Withdraw or Continue in ICU

Clifton W. Callaway, MD, PhD
Department of Emergency Medicine
University of Pittsburgh
Disclosures - Callaway

• Employer: University of Pittsburgh; UPMC Health Systems
• Grants: NHLBI (multicenter consortium to study cardiac and trauma resuscitation; institutional training grants); NINDS (NETT consortium to study neurological emergencies); NCATS (support for translational science research infrastructure)
• Patents: Use of ECG analysis to optimize timing of defibrillation; formerly licensed to Medtronic (terminated 2012).
• Research Support: Loan of cooling device from Medivance Inc, for laboratory studies of cooling
Why do patients die after CPR?

- Classify cause of death in 2,137 non-survivors after OHCA
  - Largest cause of in-hospital death was Withdrawal of Life Sustaining Treatment for “neurological” reasons (61.2%)

Resuscitation Outcomes Consortium, Resuscitation
Clinical Example (1)

• 45 yr old female collapsed at home while washing dishes. Her 18 yr old daughter and son-in-law do CPR for ~15 minutes awaiting EMS. Firefighter AED shocks x 2, EMS arrives to see asystole on monitor. Epinephrine, atropine and CPR restores pulses. Taken to local ED where emergency physician seeks to transfer to tertiary care.
**Emergency Medicine**

- **04:36**
  - **Differential diagnosis:** arrhythmia, cardiac arrest, respiratory arrest, overdose, asphyxiation.
  - **Data reviewed:** vital signs, nurses notes, EMS record, lab test result(s), EKG, X-ray(s), CT scan
  - **Cardiac monitor:** rate is 100 beats/min, rhythm is normal sinus rhythm.
  - **Pulse oximetry:** on 100% NRB ventilator is 100%.
  - **Counseling:** I had a detailed discussion with the patient and/or guardian regarding the historical points, exam findings, and any diagnostic results supporting the discharge/admit diagnosis, lab results, radiology results, the need to transfer to another facility, for higher level of care. Hospital does not immediately have the required specialist.

- **05:06**
  - **Physician consultation:** Dr. Other (RADIOLOGY) was called at 04:35, regarding CT AND FURTHER W/U.

- **05:52**
  - ECG/EKG scanned and attached to record.

- **05:59**
  - Awaiting: transfer to another facility.
  - Special discussion:
  - **ED course:** Transfer delay due to Awaiting air transport. Physician consultation: Dr. Other MICU FELLOW AT DR. WAS UNWILLING TO ACCEPT THE PATIENT IN TRANSFER STATING "SHE IS...

---

**Physician Documentation Con't.**

BRAIN DEAD AND END OF LIFE CARE SHOULD OCCUR IN THE ER IMMEDIATELY". I TRIED TO REASON WITH HIM THAT WHILE DISMAL PROGNOSIS THIS EARLY AFTER CARDIAC ARREST IN A 45 Y FEMALE I WAS UNWILLING TO DISCONTINUE LIFE SUPPORT. DISCUSSION WITH FAMILY MEMBERS WHO WERE IN AGREEMENT ASKING TO BE SENT TO PITTSBURGH.

- **06:06**
  - **Test interpretations performed by ED physician or midlevel provider:** plain radiologic studies, ECG, Laboratory studies CT scan.

<table>
<thead>
<tr>
<th>Time</th>
<th>Order name</th>
<th>Complete Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>04:03</td>
<td>Ekg Request</td>
<td>04:35</td>
</tr>
</tbody>
</table>
Emergency Medicine

**Physician Documentation Con’t.**

BRAIN DEAD AND END OF LIFE CARE SHOULD OCCUR IN THE ER IMMEDIATELY. I TRIED TO REASON WITH HIM THAT WHILE DISMAL PROGNOSIS THIS EARLY AFTER CARDIAC ARREST IN A 45 Y FEMALE I WAS UNWILLING TO DISCONTINUE LIFE SUPPORT. DISCUSSION WITH FAMILY MEMBERS WHO WERE IN AGREEMENT ASKING TO BE SENT TO PITTSBURGH.

<table>
<thead>
<tr>
<th>Time</th>
<th>Order name</th>
<th>Complete Time</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>04:03</td>
<td>Ekg Request</td>
<td>04:35</td>
<td></td>
</tr>
</tbody>
</table>
**Immediate**

| 45 F OHCA admit to ICU |

**Day 1-2**

**Awaken**

**Day 3-7**

**Long-Term Support**

**Brain Death**

**Persistent Vegetative State**
How do we really prognosticate?

Bayesian reasoning....

