

AARC Clinical Practice Guideline

Resuscitation and Defibrillation in the Health Care Setting— 2004 Revision & Update

RAD 1.0 PROCEDURE:

Recognition of signs suggesting the possibility or the presence of cardiopulmonary arrest, initiation of resuscitation, and therapeutic use of defibrillation in adults.

RAD 2.0 DESCRIPTION/DEFINITION:

Resuscitation in the health care setting for the purpose of this guideline encompasses all care necessary to deal with sudden and often life-threatening events affecting the cardiopulmonary system, and involves the identification, assessment, and treatment of patients in danger of or in frank arrest, including the high-risk delivery patient. This includes (1) alerting the resuscitation team and the managing physician; (2) using adjunctive equipment and special techniques for establishing, maintaining, and monitoring effective ventilation and circulation; (3) monitoring the electrocardiograph and recognizing dysrhythmias; (4) using defibrillators [This includes the use of conventional defibrillators and automated (automatic or semi-automatic) external defibrillators (AEDs).] and mechanical ventilators; (5) administering oxygen and drugs, including instillation of drugs via the endotracheal tube; and (6) stabilizing such patients in the post-arrest period.

RAD 3.0 SETTING:

This guideline applies to a variety of settings including but not limited to hospitals, long-term facilities, outpatient clinics, rehabilitation centers, skilled nursing facilities, and pre- and inter-hospital transport.

RAD 4.0 INDICATIONS:

Cardiac arrest, respiratory arrest, or the presence of conditions that may lead to cardiopulmonary arrest as indicated by rapid deterioration in vital

signs, level of consciousness, and blood gas values—included in those conditions are

- 4.1** Airway obstruction—partial or complete
- 4.2** Acute myocardial infarction with cardiodynamic instability
- 4.3** Life-threatening dysrhythmias
- 4.4** Hypovolemic shock
- 4.5** Severe infections
- 4.6** Spinal cord or head injury
- 4.7** Drug overdose
- 4.8** Pulmonary edema
- 4.9** Anaphylaxis
- 4.10** Pulmonary embolus
- 4.11** Smoke inhalation
- 4.12** Defibrillation is indicated when cardiac arrest results in or is due to ventricular fibrillation.¹⁻⁵
- 4.13** Pulseless ventricular tachycardia

RAD 5.0 CONTRAINDICATIONS:

Resuscitation is contraindicated when

- 5.1** The patient's desire not to be resuscitated has been clearly expressed and documented in the patient's medical record⁶⁻⁹
- 5.2** Resuscitation has been determined to be futile because of the patient's underlying condition or disease⁹⁻¹⁸
- 5.3** Defibrillation is also contraindicated when immediate danger to the rescuers is present due to the environment, patient's location, or patient's condition.

RAD 6.0 PRECAUTIONS/HAZARDS AND/OR COMPLICATIONS:

The following represent possible hazards or complications related to the major facets of resuscitation:

- 6.1** Airway management^{10,11}
 - 6.1.1** Failure to establish a patent airway¹⁹⁻²¹

- 6.1.2** Failure to intubate the trachea^{19,20}
- 6.1.3** Failure to recognize intubation of the esophagus^{19,22,23}
- 6.1.4** Upper airway trauma, laryngeal and esophageal damage²⁴⁻²⁹
 - 6.1.4.1** Vocal cord paralysis²⁸
- 6.1.5** Aspiration^{21,23,24,30}
- 6.1.6** Cervical spine trauma^{24,31,32}
- 6.1.7** Unrecognized bronchial intubation^{19,30,33}
- 6.1.8** Eye injury²¹
- 6.1.9** Facial trauma³⁰
- 6.1.10** Problems with ETT cuff^{21,34-36}
- 6.1.11** Bronchospasm^{19,21,23}
- 6.1.12** Laryngospasm³⁷
- 6.1.13** Dental accidents^{24,30}
- 6.1.14** Dysrhythmias^{37,38}
- 6.1.15** Hypotension and bradycardia due to vagal stimulation³⁷
- 6.1.16** Hypertension and tachycardia^{37,39}
- 6.1.17** Inappropriate tube size^{30,34,40}
- 6.1.18** Bleeding
- 6.1.19** Pneumonia⁴¹
- 6.2** Ventilation
 - 6.2.1** Inadequate oxygen delivery (F_{DO_2})⁴²⁻⁴⁵
 - 6.2.2** Hypo- and/or hyperventilation⁴³⁻⁴⁷
 - 6.2.3** Gastric insufflation and/or rupture^{45,48,49}
 - 6.2.4** Barotrauma^{50,51}
 - 6.2.5** Hypotension due to reduced venous return secondary to high mean intrathoracic pressure^{52,53}
 - 6.2.6** Vomiting and aspiration^{21,54}
 - 6.2.7** Prolonged interruption of ventilation for intubation⁵⁵
- 6.3** Circulation/Compressions
 - 6.3.1** Ineffective chest compression^{56,57}
 - 6.3.2** Fractured ribs and/or sternum^{24,54,58,59}
 - 6.3.3** Laceration of spleen or liver^{24,54,58,60-62}
 - 6.3.4** Failure to restore circulation despite functional rhythm
 - 6.3.4.1** Severe hypovolemia^{63,64}
 - 6.3.4.2** Cardiac tamponade^{58,64}
 - 6.3.4.3** Hemo- or pneumothorax^{63,64}
 - 6.3.4.4** Hypoxia
 - 6.3.4.5** Acidosis
 - 6.3.4.6** Hyperkalemia
 - 6.3.4.7** Massive acute myocardial infarction⁶³
 - 6.3.4.8** Aortic dissection⁶³
 - 6.3.4.9** Cardiac rupture^{59,65}
 - 6.3.4.10** Air embolus, pulmonary embolism^{58,66}
- 6.3.5** Central nervous system impairment⁵⁸
- 6.4** Electrical therapy
 - 6.4.1** AEDs may be hazardous in patients weighing < 25 kg⁶⁷
 - 6.4.2** Failure of defibrillator⁶⁸
 - 6.4.3** Shock to team members⁶⁹
 - 6.4.4** Pulse checking between sequential shocks of AEDs delays rapid identification of persistent ventricular fibrillation, interferes with assessment capabilities of the devices, and increases the possibility of operator error.⁶⁷
 - 6.4.5** The initial 3 shocks should be delivered in sequence, without delay, interruption for CPR, medication administration, or pulse checks for ventricular fibrillation and pulseless ventricular tachycardia.^{2,4,70-72}
 - 6.4.6** Induction of malignant dysrhythmias^{73,74}
 - 6.4.7** Interference with implanted pacemaker function⁷⁵⁻⁷⁷
 - 6.4.8** Fire hazard
 - 6.4.8.1** AEDs may be hazardous in an oxygen-enriched environment.⁷⁸
 - 6.4.8.2** Alcohol should never be used as conducting material for paddles because serious burns can result.⁷⁹
 - 6.4.8.3** Superficial arcing of the current along the chest wall can occur as a consequence of the presence of conductive paste or gel between the paddles.⁸⁰
 - 6.4.8.4** The aluminized backing on some transdermal systems can cause electric arcing during defibrillation, with explosive noises, smoke, visible arcing, patient burns, and impaired transmission of current;⁸¹⁻⁸⁴ therefore, patches should be removed before

fore defibrillation.

