SURGICAL TREATMENT OF ISCHEMIC HEART DISEASE

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RECENTLY the incidence of ischemic heart disease is increasing, and the death from the disorder is also increasing absolutely in Japan. Ischemic heart disease is the greatest single cause of death among the United States annually, and for this reason much effort is being directed toward surgical treatment of this disease. In Japan, as in the other countries, the surgical treatment of valvular heart disease and the most form of congenital heart disease is almost established. In contrast, the surgical treatment of ischemic heart disease in Japan has received comparatively little attention. At present cardiac surgeons are rarely consulted by the patients with ischemic heart disease. Ischemic heart disease has been categorized as a nonsurgical disease and entrusted to the internist for the medical therapy. For development of coronary artery surgery in Japan, it is apparent that the specific combination of medical and surgical means is necessary.

The clinical spectrum of ischemic heart diseases may be manifested in the patient’s history, physical examinations, electrocardiogram, or chemical laboratory examinations.

Angina pectoris and myocardial infarction are commonly associated with coronary atherosclerosis and are usually recognized without difficulty. Medical treatment of ischemic heart disease has been performed in concerned with diet therapy, anticoagulant therapy, antiarrhythmic therapy, the promotion of collateral circulation by coronary dilators, the prevention of atheromatous process and others.

Myocardial ischemia caused by coronary atherosclerosis may lead to arrhythmia including atrioventricular and intraventricular block. Sudden death resulting from cardiac arrest or ventricular fibrillation may be occurred. Acute and chronic heart failures can result from these disease. The various forms of myocardial ischemia can lead to mitral regurgitation and heart failure. Left ventricular asynergy and aneuryism secondary to ischemic and myocardial infarction are clearly associated with decreased left ventricular function. Other complications of acute myocardial infarction including shock, embolism, cardiac rupture, and the postmyocardial infarction syndrome continue to be difficult clinical problems.

The role of medical therapy for these clinical problems has already been established. However, medical management alone is not always effective, and progression of the atheromatous process can not be prevented. The utilization of suitable judgment and individual selection for surgical treatment is necessary.

Key Words:
- Selective coronary arteriography
- Internal mammary artery implantation
- Saphenous vein graft
- Myocardial infarction

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patients were referred from internists anticipating the operative indication. Clinical diagnoses are indicated in Table II. There were 8 patients of valvular heart disease with anginal pain. Thirty patients had angina pectoris with typical or atypical anginal pain. Two patients of myocardial infarction had characteristic QRS abnormalities and typical history of infarction. One patient had an aneurysm of the left ventricle after myocardial infarction. Four patients of congenital coronary artery disease had a clear evidence of the findings strongly suggestive of coronary abnormalities by the arteriograms (Table I and Table II).

METHODS

In 23 cases in the earlier stage of this experience, selective coronary arteriography was performed by the Sones technic, and in 21 cases in the later stage, by the Judkins technic. In one patient both technics were performed.

The Sones technic was performed by approaching the each coronary ostium through the exposed right brachial artery under local anesthesia. Before the arteriotomy heparin of 0.5 mg per kg was injected intravenously. The catheter tip was directed toward the coronary ostium under fluoroscopic control with an image amplifier, and contrast medium was injected under hand pressure through the catheter.

With the Sones technic, the following difficulties were encountered: 1) Failure to intubate the left coronary artery ostium 2) inability to fix the catheter tip into the coronary artery ostium, and 3) difficulty to advance the catheter beyond the innominate artery. Various types of arrhythmia may occur: however, no ventricular fibrillation was experienced with the Sones technic.

With the Judkins technic, the catheter was entered percutaneously through the femoral artery by means of the Seldinger technic. After the opacification of the left coronary artery, this catheter was removed over the guidewire and replaced with the right coronary catheter, and the right coronary artery was opacified.

The following difficulties were encountered with the Judkins technic: 1) inability to advance the catheter beyond the external iliac artery, and 2) difficulty to fall into the right coronary ostium. The tip of the Judkins catheter was more stable than that of the Sones catheter. We have been impressed on an advantage of the Judkins technic, while positioning the patient for various

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TABLE III  CLINICAL DIAGNOSIS AND DISEASED VESSELS

<table>
<thead>
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<th>Clinical diagnosis</th>
<th>0</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>Total</th>
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<tr>
<td>Valvular disease with</td>
<td>7</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
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<tr>
<td>chest pain</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Angina pectoris (typical)</td>
<td>4</td>
<td>11</td>
<td>7</td>
<td>1</td>
<td>23</td>
</tr>
<tr>
<td>(intermediate)</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>1</td>
<td>7</td>
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<td>Myocardial infarction</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Ventricular aneurysm</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>after myocardial infarction</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Congenital coronary artery disease</td>
<td>0</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>11</td>
<td>23</td>
<td>9</td>
<td>2</td>
<td>45</td>
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TABLE IV  LOCATION OF DISEASED VESSELS

