Introduction
Prevention of cardiac arrest is the first link in the chain of survival. This chapter of the Resuscitation Council (UK) guidelines stresses the importance of preventing cardiac arrest in all age groups, and the decision-making process when cardiopulmonary resuscitation (CPR) is inappropriate. This update is based on the European Resuscitation Council Guidelines 2010, and includes updates based on NICE Clinical Guideline 50, and the Joint Statement from the British Medical Association (BMA), RC(UK), and the Royal College of Nursing (RCN) on decisions relating to CPR. The recent General Medical Council publication, ‘Treatment and care towards the end of life: good practice in decision making’, also includes advice on decisions relating to CPR.

Prevention of out-of-hospital cardiac arrest
Recognising cardiac chest pain
Most sudden cardiac death (SCD) victims have a history of cardiac disease and warning symptoms, most commonly chest pain, in the hour before cardiac arrest. Early recognition of cardiac chest pain and rapid activation of the EMS is vitally important. When a call to the EMS is made before a victim collapses, arrival of the ambulance is significantly sooner after collapse, and the chance of survival is higher.

Prevention of sudden cardiac death out of hospital
Coronary artery disease is the commonest cause of SCD. Non-ischaemic cardiomyopathy and valvular disease account for some other SCD events. A small percentage of SCDs are caused by inherited abnormalities (e.g. long and short QT syndromes, Brugada syndrome, hypertrophic cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy) and by congenital heart disease.

In patients with a known diagnosis of cardiac disease, syncope (with or without prodrome – particularly recent or recurrent) is an independent risk factor for increased risk of death. Apparantly healthy children and young adults who suffer SCD may also have symptoms and signs (e.g. syncope/pre-syncope, chest pain, palpitation, heart murmur) that should alert healthcare professionals to seek expert help to prevent cardiac arrest. Features that indicate a high probability of arrhythmic syncope include:

- syncope in the supine position;
- syncope occurring during or after exercise (although syncope after exercise is often vasovagal);
- syncope with no or only brief prodromal symptoms;
- repeated episodes of unexplained syncope;
- syncope in individuals with a family history of sudden death or inherited cardiac condition.

Assessment in a clinic specialising in the care of those at risk for SCD is recommended in family members of young victims of SCD or those with a known cardiac disorder resulting in an increased risk of SCD. Specific and detailed guidance for the care of individuals with transient loss of consciousness is available from the National Institute for Health and Clinical Excellence (NICE).

Prevention of in-hospital arrest

Rates of survival and complete physiological recovery following in-hospital cardiac arrest are poor in all age groups. For example, fewer than 20% of adult patients having an in-hospital cardiac arrest will survive to go home. Cardiac arrest is rare in both pregnant women and children, but outcomes after in-hospital arrest are also poor. Prevention of in-hospital cardiac arrest requires staff education, monitoring of patients, recognition of patient deterioration, a system to call for help and an effective response.

Adults

Most adult survivors of in-hospital cardiac arrest have a witnessed and monitored ventricular fibrillation (VF) arrest and are defibrillated immediately. The underlying cause of arrest in this group is usually primary myocardial ischaemia. In comparison, cardiac arrest in patients in unmonitored ward areas is usually a predictable event not caused by primary cardiac disease. In this group, cardiac arrest often follows a period of slow and progressive physiological deterioration involving unrecognised or inadequately treated hypoxaemia and hypotension. The underlying cardiac arrest rhythm is usually asystole or PEA, and the chance of survival to hospital discharge is extremely poor.

Regular monitoring and early, effective treatment of seriously ill patients appear to improve clinical outcomes and prevent some cardiac arrests. Closer attention to patients who sustain a ‘false’ cardiac arrest (a cardiac arrest call to a patient who does not require basic or advanced life support) may also improve outcome, as up to one third of these patients die during their hospital stay.

Deficiencies in acute care

Analysis of the critical events preceding many adult cardiac arrests demonstrates many significant antecedents, usually related to abnormalities of the airway, breathing, and circulation. Additional factors include a failure to use a systematic approach to the
assessment of critically ill patients, poor communication, lack of teamwork, and insufficient use of treatment limitation plans.

Hospital processes may also have significant effects on patient outcome. For example, patients who are discharged from intensive care units (ICU) to general wards at night have an increased risk of in-hospital death compared with those discharged during the day and those discharged to high-dependency units. Higher nurse-patient staffing ratios are also associated with reduction in cardiac arrest rates, as well as rates of pneumonia, shock, and death. These suggest that adequate patient monitoring and assessment are crucial to preventing adverse outcomes.

