by types of *C. botulinum* other than E have been documented in Alaska. In September 1976 three persons (not Inuit) in Angoon became ill after eating fermented fish eggs that were found to contain type A toxin. In December 1976 two Inuit in Akiachak became ill from eating fermented salted salmon that contained type B toxin.

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Myocardial infarction, hyperthyroidism and normal coronary arteries: report of two cases

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Myocardial infarction is uncommon in persons with hyperthyroidism and also uncommon in the absence of demonstrable coronary artery disease. Cardiac catheterization and selective coronary angiography were performed in two men following apparent myocardial infarctions. Both patients were 33 years of age, thyrotoxic and angiographically free of coronary artery abnormalities.

L'infarctus du myocarde est rare chez les personnes souffrant de l'hyperthyroïdie ainsi qu'en l'absence de maladie coronarienne démontrable. Un cathétérisme cardiaque ainsi qu'une angiographie coronaire sélective ont été réalisés chez deux hommes à la suite d'infarctus apparents du myocarde. Les deux patients étaient âgés de 33 ans, thyrotoxiques et libres à l'angiographie d'anomalie des artères coronaires.

Myocardial infarction is uncommon in individuals under 35 years of age.[1] It is unusual in the absence of coronary artery disease[2] and also appears to be unusual in thyrotoxic patients.[3] We have recently studied two thyrotoxic patients, both aged 33 years, with apparent myocardial infarction and angiographically normal coronary arteries.

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Methods

Cardiac catheterization was carried out percutaneously from the right groin by standard techniques. Angiograms were recorded on 35-mm cine film with 15- and 23-cm Phillips image intensifiers. Selective coronary injections were performed in several projections, including modified cranial angulations,[4] by Judkins' technique.[5] Angiograms were interpreted independently by three experienced observers.

Thyroid function tests were performed with commercially available kits (those for measurement of serum thyroxine [T_4] concentration and triiodothyronine [T_3] uptake, from Nuclear Medical Laboratories Inc., Dallas, Texas; that for radioimmunoassay of total T_3, from Abbott Laboratories, North Chicago, Illinois).

Case reports

Case 1

A 33-year-old man presented to his family physician in August 1975 with proptosis. Graves' disease was diagnosed and he was treated with radioactive iodine Sept. 30, 1975.

Six weeks later crushing retrosternal pain occurred suddenly and lasted for 6 hours. He consulted his physician. An electrocardiogram (ECG) showed ST-segment elevation, convex upward, in leads I and V_1 to V_4, and reciprocal ST-segment depression in leads II and III. As electrocardiography was being completed, ventricular fibrillation occurred spontaneously. The physician immediately started external cardiac compression, which he continued while the patient was transferred to hospital.

At hospital the patient was resuscitated by means of defibrillation with several direct-current electric shocks. He was unresponsive and hyporeflexic; there were no localizing signs. Exophthalmos, more pronounced on the left, was noted. The thyroid gland did not feel enlarged. There was sinus tachycardia but no evidence of congestive heart failure. The remainder of the physical findings were unremarkable.

Following resuscitation the ECG showed substantial ST-segment elevation in all leads except no. III (Fig. 1; 11.11). The next day T-wave inversion developed in leads I and V_1 to V_6, with some loss of precordial R-wave voltage. The ST-segment elevation was then confined to the precordial leads (Fig. 1; 12.11).

Serum glutamic oxaloacetic transaminase and lactic dehydrogenase values were elevated at the time of admission; they declined in a curve compatible with that characteristic of myocardial infarction (Table I).

The patient remained comatose for 24 hours but eventually recovered fully. Results of thyroid function studies on the 3rd hospital day, 7 weeks following treatment with radioactive iodine, were still abnormal. He was discharged from hospital taking propylthiouracil and propranolol.

