RESUSCITATION REVIEW

Batt A, Halliwell D and Clark R
Employers - National ambulance UAE and MDT Global Solutions

This paper outlines the current position for those of us awaiting the new ILCOR guidelines in October 2015. It serves as an aide memoir of the evidence and is suggestive of some of the newer resususcitation strategies which may come later this year.

Introduction

One in three deaths in the United States is from ischemic heart disease, (Go et al 2013), whilst UK survival statistics are often quoted at 8.6% survival, whilst our colleagues in the North of Holland and Norway appear able to achieve far higher results of up to 25%. Maybe it's the first aid education given to children at school, or maybe the public access defibrillator schemes, or maybe there are other considerations such as diet, exercise or geography!

We know that the incidence and outcome of cardiac arrest varies around the globe but given that survival from out of hospital cardiac arrest is <15% in most countries, it appears that sudden cardiac arrest is seen as one of the most prevalent of health problems.

Resuscitation science continues to advance, and AHA and ERC guidelines are currently updated in a 5-yearly cycle in order to reflect these developments and advise healthcare providers on latest best practice. Whilst we await publication of the 2015 guidelines, it's perhaps a good time to reflect upon the old days, to review the science of what used to happen, since many of the latest developments on cardiopulmonary resuscitation (CPR) are focusing on optimising the quality of CPR in order to maximize survival from cardiac arrest.

In the 1970's the Ambulance crews in Bournemouth (UK) had access to only one defibrillator, which was brought to the scene of cardiac arrest patients in the town catchment area- only once cardiac arrest was confirmed by crews on scene This resulted in a delay of many minutes, yet our colleagues working in the 1970's and 80's recall that successful defibrillation in those days was commonplace, maybe because the quality of the ambulance crews was excellent and the heart was suitably 'primed' for the defibrillation attempt.

Ambulance crews of the 70's and 80's were masters of quality CPR

These days we link survival from cardiac arrest to the chain of survival (Field et al 2010) with an emphasis on early recognition, immediate activation of the emergency response system, but equally critical is the quality of CPR delivered.

We know that poor CPR quality has detrimental effects on victim's survival and post resuscitation neurological status, and quality CPR performance, monitoring and feedback (for both victim and resuscitation team) and developing team approach and quality-improvement strategies are seen as key strategies to cardiac arrest survival.

Fig 1 Photo of a London Ambulance vehicle circa 1974

1. Targeting CPR performance

To deliver high-performance CPR the essential components to be considered are chest compression fraction (CCF), chest compression rate, chest compression depth, maximising chest recoil (residual leaning), and controlling ventilation.

Chest Compression Fraction
Chest compression fraction is the proportion of time that chest compressions are performed during a cardiac arrest.

Interruptions in chest compressions are usually made for victim's initial assessment, call for help, prolonged intermittent ventilation and pre and post shock pauses.

Evidence suggests that A CCF lower than 80%, is associated with decreased return of spontaneous circulation (ROSC) and survival to hospital discharge (Christenson et al 2009).

Our current strategies include strategies to commence chest compression without need for pulse checking, to commence CPR in the presence of gasping respirations and a number of high profile cardiac arrest recognition strategies from the British Heart Foundation, American Heart Association and other organisations around the world encouraging us to focus solely on compression only/hands-only CPR.

There is strong emphasis on minimising pre shock pause and ventilation time, and immediate chest compression resumption after every shock delivery without subsequent rhythm analysis. These concepts have now become standardised and commonplace in Advanced Life Support (ALS) teaching. This should allow for increasing CCF ratio through the

continuation of chest compressions during defibrillator charging and ensuring rapid rescuer swap over when a resuscitation team is present.

Recently whilst teaching a group of Paramedic clinical team leaders, we have realised that post shock pauses may now be longer than the pre shock phase (further research is required), and will this year examine a few data downloads and video evidence to establish causation.

Regular rotation of compressors whilst doing chest compressions is an area that is gaining a lot of attention, and it was Hightower 16 in 1995 who first showed the need to swap over and the effects of fatigue. We currently are advised to swap at 2 minutely intervals, (Hightower 1995) but the reality is that as the compression rate increases the point of early fatigue decreases. (the faster we go the more tired we get).