<table>
<thead>
<tr>
<th>Diseased vessels</th>
<th>Location</th>
<th>No. of pat.</th>
<th>Total</th>
<th>Per cent</th>
</tr>
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<tr>
<td>Single vessel disease</td>
<td>LMC</td>
<td>3</td>
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<td></td>
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<td></td>
<td>LAD</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LCF</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RCA</td>
<td>2</td>
<td>19</td>
<td>65.3%</td>
</tr>
<tr>
<td>Double vessel disease</td>
<td>LAD &amp; LCF</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LAD &amp; RCA</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LMC &amp; RCA</td>
<td>1</td>
<td>9</td>
<td>30.0%</td>
</tr>
<tr>
<td>Triple vessel disease</td>
<td>LAD, LCF &amp; RCA</td>
<td>2</td>
<td>2</td>
<td>6.7%</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>30</td>
<td>30</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

LMC: Left main coronary artery  
LAD: Left anterior descending artery  
LCF: Left circumflex artery  
RCA: Right coronary artery  

projections or while moving the patient to the serial X-ray unit from the fluoroscopy unit.
In a patient with dilated aorta, earlier attempts were unsuccessful for the left coronary arteriography with the Sones technic; however, the opacification was performed quite easily by the Judkins technic. In another patients, as the Judkins catheter was unable to enter the aorta through the external iliac artery due to arteriosclerotic obstruction, successful arteriography was able to be done by the Sones technic. These both technics therefore are necessary to be chosen according to respective situation.

Coronary arteriograms of 35 cases were taken with a 16 mm cinecamera at the rate of 150 frames per second. In the remaining 10 cases a 35 mm cinecamera at the rate of 60 frames per second was used. In earlier experiences with 16 mm cinecamera, as the visualization of the individual coronary arteries was not always

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TABLE V  LOCATION AND GRADE OF OBSTRUCTION OF DISEASED VESSELS.

<table>
<thead>
<tr>
<th>Location</th>
<th>Grade of obstruction</th>
<th>Total (%)</th>
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<tbody>
<tr>
<td></td>
<td>30 - 50 %</td>
<td>50 - 90 %</td>
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<tr>
<td>Left main coronary artery</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Left anterior descending artery</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>Left circumflex artery</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Right coronary artery</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Total (%)</td>
<td>15 (34.9%)</td>
<td>17 (39.5%)</td>
</tr>
</tbody>
</table>

definite, a series of coronary arteriograms on the serial films was performed successively, and the films were available at diagnostic studies of X-ray motion picture. Recently, by the adjustment of the X-ray conditions, the view with 16 mm X-ray motion picture became more definitely than in earlier stage. The view with 35 mm cinecamera was clear enough to analyze adequately the distribution of individual coronary arteries.

Each coronary arteriography was routinely performed at the left and right anterior oblique positions and other various positions.

The contrast media employed were Conrinaxin-H® (Sodium and Meglumine Iodamide) in 17 cases, 76 per cent Urografin® (Sodium and Meglumine Diatrizoate) in 9 cases, Angiografin® (Meglumine Diatrizoate) in 4 cases and Conrinaxin-L® (Meglumine Iodamide) in 5 cases. In 10 cases of recent experience, mixture of Conrinaxin-H® and Conrinaxin-L® (1:1) was employed.

Ventricular fibrillation occurred in 3 patients of the cases with Angiografin®. The high viscosity or special toxicity of this medium may develop episodes of ventricular fibrillation. By injection of Conrinaxin-H® or 76 per cent Urografin®, the remarkable changes in the QRS complexes and the T waves were recorded. By injection of mixture of Conrinaxin-H® and Conrinaxin-L®, adequate visualization was obtained without electrocardiographic changes or complication like a ventricular fibrillation. Mixture of Conrinaxin-H® and Conrinaxin-L® seems to have following advantages over other contrast media: 1) easy to handle without hazards like a hemodynamic changes by injection or ventricular fibrillation, and 2) adequate opacification is constantly achieved.

RESULTS

In 8 patients of valvular heart disease with anginal pain, no ischemic changes appeared in the resting or postexercise electrocardiogram. Of these patients, 7 patients had no coronary arterial abnormalities. One patient with mitral stenosis and anginal pain had a slight narrowing in the left anterior descending artery. After closed mitral valvotomy without coronary manipulation, the patient became physically active and had no symptoms.

Thirty patients of angina pectoris had ischemic changes in postexercise electrocardiogram. Of these patients, 23 had a typical anginal pain. Of these 23 patients, 11 had single vessel disease, 7 had double vessel disease, one triple vessel disease and 4 normal arteriograms. Seven patients with angina pectoris were able to be classified of intermediate type, and their pain occurred at rest and continued more than 15 minutes. Of there, 7 patients had single vessel disease, one double vessel disease and the remaining had triple vessel disease. Angiographic findings of these patients revealed complete obstruction or severe narrowing of the main coronary arteries.