6.4.9 Muscle burn^{81,85}

6.4.10 Muscle injury resulting in acute renal failure^{86,87}

6.4.11 If transthoracic impedance is high, a low energy shock (< 100 J) may fail to generate enough current to achieve successful defibrillation.⁸⁸⁻⁹¹

6.4.12 Attention must be paid to factors influencing total and transthoracic impedance.^{67,79,88,90,91}

6.4.12.1 Paddle electrode pressure

6.4.12.2 The use of an appropriate conductive medium that can withstand high current flow

6.4.12.3 Electrode/paddle size—should be 8.5 to 12 cm for adults

6.4.12.4 Electrode placement

6.4.12.5 Time interval between shocks

6.4.12.6 Distance between electrodes (size of the chest)

6.4.12.7 Energy selected

6.4.12.8 Paddle-skin electrode material

6.4.12.9 Number of previous shocks

6.4.12.10 Phase of ventilation

6.4.12.11 Diaphoretic patients should be dried to prevent contact problems with adhesive defibrillation pads and/or electrodes.

6.5 Drug administration

6.5.1 Inappropriate drug or dose

6.5.2 Idiosyncratic or allergic response to drug

6.5.3 Endotracheal-tube drug-delivery failure⁹¹⁻⁹⁴—The endotracheal tube dose should be 2 to 2.5 times the normal I.V. dose, diluted in 10 mL of normal saline (or distilled water).

RAD 7.0 LIMITATIONS OF PROCEDURE:

7.1 Despite adequate efforts, resuscitation may fail because of the patient's underlying disease. Institution of resuscitation may be limited by patient or surrogate/guardian request.⁶⁻⁹

7.2 Additional limitations to defibrillation

7.2.1 Response is poor in subjects with

extremely low core temperatures, and shocks should be limited to 3 until temperature has risen above 86°F (30°C).⁹¹ Warming may improve success.⁹¹

7.2.2 Subjects whose cardiac arrest occurs as a direct result of trauma may not respond to defibrillation.⁹¹

7.2.3 The patient must not move or be moved while analysis is occurring when the automated or semi-automated defibrillator is used. (Compressions must be stopped, and the patient should not be moving.)

RAD 8.0 ASSESSMENT OF NEED:

8.1 Assessment of patient condition

8.1.1 Pre-arrest—Identification of patients in danger of imminent arrest and in whom consequent early intervention may prevent arrest and improve outcome. These are patients with conditions that may lead to cardiopulmonary arrest as indicated by rapid deterioration in vital signs, level of consciousness, and blood gas values (see Section 4.00).

8.1.2 Arrest—absence of spontaneous breathing and/or circulation

8.1.3 Post-arrest—Once a patient has sustained an arrest, the likelihood of additional life-threatening problems is high, and continued vigilance and aggressive action using this Guideline are indicated. Control of the airway and cardiac monitoring must be continued and optimal oxygenation and ventilation assured.

8.1.3.1 After arrival of defibrillator: The patient should be evaluated immediately for the presence of ventricular fibrillation or ventricular tachycardia by the operator (conventional) or the defibrillator (automated or semi-automated). Inappropriate defibrillation can cause harm.

RAD 9.0 ASSESSMENT OF PROCESS AND OUTCOME:

9.1 Timely, high-quality resuscitation im-

proves patient outcome in terms of survival and level of function. Despite optimal resuscitation performance, outcomes are affected by patient-specific factors. Patient condition post-arrest should be evaluated from this perspective.

9.2 Documentation and evaluation of the resuscitation process (eg, system activation, team member performance, functioning of equipment, and adherence to guidelines and algorithms) should occur continuously and improvements be made^{91,95-99}

9.3 Equipment management issues. Use of standard checklists can improve defibrillator dependability.¹⁰⁰

9.4 Defibrillation process issues

9.4.1 System access¹⁰¹

9.4.2 Response time^{91,102,103}

9.4.3 First-responder actions^{91,102-104}

9.4.4 Adherence to established algorithms¹⁰⁵

9.4.5 Patient selection and outcome

9.4.6 First responder authorization to defibrillate^{91,103,106}

RAD 10.0 RESOURCES:

10.1 Emergency response system—A designated resuscitation team should be continuously available (24 hours/day, 7 days/week) to respond to emergencies.⁹⁹ Specialty resuscitation teams trained to meet the needs of different hospital populations are desirable (eg, trauma, stroke). Team members should be notified simultaneously. All hospital workers must know how to activate the hospital's emergency response system.

10.2 Equipment should be rapidly available and functional. Durability, portability, reliability, and cost should be considered.

10.2.1 Ventilation devices

10.2.1.1 Mouth-to-mask devices must

10.2.1.1.1 Provide a way to increase F_{DO_2} ^{91,103,107-114}

10.2.1.1.2 Separate inhaled and exhaled gas^{91,103,107-114}

10.2.1.1.3 Incorporate an effective filter (one-way valve or bacteria filter)¹⁰⁷⁻¹¹⁴

10.2.1.1.4 Be transparent¹⁰⁷⁻¹¹⁴

10.2.1.1.5 Easily achieve an airtight seal¹⁰⁷⁻¹¹⁴

10.2.1.1.6 Have extension tube to facilitate visual monitoring and ventilation¹⁰⁷⁻¹¹⁴

10.2.1.1.7 Have dead space as low as practical¹⁰⁷⁻¹¹⁴

10.2.1.2 Manual resuscitators must

10.2.1.2.1 Be capable of providing an F_{DO_2} of 1.0 even when large volumes are delivered^{42,91,115-118}

10.2.1.2.2 Have no pressure-relief valve for adults⁹¹

10.2.1.2.3 Have a bag volume of approximately 1,600 mL for adults^{91,103}

10.2.1.2.4 Have minimal forward and back leak^{42,118}

10.2.1.2.5 Have standard 15- and 22-mm fitting^{91,118,119}

10.2.1.2.6 Be impossible to misassemble

10.2.1.2.7 Be easily sterilized or for single-patient use

10.2.1.2.8 Provide for measurement of exhaled tidal volume^{95,96}

10.2.1.2.9 Provide some indication that supplemental oxygen is being supplied (easily ascertained with bag reservoir but difficult with tube-type reservoir)

10.2.1.2.10 Be capable of being restored to proper function after being disabled with vomitus^{42,120,121}

10.2.1.2.11 Be able to be restored to proper function after being dropped from a height of 1 meter onto concrete floor

10.2.1.2.12 Be designed so that pressure generated at the patient connection port is < 5 cm H_2O during exhalation (at a flow of 5 L/min for patients weighing < 10 kg and 50 L/min for all others)^{122,123}

10.2.1.2.13 Be designed so that pressure generated at the patient

connection port does not exceed -5 cm H₂O during inspiration (at a flow of 5 L/min for patients weighing < 10 kg and 50 L/min for all others)^{122,123}

10.2.1.2.14 Be capable of providing a high F_{DO₂} during spontaneous breathing with low inspiratory and expiratory resistance (see above)^{122,123}

10.2.1.3 Face-mask design should allow a tight seal, provide minimal internal dead space, and have a clear mask body. A variety of sizes should be available.^{108-110,124}

10.2.1.4 Non-self-inflating bags vary in size from 500-2,000 mL, are inflated by a controlled gas source, have variable flow outlets, and conform to the same standards listed in 10.2.1.2 (where appropriate).