In pre hospital teams it is often difficult to swap through the chest compression phase, because of perceived skill mix and other practical issues, with the paramedic often focussing on performing critical resuscitation tasks rather than performing BLS. This practice has been questioned for many years with all members of the resus team needing to take their turn at the CPR phase.

Alan Batt a Clinical Educator and prehospital researcher at National Ambulance LLC in Abu Dhabi recently presented a paper at the Middle East Clinical Simulation Conference in Dubai which demonstrated potential improvements in key high-quality CPR indicators by implementing six simple changes to CPR performance, including swapping the compressor mid cycle, rather than combining it with the defibrillation attempt.

Improvements in chest compression depth, rate of compressions, compression fraction, hands-off time and time to first shock were seen in all participants in the study. He demonstrated that this not only saved time but also allowed for the paramedic to commit time within each two minute cycle to be both an advanced life support clinician and a high-quality BLS provider.

Chest Compression Rate

Our current guidelines suggest we should have a compression rate of at least 100 but not greater than 120 compressions per min. Experimental data suggest optimum coronary perfusion pressure within the above range and marked haemodynamic dropping for rates below or above these values. (Idris et al 2012)

Chest compression depth

The aim should be to push to a depth of at least 5 cm. Rescuers often do not compress the chest deeply enough despite recommendations. A depth of <38 mm is associated with a decrease in ROSC and rates of survival (Steill et al 2012).

Chest Recoil

In the 1980s and 1990s paramedics had to perform 2-3 minutes of textbook CPR with 100% correct hand placement to re qualify-each year, we had to achieve the desired rate and we were failed our assessments if we had a single incomplete hand release! (chest decompression phase)


SkillMeter Resusci Anne

Paramedics were obsessed with good quality CPR and although our understanding of the effects of incomplete hand release were not clearly understood we were able to identify it as poor practice.

Not allowing the chest to fully recoil after each compression by leaning onto the victim's chest, decreases the venous return and subsequent the cardiac output (Niles et al 2011)

In the early 2000's we began to use the Active Compression and Decompression (ACD) device to maximise chest recoil, and effectiveness of recoil irrespective of rib fractures!

ACD is physically demanding, but research continues into the effects of the so called 'sink plunger' CPR method as a way of enhancing elastic recoil.

Minimising ventilations

Excessive ventilation volumes and positive-pressure ventilation directly affect venous return - so we are encouraged to ensure that the tidal volumes we deliver should produce no more than visible chest rise. However, in the case of the increasing obeseity issue in our populations in developed countries, delivery of ventilation volume to produce chest-rise may result in over-inflation of the patient's lungs thus causing potential pulmonary damage, and ultimately reducing preload.

Thus a conservative approach of delivery of somewhere between 5-8 ml/kg of IDEAL body weight is the recommended strategy for these patients.

Focusing on high-quality ventilation skills via BVM should be a priority in Paramedic-delivered resuscitation.

There are so many other effects that are potentially negative relating to ventilation.

Gastric insufflation and aspiration of gastric contents caused by hyperventilation (rate or volume) can further complicate the resuscitation effort. Long pauses for ventilation efforts (squeezing the bag) and airway management (tracheal intubation) affect the CCF decrease the probability of successful defibrillation.

We have recently been reviewing the clinical skills of paramedics here in the UK who are following the Protocol C algorithm, and not ventilating for the first few minutes of a cardiac arrest – These teams have a very good understanding of the haemodynamic effects of ventilations.

We know that if we are dealing with a primary cardiac cause to the cardiac arrest event the oxygen content is initially sufficient, and high-quality chest compressions are crucial in circulating this oxygenated blood. (that's why compression only CPR is ok)

But

When asphyxia is the cause of the arrest (children, drowning, toxins) or in prolonged resuscitation efforts (depletion in oxygen content), the combination of compressions and assisted ventilation are considered essential.

To avoid hyperventilation especially in witnessed victims of cardiac arrest the ventilation rate (breaths per minute) must be under 12 per minute.

Tailoring a resuscitation attempt to causation may become a significant theme in future years, adapting our techniques to the changing clinical pictures!

2. Feedback tools for CPR

One of the most significant advances in resuscitation is monitoring CPR parameters. This can enhance CPR quality and feedback science.

Patient monitoring and feedback

The primary determinant in effective resuscitation is coronary perfusion pressure (CPP), which is the difference between aortic diastolic pressure and right atrial diastolic pressure. Many studies have shown that a CPP of greater than 15mmHg is required to obtain a ROSC. However our problem is monitoring that CPP.

