Journal of the Accident and Medical Practitioners Association (JAMPA) 2007; Vol. 4 (No. 2)

Resuscitation Matters

Conference Report

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Issues this article will address

- Resuscitation guideline changes
- Physiology of sudden cardiac arrest
- Issues associated with defibrillation in sudden cardiac arrest
- Issues associated with ventilation in sudden cardiac arrest
- Therapeutic hypothermia

Salient Points

- There are many individuals and organisations, both nationally and internationally, who are addressing issues associated with obtaining an optimal outcome from resuscitative efforts.
- The single most important change in the 2005 resuscitation guidelines was an increased emphasis on chest compressions.
- A conceptual framework for the physiology of sudden cardiac arrest has been developed and adopted by the resuscitative community. Different therapies are required depending on the phase of the arrest.
- Defibrillation is most important in the electrical phase of cardiac arrest. Different defibrillation sequences are advised depending on the type of defibrillator and the time during the arrest that the shocks are given.
- There is a significant subset of the resuscitative community who advise moving away from mouth-to-mouth ventilation in the community, although this has yet to be formally reflected in advanced cardiac life support (ACLS) algorithms. Recent studies also advocate a reduced role for endotracheal intubation in community arrests.
- Therapeutic hypothermia is increasingly being used to preserve neurological function in selected cardiac arrest patients.

Key words: Resuscitation • Defibrillation • Ventilation • Hypothermia • Intubation • Cardiac arrest

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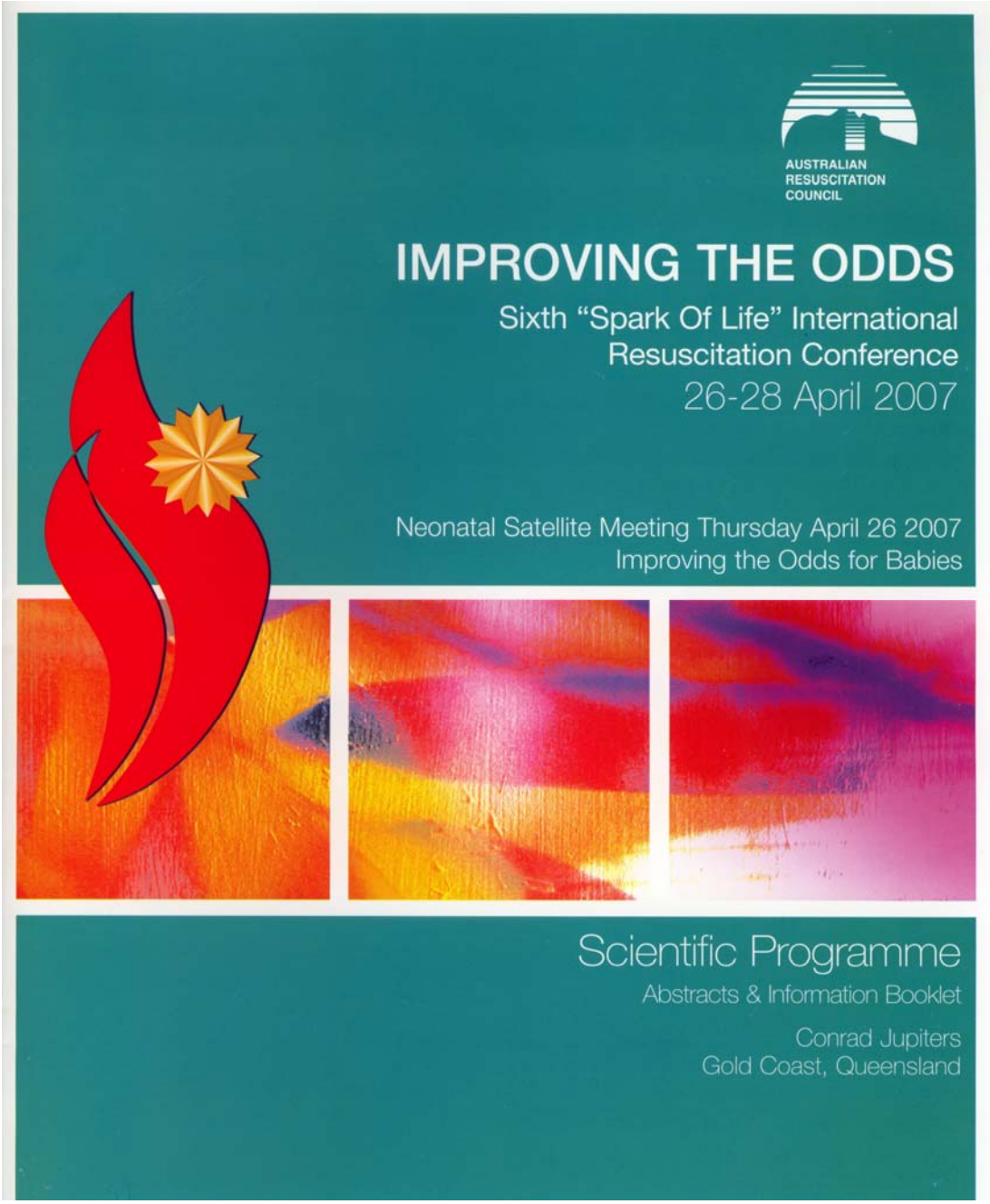
Introduction