10.2.1.5 Gas-powered resuscitators (manually triggered, commonly called demand valves) are not recommended.^{42,116,125-130}

10.2.1.6 Transport ventilators are recommended for resuscitation if they provide control over tidal volume, inspiratory time, and inspiratory flow, and deliver F_{DO₂} of 1.0.^{131,132}

10.2.1.7 The continued use of the mechanical ventilator is indicated when a patient already being mechanically ventilated is resuscitated if the ventilator provides control over tidal volume, inspiratory time, and flow; can be manually triggered; and delivers an F_{DO₂} of 1.0.

10.2.2 Circulation devices

10.2.2.1 Manually operated mechanical chest compressors are appropriate for adults and may be advantageous during transport.^{91,133-135} They must be capable of providing an adjustable stroke of 1.5 to 2 in (3.9 to 5.0 cm), deliver the compression for 50% of the compression-relaxation cycle, and should be placed in use

with only brief interruption of manual CPR. The compressor head should be designed to limit shift in position and stroke adjustment and should have a locking mechanism. The device must be portable, stored easily, and assembled quickly.

10.2.2.2 Automatic mechanical chest compressors are appropriate for adults and should have the capabilities of the manual devices plus the advantage of delivering optimal rate and depth of compression by eliminating the variables of operator technique and fatigue. The device should allow electrocardiogram (ECG) recording, and defibrillation should not require that the device be stopped or removed.⁹¹ It is not recommended that these devices be used for ventilation unless a cuffed endotracheal tube is in place.

10.2.3 Airway management devices

10.2.3.1 Oropharyngeal airways should be available in a variety of sizes for adults. Design should incorporate a flange, a short bite-block segment, and a curved body containing a channel for air movement and suctioning.

10.2.3.2 Nasopharyngeal airways should be available in a variety of sizes for adults. They consist of a soft rubber or plastic tube with a beveled tip and a flange that preferably is adjustable.

10.2.3.3 Endotracheal tubes should be available in a variety of sizes for adults. Tubes should meet ASTM standards.¹³⁶

10.2.3.4 Intubation devices facilitate intubation and access to the difficult airway. Such devices may include laryngoscope and blades (straight & curved), wire guide/stylet, forceps, fiberoptic laryngoscope or bronchoscope, "light wand," or tube changing stent.

10.2.3.5 Tube stabilization should be

reliable and effective and allow for atraumatic extubation and reintubation when necessary.

10.2.3.6 Suctioning devices should be capable of subatmospheric pressure levels of > -120 cm H₂O for pharyngeal suctioning and between -80 and -120 cm H₂O for tracheo-bronchial suctioning in adults.⁹¹ A portable system should be available for transport. A variety of rigid pharyngeal tips and a variety of sizes of sterile tracheal catheters should be available. The tracheal suction catheter selected should have an outside diameter of $< 1/2$ the inside diameter of the endotracheal (or tracheostomy) tube and have a means of manual control (thumb port).

10.2.4 Electrical therapy devices

10.2.4.1 Defibrillators

10.2.4.1.1 Monophasic or biphasic defibrillator waveforms

10.2.4.1.1.1 With monophasic devices the current is delivered in one direction. The recommended first energy shock is 200 J, the second is 200 or 300 J, and the third is 360 J. This escalating energy level is used to find the lowest level that terminates ventricular fibrillation while minimizing injury from the shock.⁶⁷

10.2.4.1.1.2 With biphasic devices the current is delivered in 2 phases. In one phase it is delivered in a positive direction, and in the second it is delivered in the negative direction. Low energy (≤ 200 J) from biphasic devices can terminate ventricular fibrillation safely with as much or more efficacy compared to escalating energy from monophasic devices.⁶⁷

10.2.4.1.1.3 Since randomized prospective studies comparing these devices are lacking, the

committee cannot recommend one type of defibrillator over the other.

10.2.4.1.2 Manual defibrillators depend upon operator for analysis of rhythm, charging, proper application of paddles to patient's thorax, and delivery of countershock; use of self-adhesive pads may increase efficacy and speed of countershock.^{137,138} Using self-adhesive pads will also prevent the application of the wrong contact gel during defibrillation.

10.2.4.1.3 Semiautomatic/automatic defibrillators utilize large, self-adhesive pads to optimize electrical contact with the patient's thorax and allow delivery of countershock more rapidly than manual defibrillators.^{68,138} Automatic defibrillators, when attached to patient, analyze rhythm and deliver countershock when appropriate without intervention by operator; semiautomatic defibrillators require pressing a button to initiate rhythm analysis and advise operator when delivery of countershock (by pressing a button) is appropriate.¹³⁹⁻¹⁴²

10.2.4.1.4 External pacemakers allow noninvasive cardiac pacing via large, self-adhesive pads, in cases of bradycardia with a pulse or high-grade block when a conducted beat results in a pulse.¹⁴²⁻¹⁴⁵

10.2.5 Monitoring devices

10.2.5.1 ECG monitors—Continuous electrocardiographic monitoring is essential for detection of dysrhythmias and for directing therapy.

10.2.5.2 CO₂ monitors—CO₂ detectors are useful for identification of correct endotracheal tube placement and for monitoring of cardiac function during resuscitation.¹⁴⁶⁻¹⁵⁰

10.2.5.3 Ventilation monitors—Be-

cause artificial ventilation, either manual or mechanical, is often inconsistent during resuscitation, monitoring of exhaled volume is recommended.^{95,96}

10.2.5.4 Pulse oximeters—Pulse oximeters, if used in the pre- and post-arrest situation, may provide useful information regarding oxygenation and cardiovascular performance. Those that display pulse waveform are preferred.

10.2.5.5 Invasive hemodynamic monitoring devices—Continuous monitoring of intravascular waveforms and pressures provides useful information for diagnosis and treatment of cardiovascular compromise.

10.2.5.6 Airway pressure monitoring is useful in adults.

10.3 Personnel: A high percentage of patients in nontraumatic cardiac arrest are in ventricular fibrillation within the first few minutes after their collapse. As time after arrest increases, the likelihood of a successful outcome decreases rapidly.^{91,106,151} Early defibrillation as a standard has been expanded to include the use of AEDs by first responders trained in basic life support (BLS), for both prehospital and in-hospital cardiac arrest due to ventricular fibrillation. All health care providers must recognize the need for and know how to activate the facility's emergency response system. They should be trained, evaluated at frequent intervals by monitoring performance, and retrained as necessary in the skills of BLS. Health care providers who are primary members of resuscitation teams in acute care hospitals should be skilled in emergency cardiac care (ECC) and advanced cardiac life support (ACLS).¹⁵²⁻¹⁵⁶

10.3.1 Level I¹⁵²⁻¹⁵⁶

10.3.1.1 Training—all Level I personnel should be trained, evaluated by performance, and retrained as necessary in BLS and the use of AED at frequent intervals that do not exceed 2 years. Retraining should

focus on identified deficiencies.

10.3.1.2 Responsibilities—Level I: All health care providers who have direct patient care responsibilities and may be the first responder to patients in cardiac arrest are considered Level I caregivers. No special professional credential is necessary to qualify as Level I, by this definition. Designated first responders must be able to recognize that the patient is unresponsive, apneic, and pulseless. They should be able to attach automated defibrillator electrodes, operate AEDs, and complete an AED checklist at least every shift.¹⁵⁷ Level I personnel also assist the primary (Level II) members of the resuscitation team. They should be capable of assisting Level II personnel by (1) assessing patients for respiratory and/or cardiac arrest, (2) activating the resuscitation team, (3) administering BLS, (4) providing mouth-to-mask ventilation, (5) attaching ECG and automatic defibrillator electrodes, (6) assisting with tracheal intubation, (7) defibrillating with automatic electronic defibrillators, (8) attaching pulse oximeter and capnograph, (9) preparing a written record of resuscitation effort, (10) moving resuscitation equipment to the scene, and (11) collecting arterial blood for analysis.

