

Cardiac Arrest: recent advances in recognition and management

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Abstract

The features of cardiac arrest will be familiar to any reader who has recently undertaken an Advanced Life Support course. Rather than reproducing algorithms which should be readily available in all UK hospitals, this article emphasises the importance of early recognitions and prevention, and looks at some of the more recent advances in resuscitation technique.

Keywords

Cardiac arrest, resuscitation

Key Points

1. Most patients who survive in-hospital cardiac arrest have either ventricular fibrillation or pulseless VT as their primary arrhythmia.
2. Recognition of the warning signs prior to in-hospital cardiac arrest may have a significant impact on mortality.
3. Vasopressin may be superior to Adrenaline in asystolic cardiac arrests.
4. The advent of automated external defibrillators has made possible public access defibrillation which may result in better survival through earlier defibrillation.
5. Hypothermia (34C for 12-24hrs) for unconscious survivors of cardiac arrest has been shown to improve outcome of resuscitation.

Introduction

Approximately 370,000 to 750,000 inpatients and more than 225,000 outpatients have a cardiac arrest each year, resulting in approximately 350,000 deaths.¹⁻⁴ Although resuscitation science has progressed over the last 40 years, the outcome of resuscitative efforts remains poor; only 1 to 20% of patients survive an out of hospital cardiac arrest.⁵⁻¹⁰

In the United Kingdom a study¹¹ of in-hospital cardiac arrests shows that out of 1368 in patient cardiac arrests, 429 patients initially presented with ventricular fibrillation (VF) or pulseless ventricular tachycardia (VT), of whom 42.2% were discharged alive. Only 6.2% of those with an initial rhythm of non-VF/VT survived. Overall, 82.2% of those successfully resuscitated were still alive at 6 months.

Recognition and Prevention of Cardiac Arrest

In the non-hospitalised adult population the underlying precipitant of cardiac arrest is usually primary cardiovascular disease. Severe chronic obstructive airways disease, drowning, road traffic accidents, head and spinal cord injury and, in children, a primary respiratory or neurological pathology, are among the other recognized causes.

The situation is slightly different in a hospitalised adult population, or adult patients seen in the emergency room. These patients may undergo a prodromal period, during which signs and symptoms may alert a vigilant physician to impending cardiac arrest. An appropriate and timely clinical intervention may prevent such progress. Unfortunately such warning signs may frequently be missed; a number of initiatives have been introduced in recent years to facilitate their recognition:

A) Medical Emergency Team (MET): This concept was initiated at Liverpool Hospital, New South Wales, in 1990 and has since been adopted by various hospitals throughout the world, including many in the UK.¹² It is based on recognition of acute changes in physiology, involving airways, breathing, circulation and neurology sequentially monitored by the ward staff. When 'triggered', an emergency team is summoned to review the acutely ill patient, hopefully intervening to prevent further deterioration [Table 1].

Table 1. "Criteria For Calling The 'Medical Emergency Team' (MET)"¹³

Areas Concerned	Acute Changes In Physiology
Airways	Threatened
Breathing	All respiratory arrests Respiratory rate < 5 Respiratory rate > 36
Circulation	All cardiac arrests Pulse rate < 40 Pulse rate > 140 Systolic blood pressure < 90 mmHg
Neurology	Sudden fall in level of consciousness i.e. Fall in GCS of > 2 points Repeated or prolonged seizures
Other	Any patient who you are seriously worried about who does not fit the above criteria

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Table 2. Modified Early Warning Score ¹⁷

	3	2	1	0	1	2	3
Systolic Blood Pressure (mmHg)	< 70	71-80	81-10	101-199		> 200	
Heart Rate (bpm)		<40	41-50	51-100	101-110	11-129	> 130
Respiratory Rate (bpm)		< 9		9-14	15-20	21-29	> 30
Temperature (°C)		< 35		35-38.4		> 38.5	
AVPU score				Alert	Reacting To Voice	Reacting to Pain	Unresponsive
Urine (ml/hr)	<10	11-30		Not measured			