Two patients of myocardial infarction had complete obstruction, and had more involved vessels in number than those of angina pectoris. One patient having a history of myocardial infarction had a left ventricular aneurysm.

Of four patients with congenital coronary
artery disease, 2 patients had abnormal distribution of the left or right coronary artery with electrocardiographic findings suspecting of myocardial infarction. The remaining patients had abnormal origin of the left coronary artery from the pulmonary artery or congenital arteriovenous fistula (Table III).

Table IV reveals the distribution of the obstructive lesions of affected vessels in 30 patients except the patients of no diseased vessel and congenital coronary artery disease.

Single vessel disease was in 19 patients (63.3%), double vessel disease in 9 (30.0%) and triple vessel disease in 2 (6.7%) (Table IV).

The location and grade of obstruction of 43 arteries in 30 patients with abnormal coronary arteriograms are summarized in Table 5. The anterior descending artery was involved in 44.8 per cent, the left circumflex artery in 30.2 per cent, the right coronary artery in 11.6 per cent and the left main artery in 9.4 per cent. In grade of obstruction, 100 per cent obstruction was demonstrated in 11 of 43 arteries (34.9%), obstruction of 50 to 90 per cent of luminal diameter occurred in 17 (39.5%) and obstruction of 30 to 50 per cent was presented in 11 (25.6%) (Table V).

Complications

Episode of ventricular fibrillation occurred in 4 patients of angina pectoris. Three episodes occurred in the right coronary opacification and one episode occurred in the left coronary opacification. Ventricular fibrillation occurred in 3 patients with the Judkins technic and in one with the Sones technic.

In one patient ventricular fibrillation disappeared after the removal of the catheter tip from the coronary ostium. In two patients, after the application of direct current counter shock, the heart restored sinus rhythm. In the last patient ventricular fibrillation continued for about 5 minutes even with energetic resuscitation and repeated counter shocks until the heart restored normal sinus rhythm without any sequela.

In one patient cardiac arrest for a several seconds occurred and disappeared by removing the catheter tip from the coronary ostium.

Hypotension during a few hours after the arteriography occurred in one patient and recovered by intravenous injection of isoproterenol.

In 2 patients thrombi developed at the site of the brachial artery by Sones technic and were removed successfully by thrombectomy. A large hamatoma developed at the site of femoral artery puncture with the Judkins technic in one patients, who he was successfully treated with anticoagulant therapy, because of insufficient compression at the site of puncture.

II. Case Reports

Case 1: A single woman aged 23 years presented with an 3 year history of severe chest
Fig. 2. Case 1. A, preoperative electrocardiogram indicated ST segment depression in the left precordial leads. B, postoperative electrocardiogram demonstrated an improved ischemic pattern.

pain. Exertion, cold and emotion provoked the attacks. Nitroglycerin decreased the pain. The increase of symptoms and the recent ineffectiveness of nitroglycerin led to her admission to out hospital.

The electrocardiograms at rest showed pathologic ST segment elevation (0.2 mV). The exercise test was unable to be performed more than single two step test, because of precipitation of severe pain during the test.

Electrocardiogram following exercise indicated depression of the ST segment in the leads II, aVF, V3, V4, V5 and V6.

Coronary arteriography showed diffuse narrowing of the left coronary artery, and complete obstruction of the circumflex artery and the left anterior descending artery at the peripheral regions, without specification of the distal to the lesion (Fig. 1).

The patient was operated upon bilateral internal mammary artery implantation. For 3 months postoperatively the pain continued, and the administration of nitroglycerin was necessary. In the third postoperative month the chest pain began to subside successfully, and then 6 months later the pain did not occur even with a severe exertion.

Her electrocardiogram at rest and after the exertion improved, and remained normal thereafter (Fig. 2).

Selective internal mammary arteriography 6 months following operation revealed patient internal mammary implants and retrograde opacification of the left coronary artery (Fig. 3).

Case 2: A 24 year-old single female, a conductress of bus, had one year history of attacks of chest pain related to exertion. She had been unable to work during the six months prior to admission. The pain did not decrease by medication.

The electrocardiogram was normal. ST depression appeared in leads II, aVF, V3, V4, V5 and V6 after exercise test.

Coronary arteriography demonstrated complete obstruction of the left anterior descending artery, and severe obstruction (50 to 90%) of the left circumflex artery (Fig. 4). In the right coronary arteriography ventricular fibrillation occurred and did not disappear with a shock of defibrillation. After cardiac resuscitation of 5 minute's duration with cardiac massage, intratracheal intubation, intravenous administration of isoproterenol, repeated countershocks and others, the heart reversed to the normal rhythm.