10.3.1.3 Credentials—Level I health care providers should have a current BLS health care provider course completion card from the American Heart Association. Hospital personnel should at a minimum be capable of assessing the patient for respiratory and/or cardiac arrest, activating the resuscitation team, and administering BLS until the team arrives.

10.3.2 Level II¹⁵²

10.3.2.1 Training—Level II personnel should be trained, evaluated by performance, and retrained as neces-

sary in ECC and ACLS as appropriate at intervals that should not exceed 2 years. Retraining should focus on identified deficiencies.

10.3.2.2 Responsibilities—Level II health professionals should be capable of serving as primary members of the resuscitation team and as team leader when they are the best qualified respondent. They may respond not only to resuscitation calls in their work areas but also to other areas of the hospital. They are skilled in the use of all adjunctive equipment and special techniques for ECC/ACLS (eg, establishing, maintaining, and monitoring effective ventilation and circulation). They have the skills of Level I personnel and the following capabilities: (1) advanced ECG monitoring and dysrhythmia recognition, (2) tracheal intubation, (3) capability to deliver shocks with automated and conventional external defibrillators, (4) use of continuous and transport mechanical ventilators, (5) use of manual or automatic external chest compressors, (6) preparation and administration of cardiac drugs, (7) stabilization of patients in the post-arrest period, (8) provision of access for rapid administration of intravenous fluids, (9) managing ventilation via transtracheal catheter and cricothyrotomy, (10) emergency treatment of tension pneumo- or hemothorax with large bore needle, (11) interpretation of hemodynamic data (12) preparing patients for emergency transport, and (13) evaluating oxygenation, ventilation and acid-base balance from blood gas reports.

10.3.2.3 Credentials—Level II health professionals should have a current BLS and ACLS certification from the American Heart Association.

RAD 11.0 MONITORING:

11.1 Patient

11.1.1 Clinical assessment—continuous observation of the patient and repeated clinical assessment by a trained observer provide optimal monitoring of the resuscitation process. Special consideration should be given to the following:

11.1.1.1 Level of consciousness

11.1.1.2 Adequacy of airway

11.1.1.3 Adequacy of ventilation

11.1.1.4 Peripheral/apical pulse and character

11.1.1.5 Evidence of chest and head trauma

11.1.1.6 Pulmonary compliance and airway resistance

11.1.1.7 Presence of seizure activity

11.1.2 Assessment of physiologic parameters—Repeat assessment of physiologic data by trained professionals supplements clinical assessment in managing patients throughout the resuscitation process. Monitoring devices should be available, accessible, functional, and periodically evaluated for function. These data include but are not limited to⁹⁵

11.1.2.1 Arterial blood gas studies (although investigators have suggested that such values may have a limited role in decision-making during CPR¹⁵⁸

11.1.2.2 Hemodynamic data^{152,158-160}

11.1.2.3 Cardiac rhythm^{153,154}

11.1.2.4 Ventilatory frequency, tidal volume, and airway pressure^{95,96}

11.1.2.5 Exhaled CO₂¹⁴⁶⁻¹⁵⁰

11.1.2.6 Neurologic status

11.2 Resuscitation process—properly performed resuscitation should improve patient outcome. Continuous monitoring of the process will identify areas needing improvement. Among these areas are response time, equipment function, equipment availability, team member performance, team performance, complication rate, and patient survival and functional status.

11.3 Equipment—All maintenance should be

documented and records preserved. Included in documentation should be routine checks of energy output, condition of batteries, proper functioning of monitor and recorder, and presence of disposables needed for function of defibrillator, including electrodes and defibrillation pads. Defibrillators should be checked and documented each shift for presence, condition, and function of cables and paddles; presence of defibrillating and monitoring electrodes, paper, and spare batteries (as applicable); and charging, message/light indicators, monitors, and ECG recorder (as applicable).⁹¹ AEDs should be checked and documented each day for function and appropriate maintenance.⁶⁷

11.4 Training—Records should be kept of initial training and continuing education of all personnel who perform defibrillation as part of their professional activities.

RAD 12.0 FREQUENCY/AVAILABILITY/DURATION:

12.1 Because the need for resuscitation occurs unpredictably, resources need to be available to respond to one or more locations simultaneously 24 hours a day, 7 days a week. BLS response should be immediate, and ACLS should be available as soon as feasible based upon the resources of the institution. Resuscitation continues until vital signs are restored. If vital signs are not restored, resuscitation efforts should continue until a physician decides further efforts are futile.

12.2 Personnel who respond to cardiac arrests should be trained to operate, equipped with, and permitted to operate a defibrillator.⁶⁷ No other therapeutic intervention, including setting up oxygen delivery systems, suction equipment, advanced airway procedures, intravenous lines, or mechanical CPR devices, should take precedence over or be routinely performed when a defibrillator is available and defibrillation is indicated.⁶⁷

RAD 13.0 INFECTION CONTROL:

13.1 Implement Standard Precautions,¹⁶¹ including mouth-to-barrier devices.

13.2 Observe all infection control guidelines posted for patient.

13.3 Disinfect all equipment to be reused on other patients.

Revised by David Vines MHS RRT, University of Texas Health Science Center, San Antonio, Texas, and approved by the 2003 CPG Steering Committee

This Clinical Practice Guideline combines 2 earlier guidelines, Defibrillation During Resuscitation [Respir Care 1995;40(7):744-748] and Resuscitation in Acute Care Hospitals [Respir Care 1993;38(11):1179-1188]

REFERENCES

1. Atkins DL, Bossaert LL, Hazinski MF, Kerber RE, Mancini MB, Ornato JP, et al. Automated external defibrillation/public access defibrillation. *Ann Emerg Med* 2001;37(4 Suppl):S60-S67.
2. Kern KB, Halperin HR, Field J. New guidelines for cardiopulmonary resuscitation and emergency cardiac care: changes in the management of cardiac arrest. *JAMA* 2001;285(10):1267-1269.
3. Auble TE, Menegazzi JJ, Paris PM. Effect of out-of-hospital defibrillation by basic life support providers on cardiac arrest mortality: a metaanalysis. *Ann Emerg Med* 1995;25(5):642-648.
4. Stults KR, Brown DD, Schug VL, Bean JA. Pre-hospital defibrillation performed by emergency medical technicians in rural communities. *N Engl J Med* 1984;310(4):219-223.
5. Hargarten KM, Stueven HA, Waite EM, Olson DW, Mateer JR, Aufderheide TP, Darin JC. Pre-hospital experience with defibrillation of coarse ventricular fibrillation: a ten-year review. *Ann Emerg Med* 1990;19(2):157-162.
6. Sachs GA, Miles SH, Levin RA. Limiting resuscitation: emerging policy in the emergency medical system. *Ann Intern Med* 1991;114(2):151-154.
7. Torian LV, Davidson EJ, Fillit HM, Fulop G, Sell LL. Decisions for and against resuscitation in an acute geriatric medicine unit serving the frail elderly. *Arch Intern Med* 1992;152(3):561-565. Erratum in: *Arch Intern Med* 1992;152(8):1659.
8. Stern SG, Orłowski JP. DNR or CPR—the choice is ours. *Crit Care Med* 1992;20(9):1263-1272.
9. Abramson N, de Vos R, Fallat ME, Finucane T, Kettler D, Pepe P, et al; American Heart Association; International Liaison Committee on Resuscitation. Ethics in emergency cardiac care. *Ann Emerg Med* 2001;37(4 Suppl):S196-S200.