Pretest
All Patients

Survival 30%
Good Outcome 20%
How do we really prognosticate?

Bayesian reasoning....

Pretest
All Patients

Survival 30%
Good Outcome 20%

Do a Test
How do we really prognosticate?

Bayesian reasoning....

Pretest
All Patients

Survival 30%
Good Outcome 20%

Do a Test

Posttest

Good Result 59%
50% survive
35% good outcome

Bad Result 41%
10% survive
5% good outcome
Ground Rules

• Want to be realistic
  – Need to set reasonable expectations

• Cannot make a mistake
  – No rebates once we stop life-sustaining therapy
  – Need a “0% False-Positive Rate”
False Positive Rate and Sample Size

When you see no survivors in a cohort (e.g. 0 out of 20), how certain can you be that there will be never be any survivors?

What is the Confidence Interval on “0/N”?
How certain do you need to be to limit care?

<table>
<thead>
<tr>
<th>N</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0% - 14%</td>
</tr>
<tr>
<td>50</td>
<td>0% - 6%</td>
</tr>
<tr>
<td>100</td>
<td>0% - 3%</td>
</tr>
<tr>
<td>200</td>
<td>0% - 1.5%</td>
</tr>
<tr>
<td>300</td>
<td>0% - 1%</td>
</tr>
</tbody>
</table>
False Positive Rate and Sample Size

When you see no survivors in a cohort (e.g. 0 out of 20), how certain can you be that there will be never be any survivors?

What is the Confidence Interval on “0/N”? How certain do you need to be to limit care?

<table>
<thead>
<tr>
<th>N</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0% -14%</td>
</tr>
<tr>
<td>50</td>
<td>0% - 6%</td>
</tr>
<tr>
<td>100</td>
<td>0% - 3%</td>
</tr>
<tr>
<td>200</td>
<td>0% - 1.5%</td>
</tr>
<tr>
<td>300</td>
<td>0% - 1%</td>
</tr>
</tbody>
</table>

Most Studies
Problem in Literature to Date

• Almost every prior study allowed the treating team to know results of the test when deciding whether or not to continue life-sustaining treatment
  – Exceptions are a handful of studies of blood markers and evoked potentials
  – “Self-fulfilling Prophecy”

• Few studies included sufficient numbers to demonstrate reliable false positive rates
  – 300 or more cases would be needed to show 0-1% confidence interval
Self-Fulfilling Prophecy

What is Prognosis?

Do Test

Likelihood Ratio = \frac{\text{Odds of Surviving with Bad Result}}{\text{Odds of Surviving Before the Test}}

Because you used the bad test to decide to withdraw, LR is artificially small…
Self-Fulfilling Prophecy

What is Prognosis?

Do Test

Good Result

Bad Result

Some Patients Live

Fewer Patients Live

Continue Support

Withdraw Support in Some

More Patients Die

Odds of Surviving with Bad Result

Odds of Surviving Before the Test

Likelihood Ratio =

Because you used the bad test to decide to Withdraw, LR is artificially small…
Emergency Medicine

Brain Death

Persistent Vegetative State

Immediate Day 1-2 Day 3-7

Awaken

45 F OHCA admit to ICU

Long-Term Support
Prognosticitation of Neurological Outcome in Comatose Cardiac Arrest Survivors - Clinical Examination

On the basis of existing studies, no clinical neurological signs reliably predict poor outcome <24 hours after cardiac arrest.

AHA Guidelines 2010
Knowing nothing else...

• Historical data can let us predict baseline probability of survival for a patient admitted to the ICU after cardiac arrest

• 2005-2012
  – 871 subjects admitted
  – 405 (46%) survive to hospital discharge
  – A majority of survivors have “Good” recovery
    • Awaken and return to baseline

• 46% Chance = “Give Aggressive Care”
Clinical Example (2)

• Initial neurological examination is
  – Pupils react (2 mm sluggish)
  – Corneal reflex present (blinks to rubbing eyelash)
  – Eyes deviated upward with no oculocephalic response
  – Triggers ventilator
  – Gag and cough
  – Flexor posturing of extremities to pain
Initial Pupil Exam

**Pretest**

- **Comatose at admission**
  - Survival: 35% (55/158)
  - Good Outcome: 23% (37/158)

**Posttest**

- **Reactive 59% (93/158)**
  - 52% (48/93) survive
  - 37% (34/93) good outcome

- **Non-reactive 41% (65/158)**
  - 11% (7/65) survive
  - 5% (3/65) good outcome

---

*Lower expectations based on initial exam, but not even brainstem signs are sufficiently accurate to limit care.*
# Pittsburgh Cardiac Arrest Categories

Examine coma and brainstem reflexes (best motor response to voice or pain, pupil reaction to light, corneal response, gag, cough, spontaneous breathing) and shock (how much pressor is required to keep SBP>100 mmHg) and pulmonary status (can you oxygenate the patient).

