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Cardio Pulmonary Resuscitation – "Retrieving pulses down the years"

Madhura Shanbhag, Brinda Desai, Vidhi Desai, Mita Bhowmick
Department of Biomedical Engineering,
Thadomal Shahani Engg College,
Mumbai-400050, India

Abstract: *Sudden Cardiac Arrest (SCA) is a leading cause of death in India. It is estimated by the WHO census statistics that approximately 4280 out of every one lakh people die every year from SCA in India. Cardiac arrest is reversible if the victim is administered immediately with proper emergency treatment in timely manner. The technique of Cardio Pulmonary Resuscitation (CPR) was developed to allow for medical personnel and bystanders to treat persons suffering from sudden cardiac arrest. Standard CPR techniques require the delivery of both emergency breaths and chest compressions to the unconscious patient. Original techniques for rescue breathing involved the use of mouth-to- mouth resuscitation but they had lot of limitations. This paper gives the review of the various CPR techniques/devices that are available today and how they have evolved with time. Some innovative designs of CPR devices are also discussed.*

Keywords: *Cardiac Arrest, Cardio Pulmonary Resuscitation, Automatic CPR devices.*

1. INTRODUCTION

Cardiopulmonary resuscitation (CPR) combines compressions of the chest with rescue breathing to keep blood flowing through the body and brain while delivering oxygen to the bloodstream. CPR is the first step in treating cardiac arrest in hopes of providing time for first responders to arrive.

CPR supports and maintains breathing and circulation for an infant, child, or adolescent who has stopped breathing (respiratory arrest) and/or whose heart has stopped functioning.[1] Cardiac arrests are very common, and they can happen to anyone at any time.

Nearly 383,000 out-of-hospital sudden cardiac arrests occur annually, and 88 percent of cardiac arrests occur at home.[2]

Many victims appear healthy with no known heart disease or other risk factors

Sadly, 90 percent of Indians may feel helpless to act during a cardiac emergency because they either do not know how to administer CPR or their training has significantly lapsed.

In India , general awareness of CPR (Cardiac Pulmonary Resuscitation) techniques is limited to physicians and

paramedics. There exists a shocking lack of awareness about resuscitation techniques in common public circles. When administered precisely, CPR can save thousands of lives each year that are lost due to causes ranging from physiological shocks such as asphyxiation due to drowning; to even Sudden Myocardial /Cardiac Arrest (SCA). Therefore there is urgent need of this device in India. CPR systems is installed in foreign countries like U.S.A , Canada and more than 80 other countries. But due to lack of awareness of this device and its high-cost, it is scarcely used in India. Manual CPR gives us about 10-20% revival rate in contrast ofautomated CPR which gives 62% revival rate.[2]

2. GENERATIONS OF CPR

2.1 Manual Techniques

During earlier years, when CPR technique was introduced, it was performed manually on the required patient .Manual CPR provided retrieval of respiration and circulation through human efforts[4].Some of the manual techniques are discussed below :

2.1.1 16th century: Mouth to Mouth Resuscitation

It is the first form of artificial Respiration. In 1773, physician William Hawes(1736–1808) began publicizing the power of artificial respiration to resuscitate people who superficially appeared to have drowned. Thomas Cogan, another English physician also was jointly working with Hawes for improving their research.

A method of artificial respiration in which the rescuer's mouth is placed tightly over the victim's mouth in order to force air into the victim's lungs

by blowing forcefully enough every few seconds to inflate them.[4][5]

Figure 1. *Mouth to mouth resuscitation. [4]*

This technique has several limitations. Firstly it required the mouth of the person performing the procedure to come in direct physical contact with the mouth of the patient, which can cause the spread of disease. Secondly, the un-comfort faced by the rescuer and the patient .[4][5]

2.1.2 19th century: Sylvester's Method Of Artificial Respiration

Doctor Henry Robert Sylvester described a method (The Sylvester'sMethod) of artificial respiration.A method of artificial respiration in which the subject is laid on his or her back and air is expelled from the lungs by pressing the arms over the chest and fresh air drawn in by pulling them above the head. This technique involves mechanical manipulation of the patient's chest or arms.