10. Bilsky GS, Banja JD. Outcomes following cardiopulmonary resuscitation in an acute rehabilitation hospital: clinical and ethical implications. *Am J Phys Med Rehabil* 1992;71(4):232-235.
11. Longstreth WT Jr, Cobb LA, Fahrenbruch CE, Copass MK. Does age affect outcomes of out-of-hospital cardiopulmonary resuscitation? *JAMA* 1990;264(16):2109-2110.
12. Murphy DJ, Matchar DB. Life-sustaining therapy: a model for appropriate use. *JAMA* 1990;264(16):2103-2108.
13. Tresch DD. CPR in the elderly: when should it be performed? *Geriatrics* 1991;46(12):47-50,54-56.
14. Tomlinson T, Brody H. Futility and the ethics of resuscitation. *JAMA* 1990;264(10):1276-1280.
15. Nelson LJ, Nelson RM. Ethics and the provision of futile, harmful, or burdensome treatment to children. *Crit Care Med* 1992;20(3):427-433.
16. Council on Ethical and Judicial Affairs, American Medical Association. Guidelines for the appropriate use of do-not-resuscitate orders. *JAMA* 1991;265(14):1868-1871.
17. Marik PE, Craft M. An outcomes analysis of in-hospital cardiopulmonary resuscitation: the futility rationale for do not resuscitate orders. *J Crit Care* 1997;12(3):142-146.
18. Hopson LR, Hirsh E, Delgado J, Domeier RM, McSwain NE, Krohmer J. Guidelines for withholding or termination of resuscitation in pre-hospital traumatic cardiopulmonary arrest: joint position statement of the National Association of EMS Physicians and the American College of Surgeons Committee on Trauma. *J Am Coll Surg* 2003;196(1):106-112.
19. Caplan RA, Posner KL, Ward RJ, Cheney FW. Adverse respiratory events in anesthesia: a closed claims analysis. *Anesthesiology* 1990;72(5):828-833.
20. Schwartz DE, Matthay MA, Cohen NH. Death and other complications of emergency airway management in critically ill adults: a prospective investigation of 297 tracheal intubations. *Anesthesiology* 1995;82(2):367-376.
21. Cheney FW, Posner KL, Caplan RA. Adverse respiratory events infrequently leading to malpractice suits: a closed claims analysis. *Anesthesiology* 1991;75(6):932-939.
22. Holland R, Webb RK, Runciman WB. The Australian Incident Monitoring Study. Oesophageal intubation: an analysis of 2000 incident reports. *Anaesth Intensive Care* 1993;21(5):608-610.
23. Williamson JA, Webb RK, Cockings J, Morgan C. The Australian Incident Monitoring Study. The capnograph: applications and limitations-an analysis of 2000 incident reports. *Anaesth Intensive Care* 1993;21(5):551-557.
24. Krischer JP, Fine EG, Davis JH, Nagel EL. Complications of cardiac resuscitation. *Chest* 1987;92(2):287-291.
25. Chen EH, Logman ZM, Glass PSA, Bilfinger TV. A case of tracheal injury after emergent endotracheal intubation: a review of the literature and causalities. *Anesth Analg* 2001;93(5):1270-1271.
26. Jaeger K, Ruschulte H, Osthaus A, Scheinichen D, Heine J. Tracheal injury as a sequence of multiple attempts of endotracheal intubation in the course of a preclinical cardiopulmonary resuscitation. *Resuscitation* 2000;43(2):147-150.
27. Hofmann HS, Rettig G, Radke J, Neef H, Silber RE. Iatrogenic ruptures of the tracheobronchial tree. *Eur J Cardiothorac Surg* 2002; 21(4):649-652.
28. Christopher K, Arbelaez C, Yodice PC. Bilateral vocal cord dysfunction complicating short-term intubation and the utility of heliox. *Respiration* 2002; 69(4):366-368.
29. Naghibi K, Jalal HS. Esophageal perforation after tracheal intubation, spontaneous or iatrogenic?—a case report. *Acta Anaesthesiol Sin* 2003; 41(1):33-35.
30. Stauffer JL, Olson DE, Petty TL. Complications and consequences of endotracheal intubation and tracheotomy: a prospective study of 150 critically ill adult patients. *Am J Med* 1981;70(1):65-76.
31. Hastings RH, Marks JD. Airway management for trauma patients with potential cervical spine injuries. *Anesth Analg* 1991;73(4):471-482.
32. Rhee KJ, Green W, Holcroft JW, Mangili JAA. Oral intubation in the multiply injured patient: the risk of exacerbating spinal cord damage. *Ann Emerg Med* 1990;19(5):511-514.
33. Owen RL, Cheney FW. Endobronchial intubation: a preventable complication. *Anesthesiology* 1987;67(2):255-257.
34. Szekely SM, Webb RK, Williamson JA, Russell WJ. The Australian Incident Monitoring Study. Problems related to the endotracheal tube: an analysis of 2000 incident reports. *Anaesth Intensive Care* 1993;21(5):611-616.
35. Heusner JE, Viscomi CM. Endotracheal tube cuff failure due to valve damage (letter). *Anesth Analg* 1991;72(2):270.
36. Siobal M, Kallet RH, Kraemer R, Jonson E, Lemons D, Young D, et al. Tracheal-innominate artery fistula caused by the endotracheal tube tip: case report and investigation of a fatal complication of prolonged intubation. *Respir Care* 2001;46(10):1012-1018.
37. Blanc VF, Tremblay NAG. The complications of tracheal intubation: a new classification with a review of the literature. *Anesth Analg* 1974;53(2):202-213.
38. MacKenzie RA, Gould AB Jr, Bardsley WT.

