I Sing the Body Electric: a Historical Perspective of Cardiopulmonary Resuscitation

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Introduction

The World Journal of Medical Education and Research (WJMER) (ISSN 2052-1715) is an online publication of the Doctors Academy Group of Educational Establishments. Published on a quarterly basis, the aim of the journal is to promote academia and research amongst members of the multi-disciplinary healthcare team including doctors, dentists, scientists, and students of these specialties from around the world. The principal objective of this journal is to encourage the aforementioned, from developing countries in particular, to publish their work. The journal intends to promote the healthy transfer of knowledge, opinions and expertise between those who have the benefit of cutting edge technology and those who need to innovate within their resource constraints. It is our hope that this will help to develop medical knowledge and to provide optimal clinical care in different settings. We envisage an incessant stream of information flowing along the channels that WJMER will create and that a surfeit of ideas will be gleaned from this process. We look forward to sharing these experiences with our readers in our editions. We are honoured to welcome you to WJMER.

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I Sing the Body Electric: a Historical Perspective of Cardiopulmonary Resuscitation

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"I sing the body electric
The armies of those I love engirth me and I engirth them,
They will not let me off till I go with them, respond to them [1]"

This verse from Walt Whitman's poem[1] sings the praises of life, and is an adept metaphor for the long and fascinating history of cardiopulmonary resuscitation.

We can trace the origins of cardiopulmonary resuscitation back to antiquity in both mythology and theology. For many years the human breath was the sign and symbol of life and one of the few available measures of it[2]. Towards the end of 18th century, the breath came to be associated with the perhaps less romantic concept of resuscitation However the development and refinement of resuscitation did not occur properly till the 19th and 20th centuries.

Airway management was advanced in the 18th Century by two important Scottish pioneers: the obstetrician William Smellie, with his introduction of the endotracheal tube in 1763, and the physician John Hunter with his studies using bellows to resuscitate dogs. In 1776 through the presentation of an article, 'Proposal for the recovery of people apparently drowned[3]', in the Royal Society of Medicine in London, Hunter demonstrated how lack of oxygen leads to cardiac dysfunction.

At the end of the 20th century, the foundations of resuscitation as a specialty were laid with the formation of rescue societies, which were forerunners of the modern ambulance and emergency medical services. The first of these societies was in the Netherlands in 1767, as the Society for Recovery of Drowned Persons[4]. This was soon followed by the Royal Humane Society in London and others in New York, Philadelphia and Boston.

Another vital development in resuscitation was the understanding of nascent electricity and its corollary experiments. The first of these experiments was conducted by the Italian scientist Luigi Galvani, who observed the contraction of the legs of frogs and of humans after electrocution. The first reported use of electric shock as a resuscitative experimental method in the literature involved a child, Sophie Greenhill, in 1776. The Humane Society of London [5], described that the girl fell from a window and was 'picked up by a man in a state of apparent death.' A Mr. Squires applied electricity to various parts of her body but only when he applied it 'through her chest' did he feel 'a small pulse, and within a few minutes the child began to breathe with great difficulty.'[6]

Writing in 1776, John Hunter in a review of the article 'Proposal for the recovery of people apparently drowned" remarked, "Electricity is a useful tool and should be used where others have failed ... it is likely that this is the only method that we have to stimulate the heart in an instant'[7]. It was audacious and extraordinary

statement at the time and echoed the romantic novel Frankenstein by Mary Shelley published 30 years earlier. From experiments conducted on dogs in 1850 by Dr. Carl Ludwig and Dr. Mauritius Hoffa[8], was the discovery that electrical stimulation was capable of causing ventricular fibrillation.

The foundation of cardiac massage was laid by the 19th century German anatomist Moritz Schiff when he attempted to counter the two potential fatal side effects of the 'new' chloroform: cardiac and respiratory arrest. Schiff's views on the influence of the CPR in maintaining the 'nutrition'[9] of the myocardium would be acknowledged and used many years later. In 1872, surgeon Thomas Green described[10] six successful resuscitations out of seven attempts following cardiac arrest from chloroform. In these cases, a galvanic battery permanently installed in his operating room was used. A few years later, the Scottish physiologist John A. Mac William, before an audience of the 1887 International Medical Congress, showed how the ventricular fibrillation could be interrupted by application of shock[11].

In 1899, the physiologists Geneva Jean Luis Prevost and Federico Batelli demonstrated[12] that electrical discharges could cause arrhythmias that return the heart to normal rhythm: and so for the first time, the effectiveness of defibrillation on animals was proven.

It was in the 20th century that the principles of resuscitation would be fully developed and make quantum leaps in development. The work of Moritz Schiff on open chest cardiac massage was succeeded by the physiologists Starling and Lane in 1902[13], with trans-diaphragmatic cardiac massage and by Inglesburd in 1904. A key step was supplied in 1906 when Dr. George W. Criley and Dr. David H. Dolley were attempting to resuscitate dogs and realized that the key to the recovery of their specimens was preventing them from acquiring ischemic brain injuries.

Other phenomenal developments made in cardiopulmonary science included the Irish anesthesiologist Ivan W. Magill inventing the endotracheal flexible tube, scissors for intubation , the anesthetic spray for intubation, the straight blade laryngoscope and other resuscitator devices in 1919. This was due to challanges he faced when attempting to ventilate veterans from World War I while they were undergoing facial surgery.

