Neurological Outcome of Prolonged Coma Survivors of Out-of-Hospital Cardiac Arrest

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SUMMARY  Nine adult survivors of out-of-hospital presumed cardiogenic cardiac arrest, who remained unresponsive for longer than their third hospital day and who eventually were discharged from the acute care hospital, are reported. Their neurological outcome fell into three distinct categories: (a) a persistent vegetative state, (b) able to follow some simple commands but requiring total nursing care, and (c) able to perform most activities of daily living but unemployed because of marked organic mental deficits.

Introduction

WITH THE EVER INCREASING AVAILABILITY of community comprehensive medical emergency systems, many more patients are being resuscitated from out-of-hospital cardiac arrest.1,2 The survivors usually fall within several broad groupings. There are those patients who awake within the first few hospital days, those who succumb to their illness during the acute hospitalization, and those who have a prolonged period of unresponsiveness but do leave the acute care hospital. It is this last group that causes a major concern regarding long-term neurological prognosis.

The neurological outcome at maximal improvement was examined in an adult group of out-of-hospital cardiac arrest survivors who remained unresponsive to simple verbal commands through at least the first three hospital days, and who were eventually discharged from the acute care hospital.

Patient Analysis

Partial illness profiles of nine adult survivors of non-hospital cardiac arrest who remained unresponsive through at least their third in-hospital day, but yet were able to leave the acute care hospital, are summarized in table 1. These patients represent the prolonged coma cardiac arrest survivors of 137 presumed cardiogenic cardiac arrest admissions in the 25-month period, January 1973 through January 1975, at our acute care emergency hospital. These patients had all been evaluated by the neurology service during their acute illness. All the long-term responsive survivors were personally examined in follow-up visits, except for Patient No. 9 who resided at a great distance. In his case, physician and family evaluations were used for follow-up.

The patients’ age, sex and race are stated in table 1. Patient Nos. 1, 4, 8, and 9 had essentially benign cardiorenal histories except for mild hypertension in Patient Nos. 4 and 8. Patient No. 2 probably had had prior arrhythmias, and Patient No. 6 had a prior myocardial infarction. Patient Nos. 3 and 7 had histories of pulmonary illness while Patient No. 5 had a post-traumatic seizure disorder. Despite alcoholism being a concomitant diagnosis in approximately 50% of our medical admissions, none of these patients had this problem.

The initial cardiac rhythm recorded in the emergency room was ventricular fibrillation in Patient Nos. 3, 6, and 7. Asystole was initially recorded in Patient Nos. 2, 4, 5, 8 and 9. These data for Patient No. 1 were uncertain.

The initial neurological status was determined after the patients arrived in the coronary care unit from their emergency room resuscitation. Most patients were in a state of hypertonic unresponsiveness while Patient No. 1 was flaccid and Patient No. 5 was flaccid with intermittent myoclonic seizures. In other patients, seizures either at the time of cardiac arrest (Patient Nos. 1 and 7) or shortly after hospitalization (Patient No. 4) were noted. Only Patient No. 5 had initially nonreactive pupils, while abnormal or absent oculocephalic or caloric responses were documented in Patient Nos. 2, 3, 4, 5, 6, 7 and 9 initially. All patients regained oculocephalic and pupillary responses at maximal improvement. Post-resuscitation respiration was considered intact in seven patients. Patient No. 2 was said to breathe sporadically while Patient No. 6 had a post-resuscitation flail chest.

CSF was examined in seven of the patients. EEG was performed in all, with the first recording occurring between Day 2 and Day 8. Various neuroradiological examinations including radioisotopic dynamic and static scintigrams, pan cerebral angiography and computerized axial tomography were performed as noted in table 1.

On discharge, acute myocardial infarction had been clinically documented in Patient Nos. 1, 3, and 4. Patient No. 9 was found to have a "midsystolic click syndrome." Patient Nos. 2, 5, 6, 7 and 8 were discharged with the diagnosis of cardiac arrest of undetermined etiology.