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
</table>
| **Category 1**  | **Awake**  
Follows commands or makes purposeful movements (e.g. pulling at tubes and lines) |
| **Category 2**  | **Coma without severe shock**  
Does not follow commands or make purposeful movement but brainstem reflexes are present.  
Modest pressor requirements (dopamine ≤10 mcg/kg/min; norepinephrine <0.1 mcg/kg/min) and reasonable to oxygenate (e.g. SaO2 90-100% with standard pressure control ventilation) |
| **Category 3**  | **Coma with severe shock or pulmonary dysfunction**  
Does not follow commands or make purposeful movement but brainstem reflexes are present.  
High pressor requirements (e.g. dopamine >10 mcg/kg/min; norepinephrine or epinephrine ≥0.1 mcg/kg/min) or very difficult to oxygenate (SaO2 <90% or requiring special ventilation modes) |
| **Category 4**  | **Coma with loss of brainstem reflexes**  
Does not follow commands or make purposeful movement and multiple brainstem reflexes are lost (e.g. no pupil response or gag or cough) |

*Rittenberger 2011; Resuscitation 82: 1399-1404*
Patients who present to ICU with shock are more likely to develop multiple organ failure, and less likely to survive.
Clinical Example (2)

• Initial neurological examination is
  – Pupils react (2 mm sluggish)
  – Corneal reflex present (blinks to rubbing eyelash)
  – Eyes deviated upward with no oculocephalic response
  – Triggers ventilator
  – Gag and cough
  – Flexor posturing of extremities to pain

• On arrival, patient has blood pressure of 150/70, on no pressors.

• ABG is pH 7.26, pCO2 46, pO2 146 on FiO2 of 0.50; PEEP 5
Test #1 - Initial Illness Severity

Pretest
Admitted after Cardiac Arrest

Survival
46% (207 / 459)

Good Outcome
31% (141 / 459)

Check Cardio-pulmonary Status and FOUR Score

Posttest

Awake 30% (141/459)
81% (114/141) survive
60% (85/141) good outcome

Coma without Shock 22% (99/459)
58% (57/99) survive
34% (34/99) good outcome

Coma with Shock 14% (63/459)
44% (28/63) survive
25% (16/63) good outcome

Brainstem Dysfunction 34% (156/459)
9% (14/156) survive
5% (8/156) good outcome

Category 1
Awake
Follows commands or makes purposeful movements (e.g., pulling at tubes and lines)

Category 2
Coma without severe shock
Does not follow commands or make purposeful movement but brainstem reflexes are present.
Modest pressor requirements (dopamine ≤ 10 mcg/kg/min; norepinephrine ≤ 0.1 mcg/kg/min) and reasonable to oxygenate (e.g., Sato 90-100% with standard pressure control ventilation)

Category 3
Coma with severe shock or pulmonary dysfunction
Does not follow commands or make purposeful movement but brainstem reflexes are present. High pressor requirements (e.g., dopamine >10 mcg/kg/min; norepinephrine or epinephrine ≥ 0.1 mcg/kg/min) or very difficult to oxygenate (Sato <90% or requiring special ventilation modes)

Category 4
Coma with loss of brainstem reflexes
Does not follow commands or make purposeful movement and multiple brainstem reflexes are lost (e.g., no pupil response or gag or cough)
Immediate | Day 1-2 | Day 3-7
---|---|---
| | | Awaken

Initial Exam

Brain Death

Persistent Vegetative State

Long-Term Support
Diffuse Cerebral Edema Associated with Mortality

Mortality increases with lower Gray-White Ratio (GWR) on initial CT for patients receiving hypothermia or no hypothermia.

(Metter, Resuscitation 2011)
A. Distribution of GWR in 211 patients who were comatose after cardiac arrest. GWR≤1.20 occurred in 58 (27%) of patients who rarely (2/58) survived.

B. All 29 patients who followed commands immediately after cardiac arrest had GWR >1.20

Good outcome was defined as returning to home or to rehabilitation. Poor outcome was defined as surviving to long-term care.