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Fig. 3. Case 1. Postoperative internal mammary arteriogram revealed patent implants with retrograde perfusion to the left coronary artery. A, anterior-posterior projection and B, lateral projection.

and the patient recovered without complications.

Left internal mammary artery implantation was performed with left posterolateral thoracotomy. Ventricular fibrillation did not occur and other operative managements were performed smoothly. Postoperative course was almost good, and her chest pain decreased sufficiently and she returned to her occupation without attacks at the sixth postoperatively month.

Selective internal mammary arteriography 6 month following operation revealed patent internal mammary implant, however, revascularization was poor (Fig. 5).

Case 3: A 62 year-old male presented with a 15 month history of severe chest pain. He had an episode of severe attack of the chest pain suggesting of myocardial infarction, though repeated electrocardiograms failed to show a certain evidence of myocardial infarction. His symptoms of angina were atypical, because of

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Fig. 4. Case 2. Aortogram demonstrated a complete obstruction of the left anterior descending artery and a smooth narrowing of the left circumflex artery.

Fig. 5. Case 2. Postoperative internal mammary arteriogram revealed a patent implant with poor myocardial revascularization.

the long duration and usual occurrence in morning, and were classified of angina pectoris of intermediate type.

The electrocardiogram at rest showed minimal depression of the ST segment and the negative T in the leads II, III, aV₃, and V₆.

The electrocardiogram after exercise test showed depression of the ST segment in the leads I, V₄, V₅ and V₆ and elevation of the ST segment in the leads II and AV₃.

Right coronary arteriography demonstrated a complete right coronary artery obstruction and opacification of the distal artery through the collateral circulation. Left coronary arteriography indicated diffuse narrowing to at least a half of the original diameter of both left anterior descending and left circumflex arteries (Fig. 6).

Operation was performed successfully with aorto-coronary bypass graft under beating heart after standing by extracorporeal circulation. Flow rate of the bypass was 30 ml/min.

Postoperatively anginal attacks disappeared and electrocardiographical findings sufficiently improved. However, 24 days after operation he had right-sided hemiplegia by cerebral apoplexy, and hemiplegia improved gradually.

Case 4: A 44 year-old woman was admitted for coronary surgery. She had been suffering...
Fig. 6. Case 3. Cineangiogram of the right coronary artery showed a complete segmental obstruction.

Fig. 7. Case 4. A, cineangiogram of the right coronary artery showed a segmental obstruction. B, cineangiogram of the left coronary artery in the right anterior oblique projection. There was a smooth narrowing of the left circumflex artery.
Fig. 8. Case 5. A, cineangiogram of the right coronary artery indicated a segmental obstruction. B, repeated cineangiogram after 6 months demonstrated the improved distal perfusion by collateral vessels.
from anginal attack for five months. She experienced anginal attacks once or twice a day in spite of medical therapy.

On admission, physical and labolatory examinations pointed out almost no findings.

Electrocardiogram during anginal attack showed depression of the ST segment in the leads II, III and aVF.

Coronary arteriography revealed complete occlusion of the diaphragmatic portion of the right coronary artery and 50 per cent stenosis of the left circumflex artery (Fig. 7).

On operation, the femoral artery, superior and inferior vena cava were canulated, and the extracorporeal circulation was achieved. After anoxic arrest, the lesion of the left circumflex artery was investigated, however the portion of stenosis was unable to be discovered. After these unsuccessful investigation, the lesion of the right coronary artery was investigated. An induration was palpated on the right coronary artery about 2 cm proximal to the bifurcation of the posterior descending artery. Aorto-coronary bypass graft was produced by a reversed saphenous vein between the distal portion of the induration and the aorta.

Postoperative course was uneventful and her chest pain has disappeared, and she does not complain of heart at the present time.

Case 5: A 54 year-old man admitted to the hospital because of the attacks of chest pain and the both lower legs due to obliterative arteriosclerosis. The chest pain had began 2 years prior to admission, while the lower leg pain had occurred since the past several months. The chest pain recently increased, usually continued for 30 minutes and did not relieved by nitroglycerinen.

The electrocardiographical findings indicated a minimal Q wave of 0.2 to 0.5 mV in the leads II, III and aVF, and a flat T wave in the lead V6.

Master exercise test was unable to be performed for the leg pain. The electrocardiograms on attacks showed slight depression of the ST segment in the leads II, III, aVF, V5 and V6.

Coronary angiography demonstrated total obliteration of the right coronary artery about 4 cm from its origin. The opacification with slow filling of the distal artery demonstrated before an anginal attack developed during coronary angiography, and disappeared during the attack.

During his hospital stay, the chest pain was readily relieved by administration of nitroglycerin and propranolol, in spite of the plan of aorto-coronary bypass operation.

