MEDICAL HISTORY

The Story of Cardiac Defibrillation

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Defibrillation is so taken for granted that physicians and paramedics are unaware of its relatively recent advent and its revolutionary life-saving ability in many patients who would previously have died from ventricular arrythmias caused by cardiac ischaemia or hypoxia.

In 1887, MacWilliam (1) of Aberdeen and London used electricity to induce fibrillation in experimental animals and went on to show that a further shock could restore normal rhythm. In 1899, MacWilliam (2) then suggested that ventricular fibrillation not cardiac standstill, as previously thought, was a major cause of cardiac death in man. He postulated that a strong electric shock could restore cardiac functions in such patients. In 1899, Prevost and Betelli (3) in Geneva also induced fibrillation in an exposed dog's heart and reversed this arrhythmia by a direct current shock. The invention of the electrocardiogram confirmed ventricular fibrillation in man. Sadly, 48 years then elapsed before defibrillation was used in man.

In 1947, Beck (4) of Cleveland first used an alternating current (AC) defibrillator successfully on an exposed heart in the operating theatre. It then came into routine use in theatres. In 1956, Zoll (5) of Boston used AC defibrillation on the closed chest. However, poor efficiency of the AC was due to its low power and long duration of the shock, 0.25 seconds. These drawbacks were overcome by Lown in Boston in 1962 (6) who developed a capacitance discharge (DC) defibrillator that could deliver a much more powerful shock to the closed chest in a shorter time, 0.0025 seconds. The strength of shock could be adjusted from 20 to 400 Joules (watts/sec). Lown also used this short shock to map the ECG QRST complex in dogs. He found the peak of the T wave was a vulnerable period when a shock could induce ventricular arrythmias. In patients with acute myocardial infarction, ectopic beats on the T wave can also provoke ventricular arrythmias (Figure).

A further result of ECG mapping in dogs was the discovery that a shock on the downstroke of the R wave could terminate atrial arrythmias. This 'triggered' the use of defibrillation routinely (7) in patients to restore normal rhythm in atrial flutter, atrial fibrillation and atrial tachycardia. 'Triggered' means that when the operator switches on the defibrillator paddle it is not discharged until the next R wave of the patient's ECG occurs. Electric shock depolarizes the heart's conducting system to cause cardiac arrest; subsequent recovery should then restore normal conduction in the heart. Using triggered impulses, 20–40 Joules may suffice for flutter, 150–300 Joules for atrial fibrillation. For ventricular arrhythmias, non-triggered shocks of 200–400 Joules are used.

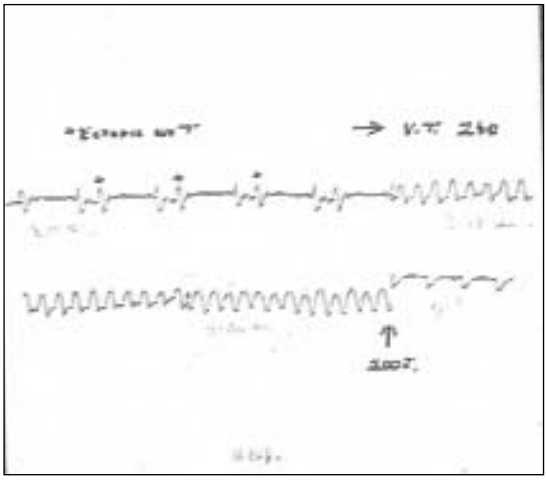

Figure: ECG in acute myocardial infarction with ventricular ectopic beats on T waves provoking ventricular tachycardia, then reversed by DC shock.

Lown helped to develop acute coronary care units where his defibrillator was life saving. Monitoring the ECG taught us warning signs of impending ventricular arrythmias that could often be prevented by medical therapy. I spent a week with Lown in 1962 and then introduced the DC defibrillator to St Mary's Hospital in London. It was initially on our 'crash' trolley and by 1966 we opened a coronary care unit (CCU) with monitors and defibrillators. After one year in service, we found that acute coronary mortality in the CCU was 18% whereas infarct mortality on the general wards was 28%. It was then agreed that all suspected myocardial infarct patients were admitted by fast track to the CCU. Coronary care units worldwide provided the same benefits largely due to Lown's invention. Advances in electronics have now produced implantable, miniaturized defibrillators that are automatically triggered by attacks of ventricular tachycardia in patients who cannot be controlled by drugs. The first was implanted in 1980 (8) but they are expensive.

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In a totally different field, Bernie Lown is equally famous. With a Russian colleague, he was awarded the Nobel Peace Prize in 1985. This recognized their worldwide organization of 200 000 physicians (including) the author for Prevention of Nuclear War. Lown also received the Ghandi peace prize.

REFERENCES

1. MacWilliam JA. Fibrillator contraction of the heart, J Physiol 1887; **8:** 296–310.
2. MacWilliam JA. Electrical stimulation of the heart in man. Br Med J 1889; **1:** 348–50.
3. Prevost JL, Batelli F. La mort par les courants electriques, courant alternative a bas voltage. J Physiol Path Gen 1899; **1:** 399–412.
4. Beck CS, Pritchar WH, Feil SA. Ventricular Fibrillation of long duration abolished by electric shock. JAMA 1947; 985–6.
5. Zoll PM, Limenthal AJ, Gibson W, Paul MA, Norman LP. Termination of ventricular fibrillation in man by externally applied countershock. N Eng J Med 1956; **254:** 727–32.
6. Lown B, Amarasingham R, Newman J. New Method for terminating cardiac arrythmias use of synchronized capacitor discharge. JAMA 1962; **182:** 548.
7. Lown B, Perbroth MG, Kaidbey S, Ale T, Harken DE. Cardioversion of atrial fibrillation. N Eng J Med 1963; **269:** 325–31.
8. Kastor JA, Michael Mirowski and the automatic implantable defibrillator. Am J Cardiol 1989; **63:** 977–82.