In April 2007, I attended the 6th “Spark of Life” International Resuscitation Conference entitled Improving the Odds. This was organised by the Australian Resuscitation Council and held at Board Beach in Queensland, Australia. It was a very inclusive conference with delegates ranging from first-aid trainers to intensivists. There were a number of eminent

speakers, including Prof *Karl Kern*, Professor of Medicine at the University of Arizona and Director of the Cardiac Catheterisation Laboratories at the University Medical Centre in Tucson, Arizona; Dr *Jerry Nolan*, Consultant in Anaesthesia and Intensive Care Medicine at Royal United Hospital, UK; and Associate Professor *Vic Callanan*, Director of Anaesthesia and Intensive Care Medicine at Townsville Hospital, Queensland, Australia. At the conference dinner, I was fortunate enough to be seated beside Dr *Tony Smith*, who is an Intensive Care Medicine Specialist in the Department of Critical Care Medicine at Auckland City Hospital. Dr *Smith* also Chairs the St John Clinical Advisory Group (CAG), and is actively involved in acute prehospital care with research interests in the areas of cardiac arrest and airway management.



The Science of Resuscitation

A number of international groups are engaged in resuscitation research. This research takes various forms, ranging from randomised, controlled trials to case studies or registry analysis, and can involve animal or human subjects. In 1992, the International Liaison Committee on Resuscitation (ILCOR) was formed. Member organisations of ILCOR include the American Heart Association (AHA), European Resuscitation Council (ERC), Heart and Stroke Foundation of Canada (HSFC), Resuscitation Council of Southern Africa (RCSA), the Australia and New Zealand Council on Resuscitation (ANZCOR), and the InterAmerican Heart Foundation (IAHF).

One of the tasks ILCOR has is to analyse the resuscitation literature and issue recommendations for its member organisations. The most recent recommendations were published in 2005, and involved analysis of over 22,000 studies. The recommendations were published simultaneously in *Resuscitation* and in *Circulation*, the journal of the American Heart Foundation. Since then, different countries and organisations have adapted the recommendations to suit their local context.

Changes to the 2005 Resuscitation Guideline

Without doubt, the most profound change in the 2005 ILCOR recommendations for sudden cardiac arrest (SCA) in adults was the increased emphasis on chest compressions. This has been adopted, albeit with slight variations, by all member resuscitation organisations. In New Zealand, for example, the guidelines have changed in several ways. Firstly, the adult compression/ventilation ratio has changed from 15/2 to 30/2. Secondly, the instruction to give “two effective breaths (up to 5 attempts)” has been removed; instead, the resuscitator is to deliver 30 chest compressions prior to any ventilation attempts. Thirdly, at the completion of a defibrillation sequence (either triplet or single shock), the resuscitator is to move directly into chest compressions, and not pause to do a rhythm or pulse check. St John New Zealand has gone so far as to completely remove ventilation attempts in some situations – for example, where lay persons are unfamiliar with resuscitation techniques or where a first response ambulance is single-crewed with a back-up ambulance close behind.[1]

The rationale for this change comes firstly from the observation that in over 40 years of resuscitation training, the improvement in outcome from SCA has been minimal. For example, a prospective observational cohort study published by Eckstein et al. in 2005 analysed 2021 consecutive cardiac arrest adult patients on whom resuscitation was attempted.[2] Overall, neurologically intact survival was 1.4% (99% CI 0.8% to 2.4%). Similar statistics have been reported for resuscitation outcomes in New York and Chicago.

