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CPR: ABC or CAB

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Cardiopulmonary resuscitation (CPR) has over the past 60 years become an ubiquitous skill amongst medical professionals and laypeople alike. Over the past several decades, a number of different research findings have led to fundamental changes in the methods used in attempts to reverse cardiac arrest. In order to understand our current practice, it is important to have a firm grip on the history of modern resuscitation.

CPR is comprised of 3 individual components; rescue breathing, compressions, and defibrillation. Each of these developed separately, in some cases over hundreds or even thousands of years.[1] Following a spate of drownings across Europe in the 18th century, the Paris Academy of Sciences (Académie des Sciences) in 1740 issued a recommendation for the use of mouth-to-mouth resuscitation in drowned victims.[2] In 1744, the first successful use of this method in a human was documented by Tossach.[1] Thereafter a number of different ventilation approaches were attempted, and it took more than 200 years before mouth-to-mouth and mouth-to-airway were shown to be the most efficient methods of artificial respiration.[3]

At around the same time, several investigations into the effect of electric shock applied to the myocardium brought forth the next leap forward in resuscitation science – defibrillation. In 1956, Zoll published his seminal paper detailing four patients in ventricular fibrillation who had been defibrillated, one of whom survived to discharge.[4] Despite this discovery it wasn't until the 60s that the various components of CPR began to be utilised together.

During defibrillation experiments on dogs, Kouwenhoven had noted that the pressure of the heavy paddles increased blood pressure, and that rhythmic pressure to the sternum maintained cerebral blood flow.[5] In 1960, he published his now famous article describing 'closed-chest cardiac massage' – so named because prior to this direct cardiac massage through an open chest had been the mainstay of cardiac arrest management.[6] A flurry of investigations and publications followed, which suggested a compression rate of 60 to 80 per minute, and a compression depth of 4 to 5 centimetres paired together with artificial respiration, as well as defibrillation and administration of vasopressors as the optimal approach to resuscitation.[7]

A few years later, in 1966, the first CPR guidelines were published and quickly spread worldwide.[8] Of note is that even at this early stage of modern CPR the danger of delay in initiation of resuscitation was clearly recognised as a poor prognosticating factor.[9]

In 1957, Safar published the 'ABC of Resuscitation' which subsequently informed the stepwise approach of 'Airway-Breathing-Circulation' by which CPR would be performed into the 21st century.[10] Up until 2005, this approach emphasised opening of the airway followed by assessment of breathing, rescue breaths as required, and then a circulatory assessment usually in the form of a pulse check, followed by chest compressions as required. In 1982, the Netherlands, noting experimental data which showed no significant drop in PO2 and O2 saturation in the first 5 minutes after arrest, changed their CPR algorithm from an ABC approach to a compressions-airway-breathing (CAB) approach. They found that starting chest compressions first resulted in quicker restoration of coronary perfusion pressure and more chance of successful defibrillation.[11] At the time, the Netherlands was the only country following this approach, briefly adopting the ABC approach to fall in line with European Resuscitation Council (ERC) guidelines before reverting to CAB with the 2005 ERC guidelines.

The Dutch decision has since been supported by evidence which shows that in animal models and human studies defibrillation performed from 3 to 5 minutes after arrest is more likely to result in return of spontaneous circulation (ROSC) if at least 90 seconds of CPR is completed immediately prior to shock. This finding is best described by a 3-phase time based physiological model of CPR divided into the electrical phase, the circulatory phase, and the metabolic phase. The electrical phase extends from the time of arrest to approximately 4 minutes thereafter and refers to a period during which the heart is exceptionally responsive to defibrillation. This explains the success of early external defibrillation as well as various devices including implantable cardioverter defibrillators (ICD). The circulatory phase, which runs from 4 to 10 minutes, is the time during which chest compressions are crucial to provide much needed oxygen amongst other substrates to the myocardium. In addition, the forward flow created by quality CPR allows for washout of various metabolic toxins which accumulate during ischaemia. The period after roughly 10 minutes following arrest is called the metabolic phase, during which it becomes increasingly difficult to adequately overcome the systemic metabolic derangement, resulting in a massive inflammatory response, translocation of gut flora and irreversible tissue damage.[12]

Given this background, the importance of compressions as the single greatest intervention in cardiac arrest, along with defibrillation, has become clearer and more evidence-based in the past 20 years. The University of Arizona Sarver Heart Center Resuscitation Group pioneered the concept of cardiocerebral resuscitation (CCR). This method focuses on continuous compressions stopping only for rhythm checks and defibrillation as required so as to minimize the time spent off the chest.[13] This is because continuous uninterrupted chest compressions have been shown to result in physiologically appropriate perfusion pressures which can and do lead to ROSC.[14] In fact, multiple studies have repeatedly shown that CPR with a focus on chest compressions, whilst keeping interruptions to an absolute minimum, increase the chances of ROSC and improve neurological outcomes as well as patient survival.[15,16] During CPR, it takes about 45 seconds of continuous chest compressions to reach an optimal perfusion pressure. Therefore, any time taken before the initiation of chest compressions, including the first 45 seconds of those compressions, are periods of non-perfusion.[17]