- Cardiac arrhythmias with endotracheal intubation (abstract). *Anesthesiology* 1980;53:S102.
39. Kaplan JD, Schuster DP. Physiologic consequences of tracheal intubation. *Clin Chest Med* 1991;12(3):425-432.
 40. Stone DJ, Bogdonoff DL. Airway considerations in the management of patients requiring long-term endotracheal intubation. *Anesth Analg* 1992;74(2):276-287.
 41. Rello J, Valles J, Jubert P, Ferrer A, Domingo C, Mariscal D, et al. Lower respiratory tract infections following cardiac arrest and cardiopulmonary resuscitation. *Clin Infect Dis* 1995;21(2):310-314.
 42. Campbell TP, Stewart RD, Kaplan RM, DeMichiei RV, Morton R. Oxygen enrichment of bag-valve-mask units during positive-pressure ventilation: a comparison of various techniques. *Ann Emerg Med* 1988;17(3):232-235.
 43. Johannigman JA, Branson RD. Oxygen enrichment of expired gas for mouth-to-mask resuscitation. *Respir Care* 1991;36(5):99-103.
 44. Stallinger A, Wenzel V, Oroszy S, Mayr VD, Idris AH, Lindner KH, Hormann C. The effects of different mouth-to-mouth ventilation tidal volumes on gas exchange during simulated rescue breathing. *Anesth Analg* 2001;93(5):1265-1269.
 45. Wenzel V, Idris AH, Dorges V, Nolan JP, Parr MJ, Gabrielli A, et al. The respiratory system during resuscitation: a review of the history, risk of infection during assisted ventilation, respiratory mechanics, and ventilation strategies for patients with an unprotected airway. *Resuscitation* 2001;49(2):123-134.
 46. Hess D, Goff G, Johnson K. The effect of hand size, resuscitator brand, and use of two hands on volumes delivered during adult bag-valve ventilation. *Respir Care* 1989;34(9):805-810.
 47. Fluck RR Jr, Sorbello JG. Comparison of tidal volumes, minute ventilation, and respiratory frequencies delivered by paramedic and respiratory care students with pocket mask versus demand valve. *Respir Care* 1991;36(10):1105-1112.
 48. Strear CM, Jarnagin WR, Schecter W, Mackersie RC, Hickey MS. Gastric rupture and tension pneumoperitoneum complicating cardiopulmonary resuscitation: case report. *J Trauma* 1998;44(5):930-932.
 49. Offerman SR, Holmes JF, Wisner DH. Gastric rupture and massive pneumoperitoneum after bystander cardiopulmonary resuscitation. *J Emerg Med* 2001;21(2):137-139.
 50. Hillman K, Albin M. Pulmonary barotrauma during cardiopulmonary resuscitation. *Crit Care Med* 1986;14(7):606-609.
 51. Burdett-Smith P, Jaffey L. Tension pneumoperitoneum. *J Accid Emerg Med* 1996;13(3):220-221.
 52. Cournand A, Motley HL, Werko L, Richards DW. Physiological studies of the effects of intermittent positive pressure breathing on cardiac output in man. *Am J Physiol* 1948;15:162-174.
 53. Venus B, Jacobs HK, Mathru M. Hemodynamic responses to different modes of mechanical ventilation in dogs with normal and acid aspirated lungs. *Crit Care Med* 1980;8(11):620-627.
 54. Nagel EL, Fine EG, Krischer JP, Davis JH. Complications of CPR. *Crit Care Med* 1981;9(5):424.
 55. Hee MK, Plevak DJ, Peters SG. Intubation of critically ill patients. *Mayo Clin Proc* 1992;67(6):569-576.
 56. Maier GW, Tyson GS Jr, Olsen CO, Kernstein KH, Davis JW, Conn EH, et al. The physiology of external cardiac massage: high-impulse cardiopulmonary resuscitation. *Circulation* 1984;70(1):86-101.
 57. Taylor GJ, Tucker WM, Greene HL, Rudikoff MT, Weisfeldt ML. Importance of prolonged compression during cardiopulmonary resuscitation in man. *N Engl J Med* 1977;296(26):1515-1517.
 58. Schneider AP 2nd, Nelson DJ, Brown DD. In-hospital cardiopulmonary resuscitation: a meta-analysis. *ACP J Club* 1994;120:21.
 59. Machii M, Inaba H, Nakae H, Suzuki I, Tanaka H. Cardiac rupture by penetration of fractured sternum: a rare complication of cardiopulmonary resuscitation. *Resuscitation* 2000;43(2):151-153.
 60. Pezzi A, Pasetti G, Lombardi F, Fiorentini C, Iapichino G. Liver rupture after cardiopulmonary resuscitation (CPR) and thrombolysis (letter). *Intensive Care Med* 1999;25(9):1032.
 61. Stallard N, Findlay G, Smithies M. Splenic rupture following cardiopulmonary resuscitation. *Resuscitation* 1997;35(2):171-173.
 62. Fitchet A, Neal R, Bannister P. Splenic trauma complicating cardiopulmonary resuscitation. *BMJ* 2001;322(7284):480-481.
 63. Vanags B, Thakur RK, Stueven HA, Aufderheide T, Tresch DD. Interventions in the therapy of electromechanical dissociation. *Resuscitation* 1989;17(2):163-171.
 64. Pirolo JS, Hutchins GM, Moore GW. Electromechanical dissociation: pathologic explanations in 50 patients. *Hum Pathol* 1985;16(5):485-487.
 65. Fosse E, Lindberg H. Left ventricular rupture following external chest compression. *Acta Anaesthesiol Scand* 1996;40(4):502-504.
 66. Hashimoto Y, Yamaki T, Sakakibara T, Matsui J, Matsui M. Cerebral air embolism caused by cardiopulmonary resuscitation after cardiopulmonary arrest on arrival. *J Trauma* 2000;48(5):975-977.
 67. Stapleton ER, Aufderheide TP, Hazinski MF, Cummins RO, editors. *Textbook of basic life*