When only an arterial line is present experts recommend rescuers to optimize chest compression so that a diastolic blood pressure >25 mm Hg can be maintained.

But for most of us, titrating CPR performance to a goal end tidal CO2 (ETCO2) of >20 mm Hg reflects good quality CPR when neither an arterial nor a central venous catheter is in place. Capnography is also good as an indicator of ROSC when there is an abrupt increase to normal levels (35 to 40 mm Hg).

Team monitoring tools

Modern sophisticated devices (such as those using accelerometers (CPR pucks etc) can monitor CPR performance. Early fatigue and rescuer-patient (size) mismatch should be reviewed. Some resus rooms are using video as a debriefing tool, and some of the very newest technology uses science similar to that found in the Xbox kinect to measure the depth of CPR on real people. These tools are used both Live and in the debrief phases.

Data downloads

Once purely the remit of researchers, the data download has become the most commonplace tool for reviewing the effectiveness of our CPR. We can spot changes in chest compression rate, we can review pre shock and post shock pauses, we can monitor transthoracic impedance and the subsequent effects of ventilation.

3. Team approach to resuscitation

The pit stop CPR system is becoming the focus for many CPR providers with evidence suggesting that every resuscitation event (in or out of hospital cardiac arrest, with two or more rescuers) should be organised by a team leader (Dine Et al 2008) and (Yeung et al 2012) The team leader prioritizes the team actions and directs all its members with a central focus on high quality CPR. The team leader should ensure leadership and consistency with best practice.

Short CPR checklists can provide invaluable feedback information and improve further team's effectiveness - these have become commonplace with many pre hospital care teams now dispatching specific cardiac arrest team leaders to ensure the best possible care is provided.

Quality-improvement can be also achieved by using simulated team-training exercises and refreshment courses (Yang et al 2012) .In situ training - in the department, on the ward, in the helicopter before or during every shift is the gold standard, adopted by many of the leading resuscitation teams worldwide.

Often the role of the senior clinician or resuscitation officer, best practice dictates that debriefing can improve resuscitation quality. (Dine 2008)

Additional Tools

Mechanical compression devices continue to be evaluated for their effectiveness, with both the *LINC and Paramedic studies* being published in recent years.

It seems a lifetime ago (2003) that Lucas 1 (oxygen driven) mechanical CPR first appeared and began to transform our understanding of chest compression. By controlling the variables associated with chest compression we can see the changes on the rest of the CPR process.

Mechanical CPR using Autopulse or Lucas continue to be studied and we can see evidence of use building (health and safety during transportation, prolonged cardiac arrest, optimising compression rate and depth and in the case of Lucas maintaining elastic recoil.)

We are seeing the role of drugs being deemphasised, and we await the guidelines in a few months to see what will happen next with the use of drugs in resuscitation.

The Future

Recent animal study papers have been advocating success with head inclined (head-up) resuscitation, and we are now seeing techniques and strategies appearing to transfer these strategies into human clinical trials, we are also seeing projects associated with measuring transthoracic impedence using defib pads.

Post resus care

We are seeing many pre hospital teams moving away from transporting patients in cardiac arrest, maintaining a 10 minute stabilisation period in the ROSC phase before any attempt to move the patient is made, thereby reducing likelihood of re-arrest.

We despair when we see on the television post arrest patients roughly handled or moved in a seated position on an ambulance carry chair in a post ROSC phase to get them down a flight of stairs. The physiology of moving post resuscitation patients should be better understood and evaluated. But sitting post ROSC patients up at 90 degrees appears to be an unwise proposition.

The concept of a bundle of care similar to that provided to sepsis patients is perhaps where the future of resuscitation lies, with no one intervention being used in isolation. A good example of the benefit of a bundle of care was the results of the recent "CHEER" trial in Australia which saw neurologically intact survival rates from refractory arrest greater than 50% through a bundle of care that included mechanical CPR, ECMO and post-ROSC cooling (Stub et al 2015)

Cooling and other strategies are still being reviewed.

We are great advocates for Compression only CPR (Sayre et al 2008) is gaining respect in large scale national observational studies as equal or some times more effective than standard ALS algorithms (Iwami et al 2007, and SOS KANTO 2007).