Data from Metter 2011
Clinical Example (3)

• Initial CT Brain is normal
  – No edema
  – No intracranial hemorrhage (~4-5% of cases have unexpected intracranial findings)
Test #2 - Edema on Initial CT Scan

Pretest

CT scan at admission

Survival 36% (87/240)

CT scan of brain without contrast within 24 hours of admission

Posttest

GWR>1.2; 76% (182/240)
47% (85/182) survive

GWR<1.2; 24% (58/158)
3% (2/58) survive
Immediate | Day 1-2 | Day 3-7
---|---|---
Initial Exam | $CT$ | Awaken

Long-Term Support

Brain Death | Persistent Vegetative State
Brain Death

CT Persistent Vegetative State
Awaken

Immediate
Day 1-2
Day 3-7

Initial Exam

Long-Term Support

Severe Cerebral Edema

Brain Death Persistent Vegetative State
EEG Monitoring

• **Burst-Suppression**
  – By itself can reflect sedation / hypothermia
  – May evolve into continuous EEG with awakening

• **Seizures**
  – Associated with worse outcome

• **Bursts + Myoclonic Jerking**
  = Myoclonic Status Epilepticus (MSE)
  = “Bad news”

EEG monitored continuously if possible during TTM or until clear improvement or until clear endpoint (e.g. brain death)
EEG monitoring

Full montage, expert interpretation
Types of EEG patterns

Malignant
- Epileptiform discharges
- Periodic discharges
- Status epilepticus
- Myoclonic status epilepticus

Benign
- Reactive
- Continuous
- Suppression-Burst or
- Suppression (that evolves into continuous)
Suppression
Continuous with periods of attenuation
Burst suppression
Hope for This...

Suppression

Continuous
Evolution of EEG over time

Suppressed

Complex

Trajectory | Survival | Good outcome
---|---|---
4 (n = 64) | 2% | 0%
3 (n = 52) | 15% | 6%
2 (n = 85) | 32% | 13%
1 (n = 88) | 64% | 40%

Elmer 2016, Neurocritical Care

Emergency Medicine
# Incidence of Malignant Patterns

<table>
<thead>
<tr>
<th>Author (year)</th>
<th>N</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Youn (2015)</td>
<td>331</td>
<td>31% malignant patterns</td>
</tr>
<tr>
<td>Rittenberger (2012)</td>
<td>101</td>
<td>10% nonconvulsive status</td>
</tr>
<tr>
<td>Cloostermans (2012)</td>
<td>60</td>
<td>14% seizures/periodic discharges</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7% polyspike burst-suppression</td>
</tr>
<tr>
<td>Crepeau (2013)</td>
<td>54</td>
<td>7% seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>37% malignant patterns</td>
</tr>
<tr>
<td>Mani (2012)</td>
<td>38</td>
<td>23% seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>45% malignant patterns</td>
</tr>
<tr>
<td>Rossetti (2010)</td>
<td>34</td>
<td>21% seizures</td>
</tr>
<tr>
<td><strong>Overall</strong></td>
<td>618</td>
<td>10-20% seizures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30-45% malignant patterns</td>
</tr>
</tbody>
</table>
Periodic discharges

We find little significance to generalized vs lateralized vs other PED, with the exception of stimulus-induced rhythmic discharges (which don’t seem as bad).
Epileptiform discharges
Seizures

Some respond to treatment
EEG, Category and Survival (n=327)

Odds Ratio for Survival: PCAC 0.37 (0.27-0.49); EEG 0.39 (0.21-0.74)

Status myoclonus (Burst-suppression)
EEG Distinguishes Two Types of Status Myoclonus

Malignant

Lance Adams Variant

Elmer et al., Ann Neurol. 2016; 80: 175–84
EEG Distinguishes Two Types of Status Myoclonus

Malignant (86%)
- 4% (2 / 50) survive
- 0% (0 / 50) good outcome

Lance Adams Variant (14%)
- 50% (4 / 8) survive
- 50% (4 / 8) good outcome

Elmer et al., Ann Neurol. 2016; 80: 175-84
Clinical Example (4)

• EEG shows
  – “Very frequent, focal (Pz) electrographic seizures.”
  – Other background activity
  – No generalized seizures

• Started on phenytoin and valproic acid
  – EEG normalizes
Test #3 - Continuous EEG

Pretest
Comatose and Hypothermia Protocol

Survival 30%

EEG Monitoring for 48 hours or until awake or endpoint

Posttest
Neither NCSE nor MSE 68% 43% Survive

Status Epilepticus 12% 8% Survive (with treatment!)