At follow-up, Patient Nos. 2, 4, 5 and 6 had remained in a persistent vegetative state.3 They had regained what is considered brain stem level function but had no recognizable cortical function as judged behaviorally. All died within a three-week to four-month period after their arrest. Post-mortem examinations were performed on two patients. Patient No. 2 showed left ventricular hypertrophy, and cerebral edema with acute ischemic alterations and focal chronic ischemic alterations. Patient No. 6 showed an extensive old left ventricular infarction, and diffuse subcortical gliosis, with spionousis in the brain. Two patients had regained the ability to comprehend and follow some simple commands but were spastically quadriparetic, incontinent, unable to swallow and totally dependent. Patient No. 1 died after 22 months of this existence in a nursing home while Patient No. 8 was being totally cared for in his home at six-month follow-up. Patient Nos. 3, 7, and 9 were ambulatory and independent in most activities of daily living at six-month to one-year follow-up. However, mentation and personality changes consisting of marked inability to retain new
### Table 1 Patient Profiles: Presentation, History and Status

<table>
<thead>
<tr>
<th>Pt. no., age, sex</th>
<th>Cardiac</th>
<th>Neurological</th>
<th>First response (day)</th>
<th>CSF</th>
<th>EEG</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 48/WM</td>
<td>At home: chest pain, diaphoresis, seizure. ER: initial rhythm data uncertain; in prior excellent health</td>
<td>Flaccid unresponsiveness; reactive pupils; dysconjugate gaze; intact respirations</td>
<td>Over 1 month</td>
<td>Normal</td>
<td>Day 7: intermittent delta</td>
</tr>
<tr>
<td>2, 42/WM</td>
<td>Found unresponsive in parking lot. ER: straight-line EKG 18 months previously, syncope with &quot;erratic EKG.&quot; Six months previously: normal physical and EKG examinations, mild hypertension</td>
<td>Decerebrate unresponsiveness with spasms; small reactive pupils; absent calories; sporadic respirations</td>
<td>Never</td>
<td>Normal</td>
<td>Day 4: continuous symmetric alpha; Days 17, 18, 51: diffusely slow</td>
</tr>
<tr>
<td>3, 49/WM</td>
<td>Chest pain for days, intermittent; collapsed in office. ER: v.f. Past history of benign lung mass; normal cardiac history</td>
<td>Decorticate posturing to pain. Pupils: asymmetrical reactive sluggishly; adduction failure on caloric testing; spontaneous respirations</td>
<td>Day 10</td>
<td>100 RBC, remainder normal</td>
<td>Days 5, 7: diffuse theta</td>
</tr>
<tr>
<td>4, 53/WM</td>
<td>Had dyspnea while mowing lawn, rested; collapsed when he returned to mowing. ER: straight-line EKG, mild hypertension history</td>
<td>Decerebrate unresponsiveness; reactive pupils; absent calories; intact respirations</td>
<td>Never</td>
<td>—</td>
<td>Day 3: diffuse theta. Day 18: periodic delta intermixed with flat record</td>
</tr>
<tr>
<td>5, 41/BM</td>
<td>Found unconscious in bathroom. ER: straight-line EKG initially; posttraumatic seizure disorder</td>
<td>Flaccid unresponsiveness with intermittent myoclonic seizures; pinpoint fixed pupils; adduction failure on calories; intact respirations</td>
<td>Never</td>
<td>Normal</td>
<td>Day 2: delta bursts with amplitude suppression; Day 10: periodic delta</td>
</tr>
<tr>
<td>6, 56/WF</td>
<td>Unconscious at home. ER: v.f.; history of hypertension, myocardial infarction 5 years previously</td>
<td>Decorticate posturing</td>
<td>Never</td>
<td>—</td>
<td>Day 2, 1 month, 2 months: diffuse high voltage delta</td>
</tr>
<tr>
<td>7, 69/WM</td>
<td>Chest pain, vomiting, seizure. ER: v.f.; history of remote pulmonary embolus, asthma, duodenal ulcer</td>
<td>Decerebrate unresponsiveness; small reactive pupils; intact oculocephalics; spontaneous respirations</td>
<td>Day 4</td>
<td>Protein 130 mg/dl; remainder normal</td>
<td>Day 3: 3–5 Hz diffusely</td>
</tr>
<tr>
<td>8, 42/WM</td>
<td>Collapsed at office. ER: straight-line EKG; good health prior except for obesity and mild hypertension</td>
<td>Decerebrate unresponsiveness; minimal flexion to pain; pupils reactive; intact oculocephalics; intact respirations</td>
<td>More than 14 days</td>
<td>7 monocytes; protein 63 mg/dl; remainder normal</td>
<td>Day 8: diffuse low voltage theta</td>
</tr>
<tr>
<td>9, 32/WM</td>
<td>Collapsed at Judo practice. ER: straight-line EKG; previously entirely well</td>
<td>Decerebrate unresponsiveness; asymmetric but reactive pupils; absent oculocephalics; intact respirations</td>
<td>Day 4</td>
<td>Day 1: 1,050 RBCs; 8 WBCs; protein: 64; remainder normal. Day 2: 144 RBCs; protein 56; remainder normal</td>
<td>Day 4: normal</td>
</tr>
</tbody>
</table>