Conclusion

We look forward to the new guidelines, but our observations on resuscitation are that we often find ourselves in positions where we can often learn from the past, before getting too excited about the technologies and advances of the future. Personalising care based on cause of cardiac arrest and age of patient may be of even greater emphasis in the future, with far more technical education given to those who will be specialists in resuscitation, team leaders and resuscitation officers. Bundles of care need to be further researched to find the greatest benefit for our patients. And research into the Physiological aspects of moving patients Post Rosc should be evaluated.

Resuscitation science continues to advance, and now includes a far greater understanding of human factors and we are seeing the development of resuscitation clinical guidelines which reflect these developments.

Refs.

Christenson J, Andrusiek D, Everson-Stewart S, et al. Chest compression fraction determines survival in patients with out- of-hospital ventricular fibrillation. Circulation 2009;120:1241– 1247.

Dine CJ, Gersh RE, Leary M, et al. Improving cardiopulmonary resuscitation quality and resuscitation training by combining audiovisual feedback and debriefing. Crit Care Med 2008;36:2817– 2822

Field JM, Hazinski MF, Sayre MR, Chameides L,Schexnayder SM,et al. Part1: executive summary: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. Circulation. 2010 Nov; 122 (18 Suppl 3): S640-56.

Go AS, Mozaffarian D, Roger VL, et al. AHA Statistics Committee and Stroke Statistics Subcommittee. Heart disease and stroke statistics–2013 update: a report from the AHA. Circulation 2013;127:e6–e245.

Hightower D(1), Thomas SH, Stone CK, Dunn K, March JA.;26(3):300-3. Decay in quality of closed-chest compressions over time. Ann Emerg Med. 1995 Sep

Idris AH, Guffey D, Aufderheide TP, et al. Resuscitation Out- comes Consortium (ROC) Investigators. Relationship between chest compression rates and outcomes from cardiac arrest. Circulation 2012;125:3004–3012.

Iwami T, Kawamura T, Hiraide A, et al. Effectiveness of by- stander-initiated cardiac-only resuscitation for patients with out-of-hospital cardiac arrest. Circulation 2007;116:2900–2907.

Linc - A comparison of conventional adult out-of-hospital cardiopulmonary resuscitation against a concept with mechanical chest compressions and simultaneous defibrillation (LINC Study). ClinicalTrials.gov Web site. http://clinicaltrials.gov.

Niles DE, Sutton RM, Nadkarni VM, et al. Prevalence and hemodynamic effects of leaning during CPR. Resuscitation 2011;82(suppl 2):23–26.

Nolan JP, Soar J, Zideman DA, et al. European Resuscitation Council Guidelines for Resuscitation 2010 Section 1. Executive summary. Resuscitation 2010;81:1219–1276

Sayre MR, Berg RA, Cave DM, et al. Hands-only (compres- sion-only) cardiopulmonary resuscitation: a call to action for bystander response to adults who experience out-of-hospital sudden cardiac arrest. A science advisory for the public from the AHA ECC Committee. Circulation 2008;117;2162-2167.

SOS-KANTO Study Group. Cardiopulmonary resuscitation by bystanders with chest compression only (SOS-KANTO): an ob- servational study. Lancet 2007;369:920–6.

Stiell IG, Brown SP, Christenson J, et al. What is the role of chest compression depth during out-of-hospital cardiac arrest resuscitation? Crit Care Med 2012;40:1192–1198.

Stub D, Bernard S, Pellegrino V, Smith K, Walker T, Sheldrake J, Hockings L,Shaw J, Duffy SJ, Burrell A, Cameron P, Smit de V, Kaye DM. Refractory cardiac arrest treated with mechanical CPR, hypothermia, ECMO and early reperfusion (the CHEER trial). Resuscitation. 2015 Jan;86:88-94. doi: 10.1016/j.resuscitation.2014.09.010. Epub 2014 Oct 2. PubMed PMID: 25281189.

Yang CW, Yen ZS, McGowan JE, et al. A systematic review of retention of adult advanced life support knowledge and skills in healthcare providers. Resuscitation 2012;83:1055

Yeung JH, Ong GJ, Davies RP, et al. Factors affecting team leadership skills and their relationship with quality of cardiopulmonary resuscitation. Crit Care Med 2012;40:2617–2621.