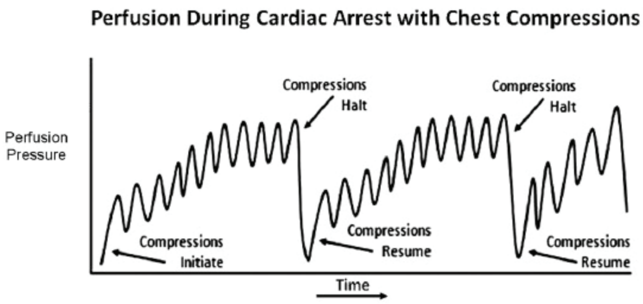

Figure 1: Perfusion pressure gradually increases with the initiation of chest compressions. Interruptions in chest compressions cause a sudden loss of this pressure[17]

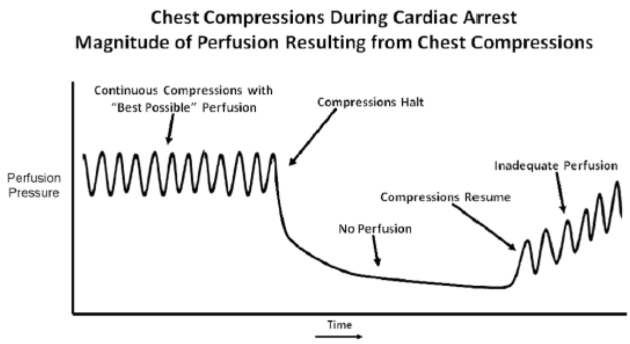

Figure 2: Prolonged interruptions in chest compressions lead to even greater periods of inadequate perfusion[17]

This information has greatly influenced the 2 major changes to CPR which took place in 2005 and 2010 respectively. The first of these was a move from a compression to ventilation ratio of 15:2 to that of 30:2 for single rescuers of victims of all age groups except neonates.[18] This change was justified by low CPR survival rates and the aforementioned evidence which highlighted improved coronary perfusion pressure and cardiac output with an increasing number of consecutive high quality chest compressions.[19] The second and arguably more controversial change was the move away from the ABC approach which had remained in place globally until 2010. The International Liaison Committee on Resuscitation (ILCOR) changed this recommendation to that of a CAB approach, emphasising that compressions should be of adequate rate and depth, allow for full chest recoil and minimize interruptions. This was done with the simultaneous removal of a step providing for initial rescue breaths prior to any chest compression.[20] The overriding justification for the implementation of CAB is the significantly shortened delay in starting compressions[21] and a reduced time to complete a cycle of compressions and ventilations.[22]

In 2015, ILCOR again released updated guidelines in which they continued to suggest CAB over ABC but noted the need for more evidence to improve the strength of the recommendation. Of note is that the approach to paediatric patients is left up to individual resuscitation councils, meaning that ABC may be recommended in this age since a greater number of arrests are hypoxia related.[23] It has however been shown that even in paediatric resuscitation rescuers identify the condition quicker, make fewer mistakes using the CAB sequence, and that this approach does not delay ventilatory support as compared to ABC.[24] Further additions to the 2015 guidelines with regards to compressions are the inclusion of a range for compression rate from 100 to 120 per minute, a maximum compression depth of 6 cm in adults, and the introduction of a compression fraction whereby chest compressions during CPR should comprise at least 60% of the total time in a resuscitation.[25] Following a CAB approach makes it somewhat easier to achieve a higher compression fraction.

The CAB mnemonic has had the effect of de-emphasising the role of airway management during CPR. Under the ABC approach, and until 2005, opening of the airway and assessing the patient for breathing, independent from any signs of circulation, was a standard of care. The 2005, 2010, 2015, and the latest 2017 guidelines all downplay the role of airway interventions in lieu of adequate chest compressions.[26] The belief that advanced airway techniques such as endotracheal intubation (ETI) or insertion of a supraglottic airway (SGA) is superior to bag-mask ventilation (BMV) is inconsistent with the available evidence, which currently indicates that advanced airway management during CPR is associated with lower survival rates.[27] In a large cohort study of more than 86 000 patients, intubation within the first 15 minutes of CPR was associated with a significant reduction in survival to hospital discharge.[28] This is most likely because intubation interrupts chest compressions by as much as 110 seconds in the average patient,[29] even though current guidelines recommend that ETI should never interrupt compressions for more than 5 seconds.[30] More recently, the use of video laryngoscopy (VL) in resuscitation has been compared to that of traditional direct laryngoscopy (DL). The literature is conflictory with some evidence suggesting greater first attempt success rates, most especially in less experienced clinicians,[31] while another study showed no difference between VL and DL in ETI success, although VL did cause fewer interruptions of chest compressions.[32]

At best when compared to BMV, the use of ETI shows no benefit over the more basic technique in a good example of clinical equipoise.[33] A related issue is that poor ventilation technique in cardiac arrest, which commonly includes hyperventilation, has poor survival outcomes.[34] This is due to various physiological derangements, most notably increased intrathoracic pressure leading to decreased cardiac output, coronary and cerebral perfusion.[35] The best approach to airway management remains unclear and there is a paucity of data with regards to CPR in the operating theatre when this process is performed by anaesthesiologists. Much of the data available for airway management during cardiac arrest is derived from out of hospital studies and then extrapolated for in-hospital practice.[36] Further investigation is thus required, but it is clear that instrumentation of the airway should not detract from time spent on the chest.

Since the invention and popularisation of CPR in the 1960s much has changed, and steady strides have been made in understanding the best approach to the patient in cardiac arrest. The CAB approach is part of this evolution, which now places emphasis on chest compressions, crucial in the initial phases of an arrest. Whilst ABC in this context serves a similar purpose, it likely delays the initiation of CPR thereby worsening outcomes, making CAB a more pragmatic and evidence-based approach to resuscitation.

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