asystole with profound slowing due to depression of the nodal pacemaker. Neither ventricular ectopic beats nor paroxysmal atrial tachycardia with block was seen, but may have been prevented by the high serum potassium; Lown and Levine (1954) observed that ectopic beats were rare in digitalis poisoning in patients without heart disease. Hyperkalaemia was probably due to anuria, metabolic acidosis, and the efflux of potassium from the myocardium which occurs with toxic doses of digitalis.

The treatment of digitalis intoxication is based on the withdrawal of digitalis, correction of potassium depletion, and specific measures directed against the arrhythmia (Lown and Levine, 1954; Sodeman, 1965). Sampson *et al.* (1943) abolished digitalis-induced ventricular ectopic beats with potassium salts given by mouth. Procainamide and beta-adrenergic blocking agents (Stock and Dale, 1963; Taylor *et al.*, 1964) have been successfully used for digitalis-induced paroxysmal atrial tachycardia with block and ventricular ectopic beats. Calcium ions potentiate digitalis action, and the chelation of calcium with disodium versenate has been recommended by Gubner and Kallman (1957) and Bernstein *et al.* (1959) in cases of digitalis overdosage.

In our case the blood pressure was well maintained, suggesting that myocardial contractility was not depressed, and that the low cardiac output was due mainly to bradycardia. Atropine was tried as it seemed likely that the extreme bradycardia was due to excessive vagal depression of the nodal pacemaker. It is well known that slowing of the ventricular rate in atrial fibrillation by digitalis is partly mediated by the vagus, though with larger doses the extravagal effect on atrioventricular conduction is more important, so that atropine is relatively ineffective in increasing the ventricular rate (Gold, 1946). In our case, though the dose was massive, the response to atropine was dramatic, but repeated injections were required to maintain a satisfactory heart rate. The nodal rhythm was replaced by a sinus mechanism or wandering pacemaker, and at this stage atropine increased the rate of discharge of both the sinoatrial and the atrioventricular node, with periods of atrioventricular dissociation.

Digitalis is excreted mainly by the kidney (Friedman *et al.*, 1954), small quantities being destroyed in the body or excreted

in the bile. Prompt restoration of urine flow was thus very important in clearing digoxin from the body.

Impaired liver function in patients with heart disease may be due to hypotension or cardiac failure (Killip and Payne, 1960; Richman *et al.*, 1961) but may be caused by digitalis itself. Le Winn (1953) found impaired sulphobromophthalein excretion in patients with gynecomastia, which was attributed to an oestrogenic effect of long-continued digitalis administration in patients with liver damage. In our patient raised transaminases and increased sulphobromophthalein retention probably resulted from reduced hepatic blood flow, but direct injury by digoxin cannot be ruled out.

We are indebted to Dr. H. G. L. Lloyd-Thomas, who referred this patient to us.

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Self-poisoning with Digitalis Glycosides

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Digitalis and its crystalline derivatives are seldom used in suicidal attempts. Moore (1937) reviewed 1,147 cases of attempted suicide; poisons were taken in 692 cases, but only one patient used digitalis. Of 16 previously reported cases of self-poisoning by digitalis (McGuire and Richards, 1936; Tomaszewski and Lapa, 1936; Moore, 1937; Duvoir *et al.*, 1938; Bickel *et al.*, 1951; Vuletic and Ivancic, 1952; Yu, 1954; Bergy *et al.*, 1957; Von Oettingen, 1958; Segre, 1959; Bachmann, 1960; Bernot and Goldberg, 1960; Johnston and Price, 1960; Aubertin *et al.*, 1961; Thomopoulos and Kokkinos, 1965) only three were fatal (McGuire and Richards, 1936; von Oettingen, 1958; Johnston and Price, 1960).

The present report describes two patients who poisoned themselves with digitoxin and digoxin respectively, adding one to this very small number of recorded fatal cases.

CASE 1

A man, aged 59, was brought to the Victoria Infirmary, Glasgow, at 9.30 p.m. on 17 June 1964. Six hours previously he had

swallowed 100 tablets (10 mg.) of digitoxin, prescribed for his deceased wife. Since her death he had been depressed and had had epigastric discomfort but no other somatic symptoms. There was no history of cardiac or vascular disease.

He was a small thin man, drowsy but in no way distressed. There were no congestive signs or cyanosis. Blood pressure was 100/70. Cardiac rhythm was totally irregular with a ventricular rate of 44 per minute. The heart was not enlarged; sounds were normal except for a very soft, short systolic murmur localized to the apex. There were no significant abnormalities in other systems. An electrocardiogram taken shortly after admission showed atrial fibrillation and ST-T segment changes in keeping with digitalis effect.

