrioventricular block, or right bundle-branch block; however, no pacing was done unless needed. As another prophylactic measure, an intravenous catheter was inserted in patients with a history of previous arrhythmia or allergy.

During the preceding 6 hours no solid foods were given, but the patient was advised to drink up to 500 cc of liquid. Secomal (100 to 200 mg) and atropine (0.6 mg) were used intramuscularly as premedication. During the procedure, intravenous atropine in increments of 0.4 mg was given when the heart rate decreased below 60, and intravenous Valtum (1 to 5 mg) for apprehension and anxiety. Nitroglycerin (1/150th or 1/200th gr) was given prior to the initial coronary injection and subsequently as needed for chest pain.

Procedure
Continuous electrocardiographic monitoring was done. The site of entry of percutaneous puncture (the right or left common femoral artery) was selected depending on the local conditions, and especially on the arterial pulsation and presence of scar tissue. No. 8 French Ducor polyurethanes* were used routinely except for small patients, especially women, and patients with severe atherosclerotic disease of the pelvic arteries, for whom no. 7 French catheters were preferred. Pressure at the catheter tip was continuously monitored except during actual injections and while a closed flushing system was being used.6,7

A pigtail catheter was introduced first to record pressures in the aorta and left ventricle and to inject contrast agent for the left ventriculogram. This involved the delivery of 30 cc of meglumine diatrizoate 76% (10 to 12 cc per second for 2% to 3 seconds) and cinefluorography in the right anterior oblique (RAO) projection.

Selective catheterization of each coronary artery with appropriate catheters followed. Depending on the size of the arterial system, 5 to 10 cc of meglumine diatrizoate 76% were injected in 3 seconds. Five injections were delivered into each coronary artery, permitting two cinefluorographic recordings and three series of direct radiographs.

Complications
There were 20 complications, 16 local and four cardiac (Table 1).

Delayed hemorrhage from the puncture site occurred in nine patients. The time of hemorrhage varied from 1 to 12 hours after the procedure, with an average of about 6 hours. Seven of the nine were outpatients who bled when they began to ambulate. Only two patients had been taking Coumadin and none was hypertensive. In each case, such bleeding was readily controlled by external compression, and the patient was hospitalized for the night.

Thrombosis of the femoral artery developed in five patients, four of whom had some form of local predisposing factor. Two female

<table>
<thead>
<tr>
<th>Table 1</th>
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<table>
<thead>
<tr>
<th>Site</th>
<th>Type</th>
<th>No. of cases (445 total)</th>
<th>%</th>
<th>Therapy</th>
<th>Sequelae</th>
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<tr>
<td>Femoral</td>
<td>Delayed bleeding</td>
<td>9</td>
<td>2.0</td>
<td>External compression</td>
<td>None</td>
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<tr>
<td></td>
<td>Thrombosis</td>
<td>5</td>
<td>1.0</td>
<td>Thrombectomy (3)</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Embolus (loss of peripheral pulse without symptoms)</td>
<td>2</td>
<td>0.45</td>
<td>Aortic aneurysmectomy (1)</td>
<td>Death</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Streptokinase infusion (1)</td>
<td></td>
</tr>
<tr>
<td>Cardiac</td>
<td>Ventricular fibrillation (left ventricular, catheter-induced)</td>
<td>1</td>
<td>0.22</td>
<td>Defibrillation</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>Significant bradyarrhythmia</td>
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<td>0.22</td>
<td>Conservative</td>
<td>Death</td>
</tr>
<tr>
<td></td>
<td>Myocardial infarction (secondary to fibrin embolus)</td>
<td>2</td>
<td>0.45</td>
<td>Conservative</td>
<td>None</td>
</tr>
</tbody>
</table>

*Corbis Corporation, P. O. Box 428, Miami, Florida 33137.