- support for healthcare providers. Dallas: American Heart Association; 2001.
68. Cummins RO, Chesemore K, White RD. Defibrillator failures: causes of problems and recommendations for improvement. Defibrillator Working Group. *JAMA* 1990;264(8):1019-1025.
 69. Gibbs W, Eisenberg M, Damon SK. Dangers of defibrillation: injuries to emergency personnel during patient resuscitation. *Am J Emerg Med* 1990;8(2):101-104.
 70. Martin RG, Hawkins NS, Weigel JA, Rider DE, Buckingham BD. Initial treatment of ventricular fibrillation: defibrillation or drug therapy. *Am J Emerg Med* 1988;6(2):113-119.
 71. Weaver WD, Fahrenbruch CE, Johnson DD, Hallstrom AP, Cobb LA, Copass MK. Effect of epinephrine and lidocaine therapy on outcome after cardiac arrest due to ventricular fibrillation. *Circulation* 1990;82(6):2027-2034.
 72. Walters G, Glucksman E. Retention of skills by advanced trained ambulance staff: implications for monitoring and retraining. *BMJ* 1989;298(6674):649-650.
 73. Geuze RH, de Vente J. Arrhythmias and left ventricular function after defibrillation during acute myocardial infarction in the intact dog. *Am Heart J* 1983;106(2):292-299.
 74. Leja FS, Euler DE, Scanlon PJ. Digoxin and the susceptibility of the canine heart to counter-shock-induced arrhythmia. *Am J Cardiol* 1985;55(8):1070-1075.
 75. Levine PA, Barold SS, Fletcher RD, Talbot P. Adverse acute and chronic effects of electrical defibrillation and cardioversion on implanted unipolar cardiac pacing systems. *J Am Coll Cardiol* 1983;1(6):1413-1422.
 76. Kerber RE. Electrical treatment of cardiac arrhythmias: defibrillation and cardioversion. *Ann Emerg Med* 1993;22(2 Pt 2):296-301.
 77. Zullo MA. Function of ventricular pacemakers during resuscitation. *Pacing Clin Electrophysiol* 1990;13(6):736-744.
 78. ECRI. Health devices alert. Defibrillation [11-132]. March 10, 1995.
 79. Sirna SJ, Ferguson DW, Charbonnier F, Kerber RE. Factors affecting transthoracic impedance during electrical cardioversion. *Am J Cardiol* 1988;62(16):1048-1052.
 80. Aufderheide TP. Pacemakers and electrical therapy during advanced cardiac life support. *Respir Care* 1995;40(4):364-376; discussion 376-379.
 81. Pride HB, Mckinley DF. Third-degree burns from the use of an external cardiac pacing device. *Crit Care Med* 1990;18(5):572-573.
 82. Wrenn K. The hazards of defibrillation through nitroglycerin patches. *Ann Emerg Med* 1990;19(11):1327-1328.
 83. Panacek EA, Munger MA, Rutherford WF, Gardner SF. Report of nitropatch explosions complicating defibrillation. *Am J Emerg Med* 1992;10(2):128-129.
 84. Wrenn K. The hazards of defibrillation through nitroglycerin patches. *Ann Emerg Med* 1990;19(11):1327-1328.
 85. Reisin L, Baruchin AM. Iatrogenic defibrillator burns. *Burns* 1990;16(2):128.
 86. Minor RL Jr, Chandran PKG, Williams CL. Rhabdomyolysis and myoglobinuric renal failure following cardioversion and CPR for acute MI. *Chest* 1990;97(2):485-486.
 87. Hojs R, Sinkovic A, Hojs-Fabjan T. Rhabdomyolysis and acute renal failure following cardioversion and cardiopulmonary resuscitation. *Ren Fail* 1995;17(6):765-768.
 88. Kerber RE, Kouba C, Martins J, Kelly K, Low R, Hoyt R, et al. Advance prediction of transthoracic impedance in human defibrillation and cardioversion: importance of impedance in determining the success of low-energy shocks. *Circulation* 1984;70(2):303-308.
 89. Kerber RE, Martins JB, Kienzle MG, Constantin L, Olsnansky B, Hopson R, Charbonnier F. Energy, current, and success in defibrillation and cardioversion: clinical studies using an automated impedance-based method of energy adjustment. *Circulation* 1988;77(5):1038-1046.
 90. Kerber RE, Kienzle MG, Olshansky B, Waldo AL, Wilber D, Carlson MD, et al. Ventricular tachycardia rate and morphology determine energy and current requirements for transthoracic cardioversion. *Circulation* 1992;85(1):158-163.
 91. Cummin RO, editor. Textbook of advanced cardiac life support. Dallas: American Heart Association; 1997.
 92. Mace SE. Effect of technique of administration on plasma lidocaine levels. *Ann Emerg Med* 1986;15(5):552-556.
 93. Orłowski JP, Gallagher JM, Porembka DT. Endotracheal epinephrine is unreliable. *Resuscitation* 1990;19(2):103-113.
 94. Aitkenhead AR. Drug administration during CPR: what route? *Resuscitation* 1991;22(2):191-195.
 95. Hess D, Eitel D. Monitoring during resuscitation. *Respir Care* 1992;37(7):739-765; discussion: 766-768.
 96. Ornato JP, Bryson BL, Donovan PJ, Farquharson RR, Jaegar C. Measurement of ventilation during cardiopulmonary resuscitation. *Crit Care Med* 1983;11(2):79-82.
 97. Elling R, Politis J. An evaluation of emergency medical technicians' ability to use manual ventilation devices. *Ann Emerg Med* 1983;12(12):765-768.
 98. Anton WR, Gordon RW, Jordan TM, Posner KL, Cheney FW. A disposable end-tidal CO₂ detector

- to verify endotracheal intubation. *Ann Emerg Med* 1991;20(3):271-275.
99. Thalman JJ, Rinaldo-Gallo S, MacIntyre NR. Analysis of an endotracheal intubation service provided by respiratory care practitioners. *Respir Care* 1993;38(5):469-473.
 100. Brison RJ, Davidson JR, Dreyer JF, Jones G, Maloney J, Munkley DP, et al. Cardiac arrest in Ontario: circumstances, community response, role of prehospital defibrillation and predictors of survival. *CMAJ* 1992;147(2):191-199.
 101. White RD. Maintenance of defibrillators in a state of readiness. *Ann Emerg Med* 1993;22(2 Pt 2):302-306.
 102. Sedgwick ML, Dalziel K, Watson J, Carrington DJ, Cobbe SM. Performance of an established system of first responder out-of-hospital defibrillation: the results of the second year of the Heartstart Scotland Project in the 'Utstein Style'. *Resuscitation* 1993;26(1):75-88.
 103. Cummin RO, editor. *Textbook of advanced cardiac life support*. Dallas: American Heart Association; 2001.
 104. Kellermann AL, Hackman BB, Dobyns R, Frazier C, Nail L. Engineering excellence: options to enhance firefighter compliance with standing orders for first responder defibrillation. *Ann Emerg Med* 1993;22(8):1269-1275.
 105. Haynes BE, Mendoza A, McNeil M, Schroeder J, Smiley DR. A statewide early defibrillation initiative including laypersons and outcome reporting. *JAMA* 1991;266(4):545-547.
 106. Eisenberg MS. Who shall live? Who shall die? In: Eisenberg MS, Bergner L, Hallstrom AP, editors. *Sudden cardiac death in the community*. Philadelphia: Praeger Scientific; 1984:44-58.
 107. Giffen PR Jr, Hope CE. Preliminary evaluation of a prototype tube-valve-mask ventilator for emergency artificial ventilation. *Ann Emerg Med* 1991;20(3):262-266.
 108. Harrison RR, Maull KI, Keenan RL, Boyan CP. Mouth-to-mask ventilation: a superior method of rescue breathing. *Ann Emerg Med* 1982;11(2):74-76.
 109. Hess D, Ness C, Opper A, Rhoads K. Evaluation of mouth-to-mask ventilation devices. *Respir Care* 1989; 34(3):191-195.
 110. Hess D, Baran C. Ventilatory volumes using mouth-to-mouth, mouth-to-mask, and bag-valve-mask techniques. *Am J Emerg Med* 1985;3(4):292-296.
 111. Lawrence PJ, Sivaneswaran N. Ventilation during cardiopulmonary resuscitation: which method? *Med J Aust* 1985;143(10):443-446.
 112. Safar P. Pocket mask for emergency artificial ventilation and oxygen inhalation. *Crit Care Med* 1974;2(5):273-276.
 113. Seidelin PH, Stolarek IH, Littlewood DG. Comparison of six methods of emergency ventilation (letter). *Lancet* 1986;2(8518):1274-1275.
 114. Sainsbury DA, Davis R, Walker MC. Artificial ventilation for cardiopulmonary resuscitation. *Med J Aust* 1984;141(8):509-511.
 115. Pulmonary resuscitators. *Health Devices* 1989;18(10):333-352.
 116. Phillips GD, Skowronski GA. Manual resuscitators and portable ventilators. *Anaesth Intensive Care* 1986;14(3):306-313.
 117. ECRI. Manual resuscitators. *Health Devices* 1979;8:133-146.
 118. American Society for Testing and Materials. Standard specification for performance and safety requirements for resuscitators intended for use with humans. Designation: F-920-Philadelphia: ASTM; 1985.
 119. American National Standards Institute. ANSI Standard Z-79.2, 1976.
 120. Barnes TA, Potash R. Evaluation of five adult disposable operator-powered resuscitators. *Respir Care* 1989;34(4):254-261.
 121. Fluck RR Jr, Sorbello JG. Comparison of tidal volumes, minute ventilation, and respiratory frequencies delivered by paramedic and respiratory care students with pocket mask versus demand valve. *Respir Care* 1991;36(10):1105-1112.
 122. International Standards Organization (ISO). Draft International Standard ISO 8382: 1988 (E)-Resuscitators intended for use with humans. New York: American National Standards Institute; 1988.
 123. Hess D, Simmons M. An evaluation of the resistance to flow through the patient valves of twelve adult manual resuscitators. *Respir Care* 1992;37(5):432-438.
 124. Hess D. Manual and gas powered resuscitators. In: Branson RD, Hess DR, Chatburn RL, editors. *Respiratory care equipment*, 2nd ed. Philadelphia: Lippincott Williams & Wilkins; 1999:187-204.
 125. ECRI. Evaluation: oxygen powered resuscitators. *Health Devices* 1974;3:207-221.
 126. ECRI. Hazard: demand valve resuscitators. *Health Devices* 1976;5:145-146.
 127. ECRI. Gas powered resuscitators. *Health Devices* 1978; 8:24-38.
 128. Harber T, Lucas BG. An evaluation of some mechanical resuscitators for use in the ambulance service. *Ann R Coll Surg Engl* 1980;62(4):291-293.
 129. Osborn HH, Kayen D, Horne H, Bray W. Excess ventilation with oxygen-powered resuscitators. *Am J Emerg Med* 1984;2(5):408-413.
 130. Paradis IL, Caldwell EJ. Traumatic pneumocephalus: a hazard of resuscitators. *J Trauma* 1979;19(1):61-63.
 131. Campbell RS, Branson RD, Davis K, Johnson