It was acknowledged at the conference that part of the reason for the apparent lack of success might be due to changes in the typical patient profile. People are living longer than ever before, and have a greater chance of significant comorbidity at arrest compared with previous generations. Similarly, with the advent of excellent primary care regimens involving drugs such as the statins, ACE inhibitors and β-blockers, as well as cardiac lifestyle classes, etc., there are now fewer ventricular fibrillation (VF) sudden cardiac arrests than previously. Since VF arrests are more amenable to resuscitation techniques such as defibrillation than asystolic or pulseless electrical activity (PEA) arrests, this change in relative proportions will have a negative effect on outcome statistics.

Nevertheless, there is still room for improvement in resuscitation attempts. Dr *Jerry Nolan* succinctly described the problem as FAT, i.e. too much “F…… around time” (see list of possible causes below). At SCA scenes, too much time is spent ineffectively. For example, bystanders are reluctant to commence cardiopulmonary resuscitation (CPR) due to a variety

of concerns – they are afraid of doing harm and they are afraid of being harmed. Automated external defibrillators (AEDs) take too long the analyse rhythms and to charge. Monitoring with pulse checks and therapeutic interventions such as inserting intravenous (IV) lines and intubation also result in significant hands-off time for the patient.[3-5]

FAT List
(*F…… Around Time*)

Procrastination

Respiration

Signs of circulation

Change of pumper

AED delay

Airway manoeuvres

IV access

Inevitable

In 2005, Stiell and colleagues in Ottawa published the results of the third phase of the Ontario Pre-hospital Advanced Life Support (OPALS) study.[6] The OPALS study was the largest multicentre controlled trial ever in the prehospital setting, and involved 5637 patients in cardiac arrest during the second (basic life support with defibrillation) and third (advanced life support) phases of the study. Emergency services arrived at the scene of the cardiac arrest in 8 minutes or less on 93.3% of occasions, and during the life support phase, intubation and IV insertion were successful on 93.7% and 89% occasions respectively. The trial clearly demonstrated that adding advanced life support manoeuvers to basic life support with defibrillation regimens, even where the advanced life support skills are performed well, did not improve survival. Stiell argues that the most effective and cost-efficient way to improve survival rates is to increase effective bystander CPR with timely emergency defibrillation via the first response team.

Phases of Resuscitation

A conceptual framework for understanding the physiology of cardiac arrest has been developed by Myron Weisfeldt, the William Osler Professor of Medicine at Johns Hopkins

University.[7] Weisfeldt proposes a temporal sequence of phases in cardiopulmonary resuscitation: electrical, circulatory and metabolic. The electrical phase lasts 0-4 minutes, and here optimal resuscitation occurs through correction of an electrical problem by defibrillation in the case of VF or pulseless ventricular tachycardia (VT), or pacing in the case of bradycardia. In the next 4 to 10 minutes of the cardiac arrest, the electrical phase gives way to the circulatory phase. In the circulatory phase, optimal results occur with provision of artificial circulation through cardiopulmonary resuscitation. Defibrillation is required, but only after circulatory support has been provided. The metabolic phase in cardiac arrest occurs after the first 10 minutes. It is the least well understood of the phases – the patient who reaches the metabolic phase with no return of spontaneous circulation has the lowest chance of success.