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patients had unusually small femoral arteries, and thrombosis occurred despite the use of no. 7 French catheters. Two men had preexisting aortoiliac disease. In one of these the thrombus was successfully lysed by streptokinase. The other had a previously undiagnosed abdominal aortic and right common iliac artery aneurysm. Attempted local thrombectomy was unsuccessful and aortoiliac resection and grafting were subsequently performed, with the patient expiring in the postoperative period. A remaining patient had aortic and mitral insufficiency with faulty left ventricular function believed to contribute to iliofemoral thrombosis, which followed the procedure.

Peripheral embolization probably occurred in two patients, who lost either the dorsalis pedis or posterior tibial pulse, but who were both asymptomatic at the end of the procedure and 6 weeks later.

Ventricular fibrillation developed immediately after introduction of the pigtail catheter into the left ventricle of a 62-year-old woman with severe coronary artery disease. Defibrillation was successful. In no instance did ventricular fibrillation develop with selective coronary injection.

Significant bradyarrhythmia occurred in an 18-year-old boy with terminal glomerulonephritis, uremia, heart failure, anemia (hematocrit 18), and angina. He had been on a biweekly hemodialysis program, and coronary arteriography was requested to facilitate a decision concerning the advisability of renal transplantation. Left ventriculography demonstrated a large, diffusely hypocontractile ventricle (end-diastolic pressure 30 mm Hg). Immediately after the initial left coronary artery injection, he developed bradycardia, then atrial flutter, with a 2:1 ativoventricular (A-V) block. Intravenous ouabain was given, and within 7 minutes sinus rhythm reappeared at a rate of 55. He expired 2 days later secondary to heart failure. Autopsy revealed marked left ventricular dilatation and hypertrophy with interstitial fibrosis, calcification of the interventricular septum and A-V node, as well as calcified, but not obstructed, coronary arteries. The indications for this particular study were unusual, and believed to warrant the recognized high risk entailed.

Myocardial infarction complicated the study of two patients, both during study of the left coronary system. In each case uneventful initial injections demonstrated normal arteries. One infarction occurred in association with a subsequent injection for serial filming in the RAO position. The films demonstrated a cutoff at the junction of the middle and distal thirds of the anterior descending artery (fig. 1A and B). This patient's postinfarction course was uneventful, and he has now returned to work as a laborer, free of symptoms. The other induced myocardial infarction involved the loss of a branch of a diagonal artery in a patient who had a cardiomyopathy. The course in this case was also uneventful. Presumably, a soft fibrin clot was inadvertently injected in both patients, despite the presence of good pressures recorded at the catheter tip just beforehand.

Discussion

Selective coronary arteriography provides uniquely valuable diagnostic information at the relatively uncommon cost of local or cardiac complications.

Local Complications

The incidence of local complications appears to be related both to the method used and to the local condition of the artery. When brachial arteriotomy was routinely employed, as in the Sones technique, segmental brachial occlusion and pulse loss occurred in from 0.9 to 7% of patients.11–13 Percutaneous transfemoral methods are reported to have caused local complications in the form of bleeding, pseudoaneurysm, dissection or thrombosis of the femoral artery, or peripheral emboli in 0.6 to 1.3%.14,15

Prevention is the best way to minimize the complications. Since it became evident that in the present series delayed bleeding had occurred following too many (5%) outpatient studies, we have confined coronary arteriography to hospitalized patients. To reduce further...
COMPLICATIONS OF CORONARY ARTERIOGRAPHY

Figure 1

Occlusion of the anterior descending artery occurring during study of the left coronary artery. (A) Lateral projection shows essentially normal left coronary system with good filling of the descending artery. (B) Right anterior oblique projection demonstrates occlusion of the anterior descending artery in its middle portion (arrow).

the risk of postprocedure bleeding, special attention is given to hemostasis in patients receiving anticoagulant drugs and those with hypertension. Serious femoral complications (in this series about 1%) appear to be related to the condition of the artery, especially the presence of atherosclerotic disease. In patients with iliofemoral disease (as shown by decreased femoral pulses and femoral bruits), we usually elect to perform the procedure using a percutaneous axillary approach.