He was discharged from hospital, and with in 6 months the attacks of the chest pain stopped completely. Since there was no recurrence of the chest pain administration of nitroglycerin and propranolol was discontinued.

Six months after discharge the repeated coronary arteriography indicated the obstruction of the right coronary artery demonstrated previously and the opacification with quick filling of the distal artery. (Fig. 8).

Case 6: This 45 year-old man presented 3 years before investigation with an episode of chest pain which was interpreted as myocardial infarction. After the recovery from myocardial infarction, attacks of chest pain occurred frequently.

The chest X-ray film indicated a slight prominence of the left ventricular segment in the cardiac silhouette 2 years ago, and the shadow enlarged gradually for recent one year (Fig. 9).

The electrocardiogram showed Q waves of 0.5 mV in the leads I, aVL, V5 and V6.

Coronary arteriography demonstrated a complete obstruction at the root of the left anterior descending artery with no opacification of the distal vessel, and the region at the prominence of the ventricular aneurysm was avascular. (Fig. 10).

The left ventricular aneurysm with the content of blood coagula was removed successfully with the aid of extracorporeal circulation.

These abovementioned cases demonstrate the useful application of the surgical treatment to ischemic heart diseases.
DISCUSSION

1. Selective coronary arteriography

For suitable operation, accurate diagnosis of the lesion due to coronary atherosclerosis and adequate selection of patients are available for the first time. The diagnosis of ischemic heart disease had been made usually from the history of either angina pectoris or myocardial infarction, in combination with an electrocardiogram at rest or exercise with findings of myocardial ischemia. However, these examinations may not decide on the figure of the coronary artery, though the examination may suggest the presence of ischemic heart disease.

The use of coronary arteriography has added new dimensions to the treatment of ischemic heart disease. Selective coronary arteriography is a technic that has proved of great importance for the studies of arterial obstructive disease. When coronary arteriography is performed selectively, there are some difficult problems in addition to the technical performance. 1) Serious complications occur when the coronary circulation is interfered, especially in cases with advanced coronary artery disease. 2) The coronary arteries can not be opacified clearly by an arteriography or serial aortography, for the movement of the coronary arteries as they are moving with ventricular contractions.

The first selective coronary arteriography was performed more than a decade ago, in 1958, by Mason Sones. The technic of Sones includes not only the separate catheterization of the coronary ostia but also an image amplifier and rapid movie camera, in order to promote the contrast of the image of the coronary arteries. Sones catheter is designed with a special tip to allow selective catheterization of the coronary ostium.

The safety and accuracy of the procedure of coronary arteriography have been established presently. The Sones technic and Judkins technic are the most satisfactory. The Sones technic requires passage of a catheter through the brachial artery to the ascending aorta, where the tip is positioned into the ostia of the right and left coronary arteries. The Judkins technic requires passage of a catheter through the femoral artery to the ascending aorta. After contrast medium is injected, the flow of the medium through the arteries is observed on an image intensifier and simultaneously recorded with a 35 mm motion-picture camera at a rate of 60 frames per second.

Selective coronary arteriography outlines the internal caliper of the vessels as well as branches and collateral channels with a caliber of 100 to 200 μ. Lesions occluding as little as 20 per cent. of a artery with an internal diameter larger than 1 mm can be recognized.

Coronary arteriography is indicated whenever knowledge of the origin, distribution or internal caliber of the arteries is essential for diagnosis or treatment.

As presented by William Likoff within the category for diagnosis are following patients: 1) suspected coronary heart disease 2) atypical chest pain 3) nonspecific electrocardiographic
alteration, including conduction defects or arrhythmia of unknown cause 4) cardiac enlargement of questionable etiology 5) angina pectoris associated with rheumatic heart disease, and 6) evidence of unusual abnormalities of the coronary arteries, including congenital abnormalities, arteriovenous fistula, aneurysm and traumatic defects.

Coronary arteriography is a study of the anatomy, not the physiology, of the coronary circulation. Prodfit and associates\textsuperscript{10,11} reported the data of 1000 coronary arteriographic studies and their correlation with the clinical findings. In their patients with angina pectoris, the correlation was satisfactory in 93.7 per cent. The rate of correlation was lower among patients who had pain at rest or who had episodes of coronary failure. When the electrocardiogram showed a pattern of myocardial infarction, the accuracy of diagnosis was high (98.9%), but among the patients with intramural infarction by borderline QRS abnormalities or sharp inversions of T waves, the correlation rate was decreased to 74 per cent.

Cohen and associates\textsuperscript{12} suggested that clinical history gave an idea of the severity and distribution of the coronary pattern, mainly in relation to the duration of the symptoms.

Prodfit and associates\textsuperscript{11} concluded that the increase in length of history would correlate with progressive increase in the frequency of involvement of three arteries.