B) Early Warning Scoring Systems (EWS)

Similar in concept to the above, the Early Warning Score (EWS) and the Modified EWS (MEWS) were developed as simple tools for bedside evaluation in surgical patients.^{14,15} Numerical data are attached to deviations in physiological variables to give an overall score (table 2). Sequential scoring identifies worsening of a patient's condition, while a single score of 5 or more supports further assessment and possibly HDU or ICU admission. Close observation and monitoring of patients may, in itself, be of some benefit. The more rapid recognition of cardiac arrest and consequent early intervention is reflected in a better prognosis.¹⁶

C) Critical Care Outreach:

The UK government-sponsored, 'Comprehensive Critical Care: A Review of Adult Critical Care Services',²² attempted to address the shortage of UK Critical Care facilities. Patients are defined in terms of need, rather than location of treatment, in theory pushing this care out onto the general wards. To facilitate this, the 'Outreach' concept places appropriately trained personnel on the wards, intervening early to prevent the need for ICU admission (cf. MET). The same team should also support the transfer (step down) of ICU patients back to the wards. Monitoring with MEWS identifies the patients at risk.² The effectiveness of this initiative remains unproven.¹⁸

Causes of Cardiac Arrest

a) Obstruction to the airway.

This is the most important acute, precipitous and often preventable initiator of cardiac arrest. Total airway obstruction for just a few minutes will often lead to hypoxia of sufficient severity. With partial obstruction the time course may be longer, depending on the patient's underlying condition, but ultimately exhaustion will supervene. The circulation cannot function without oxygenation, which is reliant on a patent airway. Restoration of the airway is therefore the critical first step in all resuscitation protocols. Causes are listed in table 3.

b) Respiratory.

Cardiac arrest frequently results from hypoxia, consequent upon gross respiratory inadequacy. The

Table 3.

Causes Of Airways Obstruction Include:

- Blood
- Vomitus
- Other Foreign Body (e.g. tooth, food)
- Direct Trauma, to face or throat
- CNS Depression
- Pharyngeal Swelling (e.g. infection, oedema)
- Laryngospasm (blood, secretions, fumes, foreign body)
- Bronchospasm
- Bronchial secretions

Table 4. Respiratory Causes of Cardiac Arrest

Respiratory Causes of Cardiac Arrest	
1. Primary Lung pathologies:	- Pneumonia - COPD - Asthma - Acute Lung Injury/ARDS - Lung Trauma - Perfusion related defects e.g.: emboli - Inflammation e.g.: aspiration - Pulmonary oedema
2. Lung pathology secondary to:	- Head Injuries - Alcohol/drug intoxication - Cerebro-vascular accidents - Myasthenia Gravis - Poliomyelitis - Guillain-Barre Syndrome - Multiple Sclerosis - Spinal cord lesions - Chest wall abnormalities - Haemo +/- pneumothoraces

common 'respiratory' conditions which may precipitate cardiac arrest are listed in Table 4.

c) Cardiac causes.

Cardiac arrest consequent upon *primary* cardiac pathology may be unpredictable and sudden. Common causes are listed below in table 5. Dissociation of cardiac mechanical function from electrical activity (resulting in pulseless electrical activity) may also be acute and unpredictable. While this is most commonly seen with myocardial pump failure secondary to infarction there are important mechanical, metabolic and pharmacological precipitants. These are potentially treatable if detected and managed early. An exhaustive list of these conditions is beyond the scope of this review but the more important are listed in table 5.