Recognition of ‘at-risk’, or critically ill, adult patients

When patients deteriorate, they display common signs that represent failing respiratory, cardiovascular, and nervous systems. This is the basis for monitoring patients’ vital signs. Abnormal physiology is common on general wards, yet the important physiological observations of sick patients are measured and recorded less frequently than is desirable. To assist in the early detection of critical illness, every patient should have a documented plan for vital signs monitoring that identifies which variables need to be measured and the frequency of measurement.

In recent years, early warning scores (EWS), or ‘calling-criteria’ have been adopted by many hospitals to assist in the early detection of critical illness. EWS systems allocate points to routine vital sign measurements on the basis of their deviation from an arbitrarily agreed ‘normal’ range. The weighted score of one or more vital sign observations, or more often the total EWS, is used to alert ward staff or critical care outreach teams to the deteriorating condition of the patient. Systems that incorporate ‘calling-criteria’ activate a response when one or more routinely measured physiological variables reach an extremely abnormal value.

The sensitivity, specificity, and accuracy of EWS or calling-criteria systems to identify sick patients have been validated for death but not for other outcomes such as hospital length of stay, cardiac arrest, or need for higher care. Several studies have identified abnormalities of heart rate, blood pressure, respiratory rate, and conscious level as possible markers of impending critical events. However, as not all important vital signs are, or can be, recorded continuously in general ward areas, the ability of these systems to predict cardiac arrest remains unconfirmed. Gaps in vital sign data recording are common; the use of EWS, calling-criteria and rapid response systems can increase the completeness of vital sign monitoring.

The clinical response

The medical and nursing response to a patient’s abnormal physiology needs to be both appropriate and speedy, yet this is not always the case. Traditionally, the response to cardiac arrest has been reactive, with a cardiac arrest team attending the patient after the cardiac arrest. The use of such teams appears to improve survival in circumstances where no coordinated cardiac arrest response previously existed. However, their impact
in other settings is questionable. For example, in one study only patients who had return of spontaneous circulation before the cardiac arrest team arrived were alive at hospital discharge.\textsuperscript{72} In some hospitals the role of the cardiac arrest team has been changed to include that of a medical emergency team (MET). This team responds not only to cardiac arrests, but also to patients with acute physiological deterioration. The MET usually comprises medical and nursing staff from intensive care and general medicine and responds to specific calling criteria. MET interventions often involve simple tasks such as starting oxygen therapy and intravenous fluids.

The results of research into the benefits of introducing a MET are variable.\textsuperscript{73} Studies with historical control groups show a reduction in cardiac arrests, deaths and unanticipated intensive care unit admissions, improved detection of medical errors, treatment-limitation decisions, and reduced postoperative ward deaths. A cluster-randomised controlled trial of the MET system demonstrated that the introduction of a MET increased the calling incidence for the team, but did not reduce the incidence of cardiac arrest, unexpected death, or unplanned ICU admission.\textsuperscript{74}

In the UK, a system of pre-emptive ward care, based predominantly on individual or teams of nurses known as critical care outreach, has developed.\textsuperscript{75} Although the data on the effects of outreach care are also inconclusive, it has been suggested that outreach teams may reduce ward deaths, postoperative adverse events, ICU admissions and readmissions, and increase survival.\textsuperscript{76, 77}

**The role of education in cardiac arrest prevention**

The recognition that many cardiac arrests may be preventable has led to the development of postgraduate courses specifically designed to prevent physiological deterioration, critical illness, and cardiac arrest (e.g. Acute Life Threatening Events – Recognition and Treatment: ALERT).\textsuperscript{78} Early evidence suggests that they can improve knowledge and change attitudes about acute care. The Immediate Life Support and Advanced Life Support Courses also include sections related to this important topic and appear to be effective at reducing arrests.\textsuperscript{79} Other courses focus on managing sick patients in the first 24 hours of critical illness when more direct critical care expertise is not available immediately. It is recognised that training in acute and critical care should commence early, and many countries have established curricula for inclusion in undergraduate medical education programmes. Simulation is also being used increasingly to train staff in the prevention of patient deterioration.

