savemiheart
Working to Improve Cardiac Arrest Survival

Hospital Best Practices

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The **SaveMiHeart** (SMH) Hospital Workgroup aims to advocate for an organized, evidence-based approach to post-resuscitation care. There is a need for quality inpatient care and key hospital-based interventions for resuscitated patients. Without these, all of the community's efforts, 911 dispatchers, and prehospital providers will never come to fruition. To this end, we have outlined a guide to the key components of robust hospital-based post-cardiac arrest care. We have also collected resources and protocols from hospitals across the state of Michigan and compiled links to important guidelines, best practices, and reference materials.

The SMH Hospital Workgroup believes all post-cardiac arrest patients should be ideally cared for at a regional cardiac arrest receiving center capable of "around-the-clock" coronary revascularization, temperature management, complete critical care services, and standardized neuroprognostication, among a myriad of other support services (Table 1).

At a minimum, any hospital caring for post-cardiac arrest patients should be able to provide the following:

1. Temperature Management
2. Coronary revascularization
3. Structured, multi-modal, evidence-based neurologic prognostication with deferred withdrawal of life-sustaining therapy due to neurologic reasons for at least 72 hours

For further details or assistance in formulating a protocol to implement in your hospital, please contact SaveMiHeart.

Best Practices

1. General considerations: All patients should be cared for at a regional cardiac arrest center capable of around-the-clock coronary revascularization, temperature management, critical care services, and standardized neuro-prognostication. [1]

2. Temperature Management
    a. If the patient is following commands, then maintain strict fever suppression. [2]
    b. If not following commands, then actively induce temperature management as soon as possible. The goal temperature is 32°C - 36°C for at least 24 hours with controlled rewarming at 0.25°C - 0.5°C per hour after the 24 hour period. Maintain fever suppression following this period of targeted temperature management [3]
    c. Central venous or esophageal temperature monitoring are considered the most accurate. Bladder temperature is an alternative but can lag central temperature. Rectal temperatures lag during acute changes and can vary up to 1.5°C. [4]
    d. If core temperature is >36°C, initiate and maintain cooling with a surface or endovascular cooling device. Administration of up to 30 mL/kg rapid ice-cold crystalloid infusion (2-4℃) can accelerate cooling if concern for cardiomyopathy does not preclude rapid crystalloid infusions. [5-8]
    e. Measures to reduce shivering should begin with non-pharmacologic methods (skin counter warming) followed by pharmacologic treatments, which include sedatives and neuromuscular blockade to suppress shivering. [9-10]

3. Acute coronary revascularization
    a. The post-return of pulses EKG is less sensitive for STEMI and acute coronary syndrome. [10-13]
    b. Activate the cardiac catheterization laboratory or transfer to a capable center for STEMI or "STEMI-equivalents" (shockable initial rhythm or suspicious clinical history). [14]
    c. Maintain goal temperature throughout revascularization. [15-17]

4. Quality intensive care to minimize secondary brain injury
    e. Ventilator Management
        i. Ventilate to achieve normocarbia to optimize cerebral perfusion (goal $PaCO_2$ 35-45 mmHg). [18-19]
        ii. Consider avoidance of hyperoxia to minimize reperfusion/free radical injury (goal SaO2 94-98%). [20-21]
    f. Hemodynamic management
        i. The post-cardiac arrest brain often has impaired cerebrovascular autoregulation. Use vasopressors to achieve a mean arterial pressure that maintains adequate cerebral perfusion (goal mean arterial pressure at least 65 mmHg). Profound myocardial stunning may preclude this higher mean arterial pressure. [18, 22-23]
    g. Glycemic control
        i. Pursue euglycemia (goal serum glucose 140-180 mg/dL). There is no evidence to support stricter control. [25]

5. AICD placement
    a. Some, but not all, patients after surviving cardiac arrest require an AICD to be placed as a secondary prevention measure.
    b. Joint ACC/AHA guidelines recommend secondary prophylaxis in cardiac arrest survivors due to ventricular fibrillation or ventricular tachycardia. [26-27]
    c. It is essential to evaluate patients for potential electrophysiological etiologies of cardiac arrest, which may also impact their relatives if familial.

