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Review Article

Sudden cardiac death – Historical perspectives

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ARTICLE INFO

Article history:
Received 11 December 2013
Accepted 6 January 2014
Available online 11 February 2014

Keywords:
Sudden cardiac death
Defibrillator
Cardiopulmonary resuscitation

ABSTRACT

Sudden cardiac death (SCD) is an unexpected death due to cardiac causes that occurs in a short time period (generally within 1 h of symptom onset) in a person with known or unknown cardiac disease. It is believed to be involved in nearly a quarter of human deaths, with ventricular fibrillation being the most common mechanism. It is estimated that more than 7 million lives per year are lost to SCD worldwide. Historical perspectives of SCD are analyzed with a brief description on how the developments in the management of sudden cardiac arrest evolved over time.

1. Sudden cardiac death (SCD) – historical perspectives

Sudden cardiac death (SCD) describes the unexpected natural death from a cardiac cause within a short time period, generally ≤1 h from the onset of symptoms, in a person without any prior condition that would appear fatal.[1] It is estimated that more than 7 million lives per year are lost to SCD worldwide. Nearly a quarter of human deaths are believed to be due to SCDs, with ventricular fibrillation (VF) as the most common mechanism. Interestingly, the concept that SCD in human beings is due to VF was first proposed more than 120 years ago by MacWilliam, well before the electrocardiogram was invented.[2]

The conceptual evolutions in the understanding of relation between SCD and VF, developmental design of defibrillators and practice of cardiopulmonary resuscitation methods have undoubtedly improved the survival of patients at higher risk of SCD. The historical perspectives of these three important aspects will be discussed below.

2. Sudden cardiac death and ventricular fibrillation

The sudden collapse and instantaneous death of a person had long intrigued and puzzled medical science and for centuries, no satisfactory explanation was available. The initial description of SCD in the history was made as early as 4th century BC by the first physician and the legendary founder of modern medicine – Hippocrates. Hippocrates stated in his aphorisms that "those who are subject to frequent and severe fainting attacks without obvious cause die suddenly." This might be the first description of SCD.[3] Lyman Brewer suggested that the first recorded account of VF dates as far back as

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0019-4832/$ – see front matter
http://dx.doi.org/10.1016/j.ihj.2014.01.002

1500 BC, and can be found in the Ebers papyrus of ancient Egypt.[4] It states: "When the heart is diseased, its work is imperfectly performed: the vessels proceeding from the heart become inactive, so that you cannot feel them… if the heart trembles, has little power and sinks, the disease is advanced and death is near." The next recorded description is from the sixteenth century and is recorded by Vesalius who described the appearance of "worm-like" movements of the heart in animals prior to death. The clinical importance of these observations and descriptions, possibly of VF, were not recognized until John Erichsen in 1842 described VF following the ligation of a coronary artery of a dog.

In 1849, Carl Ludwig and M Hoffa demonstrated that VF could be induced by applying an electric current to the heart of a dog (Fig. 1). It was in the classic work in 1889, "cardiac failure and sudden death" that John A MacWilliam, a British scientist,[2] first proposed the hypothesis that VF was the mechanism of sudden death in human beings. Until that time, many assumed that sudden death – or "cardiac failure" as it was then commonly called – was due to sudden stoppage of the heart in diastole.[5] He recognized the role of the autonomic nervous system in modulating both the mechanical and the electrical properties of the heart and was the first to suggest that autonomic nervous system had a role in the genesis of SCD.

MacWilliam also noted that the ventricles contained within them the entire mechanism necessary for the execution of regular coordinated pumping action. Separating the ventricles from the atria physiologically or anatomically by sectioning through the atrioventricular groove showed that the ventricles could function normally; albeit at a slower rate. He demonstrated that in such a sectioned heart too, fibrillation could be induced, demonstrating that extrinsic control was not essential for either ventricular contraction or the induction of fibrillation. His experiments in dogs showed that a fibrillating heart could be brought back to normal rhythm with internal cardiac massage and injectable pilocarpine.[6,7] These methods were the beginning of a systematic and meaningful approach to successful cardiopulmonary resuscitation.

