esophagus and both the trachea and aorta has been reported in one previous instance. These two cases and the case reported here all were complicated by sudden exsanguinating hemorrhage into the esophagus. In the two cases which also involved the trachea, the tracheo-esophageal fistula occurred prior to the aortic fistula.

The majority of aorto-esophageal fistulae are complications of carcinoma of the esophagus or aortic aneurysm. An extensive review of aorto-esophageal fistulae due to other causes by Sloop and Thompson indicated that the majority of these cases are complications of esophageal injury, usually a foreign body in the esophagus. Emphasis has been placed upon the occurrence of one or more small bleeding episodes ("signal hemorrhage") which occur hours or days before the exsanguinating episode. Vomiting bright red blood may be a clue to the arterial nature of the bleeding and the aortic perforation as a source. The patient with tracheo-esophageal-aortic fistula reported by McCabe et al had such a "signal hemorrhage" three days before the fatal hemorrhage into the esophagus.

Successful operative intervention has been reported in a case of aorto-esophageal fistula which occurred following an operation for a vascular ring anomaly. Emergency thoracotomy was done to control massive hemorrhage from the fistula; and the aorta involved with the fistula was bypassed with a Dacron graft, and the fistula and adjacent aorta were resected. Any evidence of blood loss, particularly bleeding which can be identified as gastrointestinal, in a patient who has an esophageal lesion, including lye burn, should arouse suspicion that the bleeding is a "signal hemorrhage" of aorto-esophageal fistula. If esophagoscopic examination is possible, identification of the bleeding site would be helpful. If other causes of bleeding are not identified and an aorto-esophageal fistula is likely, consideration should be given to emergency surgery, with the intention of resecting the involved aorta and bridging the aortic defect with a graft. The esophageal fistula may be handled by resection of the esophagus or by cervical esophagostomy and placing a ligature at the cardio-esophageal position, to be followed later with an appropriate procedure to restore continuity.

References

Right Coronary Artery Dissection*
A Complication of Cardiac Catheterization and Coronary Angiography

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Four patients are described in whom right coronary artery dissection occurred during retrograde catheterization of the left ventricle or coronary arteries. In two patients, acute myocardial infarction occurred. The possible causes, radiographic features, and clinical implications of this infrequent complication are discussed.

A cute myocardial infarction may be a serious complication of diagnostic cardiac catheterization. Among its causes, embolization of thrombi, air, or atheromatous material into a coronary artery has been recognized and appears to be preventable by the routine use of heparin and meticulous attention to technique.

Dissection of a coronary artery may also result in acute myocardial infarction during or following diagnostic cardiac catheterization. We report four patients in whom dissection of the right coronary artery (RCA) occurred during retrograde brachial artery catheterization in approximately 5,000 cases studied in our laboratories. The clinical features, management, and possible causes of this complication are discussed.

Case Reports

Case 1

A 47-year-old man with aortic stenosis underwent cardiac catheterization and coronary angiography. A No. 8F Lehman ventriculography catheter was advanced from the right brachial artery to the aortic root where some difficulty was encountered crossing the aortic valve. Following left ventriculography, a No. 8F Sones coronary arteriography catheter was substituted. Coronary angiography was performed without difficulty using 4 to 8 ml of contrast medium injected by hand from a 12 ml plastic syringe. Pressure at the tip of the angiographic catheter was monitored throughout the procedure. The right coronary artery showed dilatation and a "spiral" irregular margin in its proximal third, with a smooth distal lumen (Fig 1). Staining of dye in the proximal part of the vessel persisted for several minutes (Fig 2). The left coronary artery (LCA) showed complete obstruction of the left anterior descending artery (LAD) and 90 percent ob-

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striction in the circumflex artery. At no time during or subsequent to the procedure did the patient complain of chest pain, nor were there ECG changes or elevation of cardiac enzymes suggestive of myocardial infarction. Fifteen days after catheterization, the patient expired suddenly. No autopsy was performed.

In the following cases, similar techniques were used.

**CASE 2**

Cardiac catheterization and coronary arteriography were performed in a 60-year-old man with a clinical diagnosis of coronary atherosclerosis. Difficulty was encountered in crossing the aortic valve with a No. 8F Lehman ventriculography catheter. Using a No. 8F Sones catheter, the right coronary artery was visualized and showed a filling defect in the proximal third with a patent distal lumen (Fig 3). Persistence of the dye was seen for several minutes at the area of the filling defect. The left coronary artery was also visualized and showed a 60 percent obstruction of the left anterior descending artery and complete obstruction of the circumflex artery. As in Case 1, there were no symptoms, ECG, or enzyme changes suggestive of myocardial infarction.