6. Standardized neurologic prognostication
    a. Overview
        i. Early signs of neurologic activity after the return of circulation are encouraging, but the absence does not preclude recovery
        i. A multi-modal approach is needed for neuro-prognostication. No single exam finding or clinical test provides adequate test performance characteristics. [28]
        ii. Patients take at least 72 hours to display the trajectory of neurologic recovery after targeted temperature management. Unless clear advance directives exist, avoid premature withdrawal of life support for poor neurologic prognosis before 72 hours after targeted temperature management. [29-30]

    b. Physical Examinations
        i. A practical method is to estimate the probability of recovery based on daily clinical exams. As information is added over time from clinical progression, imaging, and neurophysiological studies, this estimate is revised up or down to advise families and proxy decision-makers. Daily re-evaluation is required to determine if ongoing therapy is consistent with the patient's goals of care in light of the best estimate of the probability of recovery.
        ii. Daily neurologic examinations should focus on brainstem reflexes and the best motor response. The persistent absence of bilateral pupillary light reflex and corneal response for more than 72 hours is highly predictive of permanent coma. The motor examination is less reliable with unacceptable false-positive rates for predicting poor outcomes. [31-32]
        iii. Myoclonus is not reliable for predicting poor outcomes. [33]
        iv. Physiologic response to temperature management provides additional insight into neurologic recovery. A functioning hypothalamus will attempt to regulate body temperature and oppose cooling efforts. The presence of shivering, the amount of patient heat generation (derived from the inverse average water temperature of cooling devices), and the presence of bradycardia during periods of induced hypothermia are all favorable prognostic signs. [34-36]
    c. Imaging
        i. Non-contrast CT brain assesses for intracranial hemorrhage as the etiology of cardiac arrest, which is prudent prior to anti-coagulation or fibrinolytic therapy.

ii. Brain edema is a common sequela of anoxic injury. Early CT provides estimates of the severity of brain edema, which is inversely associated with survival and functional outcome. Additionally, early Head CT after cardiac arrest may identify actionable abnormalities in approximately 1/3 of cardiac arrest patients. [37-39]
iii. MRI can visualize subtler changes in the brain after cardiac arrest. For patients who remain comatose for several days and have indeterminate clinical or neurophysiological testing, MRI provides additional information about the extent and regions of anoxic brain injury. Extensive cortical lesions reduce expectations and enthusiasm for long-term support. However, the anatomic complexity of the brain precludes any simple quantitative relationship between the number or size of lesions and outcome. [40-41]

d. Neurophysiology
   i. The prognostic value of EEG is limited by the non-specificity of findings and dynamic changes over time. [42-43]
   ii. The most significant utility of EEG is to detect seizures and exclude non-convulsive seizures as an etiology of coma. Seizures are diagnosed clinically in 5-20% of comatose patients after cardiac arrest, and the true incidence of non-convulsive seizures is likely higher. Termination of seizures, if possible, allows for untainted assessment of the neurologic examination. [44-45]
   iii. Seizures and other malignant EEG patterns that develop after ROSC should be treated aggressively with anti-epileptic therapy.
   iv. Certain malignant EEG patterns have strong but imperfect associations with poor outcome (generalized suppression, burst-suppression associated with generalized epileptic activity, or diffuse periodic complexes on a flat background). [45]
   v. Recovery of long-latency somatosensory evoked potentials (SSEP) is associated with awakening. Conversely, the absence of cortical response to the evoked potential after rewarming is specific for poor neurologic outcomes. [31-32]

7. Withdrawal of Life-Sustaining Treatment
   a. In North America, it is more common to die in the hospital after resuscitation from cardiac arrest than to receive long-term care. [46]
   b. Among resuscitated patients from out-of-hospital cardiac arrest, ~60% die after withdrawal of life-sustaining treatments due to poor predicted neurologic prognosis. Consequently, the quality of life for patients that leave the hospital is generally high. [47-49]
   c. Patients take at least 72 hours to display the trajectory of neurologic recovery. Unless clear advance directives exist, avoid premature withdrawal of life support for poor neurologic prognosis before 72 hours. [34-35]

d. It is appropriate for patients who survive cardiac arrest but later progress to death or formal brain death to assess candidacy to become organ donors. Outcomes for transplanted organs from this population are comparable to other donors. [50]

8. Rehabilitation services
    a. Analogous to acute stroke and traumatic brain injury, early rehabilitative services offer opportunities for continued improvements after leaving the hospital. Patients and caregivers' needs are complex and range in severity depending on the degree of brain injury. [51-53] These services include:
        i. Physical Therapy & Occupational Therapy
        ii. Cognitive Rehabilitation
        iii. Counseling and support services

9. Provision of Patient/Family Resources
    a. There are several national organizations with state chapters in Michigan to support survivors and families. Furthermore, the University of Michigan offers a CPR training program to family members of cardiac arrest survivors.
        i. UM family CPR training program
        ii. Heart Rescue Project
        iii. Sudden Cardiac Arrest Association: Michigan Chapter
        iv. Sudden Cardiac Arrest Foundation
        v. Life After Sudden Cardiac Arrest

Sample Hospital Protocols:

William Beaumont Hospital
University of Michigan Health System
Spectrum Health Hospitals
Henry Ford Hospital

Table. Clinical Services for Cardiac Arrest Centers

Neurologic Services	
Targeted temperature management Continuous EEG monitoring Seizure management Neurology and Neurocritical care consultation	Neurosurgical consultation Cerebral imaging (MRI, perfusion studies) Neurophysiological testing (evoked potentials) Prognostication services
Critical Care Services	

