below). The occurrence of otherwise unexplained syncope or documented life-threatening arrhythmias in patients with long QT syndromes or right ventricular dysplasia are also associated with increased risk of SCD.

CLINICAL CHARACTERISTICS OF CARDIAC ARREST

PRODROME, ONSET, ARREST, DEATH

SCD may be presaged by days to months of increasing angina, dyspnea, palpitations, easy fatigability, and other nonspecific complaints. However, these *prodromal symptoms* are generally predictive of any major cardiac event; they are not specific for predicting SCD.

The *onset of the clinical transition*, leading to cardiac arrest, is defined as an acute change in cardiovascular status preceding cardiac arrest by up to 1 h. When the onset is instantaneous or abrupt, the probability that the arrest is cardiac in origin is >95%. Continuous electrocardiogram (ECG) recordings fortuitously obtained at the onset of a cardiac arrest commonly demonstrate a tendency for the heart rate to increase and for advanced grades of PVCs to evolve during the minutes or hours before the event.

The probability of achieving successful resuscitation from cardiac arrest is related to the interval from onset of loss of circulation to return of spontaneous circulation (ROSC), the setting in which the event occurs, the mechanism (VF, VT, PEA, asystole), and the clinical status of the patient before the cardiac arrest. ROSC and survival rates as a result of defibrillation decrease almost linearly from the first minute to 10 min. After 4-5 min, survival rates are no better than 25–30% in out-of-hospital settings without bystander cardiopulmonary resuscitation (CPR). Those settings in which it is possible to institute prompt CPR followed by prompt defibrillation provide a better chance of a successful outcome. The outcome in intensive care units and other in-hospital environments is heavily influenced by the patient's preceding clinical status. The immediate outcome is good for cardiac arrest occurring in the intensive care unit in the presence of an acute cardiac event or transient metabolic disturbance, but survival among patients with far-advanced chronic cardiac disease or advanced noncardiac diseases (e.g., renal failure, pneumonia, sepsis, diabetes, cancer) is low and not much better in the in-hospital setting. Survival rates after unexpected cardiac arrest in unmonitored areas in a hospital do not differ from witnessed out-of-hospital arrests. Since implementation of community response systems, survival from out-of-hospital cardiac arrest has improved, although it still remains low, under most circumstances. Survival probabilities in public sites exceed those in the home environment, where the majority of cardiac arrests occur.

The success rate for initial resuscitation and survival to hospital discharge after an out-of-hospital cardiac arrest depends heavily on the mechanism of the event. When the mechanism is pulseless VT, the outcome is best; VF is the next most successful; and asystole and PEA, now the most common mechanisms, generate dismal outcome statistics. Advanced age also adversely influences the chances of successful resuscitation.

The probability of *progression to biologic death* is a function of the mechanism of cardiac arrest and the length of the delay before interventions. VF without CPR within the first 4–6 min has a poor outcome even if defibrillation is successful because of secondary brain damage; the prompt interposition of bystander CPR (basic life support; see below) improves outcome at any point along the time scale, especially when followed by early successful defibrillation. However, there are few survivors among patients who had no life support activities for the first 8 min after onset. Evaluations of deployment of automatic external defibrillators (AEDs) in communities (e.g., police vehicles, large buildings, airports, and stadiums) are beginning to generate encouraging data, but the data for home deployment has been have been less impressive.

Death during the hospitalization after a successfully resuscitated cardiac arrest relates closely to the severity of central nervous system injury. Anoxic encephalopathy and infections subsequent to prolonged respirator dependence account for 60% of the deaths. Another 30% occur as a consequence of low cardiac output states that fail to respond to interventions. Recurrent arrhythmias are the least common cause of death, accounting for only 10% of in-hospital deaths.

In the setting of acute MI (Chap. 295), it is important to distinguish between primary and secondary cardiac arrests. *Primary cardiac arrests* are those that occur in the absence of hemodynamic instability, and *secondary cardiac arrests* are those that occur in patients in whom abnormal hemodynamics dominate the clinical picture before cardiac arrest. The success rate for immediate resuscitation in primary cardiac arrest during acute MI in a monitored setting should exceed 90%. In contrast, as many as 70% of patients with secondary cardiac arrest succumb immediately or during the same hospitalization.

TREATMENT CARDIAC ARREST

An individual who collapses suddenly is managed in five stages: (1) initial evaluation and basic life support if cardiac arrest is confirmed, (2) public access defibrillation (when available), (3) advanced life support, (4) postresuscitation care, and (5) long-term management. The initial response, including confirmation of loss of circulation, followed by basic life support and public access defibrillation, can be carried out by physicians, nurses, paramedical personnel, and trained laypersons.

INITIAL EVALUATION AND BASIC LIFE SUPPORT

Confirmation that a sudden collapse with loss of consciousness (LOC) is due to a cardiac arrest includes prompt observations of the state of consciousness, respiratory movements, skin color, and the presence or absence of pulses in the carotid or femoral arteries. For lay responders, the pulse check is no longer recommended because it is unreliable. As soon as a cardiac arrest is suspected, confirmed, or even considered to be impending, calling an emergency rescue system (e.g., 911) is the immediate priority. With the development of AEDs that are easily used by nonconventional emergency responders, an additional layer for response has evolved (see below).

Careful attention to the respiratory status after abrupt LOC is important. Although normal breathing or tachypnea after LOC makes cardiac arrest less likely, gasping respiratory movements may persist during a true cardiac arrest, and their presence should not deter appropriate responses. In fact, continued gasping is considered a good prognostic sign for successful outcome. It is also important to observe for severe stridor with a persistent pulse as a clue to aspiration of a foreign body or food. If this is suspected, a Heimlich maneuver (see below) may dislodge the obstructing body. A precordial blow, or "thump," delivered firmly with a clenched fist to the junction of the middle and lower thirds of the sternum may occasionally revert VT or VF, but there is concern about converting VT to VF. Therefore, it is recommended to use precordial thumps as a life support technique only when monitoring and defibrillation are available. This conservative application of the technique remains controversial.

The third action during the initial response is to clear the airway. The head is tilted back and the chin lifted so that the oropharynx can be explored to clear the airway. Dentures or foreign bodies are removed, and the Heimlich maneuver is performed if there is reason to suspect that a foreign body is lodged in the oropharynx. If respiratory arrest precipitating cardiac arrest is suspected, a second precordial thump is delivered after the airway is cleared.

Basic life support, more popularly known as CPR, is intended to maintain organ perfusion until definitive interventions can be instituted. The initial and primary element of CPR is maintenance of perfusion until spontaneous circulation can be restored. Closed chest cardiac compression maintains a pump function by sequential filling and emptying of the chambers, with competent valves maintaining forward direction of flow. The palm of one hand is placed over the lower sternum, with the heel of the other resting on the dorsum of the lower hand. The sternum is depressed, with the arms remaining straight, at a rate of 100 per minute. Sufficient force is applied to depress the sternum 4–5 cm, and relaxation is abrupt.