Four months later he was readmitted for cardiac catheterization. His ECG at this time (Fig. 1; 9.9) showed only residual T-wave abnormalities in leads V_1 to V_3. The cardiac index, intracardiac pres-

Table I—Laboratory data* in two patients with apparent myocardial infarction

Patient and day after onset of chest pain	Serum concentrations† SGOT, IU/L (0-40)	LDH, IU/L (87-185)	CPK, IU/L (0-70)	Total T_4, μg/dL (4.5-11.5)	Total T_3, ng/dL (75-200)	T_3 uptake, % (35-45)
Patient 1						
1	514	—	—	—	—	—
2	210	835	—	—	—	—
3	152	—	—	18	305	57.7
4	66	175	—	—	—	—
5	29	164	—	—	—	—
Patient 2						
1	—	—	143	—	—	—
3	—	—	91	—	—	—
23	—	—	—	14.6	336	50.2

*SGOT = serum glutamic oxaloacetic transaminase; LDH = lactic dehydrogenase; CPK = creatine phosphokinase; T_4 = thyroxine; T_3 = triiodothyronine.
†Normal values in parentheses.

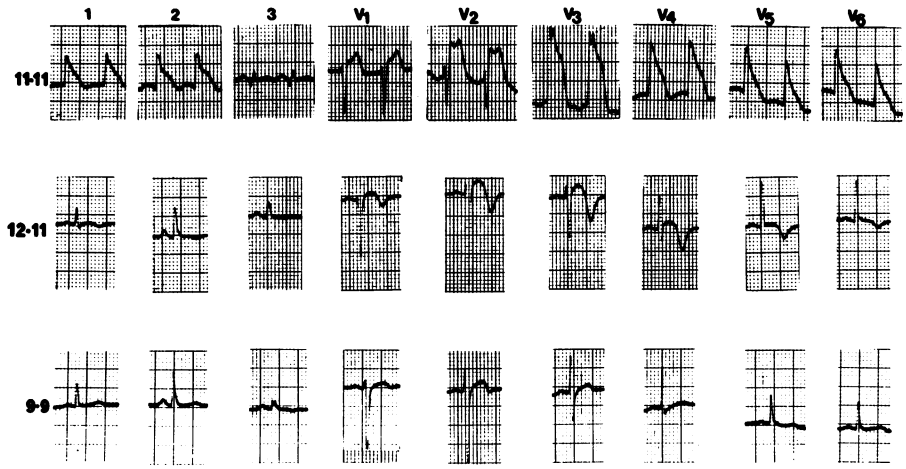

FIG. 1—Case 1. Electrocardiograms at time of admission (11.11), next day (12.11) and prior to cardiac catheterization (9.9). See text for details.

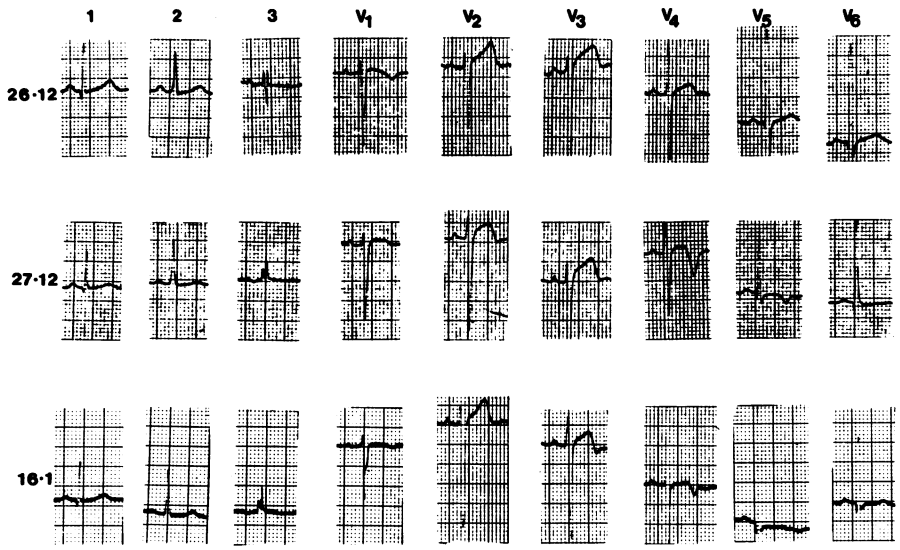

FIG. 2—Case 2. Electrocardiograms at time of admission (26.12), next day (27.12) and prior to cardiac catheterization (16.1). See text for details.