Recently, it was suggested by Kemp and associates\textsuperscript{13} in a study of 50 patients with chest pain indicative of coronary artery disease and normal coronary arteriograms that perhaps the disease was at the level of the microcirculation and can not be visualized from routine coronary arteriography.

Although the risk of the coronary arteriography includes damage to the vascular channels through which the catheter is manipulated, systemic reactions to the contrast medium, arrhythmia including ventricular fibrillation and perhaps myocardial infarction, the actual incidence and severity of these complications are small. The mortality rate attributed to coronary arteriography is now recorded as under 1 per cent.

In conclusion, coronary arteriography is absolute essential procedure in preoperative selection of the patients in whom it would seem to be appropriate to perform revascularization procedures. The examination can be performed with a low risk to the patient and minimal complications.

2. Surgical treatment of ischemic heart disease

The idea of a surgical approach for coronary artery disease is not new. Operative technics, such as omental and muscle grafts, dorsal sympathectomy, coronary sinus ligation, aorto-sinus fistulas, and others were only a few of the procedures given clinical application. The most recognized procedures were internal mammary artery implantation and aorto-coronary bypass graft operation.

Internal mammary artery implantation

In 1946 Vineberg\textsuperscript{14} first reported the development of anastomosis between coronary arteries and an internal mammary artery implanted in the left ventricular myocardium. Although Vineberg and a few others had been doing mammary implants on patients for many years, there was very little acceptance of the operation clinically until Sones demonstrated the evidence of prolonged patency and opacification of the coronary arterial system through the implanted internal mammary artery by arteriography.

Veneberg's original technic was a implantation of the internal mammary artery dissected clearly from other tissue. Swell\textsuperscript{15} used an internal mammary pedicle composed of artery, vein, pleura and muscle. He reported that such a pedicle helped to maintain a patent and undis-torted internal mammary artery. Favaloro\textsuperscript{16} reported the implantation of bulky pedicle into the myocardium and suggested trimming the implanted portion, but left the more bulky pedicle proximally. In our cases the implantation of the bulky pedicle was performed, and the procedure had an advantage of the minimum disturbance of myocardial function.

By the report of Cleveland Clinic, the most experienced group in this field, over a 5 year period from 1961 to 1966, Vineberg internal mammary implantation was performed in a selected group of 218 patients with a mortality rate of 4.6 per cent. This rate dropped to 2.1 per cent for the last 280 patients so treated. Of 127 postoperative selective internal mammary arteriograms, 54 per cent were patient with opacification of coronary arteries, 38 per cent demonstrated patency without coronary artery opacification, and 8 per cent were occluded\textsuperscript{17}

Vineberg presented experimental and clinical evidences for the use of free omental grafts. Combined internal mammary artery implants

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with posterior omentopexy were employed in 92 patients with a 6.5 per cent of mortality rate. Subsequent arteriographic evaluation has confirmed vascular ingrowths into the posterior myocardium from such sites\textsuperscript{18}

Favaloro reported the results with bilateral internal mammary artery implants of 248 patients. The left internal mammary artery was implanted into the lateral and diaphragmatic walls of the left ventricle and the right mammary artery into its anterolateral portion. Preoperatively, all cases demonstrated perfusion deficits in the anterolateral and diaphragmatic aspects of the left ventricle. A hospital mortality rate of 9.3 per cent was recorded. Of the 31 patients undergoing postoperative angiographic studies, 61 mammary arteries were opacified. Fifty eight remained patent and 37 showed communications with coronary arteries\textsuperscript{19}

The recent report of Cleveland Clinic experiences, 1624 cases of single mammary artery implantation were performed with a mortality rate of 3.9 per cent, and 1080 double internal mammary artery implantation with a mortality rate of 5.6 per cent\textsuperscript{20}

Vineberg offered following indications for internal mammary artery implantation: 1) anginal pain persisting inspite of adequate medical treatment, 2) myocardial infarction, 3) coronary artery insufficiency, even though asymptomatic, 4) ventricular failure due to coronary artery insufficiency. Contraindications were offered as follows: 1) recent myocardial infarction, 2) evidence of unstable disease, 3) associated incurable incapacitation disease, and 4) left ventricular enlargement due to dilatation\textsuperscript{21}

It is accepted with sufficient evidences that the ventricular myocardium may be revascularized by internal mammary artery implantation. Subsequent laboratory and clinical experiences with internal mammary artery implant have established the fact that the implant remains patent and makes myocardial revascularization. In spite of the development of direct coronary surgery, the improvement of myocardial ischemia distal to the site of obstruction must be made only by indirect myocardial revascularization. Actually the operative risk of internal mammary artery implantation is reasonably low, and clinical aspects after surgery demonstrate the relief of angina and improvement of clinical symptoms in large majority of patients. Postoperative angiographic studies confirm that good results are directly related to the patency of the implanted artery. The suitable selection of the patients relates to the success of myocardial revascularization.