Ventilator management Glucose control	Goal-directed hemodynamic management
Cardiovascular Services	
Cardiac catheterization / percutaneous coronary intervention Coronary artery bypass grafting Intra-aortic balloon pump ICD placement	Cardiovascular mechanical support devices Extra-corporeal membranous oxygenation (ECMO) Transplant surgery consultation Electrophysiology consultation
Other Services	
Physical medicine and rehabilitation consultation Physical and occupational therapy Social work	Organ donation Outpatient neurological rehabilitation Outpatient psychological services

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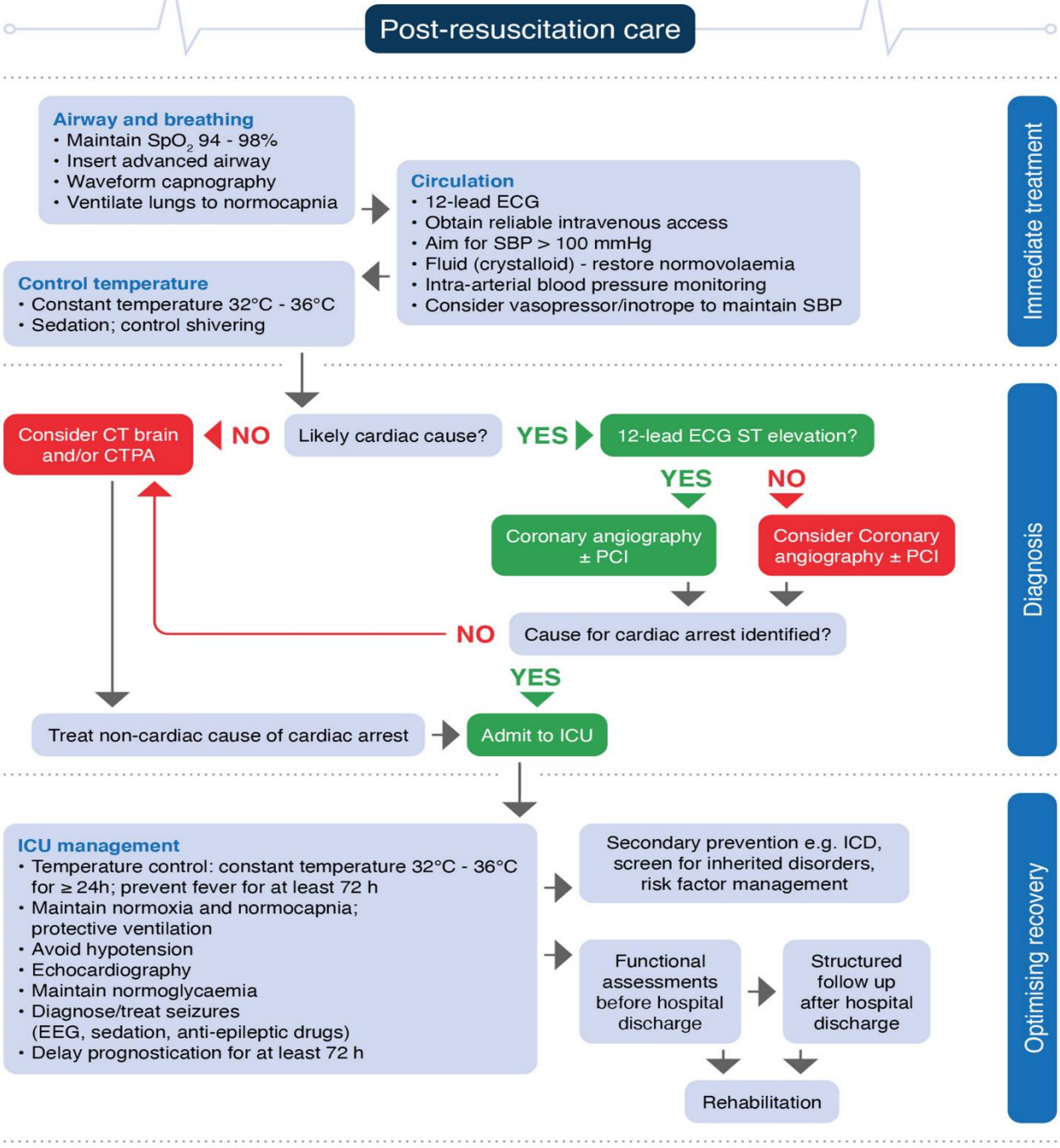

Figure: From: [European Resuscitation Council and European Society of Intensive Care Medicine guidelines 2021: post-resuscitation care](https://link.springer.com/article/10.1007/s00134-021-06368-4)
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