sures and ejection fraction were normal. Left ventricular angiogram showed mild, diffuse impairment of contractility. No abnormality was visualized in his coronary arteries.

Case 2

A 33-year-old man was well until December 1975, when he experienced severe retrosternal pain while playing cards. He went immediately to another hospital. An ECG showed ST-segment elevation in leads V_1 to V_4 (Fig. 2; 26.12) and a diagnosis of probable acute anterior myocardial infarction was made. He had a palpable goitre but no other features of hyperthyroidism. Sinus rhythm was noted; the rate was 116 beats/min. His blood pressure was 150/80 mm Hg. There was a soft systolic murmur along the left sternal border. The physical findings were otherwise unremarkable.

The serum concentration of creatinine phosphokinase, the only enzyme assayed, was elevated to twice the normal value (Table I).

The next day symmetric T-wave inversion developed in leads V_4 and V_5 (Fig. 2; 27.12). His hospitalization was uneventful.

Three weeks later he was admitted to our hospital for investigation. At this time his ECG (Fig. 2; 16.1) showed residual T-wave abnormalities in the lateral precordial leads. Cardiac catheterization, 24 days after his initial episode of pain, revealed normal intracardiac pressures; the cardiac index was at the upper limits of normal. Left ventricular angiogram showed pronounced hypokinesis of the anterolateral wall of the left ventricle, with normal contractility of the rest of the ventricle, and an ejection fraction of 42%. His coronary arteries were angiographically normal.

Results of thyroid function tests were in the hyperthyroid range (Table I). He was treated with radioactive iodine, propylthiouracil and propranolol.

Discussion

Patients with thyrotoxicosis frequently complain of chest pain typical of angina pectoris.[6,7] In fact, artificial induction of hypothyroidism was once in vogue as therapy for angina pectoris in euthyroid patients.[8] Despite this recognized interrelation and despite the frequency of both thyrotoxicosis and myocardial infarction, the concurrence of these two conditions has not commonly been reported. In 1973 Kotler and colleagues[3] added 1 case to the 20 previously reported cases. We are aware of only one additional case published since their review.[9] In a more extensive review of the literature, including that from eastern Europe, Martinez-Rovira, Haddock and Crenshaw[10] found 46 cases. However, since their patient had mitral stenosis as well, they apparently did not exclude patients with valvular heart disease from their review.

Excess circulating thyroid hormone decreases the serum cholesterol concen-

tration and it has been postulated that this may prevent the development of coronary atherosclerosis.[3] However, significant coronary artery disease has been documented in the four reports of postmortem examinations of patients with thyrotoxicosis and myocardial infarction.[7,11-13]

Myocardial infarction in patients with normal coronary arteries has been well documented by both angiographic[2] and postmortem studies.[14] At least 40 patients have been described with myocardial infarction in whom subsequent angiography showed normal coronary arteries. Eliot, Baroldi and Leone[14] reported histopathologic evidence of recent myocardial infarction and no demonstrable narrowings of the coronary arteries in six necropsies. They suggest that approximately 7% of patients dying with the clinical picture of typical myocardial infarction will have minimal or no coronary artery disease.