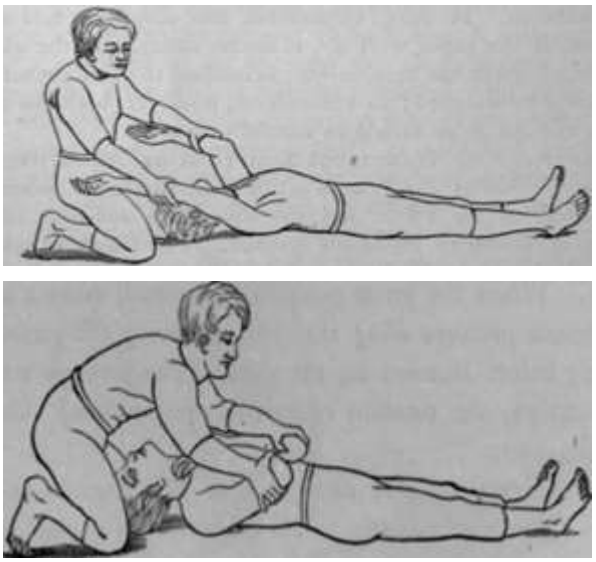

Figure 2. *Sylvester's method of artificial respiration[6]*

The procedure is repeated sixteen times per minute. Artificial respiration is a part of most protocols for performing cardiopulmonary resuscitation (CPR) [6]

This technique has several limitations.

- Lot of physical efforts taken by rescuer, therefore no continuous procedure performed on patient due to tiredness of rescuer.
- Time consuming technique.

2.1.3 20th century: Holger Nielsen technique (1950s)

The Holger-Nielsen method of CPR was a manual method of resuscitation popular around the turn of the 20th century. It was described in detail in the 1911 edition of the "Boy Scouts of America Handbook," and became widely used until the 1950s,

It is a form of artificial respiration where the person was laid face down, with their head to the side, resting on the palms of both hands. Upward pressure applied at the patient's elbows raised the upper body while pressure on their back forced air into the lungs.[6]

Figure 3. *Holger Nielsen Technique[6]*

This technique has several limitations**.**

- Only Doctors or highly trained and experienced medical personnel required.
- Time required is more.
- More number of compressions are not possible due to human fatigue.

This technique was then replaced by modern CPR techniques.

2.2 Semi-Automated Cpr Techniques

Mechanical techniques

Mechanical techniques used pneumatics in developing the CPR device with minimal efforts required from human. Due to compressions through mechanical device more number of compressions are achieved and rate of recovery increases.

2.2.1 Piston Chest Compression (1960s)

Piston chest compression devices have been shown to be actually less damaging than manual CPR.Early research investigated variables of compression rate, duty cycle, and depth of compression, thus contributing to the on-going development of manual CPR techniques. Most piston compression devices use pneumatic power derived from compressed oxygen if there is an associated integrated ventilator or from compressed medical air or oxygen if the device does not have a ventilator. The early Heart Lung Resuscitator (HLR) piston compression device had to be centered in the middle of the sternum by four straps.

The most widely used piston device is the Thumper, which has a built-in ventilator and is programmed to perform ventilations in the correct ratio of compressions to ventilations.

2.2.2 Vest CPR (late 1970s and early 1990s)

With vest CPR, a bladder-containing vest is placed circumferentially around part of the patient's chest and cyclically inflated and deflated by an automated pneumatic system. Adherent defibrillation pads are placed on the chest before applying the vest to allow for defibrillation without having to remove the vest or interrupt CPR.

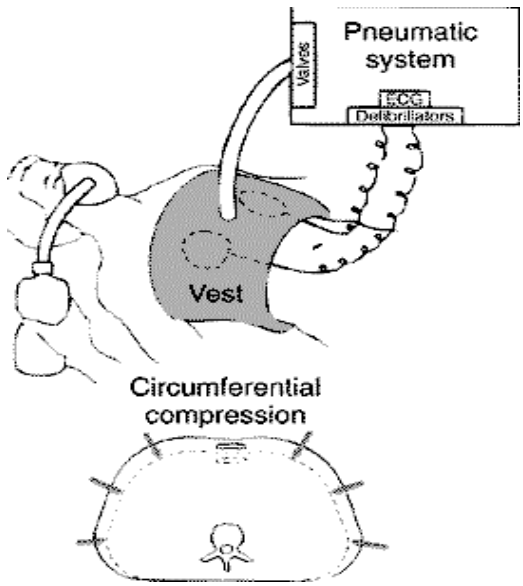

Figure 4. *Vest CPR arrangement. [8]*

Vest CPR was designed to maximize the force applied to the chest during compression. Force is distributed over the chest, which reduces local stresses on the chest wall and allows high forces to be applied safely. This distributed compression allows for large increases in intra-thoracic pressure during chest compression, without the trauma inherent in applying force to a single point. It hasn't been tested in large, clinical trials.[8]

2.2.3 Active Decompression (1990s)

This piston technique was further modified by the addition of an integral suction cup. Allowing for active return of the chest to the neutral, uncompressed position, it was an evolution that used both active chest compression and active chest decompression (ACD-CPR).