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Table 5. Cardiac causes

Myocardial (Primary) Causes of Cardiac Arrest:	
Ischaemia	
Myocardial Infarction	
Hypertensive Heart Disease	
Valvular Heart Disease	
Myocarditis	
Cardiomyopathy (e.g. HOCM)	
Secondary (treatable) causes of Cardiac Arrest	
• Electrolyte disturbances	
	Hypo/hyperkalaemia
	Hypocalcaemia
	Hypomagnesaemia
• Severe metabolic acidosis	
	Sepsis
	Renal failure
	Drug overdose
	Hypovolaemia
• Drugs	
	Antiarrhythmics
	Digoxin
	Beta blockers
	Antidepressants
• Hypothermia	
• Hypovolaemia	
• Pulmonary embolism	
• Tension pneumothorax	

Management of Adult Cardiac Arrest

Protocol driven management of adult cardiac arrest is well established and current guidelines issued by the Resuscitation Council (UK) are given in detail in the 4th edition of the Provider Manual of the 'Advanced Life Support Course'. Some of the key points will be summarised below. The guidelines are constantly under review, based on 'best evidence' with the next revision due later this year. Thus management in some areas may change. It is evident that the best chance of a successful outcome requires rapid and appropriate interventions depicted by the Resuscitation Council's **"Chain Of Survival"**, consisting of the following four links:

- **Early Access** – To the emergency services or cardiac arrest team.
- **Early Basic Life Support (BLS)**
- **Early Defibrillation.**
- **Early Advanced Life Support (ALS)**

Early Access

In out of hospital cardiac arrest, immediate access to the Emergency Medical Services (EMS) via a single telephone number is vital, as is bystander CPR pending arrival of appropriately trained and equipped paramedical staff. For in-hospital cardiac arrests, the 'Cardiac Arrest Team' is summoned immediately via the internal telephone paging system. Once the diagnosis of cardiac arrest has been made, defibrillation should not be delayed until the arrival of this team and health care providers at ward level should be trained to defibrillate the patient.

Early Basic Life Support (BLS)

Ventilation of the lungs and chest compressions of the victims of cardiac arrest will slow down the rate of deterioration of the brain and heart. In out-of-hospital arrest bystander CPR increases the likelihood of successful resuscitation.¹⁹ A 'Pulse Check' to confirm cardiac arrest is no longer recommended, except by health professionals, as it is generally unreliable. 'Bystander CPR' should only be withheld if there are obvious signs of life such as coughing, body movement, breathing etc.

Early Defibrillation

The commonest rhythm encountered in the management of adult cardiac arrest is Ventricular Fibrillation (VF). A number of studies have demonstrated that the chances of successful defibrillation decreases rapidly over time as VF evolves to asystole. Early defibrillation is therefore an important determinant of survival in adult cardiac arrest. In casinos equipped with automated external defibrillators there was a 74% survival rate of those defibrillated within 3 minutes of collapse and a 49% survival rate for those defibrillated after 3 minutes.²⁰

As 90% of cardiac arrests occur in the community, initiatives such as 'public access defibrillation' aim to improve the chances of survival of this group of patients. More widespread availability of the automated external defibrillator and sufficient numbers of trained personnel would allow victims of cardiac arrest the chance of early defibrillation, whether in the community or in hospital. About 10% of cardiac arrest victims tend to belong to a known high risk group and in this population an implanted cardioverter defibrillator may be the best way of reducing the risk of death from sudden cardiac arrest.

Early Advanced Life support

Advanced Life Support involves definitive airway management, intravenous access and drug therapy. These interventions are often required when cardiopulmonary resuscitation and defibrillation alone are not enough to sustain a perfusing rhythm.

A few developments in the techniques of CPR, and in the drugs used will be discussed.

Airway & Ventilation during CPR

The immediate need for early ventilation in non asphyxial cardiac arrests has been questioned.²¹ New aids to maintain the airway such as the laryngeal mask, the combitube and minimally invasive cricothyroidotomy devices are being evaluated.

Studies in the 1990's showed that survival and neurological outcome (at 24 hours) in animal models of ventricular fibrillation with an occluded airway were not different if ventilation was withheld during chest compression for up to 6 minutes.²² Concentrating on chest compression, in theory, allows more effective circulatory support, improved organ perfusion and thus maintenance of the brain stem conditions necessary for continued self ventilation. The evidence to support this is sparse,²³ and randomised controlled trials would be hard to

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undertake. Though there is certainly a trend towards emphasis of early effective chest compression over ventilation in primary dysrhythmic cardiac arrests, more controlled human studies are awaited.