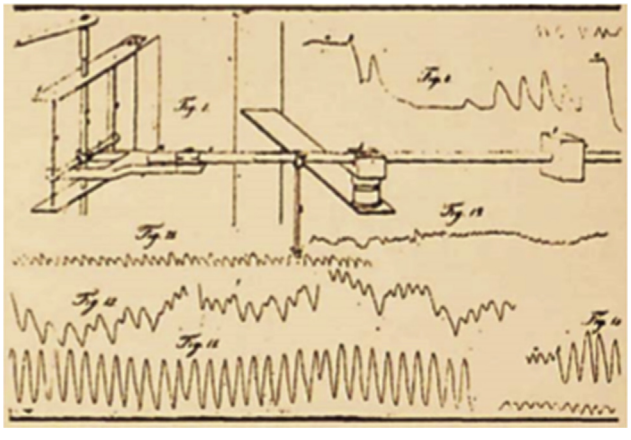

Fig. 1 – The first graphic documentation of ventricular fibrillation. M Hoffa, in Carl Ludwig's laboratory, while investigating vagal influences on cardiac activity noted the bizarre unregulated actions of the ventricles when exposed to strong faradic or constant currents. The rhythm was noted to persist even after electrical stimulation and to result in no cardiac output. The atria were noted to be free from arrhythmia.

Ziemssen's experiments in Munich in 1880 in which a women's heart was stimulated with electrical pulses with no apparent harm were the first reports of stimulation of living human heart by electricity.[8] In 1889, in another paper[9] MacWilliam commented on the electric treatment of a systole, which he boldly entitled "electrical stimulation of the heart in man". He wrote that a series of electrical stimulation might be useful in rousing into action a heart arrested by a temporary cause; for example, by inhibitory impulses profoundly depressing the rate and force of its action, or causing it to stand still in diastole. He was careful to point out, however, that application of a strong current would cause VF, especially in a heart compromised by metabolic or structural alterations. The importance of VF in man became clear in the early decades of last century following the development of electrocardiography and its subsequent use in examining cardiac patients.

3. Evolution of defibrillation therapy for SCD

There were two reports on the effects of successful resuscitation in animals and humans using Leyden jar discharges-that of Squires in 1774 and Abilgaard in 1775.[10] The Swiss researchers Jean Luis Prevost and Frédéric Battelli reported in 1899 that low currents provoked VF and that strong discharges terminated this arrhythmia.[11]

When General Electric, the company cofounded by Thomas Edison, switched from direct current (DC) to alternating current (AC) transmission in the early 1900s, a few linemen died from accidental electrocution. In response, General Electric company funded research at several universities to study what made electric current lethal. Two electrical engineering professors, William Kouwenhoven and Guy Knickerbocker, at Johns Hopkins University, in Baltimore, tested the phenomenon by shocking stray dogs to death. Serendipitously, they noticed that a second AC shock could sometimes bring an electrocuted dog back to life.

In 1933, Albert Hyman and C. Henry Hyman, looking for an alternative to injecting powerful drugs directly into the heart, came up with an invention that used an electrical shock in place of drug injection. This invention was called the *Hyman Otor* where a hollow needle is used to pass an insulated wire between first and second ribs to the right auricle to deliver the electrical shock. However *Hyman Otor* was a failure and was not accepted by the medical community.

3.1. *'Open chest' defibrillators*

The first use of a defibrillator on a human being was in 1947 by Claude Beck.[2] He observed that VF could occur even in 'essentially healthy' hearts. In an attempt to save such "hearts", Beck successfully defibrillated a 14-year-old boy being operated on for a congenital chest defect. Open cardiac massage was done for 45 min while waiting for the defibrillator. This first defibrillator used two table spoons as electrodes, a transformer to isolate the patient from the AC wall supply, and a variable resistor to limit the current to a heart-safe value. This early defibrillator by Beck used AC current