**CASE 3**

A 44-year-old man underwent diagnostic cardiac catheterization for evaluation of chest pain. Left ventriculography was performed without difficulty. A No. 8F Sones catheter was then substituted. The first right coronary artery angiogram appeared normal. However, subsequent injection into the RCA showed persistent dye staining at the proximal third of the RCA. The left coronary artery was entirely normal. Approximately one hour later, the patient complained of substernal pain and the electrocardiogram showed Q waves, ST elevation and T wave inversion in leads 2, 3, and aVF suggestive of acute inferior wall myocardial infarction. The patient was taken to the operating room approximately six hours later where the RCA was found to be dissected in the proximal third. The damaged vessel was repaired and a saphenous vein aortocoronary bypass to the distal portion of the RCA was performed. During the immediate postoperative period, the patient did well, although the ECG pattern of inferior myocardial infarction persisted. Thrombophlebitis of the right thigh (at the site where the vein graft had been obtained) developed six days following surgery and sudden death occurred three days later. Autopsy disclosed the immediate cause of death to be a massive pulmonary embolism. A recent inferior wall myocardial infarction was present. The vein graft was patent and the RCA showed a false lumen beginning at its os and extending for 2 cm.

**CASE 4**

Diagnostic cardiac catheterization was performed in a 34-year-old man with a prior history of anterior wall myocardial infarction complicated by cardiac arrest. Left ventriculography was done without incident using a No. 8F Lehman left ventriculography catheter. Because of difficulty in entering the right coronary artery, a No. 7Fr postitrol Sones catheter was substituted for the No. 8F Sones catheter. The RCA angiogram showed persistent staining of dye at its location.
orifice. The left coronary artery showed 70 percent obstruction in the left main coronary artery, 100 percent obstruction in the LAD and a 60 percent obstruction in the circumflex artery. Shortly after the procedure, the patient complained of substernal chest pain. Serial electrocardiograms showed ST elevation and T wave inversion, followed by Q waves, in leads 2, 3, and aVF compatible with acute inferior wall myocardial infarction. Emergency cardiac surgery was initiated five hours later. The RCA showed a dissection in its proximal third with a false lumen. The dissection was repaired and aortocoronary bypass grafts were placed in the distal RCA and LAD. The patient's postoperative course was uncomplicated and six months later, he was asymptomatic and had returned to work. The ECG changes of inferior wall infarction have persisted.

DISCUSSION

Dissection of a coronary artery may occur as a spontaneous event,\textsuperscript{6,7} or as a complication of diagnostic cardiac catheterization.\textsuperscript{5,6} Sones (reported in reference 5) reported four patients who developed RCA dissection associated with transbrachial coronary angiography done with the Sones catheter. Acute inferior myocardial infarction occurred in three of the four cases and in the fourth emergency aortocoronary bypass and repair of the RCA was done. Others have reported two patients with right coronary artery dissection following coronary arteriography done by the percutaneous transfemoral route using a preformed catheter.\textsuperscript{8} However, no clinical information was given.

In our four cases, right coronary artery dissection was recognized by the appearance of the proximal RCA following selective RCA angiography. In each patient, the radiopaque dye was seen to persist outside the arterial lumen for several minutes following injection of the contrast medium. This finding appears to be a useful sign of coronary artery dissection. In addition, one of our patients showed a spiral type irregularity in the proximal RCA and one patient showed an atypical filling defect with persistence of contrast medium around it. These angiographic findings, although not specific for arterial dissection, are certainly suggestive of it.

In each of our patients, as in others described, it seems reasonable to implicate catheter-induced trauma of the proximal right coronary artery as the most likely cause for the acute RCA dissection. In three of our four patients, the initial right coronary artery angiogram showed evidence of dissection. It is possible that in the first two patients, right coronary artery dissection occurred from inadvertent placement of the ventriculography catheter tip into the RCA during attempts to enter the left ventricle. Since no clinical manifestations were observed, the diagnosis of right coronary artery dissection would not have been made if subsequent RCA angiography had not been performed. In the last two cases, dissection of the right coronary artery probably occurred during attempts to enter the RCA with the Sones catheter.

The clinical manifestations of catheter-induced right coronary artery dissection were variable and did not appear to be related to the presence or severity of pre-existing right or left coronary artery disease.

In patients 1 and 2, no evidence of acute myocardial infarction occurred, and although patient 2 expired 15 days later, it seems unlikely that his death was related to right coronary artery dissection. One might speculate that in spite of right coronary artery dissection, a marked reduction of blood flow beyond the proximal RCA did not occur in these two patients. In the third and fourth patients, the RCA dissection was followed by clinical evidence of acute inferior myocardial infarction several minutes to an hour later. The time course in these patients suggests that a progressive reduction in RCA flow occurred following the dissection, possibly due to gradual narrowing of the true lumen. An additional factor may have been edema or hemorrhage within the damaged arterial wall.

The optimal management for patients in whom right coronary artery dissection is recognized during or immediately following coronary arteriography is unsettled. In the absence of symptoms or ECG evidence of myocardial injury (as in our first two patients), a conservative approach appears to be justified. When, however, clinical evidence of myocardial infarction occurs during or shortly after the procedure (as in cases 3 and 4), one may consider emergency surgical intervention to repair and/or bypass the damaged arterial segment. Although our two patients who had emergency surgery survived the immediate procedure, the ECG changes of inferior myocardial infarction persisted in both, and one of these two patients died of acute pulmonary embolism probably related to venous thrombosis occurring at the site of vein graft removal.

REFERENCES