Cardiac Complications

Occurrence of cardiac complications has been reported in about 0.5 to 1.5% of patients.1, 7, 14 In this series of 445 arteriograms, ventricular fibrillation, bradyarrhythmias, and myocardial infarction occurred in less than 1%.

Patients should be in a condition of optimal fitness for the procedure; careful preoperative evaluation and preparation are essential if cardiac complications during coronary arteriography are to be minimized. In our institution, patients with acute congestive heart failure are intensively treated first and abnormal serum potassium levels corrected, unless the procedure has to be done on an emergency basis. Further, our prophylactic measures include the use of pacemakers for patients with conduction abnormalities and intravenous catheters in all high-risk patients.

Meticulous catheterization techniques with continuous monitoring of catheter-tip pressures and the use of a closed flushing system are also important in preventing complications. Knowledge of appropriate emergency countermeasures and readiness to apply them are similarly essential.

“Vagal reactions” are reported to be a frequent complication of coronary arteriography.15 Such reactions can have serious consequences in patients with coronary disease and must be vigorously met or prevented. Adequate hydration and premedication with intramuscular atropine and its additional intravenous use during the procedure whenever it is necessary are useful in this connection.

Guidelines for Minimizing Complications

Based on the experience reported here, in order to minimize the complications of coronary arteriography we propose and use the following simple guidelines.
Beforehand

1. All patients are hospitalized for percutaneous selective coronary arteriography.
2. In each case, the patient is examined and his clinical status carefully evaluated by the angiographer prior to acceptance for study.
3. Patients with prothrombin times less than 30% are excluded from the study.
4. Acute congestive heart failure and abnormal serum potassium levels are corrected when possible.
5. Dehydration is avoided.
6. Atropine and Seconal or Valium are used as premedication and additional atropine is given intravenously during the procedure whenever the pulse rate falls below 60.
7. A temporary pacemaker is placed in the presence of second- or third-degree atrioventricular or right bundle-branch block, and in persistent bradycardia not responding to intravenous atropine.
8. An intravenous catheter is placed in advance to facilitate possible emergency countermeasures in all high-risk patients.

During the Procedure

1. Continuous electrocardiographic monitoring is done.
2. Pulses are carefully evaluated to determine the site of entry and size of the catheter. Small (7F) catheters are used for small or seriously diseased arteries.
3. A closed flushing system is employed and double aspiration done each time a guide is changed (the initial aspirate is discarded). It is imperative that free backflow of blood be present at all times during selective coronary catheterization.
4. Nitroglycerin is routinely given sublingually prior to selective coronary catheterization.
5. Selective catheterization is done with minimal instrumental manipulation.
6. Pressure at the catheter tip is rigorously monitored. Damping when the catheter is in the coronary artery signals the need for catheter withdrawal and correction prior to reinsertion. Injection must not be done unless the catheter tip lies free within the coronary artery, as evidenced by the monitored pressure.
7. Time should not be wasted while a catheter lies within a coronary artery. An average of 2½ to 4 minutes' dwell-time should suffice for all necessary filming in each artery. Should there be a delay for any reason, the catheter should be removed, aspirated, flushed, and reinserted when ready to continue.
8. Flushing and the continuous drip delivery of saline should not be done while the catheter is in the coronary artery.
9. Injection should not be done while the patient is experiencing anginal pain.
10. Injections should not be done until electrocardiographic ischemic changes from a previous injection of contrast medium have returned to normal. In most cases these changes clear rapidly.
11. In the presence of a dominant left system (posterior descending and posterolateral descending arteries are branches of the circumflex system), time must not be wasted trying to catheterize a small hypoplastic right coronary artery. Such arteries are often so small that pressure damping occurs with selective catheterization and arrhythmias can occur. In this case, injection close to the coronary orifices is a preferable alternative.

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