ER = emergency room; v.f. = ventricular fibrillation; EKG = electrocardiogram; W = white; BM = black; F = female; M = male.

**Discussion**

In 1959, Bokonjic and Buchtal⁴ stated that the critical duration of postanoxic unconsciousness for total recovery was 48 hours in cardiac arrest. Beyond this time, there was an irreversible clinical deficit in their patients. Little appears changed in the intervening years as our current data reaffirm their conclusion. Moreover, by extending the dura-
Neuromuscular Outcome of Coma Survivors/Yarnell

<table>
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<tr>
<th>Neuroradiology</th>
<th>Discharge diagnosis</th>
<th>Follow-up status</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Anterolateral myocardial infarction, acute</td>
<td>At maximal improvement: verbalized “yes, no,” name. Follows some simple commands, smiles in recognition. Tube-fed, incontinent, spastic quadriparesis, never left complete care nursing home. Died at 22 months</td>
</tr>
<tr>
<td>Radioscintigrams, Days 16, 29: normal; pan cerebral angiography, Day 29: mild ventricular dilatation</td>
<td>Cardiorespiratory arrest, uncertain etiology</td>
<td>At maximal improvement: remained unresponsive but had sleep, awake cycles. Would open eyes to pinch. Total limb flexion posture, intact oculocephalics. Died at 7 weeks needing complete care. Postmortem: left ventricular hypertrophy, diffuse brain edema, ischemic changes</td>
</tr>
<tr>
<td>Radioscintigram at 1 year: marked decreased right-sided perfusion</td>
<td>Anterolateral myocardial infarction, acute</td>
<td>At 1 year: alert, excellent in spelling, simple arithmetic, naming, proverb interpretation. Follows complex commands; poor concentration, now can read only comics. Spotty past memory, marked irritability to retain new information over 30 seconds, “my mind is not reliable.” Hyperirritable, mild left hemiparesis, able to care for self at home, but unemployable</td>
</tr>
<tr>
<td>Radioscintigram, Day 17: normal</td>
<td>Anterior and superior myocardial infarction, acute</td>
<td>At maximal improvement: opens eyes spontaneously with roving conjugate eye movements, intact oculocephalics response, spontaneous chewing and yawning, no comprehension or speech. Quadriplegic, fed via gastric tube. Died in nursing home on Day 40</td>
</tr>
<tr>
<td>Radioscintigram, Day 18: bilateral “watershed infarction” pattern</td>
<td>Cardiac arrest coma, unknown etiology</td>
<td>At maximal improvement: pupils midposition, reactive, gastrostomy fed. Died Day 21</td>
</tr>
<tr>
<td>0</td>
<td>Atherosclerotic cardiovascular disease; cardiac arrest of uncertain etiology</td>
<td>At maximum improvement: eyes open but not following; made humming sounds; unresponsive to commands; quadriplegic, incontinent, unable to swallow; died at 4 months. Postmortem: old anterior myocardial infarction with diffuse myocardial fibrosis; diffuse cerebral subcortical gliosis</td>
</tr>
<tr>
<td>Radioscintigram, Day 9: normal</td>
<td>Cardiac arrest, unknown etiology</td>
<td>At 8½ months: alert, friendly; can do some simple calculations but unable to maintain train of thought; intact ability to name, follow simple commands; cannot read for comprehension; spotty remote memory; marked inability to retain new information, “I kind of lost control of my memory;” increased irritability; able to take care of daily needs but unemployable</td>
</tr>
<tr>
<td>Pan cerebral angiography, Day 0: normal</td>
<td>Cardiac arrest, unknown etiology</td>
<td>At 6 months: nonverbal, choreoathetotic movements of head and extremities constant; follows some simple commands; recognizes people; incontinent, hypertonic, quadripletic; places any grasped object in mouth; minimal swallowing; needs complete care</td>
</tr>
<tr>
<td>Computerized axial tomography 5 months: possible slight atrophy</td>
<td>Cardiac arrest secondary to midystolic click syndrome</td>
<td>At 6 months: has had to be hospitalized for paranoid ideation; withdrawn; hyperirritability; unable to concentrate; cannot recall a series of commands; poor recent memory ability; intact motor and gait; childlike, has to be shown where clothes are to dress himself; excellent vocabulary, spelling; unemployable</td>
</tr>
</tbody>
</table>