Obviously this does not apply where the primary insult is respiratory and when ventilation is otherwise inadequate. In these situations, respiratory support will always be required initially via mouth to mouth or bag-valve-mask ventilation in combination with airway opening manoeuvres like the chin lift and jaw thrust. There is a reluctance amongst lay and professional rescuers to administer mouth to mouth resuscitation²⁴ especially due to fear of contracting infections (e.g hepatitis, herpes simplex virus, tuberculosis etc) and this has resulted in recommendations to use barrier mask devices to protect the rescuer from infective secretions.

When bag-valve-mask ventilation is used, lower tidal volumes (6ml/Kg or a paediatric bag) and supplemental oxygen result in adequate oxygenation and ventilation with decreased risks of gastric insufflation.²⁵ It has been shown that lower tidal volumes (450–600mls) can be administered by both males and females (despite different sized hands) by using a single handed technique of squeezing the bag.²⁶ In the absence of added oxygen, higher tidal volumes (10–12ml/Kg) are needed to ensure adequate oxygenation and elimination of carbon dioxide.²⁵ This can be achieved by fully squeezing the self inflating bag against the rescuer's flexed knee placed next to the patient's head.²⁶

Although endotracheal intubation remains the gold standard for protection of the airway, the procedure requires intensive training to perform confidently in the out of hospital situation. It also carries the risk of tube misplacement (oesophageal) or dislodgement which if unrecognised increases the risk of aspiration and greatly decreases the likelihood of successful resuscitation. A number of alternative methods of clearing and maintaining the airway have been investigated.

The Laryngeal Mask Airway (LMA) is well established in anaesthetic practice where it can transform a difficult airway into a manageable airway. Its role in out of hospital situations is still being defined, but based on anaesthetic experience its use can be justified where endotracheal intubation has been unsuccessful and establishment of an airway is essential. Paramedic students in the USA correctly placed an LMA on the first attempt in 94% of cases compared to 69% for endotracheal intubation.²⁷ An LMA does not however protect the airway from the risk of aspiration and inflation pressures greater than 15 to 30cm H₂O are likely to increase the risks of gastric insufflation and aspiration.

The Combitube is a double lumen tube which is an alternative in patients at risk of aspiration as it provides a seal of the upper airway. Though it is inserted blindly, it requires more training than the Laryngeal mask for correct use as it has two cuffs and two lumens. It is ideal in the unconscious patient undergoing CPR or in those with a cervical spine injury but is much less well tolerated than the LMA in a semi-conscious patient with an intact gag reflex.

Tracheostomy or Cricothyroidotomy are only indicated when traditional airway maintenance is rendered impossible by severe trauma or pharyngeal pathology.

Devices to Aid CPR

The use of the 'Active Compression- Decompression' device and the Minimally Invasive Direct Cardiac Massage device, a plunger like instrument designed to deliver internal cardiac massage through a mini thoracotomy, cannot be supported on current evidence.

Phased chest & abdominal compression involves applying abdominal compression during the relaxation phase of external chest compression. The theoretical benefits are an elevated aortic diastolic pressure improving coronary perfusion, and increased venous return to the thorax. Both human and animal studies support this when compared to standard external chest compression. Randomised studies in humans have shown greater rates of return of spontaneous circulation and 24hr survival in groups receiving phased chest and abdominal compression with some evidence of improved survival to discharge. The Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (2000)²⁸ recommend this technique for in hospital resuscitation when trained personnel are available.

Drugs & Advanced Life Support

Amiodarone vs. Lidocaine

Anti-arrhythmics are used in the acute situations in the hope that they will raise the fibrillation threshold and/or decrease the defibrillation threshold. Lidocaine has been used in refractory ventricular fibrillation until recently but with no supportive evidence. The use of Amiodarone for ventricular fibrillation in the out-of-hospital situation was investigated in the ARREST²⁹ and ALIVE³⁰ trials. Both trials found that those patients receiving amiodarone were 10% more likely to survive to hospital admission when compared to placebo and Lignocaine respectively. However there was no improvement in survival to hospital discharge in either study.