**Pregnant patients**

The latest report of the triennial Confidential Enquiry into Maternal and Child Health (CEMACH) makes several recommendations to prevent deaths associated with pregnancy, including the need for hospitals to implement, audit, and regularly update multidisciplinary guidelines for the management of women at risk of, or who develop, complications in pregnancy.\textsuperscript{80} It also recommends that clinical protocols and local referral pathways, including patient transfer, should be developed for pregnant women with pre-existing medical conditions, a history of psychiatric illness, and serious
complications of pregnancy (sepsis, pre-eclampsia and eclampsia, obstetric haemorrhage). Maternity teams should be trained to recognise and manage medical emergencies, and to demonstrate their competency in scenario-based training using simulation. CEMACH has recommended the use of obstetric early warning scoring systems for all obstetric admissions in all clinical settings. Outreach services for maternity have also been described elsewhere.81

Children

In children, cardiopulmonary arrest is more often caused by profound hypoxaemia and hypotension than primary cardiac disease. Ventricular fibrillation is less common than asystole or pulseless electrical activity. As with adults, there may be opportunities to introduce strategies that will prevent arrest.

There is already evidence of marked, often untreated, abnormalities of common vital signs in the 24 hours prior to the admission of children to an ICU, similar to those reported in adults.82 Recognition of the seriously ill child relies on determination of the normal and abnormal age-related values for vital signs, and reassessing them in the context of the progression of the child’s condition. As in adults, serial measurement of heart rate, respiratory rate, temperature, blood pressure, and conscious level, particularly following any clinical intervention, must be performed and acted upon. Intervention at an early stage in an unwell child reduces significantly the risk of developing irreversible shock. Systemic blood pressure decreases at a late stage in shock in the child compared with the adult, and should not be used as the sole determinant of whether or not treatment is required.

Paediatric emergency teams, responding to early warning scores, have been established in some hospitals and appear to reduce the incidence of cardiac arrest.83, 84

Resuscitation decisions

Cardiopulmonary resuscitation was originally developed to save the lives of people dying unexpectedly – ‘hearts too young to die’. In-hospital death now often involves attempted CPR, even when the underlying condition and general health of the patient makes success unlikely. However, even when there is clear evidence that cardiac arrest or death are likely, ward staff rarely make decisions about the patient’s resuscitation status. Improved knowledge, training, and do-not-attempt-resuscitation (DNAR) decision-making should improve patient care and prevent futile CPR attempts. Patients for whom CPR will not prolong life, but may merely prolong the dying process, should be identified early. Medical emergency teams may have an important role in improving end-of-life and DNAR decision-making.85-87

A DNAR decision should be considered when the patient:

- does not wish to have CPR, or
- will not survive cardiac arrest even if CPR is attempted.
The decision-making process should be based on current guidance from the BMA, RC(UK) and RCN. A standardised form should be used to record and communicate DNAR decisions. A DNAR decision (also referred to as DNACPR) refers specifically to CPR and not to other treatment.

**Recommended strategies for the prevention of avoidable in-hospital cardiac arrests**

1. Place critically ill patients, or those at risk of clinical deterioration, in areas where the level of care is matched to the level of patient sickness.
2. Monitor regularly such patients using simple vital sign observations (e.g. pulse, blood pressure, respiratory rate, conscious level, temperature and SpO₂). Match the frequency and type of observations to the severity of illness of the patient.
3. Use an EWS system or ‘calling criteria’ to identify patients who are critically ill, at risk of clinical deterioration or cardiopulmonary arrest, or both.
4. Use a patient vital signs chart that encourages and permits the regular measurement and recording of vital signs and, where used, early warning scores.
5. Ensure that the hospital has a clear policy that requires a timely, appropriate, clinical response to deterioration in the patient’s clinical condition.
6. Introduce into each hospital a clearly identified response to critical illness. This will vary between sites, but may include an outreach service or resuscitation team (e.g., MET) capable of responding to acute clinical crises. This team should be alerted, using an early warning system, and the service must be available 24 hours a day.
7. Ensure that all clinical staff are trained in the recognition, monitoring, and management of the critically ill patient, and that they know their role in the rapid response system.
8. Empower staff to call for help when they identify a patient at risk of deterioration or cardiac arrest. Use a structured communication tool to ensure effective handover of information between staff (e.g. SBAR - Situation-Background-Assessment-Recommendation).
9. Agree a hospital DNAR policy, based on current national guidance, and ensure that all clinical staff understand it. Identify patients who do not wish to receive CPR and those for whom cardiopulmonary arrest is an anticipated terminal event for whom CPR would be inappropriate.
10. Audit all cardiac arrests, ‘false arrests’, unexpected deaths, and unanticipated intensive care unit admissions, using a common dataset. Audit the antecedents and clinical responses to these events. All hospitals should consider joining the National Cardiac Arrest Audit.