...tion of postarrest unresponsiveness to three days, our patient population amplifies the clinical deficits. Our patients fell into three distinct survival categories: four patients remained in a persistent vegetative state, two patients were able to follow simple commands and recognized familiar persons but needed total nursing care, while three patients were mostly independent in the activities of daily living but were unemployable because of major organic mental defects. Others have noted similar postarrest coma findings.8,9

Neurological findings of only reflex motor responsiveness, at best, shortly after arriving on the intensive care ward were found in all our patients and supported a previous report of worse final outcomes.7

In examining the first noted cardiac rhythms in the emergency department, two of the three ambulatory sur-
vivors were in ventricular fibrillation, while three of the four persistent vegetative coma patients had straight line electrocardiograms. Perhaps asystole correlates with a longer or a more severe cerebral anoxic insult, as it is believed to yield a more difficult resuscitation. This correlation remains to be tested prospectively with in-field cardiograms and longitudinal evaluations.

The possibility that both the cardiac arrhythmia and neurological sequelae resulted from a primary cerebral process, i.e., hemorrhage, appears to be excluded by the history, course and neurological laboratory findings. However, Patient No. 5, an epileptic, still remains suspect of having a nervous system-initiated arrest with the possibility of seizures leading to a lethal cardiac arrhythmia. The neurological laboratory examinations were useful for exclusion and follow-up rather than diagnosis. In Patient No. 5, the third-week radioscintigram demonstrated bilateral watershed infarcts consistent with post-cardiac arrest anoxic damage, while Patient No. 3 demonstrated decreased right brain perfusion on his one-year radioscintigram study. Thus, in none of the long-term survivors could primary cerebral disease be found culpable of causing the neurological outcome.

The initial EEG did not differentiate early between the three categories of prolonged coma survival. The records ranged from periodic delta to continuous alpha. There were no isoelectric tracings. Perhaps very early post-arrest and serial tracings, along with using more recently described refined techniques, will prove more informative prognostically.

The documented acute myocardial infarction in one-third of this group of patients is in accord with the characteristics noted in a recent comprehensive survey of cardiac arrest survivors.

The cerebral pathology of the two autopsied patients was consistent with known cerebral stagnant anoxic insult. The amnestic phenomena and personality alterations are well-known sequelae of brain injury. These patients most probably would have failed to survive their out-of-hospital cardiac arrest without the modern emergency ambulance systems. Also, the cardiac care unit enhances the abilities of the initial resuscitation survivors to leave the acute care hospital. However, the immediate successes here are overshadowed by the severe neurological sequelae in the prolonged coma group. Hopefully, in the future, better definition of the existing cerebral insult at the initiation of resuscitation and the development of more effective therapy of the post-arrest cerebral injury may limit the number of neurologically devastated survivors.

Acknowledgment

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References

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