Gastric aspiration yielded no tablets or particles. At 10 p.m. he was given ephedrine 60 mg. and potassium chloride 6 g. by mouth. At 11 p.m. the heart rate was about 50. Atropine sulphate 0.5 mg. was injected subcutaneously. His general condition remained satisfactory until just after midnight, when he suddenly collapsed in coma. He died about 45 minutes later. Electrocardiograms (lead I) were recorded during this period (see Fig.).

Permission for necropsy was not granted

CASE 2

A man, aged 22, had rheumatic mitral and aortic valve disease with atrial fibrillation. He had been taking digoxin 0.25 mg. twice daily for at least seven years. He had been depressed for several weeks on account of increasing cardiac disability. On the evening of 13

January 1966 he drank some alcohol and swallowed between 16 and 20 tablets (4–5 mg.) of digoxin. He developed headache, giddiness, and nausea but did not have abdominal pain. He was given saline to drink by his family doctor and vomited.

On admission to Stobhill Hospital, Glasgow, early on the morning of 14 January he was fully conscious but depressed. His general condition was good. Blood pressure was 125/65. Cardiac rhythm

CASE 1.—Electrocardiogram (lead I) after collapse. A (at 12.05 a.m.) shows ventricular fibrillation. B (at 12.20 a.m.) shows ventricular fibrillation and periods of cardiac asystole. C and D (continuous) (at 12.30 a.m.) show idioventricular rhythm with a brief episode of ventricular tachycardia followed by ventricular fibrillation. E (at 12.40 a.m.) shows very slow idioventricular rhythm, which led to final cardiac asystole.

was totally irregular with a ventricular rate of 60. The heart was considerably enlarged with signs of double mitral and aortic valve lesions. There were no congestive signs. No abnormalities were found in other systems.

Gastric lavage yielded no tablets or particles. Heart rate fell to 40 and rhythm remained irregular. He was given propranolol 10 mg. intravenously without significant effect. After a further slight decrease in heart rate atropine sulphate 0.5 mg. was injected with little effect. Heart rate was 42 eight hours after admission. Subsequent clinical progress was uneventful and bradycardia disappeared within a few days. By 20 January the electrocardiogram showed no clear evidence of digitalis toxicity and the heart rate was 75. On 24 January the previous maintenance dose of digoxin was resumed without ill effect.

DISCUSSION

Treatment of Digitalis Poisoning.—Digitalis has its most toxic effect on the heart, probably related to a shift of potassium from the myocardium (Calhoun and Harrison, 1931). To some extent this may be counteracted by the administration of potassium (Kay, 1955), which was given to Case 1. In animals, digitalis derivatives may cause focal myocardial necrosis (Dearing *et al.*, 1943) possibly owing to vagal stimulation, since atropine can prevent its occurrence (Kyser *et al.*, 1946). Myocardial necrosis ascribed to digitoxin poisoning in man was recorded by Johnston and Price (1960). Atropine was therefore given in both the above cases. Propranolol was given in Case 2 to avert the possible onset of serious arrhythmias. Vaughan Williams and Sekiya (1963) proposed beta sympathetic blockade as an antidote in glycoside intoxication. This measure may be

required to maintain sinus rhythm after abolition of digitalis-induced ventricular fibrillation by direct current countershock (Sloman *et al.*, 1965). A combination of all these measures with monitoring in a coronary care unit might prove life-saving in digitalis poisoning, whether suicidal or otherwise.

Digitalis and the Electrocardiogram.—The characteristic effects of digitalis on the electrocardiogram—depression of the S-T segment, shortening of the Q-T interval, and inversion of the T wave (Wood, 1956)—were observed in the electrocardiograms of both cases shortly after admission. In Case 1 digitoxin poisoning presumably caused atrial fibrillation, but in Case 2 it had existed for several years. Digitalis may provoke almost any cardiac arrhythmia. Ventricular tachycardia and fibrillation were observed in Case 1 in addition to very slow idioventricular rhythm (see Fig.). The tracings closely resemble those of patients dying suddenly from myocardial infarction. The heart often shows electrical activity with slowing idioventricular rhythm after apparent clinical death (Stroud and Feil, 1948). This terminal rhythm does not seem to have been reported previously in connexion with digitalis overdosage.

Organic Heart Disease and Self-poisoning with Digitalis.—There have been only three previous reports of successful suicide with digitalis derivatives (McGuire and Richards, 1936; von Oettingen, 1958; Johnston and Price, 1960). In none of these cases and in few of the documented non-fatal cases was there clear evidence of pre-existing heart disease. This can also be said of the fatal case now reported.

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