The justification for the clinical application of internal mammary artery implantation is based upon the encouraging results in patients with ischemic heart disease. Finally, it should be stated that direct coronary surgery, as the following discussion, is one form of revascularization surgery and does not reduce the importance of indirect revascularization. as it is provided by the internal mammary artery implantation procedure.

Direct coronary surgery

The concepts upon which the direct coronary surgery is able to performed have been aided by the classic studies of Blumgart\textsuperscript{22} and other investigators. Their observations indicate that obstructions the most often located in the proximal third or half of the coronary arteries.

In 1957 Bailey\textsuperscript{23} introduced coronary endarterectomy, which was modified by Longmire in the following year. Thies procedure was useful for selected patients with angina pectoris, but its application was found to be relatively restricted.

Green\textsuperscript{24} has described early experiences with the use of the internal mammary artery for bypass grafting. The saphenous vein for bypass grafting in the coronary circulation was first widely used by Favaloro\textsuperscript{25,26} at the Cleveland clinic to bypass a short segment of occlusive disease in the right coronary artery. Initially the grafts were interposed in the coronary artery, dividing the artery proximal and distal to the occluded segment. The indication for saphenous vein graft interposition is determined from preoperative coronary arteriograms. Located obstruction of the dominant coronary artery is main indication for the operation.

In the recent years, the contributions of Favaloro\textsuperscript{26} and associates have led to an extensive development of the surgical approach, in which coronary arteries of extremely small caliber may be successfully anastomosed to a venous autograft from the aorta. These workers have demonstrated that coronary arteries with a diameter as small as 1 mm may be jointed by suture anastomosis with prolonged patency, as confirmed by postoperative arteriography. The results following operation and the reliable data are being accumulated. The effects of the operative procedure, including morbidity, mortality, and patency of the graft are of import-

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ance.

Effler and associates\textsuperscript{27} reported experiences with 224 operations utilizing saphenous vein graft technics. The majority of the operations were performed for the right coronary artery disease. Seventeen vein bypass grafts have been applied to the occlusive lesions in the left main coronary artery extremely proximal to the take off of its anterior descending branch. There were 8 hospital deaths in the right coronary artery series, and 2 hospital deaths in the left coronary arteries. Evaluation of the immediate postoperative angiographic studies demonstrated the potential of saphenous vein grafts for immediate myocardial revascularization, and they were encouraged to continue the application of these technics.

Green and associates\textsuperscript{28} reported their experiences with coronary bypass grafts in 82 patients during the 24 month period from 1968 to 1970. Thirty-five had single graft, 16 were internal mammary artery grafts to the anterior descending coronary artery, 13 were vein grafts to the right coronary artery, and 6 were vein grafts to the anterior descending artery. There were 2 operative deaths in this group.

Double grafts were employed in 44 patients. In majority of this group, 20 were internal mammary artery grafts to the anterior descending artery and vein grafts to the coronary artery, and 20 were vein grafts to both the left anterior descending and the right coronary artery. Among the 44 patients, 8 hospital deaths occurred. Three patients had triple grafts consisting of combination of double vein grafts with an internal mammary artery graft, and there were no deaths in this group. Postoperative internal mammary arteriography was performed, and in each patient a patent graft was demonstrated. Green concluded that the results indicated a much wider application of bypass grafting by internal mammary or vein for patients with serious coronary artery disease.

In the recent report of Cleveland Clinic Hospital\textsuperscript{30} a total of 1965 patients underwent surgery by saphenous vein graft technic in the 4 year period of between May, 1967, and April 1971.

Effler and Favaloro described that simplified operative procedure of this technic rewarded by dramatic reduction in hospital mortality rates (under 4.0\%), and marked improvement in surgical results. Postoperative angiographic studies were performed in 400 patients approximately 6 months later, and graft patency was demonstrated in approximately 85 per cent. Occlusions of the graft were attributable to thrombosis, which seemed to occur within a relatively short period after operation.

Hill and associates\textsuperscript{29} reported emergency aortocoronary bypass for impending extending myocardial infarction. Emergency coronary arteriography and aortocoronary bypass were successfully performed in three patients with preinfarction angina. They offered that aortocoronary bypass was able to prevent infarction in selected instances of preinfarction angina.

By the development of aortocoronary bypass grafts, the need for an exacting technic is clear, with anastomoses being accomplished with very fine sutures, and some operations have found the magnification provided by special glasses to be quite helpful. In addition to the luminal diameter of the coronary arteries to be anastomosed successfully, it is important that the vessels should be essentially normal at the site of anastomosis and not be involved with marked atherosclerosis. The venous autograft appears to be satisfactory and the use of the internal mammary artery is interest, however, these procedures have several problems awaiting solution.