Support for the electrical phase comes from extensive experience with the automatic implantable defibrillator, where defibrillation occurring within 15 to 20 seconds after the onset of what would be a lethal VT or VF is almost uniformly life-saving. Survival rates from an arrhythmia for those with a permanent defibrillator exceed 95% in most series. At this time point, there is clearly no need for artificial circulation and there is little or no metabolic embarrassment.[8] Similarly, many working in cardiac care facilities will attest to the effectiveness of prompt defibrillation delivered to monitored patients. In the community, AED studies in Rochester, New York, Chicago airports, and Las Vegas casinos have demonstrated that, where the mean response time is no more than 5.5 minutes, survival rates are over 40%.[9-11]

Theoretical considerations for the importance of CPR in the circulatory phase include the idea that chest compressions and ventilation maintains oxygen and substrate delivery to the heart and brain. Chest compressions help coarsen fine ventricular fibrillation, thus optimising the chances of success with defibrillation.[12] In addition, chest compressions reduce dilatation of the right ventricle, which also aids the return of an organised rhythm after defibrillation.[13]

Empirical support for the concept of the circulatory phase comes first from animal studies. Steen et al.[14] reported a study involving 18 pigs subjected to VF arrest for 6½ minutes before any resuscitative measures were undertaken. After 6½ minutes of VF, six pigs received defibrillation alone. None of these pigs survived. A second group of six pigs received mechanical CPR (mCPR) for 3½ minutes, followed by a 40 second hands-off time, designed to mimic current AED delays due to rhythm analysis and charging, and then defibrillation. One of the six pigs in this group survived. In a third group of six pigs, mCPR

was continuous for 3½ minutes and continued during defibrillation. Five out of these six pigs survived.[14] The explanation provided by Steen for these results related to the delivery of blood from the left ventricle to the venous circulation during the first few minutes of cardiac arrest. This results in the blood pooling in a distended right ventricle, with subsequent underfilling of the left ventricle. Chest compressions help to correct this situation by establishing an adequate coronary perfusion pressure – which is quickly lost if chest compressions are interrupted. The concept of right ventricular dilatation was reiterated by Prof *Kern* at the "Spark of Life" conference, and was illustrated with MRI images from the porcine laboratories in Tucson, Arizona.

Several human studies have now been conducted which also support the notion that, after the first few minutes of cardiac arrest, outcomes are improved by performing chest compressions prior to defibrillation. An early study by Cobb et al. from Seattle demonstrated that, where response times were four minutes or longer, survival was improved significantly by the addition of 90 seconds of CPR prior to the delivery of a shock.[15] Wik and colleagues from Norway also demonstrated a statistically significant ($p < 0.006$) increase in survival rate in patients receiving CPR prior to defibrillation where the emergency response time was longer than 5 minutes.[12]

In addition to preceding defibrillation by CPR in selected groups of SCA, there is now also an emphasis on commencing CPR immediately after the cessation of defibrillation, without pausing to do a pulse or rhythm check. The argument supporting this is that even though defibrillation may be successful at returning an organised rhythm, this rhythm may not be sustained because of structural abnormalities in the heart such as right ventricular dilatation. Proponents of chest compressions argue that superimposing chest compressions on slow, isolated sinus beats post-defibrillation does no harm, and in fact does good by increasing the chances that the isolated sinus beats will organise into a rhythm supporting the return of spontaneous circulation. An excellent ECG example of this phenomenon can be found in the paper by Valenzuela et al. on interruptions of chest compressions during emergency medical systems resuscitation.[4]

Thoughts on Defibrillation

In the 2005 guideline for defibrillation, ILCOR asserted that "biphasic waveform shocks are safe and effective for termination of VF when compared to monophasic waveform shocks."[16] However, the emphasis on biphasic defibrillators has been undermined recently through the publication in *Circulation* of a trial by Kudenchuk et al. showing no statistically significant

difference in outcome for out-of-hospital VF arrest treated with either monophasic or biphasic defibrillators.[17] This may lead to a revised opinion from ILCOR, as at the very least, it implies that medical centres need to consider carefully the cost implications of replacing their older but fully functioning monophasic defibrillators with new biphasic models. In addition, the optimal energy for the first shock for biphasic machines is unknown, and there is no evidence supporting the superiority of either escalating or non-escalating shock energy. In the latter case, the New Zealand Resuscitation Council (NZRC) has opted in favour of a non-escalating regimen, for reasons of simplicity, ease of teaching and greater compliance. In the case of single versus triplets of shocks, the NZRC advises that shock triplets should be delivered where the defibrillator is monophasic or where the time to defibrillation is short. Single shocks should be considered for biphasic machines where the time to defibrillation is longer and/or the resuscitation attempt is prolonged.