A variety of mechanisms have been implicated to explain infarction with normal coronary arteries.[2,15] The most difficult question to resolve is whether myocardial infarction actually occurred. In our first patient there was a history of 6 hours of typical pain, culminating in ventricular fibrillation. Although the typical evolving patterns of the ECG and serum enzymes could perhaps to attributed to resuscitation, an ECG prior to his cardiac arrest had shown a pattern typical of acute anterior myocardial infarction. In our second patient the acute episode was less well documented. However, his left ventricular angiogram showed localized anterior hypokinesia, typical of myocardial scarring secondary to an anterior wall myocardial infarction. Thus, we believe that in both cases we have sufficient evidence to support a diagnosis of myocardial infarction, perhaps subendocardial since in neither patient did Q waves develop on the ECG.[16] However, the ST-segment changes were similar to those typically associated with transmural infarction.[16]

The inadequate coronary perfusion of prolonged hypotension or abnormalities of the oxygen-carrying capacity of the blood (for example, anemia or abnormal hemoglobin–oxygen dissociation curve) can result in myocardial infarction. These mechanisms do not seem to apply to most of the cases described in the literature. Both our patients had normal hemoglobin values. Hemoglobin–oxygen dissociation curves were not constructed.

With increased myocardial mass the perfusion capacity of even normal coronary arteries can be exceeded, with resultant infarction. Neither of our patients had any associated cardiac abnormalities. Cardiomegaly was not present and the left ventricular wall thickness was within normal limits angiographically.

Disease of the microcirculation cannot be ruled out by angiography. Similarly, a small intramyocardial vessel totally obstructed at its origin and without collateral flow cannot be detected angiographically. It seems unlikely that either of these abnormalities would result in the extensive changes seen on the ECGs of our two patients. Furthermore, the detailed histopathologic studies of Eliot and associates[14] failed to document abnormalities of small vessels.

Coronary spasm has been shown to reproduce ischemic pain even in patients with angiographically normal coronary arteries. Actual infarction on this basis has been suggested in only two patients.[17,18] Furthermore, all patients in whom spasm has been reported have had recurrent angina, usually associated with "Prinzmetal variant syndrome". Our patients did not have recurrent pain and there was no evidence of spasm during angiography.

Arnett and Roberts[2] suggested that embolic occlusion with subsequent recanalization appeared to be the most likely explanation in view of the usual delay of 1 month or longer between infarction and angiography. However, in the cases reported by Eliot and colleagues[14] necropsy was performed within 25 days of infarction. A number of these patients had histopathologic evidence of transmural infarction less than 5 days old without evidence of coronary occlusion or narrowing, either embolic or atheromatous. Similarly, one of our patients had angiographically normal coronary arteries 25 days after his apparent myocardial infarction. Embolism is a particularly attractive hypothesis in hyperthyroid patients,[19] in whom paroxysmal atrial fibrillation is common. However, neither of our patients had evidence of atrial arrhythmias or any other condition associated with an increased risk of embolism.

Our two patients were in their early 30s. Both had apparently suffered myocardial infarction and both had normal coronary arteries as revealed by subsequent angiography. Furthermore, they were thyrotoxic. Thus, both exhibited the concurrence of two unusual conditions: (a) infarction with normal coronary arteries and (b) infarction with hyperthyroidism. Kotler and associates[3] described a 30-year-old hyperthyroid woman whose coronary arteries were shown to be normal by angiography 5 months after a myocardial infarction. Their patient and one of ours had obvious clinical manifestations of excess circulating thyroid hormone. There is no suggestion of hyperthyroidism in any other of the patients with infarction and normal coronary arteries described in the literature. If hyperthyroidism could lead to myocardial infarction in the absence of coronary artery disease, one would expect to see infarction much more commonly in thyrotoxic patients both with and without coronary artery disease. Thus, these cases may represent simply the chance concurrence of two unusual conditions. Further studies of the thyroid status and coronary anatomy of patients with clinical evidence of myocardial infarction, particularly if under 35 years of age, are required to assess the possible role of thyroid hormone in myocardial infarction when the coronary arteries are normal.

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