Vasopressin vs Adrenaline

Vasopressive agents are given in order to increase peripheral vascular resistance, aortic diastolic pressure and thus coronary perfusion pressure and flow. Coronary perfusion pressure during cardiac arrest has been correlated positively with return of spontaneous circulation and survival.³¹

Adrenaline and Vasopressin are two such drugs used to increase coronary perfusion pressure, though there is little hard evidence of improved long term outcome, particularly with adrenaline. Though the α (vasoconstrictive) effects of adrenaline may be beneficial the β effects (arrhythmogenicity, increased myocardial oxygen consumption) may be detrimental.

Vasopressin is a potent vasoconstrictor particularly in shock states and acts on the vasculature (via V1 receptors), on the kidneys (via V2 receptors), and on the pituitary (via

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V3 receptors). In shock states, the vasoconstriction caused by its vascular (V-1) receptor activity results in blood being diverted away from muscle, bowel and skin to the brain and heart. The European Resuscitation Council's Vasopressor during Cardiopulmonary Resuscitation Study Group recently published the results of a large (1186 patients) multicentre trial comparing adrenaline (1mg) and vasopressin (40IU) in the management of out of hospital cardiac arrest. They found that Vasopressin led to greater return of spontaneous circulation, survival to hospital admission and discharge when used in patients with asystole but there was no difference in efficacy in those with pulseless electrical activity or ventricular fibrillation.³²

The 2000 Guidelines for Cardiopulmonary resuscitation and Emergency Cardiovascular Care³³ recommended that "Vasopressin is an acceptable, safe and useful alternative to Adrenaline for shock refractory VF" though its use in asystole, PEA or in infants and children was deemed 'indeterminate'. However, the European Resuscitation council did not include vasopressin in their 2000 guidelines for adult ALS.³⁴ The results of the recent trial are likely to result in changes to the current guidelines.

Thrombolysis

Until recently, the fear of major bleeding has deemed CPR a relative contraindication to thrombolysis. Though evidence from large randomised controlled studies is still awaited on the efficacy of thrombolysis during CPR, a number of studies have suggested that the risk of bleeding is no higher when thrombolysis is used during CPR than when CPR is performed without thrombolysis. Thrombolytics may also improve cerebral and coronary reperfusion after cardiac arrest by improving microcirculatory blood flow.³⁵

A study by Abu-Laban et al failed to show any beneficial effect of Thrombolysis for pulseless electrical activity.³⁶ Case series however have shown increased survival to hospital discharge when thrombolysis is used during CPR in patients with massive pulmonary embolism.³⁷

Post resuscitation care:

Hypothermia: Following two landmark prospective randomised studies published in the New England Journal of Medicine, the Advanced Life Support Task Force of the International Liaison Committee on Resuscitation recommended in October 2002 that:

"Unconscious adult patients with spontaneous circulation after out of hospital cardiac arrest should be cooled to 32-34 C for 12-24h when the initial rhythm was VF. Such cooling may also be beneficial for patients in other initial rhythms and in-hospital arrest".³⁸

Termination of Resuscitation in Cardiac Arrest

The decision to terminate efforts at resuscitation is dependent on many factors. International, national,

regional and local guidelines may help clinicians, although these may change periodically. Patient and provider factors are of significant importance. Advanced directives etc should be observed and general prognostic factors considered.

Ideally poor prognostic indicators should dictate initiation rather than termination but CPR status is, all too often, not documented.

For those in whom CPR is at least attempted, most providers make termination decisions on perceived prognosis. Review of the literature reveals that objective predictors of in-hospital mortality include advanced age, asystole, and non ICU location.³⁹ Any resuscitative efforts longer than 30 minutes indicate a dismal prognosis except in special circumstances such as hypothermia. Most studies reveal that those longer than 15 to 20 minutes have a significantly increased risk of mortality.⁴⁰⁻⁴⁵ In cases of asystole in which no reversible cause can be found, it is reasonable to stop any resuscitative efforts after 10 minutes.⁴⁶

A Canadian study evaluated resuscitation outcomes in 3888 pre-hospital cardiac arrests. Factors associated with 100% mortality were age greater than 80 years, un-witnessed arrest, defibrillation response interval greater than 8 minutes, non-ventricular tachycardia /ventricular fibrillation rhythm and unsuccessful intubation.⁴⁷ The study revealed low (0.2%) overall survival from asystole and the only modifiable factor associated with improved survival to discharge was a response time shorter than 8 minutes.