In the years preceding the Second World War, New Zealand anesthesiologist Robert R. Macintosh further improved intubation techniques with his namesake curved blade laryngoscope.

Inn 1953 the German engineer Holger Hesse and the Danish anesthesiologist Henning Ruben invented the first self-inflating balloon, marketed by AMBU®. AMBU® was the company that created them and their namesake has become their legacy, still used today. A few years later, the Guedel cannula was invented by US anaesthesiologist Arthur Guedel.

In 1936 professor of Physiology Carl J. Wiggers demonstrated to the American Physiological Society the combined use of defibrillation with cardiac compressions in an attempt to increase the chances of success. In 1940, together with Dr. René Wegria they discovered that ventricular fibrillation could be induced in the heart during a precise period called the 'vulnerable period'. The future cardiac pacemaker science was consequently deduced from these findings.

In 1957 the American engineer William Bennet Kouwenhoven, who dedicated almost three decades of his life on cardiopulmonary research, after conducting experiments on dogs developed the (second) external defibrillator used on human beings. In the same dacade, the Harvard cardiologist Paul Zoll made a similar discovery.

It was, however, William Bennet Kouwenhoven, with Guy Knickerbocker and James Jude of Johns Hopkins University who serendipitously discovered a crucial finding. In their studies on the defibrillation of dogs, they applied paddles with pressure on the chest of the dog and obtained a femoral pulse. In 1960 they demonstrated [14,15] the effectiveness of the technique of the 'closed-chest cardiac massage' in 20 clinical cases of intra-hospital arrest. The survival rate was an astounding 70%.

This technique was already described by British dentist John Hill in 1868[16] and and several other times in the annals of cardiopulmonary research. The group Kouwenhoven perfected the technique in order to be able to compress the heart in human subjects without damaging the chest and abdominal structures.

An effective technique albeit with a misnomer is 'cardiac massage', the term used by the cardiac surgeon Claude B. Beck in 1947 . Beck described massaging the heart of a boy with his hands for 45 minutes in ventricular fibrillation and subsequently performed defibrillation with an internal electrical defibrillator developed by scientist (and friend) James Rand[17]

The principle of the external defibrillator by using direct current (DC) to re-start the heart was put to the test by Dr. Bernard Lown in the early 1960s who demonstrated that this was both a safe and effective technique. James Francis Partridge, a 20th Century Irish Cardiologist and Dr John Geddes developed this technique and invented the first portable external defibrillator in 1965 (the device itself weighed approximately 70 kg and was actually installed in ambulances in Belfast, Northern Ireland and was connected to the battery of the vehicle). A 3kg portable external defibrillator, however, soon followed suit and became available only 3 years after Partridge's and Geddes's contraption. It was Dr. Thomas and Dr Watkins, however, who are credited for the creation of the first implantable defibrillator.

Taking a little trip down history lane, during the 1946 polio epidemic in Minnesota, physician James Elam applied mouth-to-mouth respiration on an child with no spontaneous breathing.
As he described it:

'*I sealed my lips around his nose and his lungs inflated. In four breaths, he was pink*.[20]'

Elam had fortuitously come across this technique the previous night when perusing a book on the history of neonatal resuscitation.

This episode informed and guided his subsequent research with the physician Peter Safar. Together they demonstrated the effectiveness of their technique of artificial mouth-to-mouth respiration. It was promoted in 1958 by the peer-reviewed medical Journal of the American Medical Association (JAMA) as an "easily learned, lifesaving procedure in both emergency conditions and in the field[21]".

From their work disseminating ideas to the scientific community and to the general public, there arose the need to introduce manikins for training in ventilation techniques. The first manikin was called 'Miss Sweet Breath' and was invented by Roger Mehalek in 1959. Mehalek was a Red Cross volunteer in Kalamazoo, Michigan. The second manikin was designed by Safar and the Norwegian toymaker Asmund Laerdal and was renowned globally: what was truly extraordinary about CPR Annie was that it was a manikin with human features and size.

However, the formal marriage between the ventilation techniques of Helam and Safar and the cardiac massage and defibrillation procedure of Kouwenhoven and Jude took place in September 1960 at the annual meeting of the Maryland Medical Society, where they were presented for the first time together. This event was promulgated as the birth of modern CPR and this reconciliation was heralded by great advances in this field.

Kouwenhoven and Jude embarked on a world tour to disseminate the newly formed CPR Safar and they assigned director David Adams to produce an educational video. Thus was born 'The Pulse of Life', a 27-minute motion picture in which for the first time the letters of the acronym A (for 'airways'), B ('breathing'), C ('circulation') were emphasized as an aide memoir to students to remember the life-saving sequence for resuscitation. The defibrillator arrived on the scene in 1965, thanks to professor Pantridge, who formed the first coronary care unit in Belfast Mobile (MCCU). Professor Pantridge drafted a report[22] in 1967 on 312 patients treated by the MCCU staff over a 15 month-period , half of this sample had heart attacks in progress and 10 were rescued with a cardiac arrest in progress. All 10 were resuscitated and admitted to the hospital, which was a truly amazing achievement. The foundations of the modern chain of survival had been laid[23].

200 years since the birth of the first rescue company on August 1767 and with the "System Belfast" of Professor Pantridge[22] and the discoveries of Jude, Helam, Safar and Kouwehowen CPR continues to be used as a standardized approach all over the world and has saved a countless number of human lives. Yet the mantra today as it was yesterday, remains the same: to fulfill the promise: to save 'hearts too good to die'[24].

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