In spite of clinical acceptance of aortocoronary bypass grafts, progressive and late obstruction of the graft was recently reported by Johnson\textsuperscript{30} Grondin\textsuperscript{31} and other authors. A criticism of the direct coronary surgery would include: 1) ultimate patency rate, 2) likelihood of involvement of the graft by atherosclerosis, fibrosis or aneurysmal dilatation, 3) effect on recurrent myocardial infarction, and 4) relationship of the operation to extension of the life.

The indications for direct coronary surgery are not firmly agreed. A primary requisite is an established diagnosis of coronary artery occlusion by selective coronary arteriography. Moreover, the demonstration of distal patency in one or more arterial vessels at the time of arteriography is desirable. At present, the chief indication is uncontrolled angina pectoris.

For the present, there appears to be required more widespread use of this approach in patients with myocardial ischemia, especially in Japan. The answers to these critical questions can be made only when both time and appropriate evaluations permit.

With an approach to the future, it is possible that not only patients with uncontrolled angina
but also with recurrent myocardial infarction, and those with acute myocardial infarction may be helped by direct coronary surgery.

Surgical procedures of coronary heart disease other than myocardial revascularization.

Rupture of an infarcted ventricular septum entails mortality rate of 24 per cent in the first 24 hours and up to 70 per cent within 2 weeks. Attempt at closure in an interval of three to six weeks is desirable. Complete heart block occurs in 3.4 per cent of cases of myocardial infarction. Persistence for over three weeks requires implantation of pacemaker. Mitral valvular insufficiency is of surgical importance when ruptured papillary muscle is resulted from infarction. This usually requires mitral valve replacement. Excision of acute myocardial infarction to relieve paradoxic myocardial contraction has proved useful in experimental animals, though clinical application is not always often. Extensive localized fibrosis with intractable failure has been aided by localized excision.

Ventricular aneurysm occurs in 3.5 to 15 per cent cases of myocardial infarction. Surgical resection is indicated for aneurysm responsible for persistent congestive heart failure or peripheral embolism. Preliminary coronary arteriography and left ventriculography are helpful in confirming the diagnosis and planning the surgical procedure.

In our patient case 6, coronary arteriography indicated total occlusion of the anterior descending artery. By Favaloro and Effler analysis of the arteriography of 49 patients with ventricular aneurysm showed the anterior descending artery to be totally occluded in 29 patients, and the ventricular aneurysm was located in the anterolateral wall and apex in these patients.

A recent report of a large series by Effler and associates indicated the successful resection of ventricular aneurysm with an operative mortality of 9.2 per cent. However, they offered that the surgical treatment for ventricular aneurysm was not curative, since the underlying disease process remained, and they emphasized the necessity to combine simultaneously revascularization procedures with resection of the ventricular aneurysm.

As discussed previously, there are three reconstructive operation for the surgical treatment of ischemic heart disease: Indirect revascularization by internal mammary artery implantation for diffuse distal obstruction, direct coronary surgery for localized segmental obstruction, and resection of postinfarction ventricular aneurysm.

The most favorable combination for postinfarction ventricular aneurysm would be either ventricular aneurysmectomy, and implantation of internal mammary arteries on the wall of the left ventricle and direct coronary surgery on severe localized obstruction.

By recent report from the Cleveland Clinic a total of 124 combined simultaneous revascularization procedure were performed. Favaloro offered that these patients were benefited by an immediate increase in the coronary circulation and were also able to look forward to improvement in the future by internal mammary implantation.

Combined simultaneous revascularization procedure can be attributed to an immediate increase in myocardial perfusion with reasonable operative risk.

Personally, the author do hope that in the near future in Japan, patients with severe ischemic heart disease will be treated with these procedure. The patients with ischemic heart disease should be treated under the connection of a combined surgical and medical team. Coronary arteriography is performed and surgical intervention is routinely performed, with total recovery in a significant number of them. Further clinical experience will be necessary to be demonstrated the effectiveness of surgical treatment.

Summary

The importance of selective coronary arteriography associated with treatment of ischemic heart disease was stressed. Of 45 patients with selective coronary arteriography, 23 cases were performed by Sones technic, and 21 cases by Judkins technic. These both technics are necessary to be chosen according to respective situation. Mixture of Conrarin-H and Conrarin-L seemed to have advantage to be employed without hazards over other contrast media.

Reported cases were two cases of internal mammary artery implantation, two cases of aorto-coronary bypass graft, a case of medical treatment and a case of ventricular aneurysmectomy. Surgical procedures concerning ischemic heart disease were discussed in detail from the view point of advantage and effectiveness of each procedure.

For the further progress in this field, cooperation of internists should be necessary.

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REFERENCES