The piston and active decompression devices are self-contained and do not require any disposable accessories or replacement expenses.[11]

This technique has several limitations.

- Pneumatic systems are bulky and generate some noise.
- Needs high maintenance.

Cannot be used by Lay man.[5]

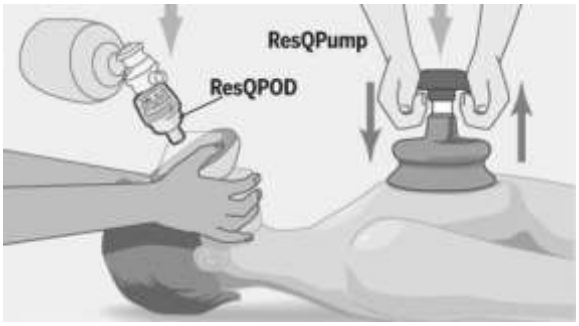

Figure 5. *Active Decompression [11]*

2.3 Automated Cpr Techniques

The advent of automated CPR devices increased the number of compressions per two breaths drastically about 80 to 100 compressions per two breaths. They are very easy to use and portable which can be used immediately in case of emergency.

2.3.1 Lucas (2000s)

Lucas is advanced version of piston chest compression. The lucas Chest Compression System is designed to help improve outcomes of sudden cardiac arrest victims and improve operations for medical responders. Performing at least 100 compressions per minute with a depth of 2 inches.[9,10]

Figure 6. *Lucas Device [9]*

2.3.2 Autopulse (2000s)

Autopulse is the advanced version of active decompression. A more recent development is the load-distributing band (LDB). This battery-powered device uses a disposable electromechanically actuated band to distribute the compression load over the entire anterior chest at fixed intervals.It presumes 80 compressions for 2 breaths as per CPR standards. The concept is that circumferential pressure can be delivered around the thorax, and not just to the sternum, for forward flow to occur.[12]

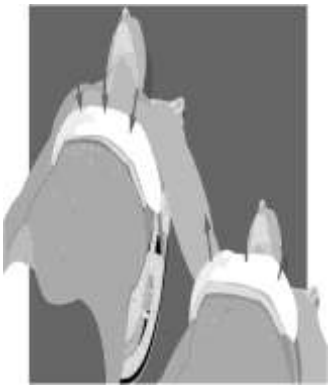

Figure 7. *Load distributing band system[12]*

Recent trials showed improved hemodynamics, with coronary perfusion pressures above the level generally associated with improved survival, as well as improvement in survival to arrival at the emergency department when compared with manual CPR.[12]

2.4 Proposed Designs

2.4.1 ACR (Automated Cardio Pulmonary Resuscitation) Device

The project proposed to employ high torque motors for rotary to rectilinear conversion which can achieve the desired results. The entire apparatus will rely heavily on mechanical components like the L- arm, circular disk, adjustable stands etc.

The basic idea of the project is to have a localized thumping piston like rod above the chest of the patient , DC motors will be used to achieve this goal. The project will use the principle of Vertical Displacement using a disc , rod and L-arm made of aluminium and stainless steel. Vertical Displacement of two inches will be achieved as per CPR standards.

CPR could be given with the help of this device by simply placing the base plate under the patient's chest, placing the base plate on the stands, locking in the base of the stands on the under-side of the patient plate and tightening the base plate to maintain its position, the system would become one piece and function as a single unit by providing the motor with power supply.

2.4.2 APR (Automated Pulse Retrieval) using LDS (load distributing strap)

This device will work on the principle of rhythmic abdominal compression to produce blood flow during CPR with ventricular fibrillation (VF). This system will consist of a strap wrapped around the abdomen of the patient and compressions are applied on the region. This method could be more effective than standard CPR as it increases blood flow through the heart .APR device using LDS system will help us provide better CPR automatically to the needy than manual CPR.

3. Manual CPR Vs Automated CPR

To understand the problems that are faced by paramedics while delivering Manual CPR and to then compare it with the capabilities of Automated CPR, the following table of is presented below: [13]

Quality CPR Requirements	Manual CPR	Automated CPR
100 compressions/minute	Difficult to perform well	Delivers 80compressions /minute
Compressions depth 1.5" to 2.0"	Difficult to perform well	Exact depth can be set.
Full chest release	Difficult to perform well	Active full chest release

4. Conclusion

Most of the people are still unaware of CPR and the right methods and devices to provide the needy. Therefore, this paper explains evolution of CPR techniques from manual to fully automated devices and their need in India. It also gives a gist of student projects which gives a contribution to the resuscitation technology.

Due to the paucity of the CPR equipment's many lives are endangered hence this paper can be a medium to aware people about automated CPR and its advantages in saving many lives.

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