- DJ, Porembka D, Hurst JM. Laboratory and clinical evaluation of the Impact Uni-Vent 750 portable ventilator. *Respir Care* 1992;37(1):29-36.
132. McGough EK, Banner MJ, Melker RJ. Variations in tidal volume with portable transport ventilators. *Respir Care* 1992;37(3):233-239.
133. Kern KB, Carter AB, Showen RL, Vorhees WD 3d, Babbs CF, Tacker WA, et al. Comparison of mechanical techniques of cardiopulmonary resuscitation: survival and neurologic outcome in dogs. *Am J Emerg Med* 1987;5(3):190-195.
134. Taylor GJ, Rubin R, Tucker M, Greene HL, Rudikoff MT, Weisfeldt ML. External cardiac compression: a randomized comparison of mechanical and manual techniques. *JAMA* 1978;240(7):644-646.
135. McDonald JL. Systolic and mean arterial pressures during manual and mechanical CPR in humans. *Ann Emerg Med* 1982;11(6):292-295.
136. American Society for Testing and Materials (ASTM). Standards for cuffed and uncuffed tracheal tubes (F290201). Philadelphia: ASTM; 1989.
137. American Society for Testing and Materials (ASTM). F 1254-90. Standard practice for performance of prehospital manual defibrillation. In: Annual book of ASTM standards, Vol 13.01:661-662. Philadelphia: ASTM; 1990.
138. Stults KR, Brown DD, Cooley F, Kerber RE. Self-adhesive monitor/defibrillation pads improve prehospital defibrillation success. *Ann Emerg Med* 1987;16(8):872-877.
139. American Society for Testing and Materials (ASTM). F 1255-90. Standard practice for performance of prehospital automated defibrillation. In: Annual book of ASTM standards. Vol 13.01:663-664. Philadelphia: ASTM; 1990.
140. Stults KR, Brown DD, Kerber RE. Efficacy of an automated external defibrillator in the management of out-of-hospital cardiac arrest: validation of the diagnostic algorithm and initial clinical experience in a rural environment. *Circulation* 1986;73(4):701-709.
141. Weaver WD, Hill D, Fahrenbruch CE, Copass MK, Martin JS, Cobb LA, et al. Use of the automatic external defibrillator in the management of out-of-hospital cardiac arrest. *N Engl J Med* 1988;319(11):661-666.
142. Bocka JJ. Automatic external defibrillators. *Ann Emerg Med* 1989;18(12):1264-1268.
143. Zoll PM, Zoll RH, Falk RH, Clinton JE, Eitel DR, Antman EM. External noninvasive temporary cardiac pacing: clinical trials. *Circulation* 1985;71(5):937-944.
144. Falk RH, Jacobs L, Sinclair A, Madigan-McNeil C. External noninvasive cardiac pacing in out-of-hospital cardiac arrest. *Crit Care Med* 1983;11(10):779-782.
145. Bocka JJ. External transcutaneous pacemakers. *Ann Emerg Med* 1989;18(12):1280-1286.
146. Murray IP, Modell JH. Early detection of endotracheal tube accidents by monitoring carbon dioxide concentration in respiratory gas. *Anesthesiology* 1983;59(4):344-346.
147. Sayah AJ, Peacock WF, Overton DT. End-tidal CO₂ measurement in the detection of esophageal intubation during cardiac arrest. *Ann Emerg Med* 1990;19(8):857-860.
148. Sanders AB, Kern KB, Otto CW, Milander MM, Ewy GA. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation: a prognostic indicator for survival. *JAMA* 1989;262(10):1347-1351.
149. Garnett AR, Ornato JP, Gonzalez ER, Johnson EB. End-tidal carbon dioxide monitoring during cardiopulmonary resuscitation. *JAMA* 1987;257(4):512-515.
150. Falk JL, Rackow EC, Weil MH. End-tidal carbon dioxide concentration during cardiopulmonary resuscitation. *N Engl J Med* 1988;318(10):607-611.
151. Bayes de Luna A, Coumel P, Leclercq JF. Ambulatory sudden cardiac death: mechanism of production of fatal dysrhythmia on the basis of data from 157 cases. *Am Heart J* 1989;117(1):151-159.
152. Curry L, Gass D. Effects of training in cardiopulmonary resuscitation on competence and patient outcome. *CMAJ* 1987;137(6):491-496.
153. Heath ML, Brown RW. Quality of cardiopulmonary resuscitation (letter). *Lancet* 1992;339(8808):1542.
154. Kaye W, Mancini ME. Use of the Mega Code to evaluate team leader performance during advanced cardiac life support. *Crit Care Med* 1986;14(2):99-104.
155. Kaye W, Mancini ME. Retention of cardiopulmonary resuscitation skills by physicians, registered nurses, and the general public. *Crit Care Med* 1986;14(7):620-622.
156. Lowenstein SR, Hansbrough JF, Libby LS, Hill DM, Mountain RD, Scoggin CH. Cardiopulmonary resuscitation by medical and surgical house-officers. *Lancet* 1981;2(8248):679-681.
157. Weil MH, Rackow EC, Trevino R, Grundler W, Falk JL, Griffel MI. Difference in acid-base state between venous and arterial blood during cardiopulmonary resuscitation. *N Engl J Med* 1986;315(3):153-156.
158. Sanders AB, Ewy GA, Taft TV. Prognostic and therapeutic importance of the aortic diastolic pressure in resuscitation from cardiac arrest. *Crit Care Med* 1984;12(10):871-873.
159. Paradis NA, Martin GB, Rivers EP, Goetting MG, Appleton TJ, Feingold M, Nowak RM.

- Coronary perfusion pressure and the return of spontaneous circulation in human cardiopulmonary resuscitation. *JAMA* 1990;263(8):1106-1113.
160. Kannel WB, Doyle JT, McNamara PM, Quicken-ton P, Gorton T. Precursors of sudden coronary death: factors related to the incidence of sudden death. *Circulation* 1975;51(4):606-613.
161. Bolyard EA, Tablan OC, Williams WW, Pearson ML, Shapiro CN, Deitchmann SD. Guideline for infection control in healthcare personnel, 1998. Hospital Infection Control Practices Advisory Committee. *Infect Control Hosp Epidemiol* 1998;18(6):4407-4462. Erratum in: *Infection Control Hosp Epidemiol* 1998;19(7):4493.

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