The Resuscitation Council (UK) in its 'Provider Manual', 4th Edition, on Advanced Life Support, lists the following points of influence in the decision to terminate resuscitative efforts:

- The environment and access to Emergency medical Services (EMS)
- The interval between the onset of arrest and the application of Basic Life Support (BLS)
- The interval between the BLS and the application of Advanced Life support (ALS)
- Evidence of cardiac death.
- Potential prognosis and underlying disease processes
- Age
- Temperature
- Drugs intake prior to cardiac arrest
- Remedial precipitating factors

Legal issues surrounding resuscitation are now essential considerations. They are now included as an integral part of the ALS Provider Course and details of "The Legal Status of those who Attempt Resuscitation", and "Decisions relating to Cardiopulmonary Resuscitation" have recently been added to appendices of ALS Provider's Manual, 4th edition. If doubt exists, or questions asked about the legality of a resuscitation decision, legal advice should be sought. Depending on the time of the day and also urgency of the situation it could be from a Court of Justice or one of the professional bodies

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or Medical Defence organisations.

Finally, consider the "European Convention on Human Rights Act 1998," implemented in October 2000. In order to meet their obligations under the Act, health professionals must be able to show that their decisions are compatible with the human rights set out in the Articles of the Convention.⁴⁸ Particularly relevant to decisions about attempted CPR are the rights to:

- Life (Article 2).
- Be free from inhuman or degrading treatment (Article 3)
- Respect for privacy and family life (Article 8).
- Freedom of expression, which includes the right to hold opinions and to receive information (Article 10)
- Be free from discriminatory practices in respect of these rights (Article 14).

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National Confidential Enquiry into Patient Outcome and Death (NCEPOD) Emergency Admissions Study

- Advanced notice of a forthcoming investigation

NCEPOD will shortly be reviewing the process of care of adult patients (≥ 16 years) admitted to hospital as emergency admissions. The primary aim of this study is to identify remediable factors in the organisation of the immediate and continuing care of medical and surgical emergency admissions.

Issues to be addressed were determined by a multidisciplinary group of experts, and will include:

- Location and quality of initial assessment.
- The availability of radiology and blood tests at the first consultant review.
- Time to first consultant review.
- Frequency of ward transfers.
- Appropriateness of first location post Assessment Unit.
- Access to pre-existing notes.
- Occurrence of daily clinical assessment.
- Recording of appropriate observations.
- Consultant commitment whilst on take.

Data will be collected on emergency admissions on a pre-determined day in late 2004 or early 2005 from all sites across England, Wales, Northern Ireland, Isle of Man, Guernsey, Defence Secondary Care and the Independent sector. Patients will be selected if one of the following events occurs between day 0 (admission) and day 7; death in

hospital, transfer to critical care, discharge and subsequent death in the community within 7 days of discharge. Data will be collected via two semi-structured questionnaires, which will be sent to the clinicians involved in the management of the patient. Relevant copies of the patients' casenotes will also be requested, from which further information on the patient journey will be extracted by NCEPOD. A multi-disciplinary group of advisors will be invited to review the information and provide expert opinion on the organisation of care of emergency admissions.

This study aims to identify factors that enhance the process of care of patients admitted as emergencies and can be used as examples of good practice, as well as factors that detract from this process. These detrimental factors will be reviewed to determine how they can be amended to improve care. Consequently, this analysis will have a major impact on the delivery of health care to patients admitted as an emergency in the UK.

Further information, including a copy of the protocol, can be obtained from NCEPOD.

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