Ventilation

As alluded to earlier, increased emphasis on chest compressions has resulted in a corresponding decreased emphasis on ventilation, particularly in the early stages of an arrest. This is due partly to an acknowledgment of poor bystander participation rates due to factors such as lack of training and concerns regarding the transmission of infectious disease. Previous work has shown that lay people take 15 to 16 seconds each time to deliver two mouth-to-mouth breaths,[3] during which no chest compressions are delivered. A recent observational study by the SOS-Kanto group showed no evidence of benefit from the addition of mouth-to-mouth ventilation in any subgroup of sudden cardiac arrest patients. This group also noted that 72% of 4068 arrests received no bystander CPR.[18] Reducing the role of bystander mouth-to-mouth ventilation does not obviate the need for a patent airway however, as animal studies have clearly demonstrated that the effect of an occluded airway on resuscitation attempts is catastrophic.[19]

The role of intubation in the community has also been de-emphasised recently. The advantages of intubation are that it minimises gastric inflation, protects against aspiration, enables effective ventilation, even with poor lung/chest compliance, and enables uninterrupted chest compressions. Unfortunately, intubation is not necessarily an easy skill to learn. A study published in 1998 demonstrated in that in the case of first-year anaesthetic registrars, the intubation learning curve reached a 90% success rate after a mean of 57 attempts.[20] It is becoming increasingly difficult to get into theatres for practice, due to increased competition from various groups for decreased slots with the advent of ventilation adjuncts such as supraglottic airways and spinal anaesthesia. There have been several

studies demonstrating an unacceptable rate of failed intubation – oesophageal intubation, right main stem intubation, or tube above the vocal cords – in patients arriving at Emergency Departments.[21] Even where intubation is successful, Stiell argues that there is no difference in outcome compared with basic life support with defibrillation.[6] In New Zealand, St John advanced paramedics continue to train in intubation; however, the post-intubation ventilation rate has been reduced from 1 ventilation per 5 chest compressions to 8 to 10 ventilations per minute.[1] The reason for this is two-fold: to avoid hyperventilation and to reduce the amount of time there is positive pressure in the chest, as the latter compromises blood flow.

New Directions – Therapeutic Hypothermia

Interest in the metabolic phase of cardiac arrest has centered largely on the role of therapeutic hypothermia in preserving neurological function in cardiac arrest patients. In 2003, ILCOR advised that unconscious patients with spontaneous circulation after out-of-hospital cardiac arrest should be cooled to 32°C to 34°C for 12 to 24 hours when the initial rhythm is VF.[22] Similar recommendations were made by the Australian Resuscitation Council in 2006. In New Zealand, all four Auckland hospitals follow a policy of therapeutic hypothermia for selected patients,[23] and while patients are not actively cooled in the community, St John personnel are encouraged to uncover unconscious VF arrest patients and not try to warm them.[1] Support for this initiative comes from two prospective randomised trials, one from Europe and the other from Australia. Both trials demonstrated a statistically significant improvement in neurologically intact survival for patients who were cooled for up to 24 hours compared with normothermic patients, although the Australian trial did not demonstrate a statistically significant difference in mortality.[24,25] These recommendations have not been universally adopted, perhaps partly due to the strict patient selection criteria, and partly due to cost considerations.

Other resuscitation initiatives currently being developed include AEDs that can analyse rhythms while chest compressions are ongoing and also provide immediate feedback on the rate and depth of compressions and ventilations.

Conclusion

Attending the Australian Resuscitation Council 2007 Improving the Odds conference was time well spent. It proved an ideal way to become more informed regarding resuscitation issues, and to learn more about the history behind the recent NZRC algorithm changes.

Speakers and attendees were very approachable and more than willing to share their knowledge and experience. I would recommend the conference to all those interested or involved in resuscitation.

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