GPED 8% 13% Survive (with treatment!)

Burst-Suppression 30% 17% Survive

Myoclonic Status 21% 0% Survive

>>If EEG is becoming normal, then it likely correlates with improving exam
Immediate

Day 1-2

Day 3-7

Awaken

CT

EEG

Initial Exam

Severe Cerebral Edema

Brain Death

Persistent Vegetative State

Long-Term Support
Brain Death
CT EEG
Persistent Vegetative State
Continuous Burst – Suppression NCSE MSE Awaken
Immediate Day 1-2 Day 3-7
Initial Exam
Severe Cerebral Edema
Brain Death
Long-Term Support
Persistent Vegetative State
Brain Death

CT EEG

Persistent Vegetative State

Continuous Burst – Suppression NCSE MSE

Awaken

Immediate Day 1-2 Day 3-7

Long-Term Support

Initial Exam

Severe Cerebral Edema

Brain Death

Persistent Vegetative State
Clinical Example (5)

• By day 3, neurological examination is
  – Pupils react (4 mm)
  – Corneal reflex present
  – Oculocephalic reflex present
  – Triggers ventilator
  – Gag and cough
  – Withdraws extremities to pain
Clinical Exam

- Motor
  - Purposeful
  - Localize
  - Withdraw
  - Flexion
  - Extension
- Oculocephalic
- Pupils
- Corneals
- Gag
- Cough
- Breathing

Wijdicks, Ann Neurol 2005;58:585–593

FOUR Score
Clinical Exam

- **Motor**
  - Purposeful
  - Localize
  - Withdraw
  - Flexion
  - Extension

- **Oculocephalic**
- **Pupils**
- **Corneals**
- **Gag**
- **Cough**
- **Breathing**
Clinical Exam

• Motor
  – Purposeful
  – Localize
  – Withdraw
  – Flexion
  – Extension

• Oculocephalic

• Pupils

• Corneals

• Gag

• Cough

• Breathing

Emergency Medicine
Clinical Exam

- Motor
  - Purposeful
  - Localize
  - Withdraw
  - Flexion
  - Extension

- Oculocephalic
- Pupils
- Corneals
- Gag
- Cough
- Breathing

Sufficient to Remain Alive
Clinical Exam

- Motor
  - Purposeful
  - Localize
  - Withdraw
  - Flexion
  - Extension
- Oculocephalic
- Pupils
- Corneals
- Gag
- Cough
- Breathing

Necessary for Good Outcome

Sufficient to Remain Alive

Emergency Medicine
Recovery follows Cortical Response
Brainstem and Cortical Recovery over Time

**Brainstem**
- FOUR-B Score
- Four points over time
- N=47

**Cortical**
- FOUR-M Score
- Four points over time
- N=18

**Good Outcome**
- FOUR Motor
- Four points over time
- N=47

**Poor Outcome**
- FOUR Motor
- Four points over time
- N=29

Alessandra Cardi, unpublished data
Brainstem and Cortical Recovery over Time

Brainstem

- FOUR Brainstem
- FOUR Motor

Cortical

- FOUR Motor

Good Outcome

- FOUR Motor

Poor Outcome

- FOUR Motor

N=47

N=18

N=29

Alessandra Cardi, unpublished data
Immediate | Day 1-2 | Day 3-7
---|---|---
Initial Exam | CT | EEG
Severe Cerebral Edema | Continuous | NCSE | MSE
Light Coma | Long-Term Support
Brain Death | Persistent Vegetative State
Clinical Exam and Special Tests

- **Motor**
  - Purposeful
  - Localize
  - Withdraw
  - Flexion
  - Extension

- **Oculocephalic**

- **Pupils**

- **Corneals**

- **Gag**

- **Cough**

- **Breathing**

- **SSEP**

- **EEG**

- **MRI**

- **Function**
Somatosensory Evoked Potentials (SSEP) after Cardiac Arrest

Normal N20

Absent N20

Left

Right

Rothstein 2004
Jorgensen 2006
Test #5 - SSEP Cortical Response

Pretest

Comatose without clinical cortical response > 24 hours

Survival 10% (4/39)

SSEP - N20 response to median nerve

Posttest

Present N20; 64% (25/39)
16% (4/25) good outcome

Absent N20; 36% (14/39)
0% (0/14) good outcome

**3% (1/36) good outcome

**Leithner 2010; Zandbergen 1998, 2006
Brain Death

CT EEG

Persistent Vegetative State

Continuous Burst – Suppression NCSE MSE

Awaken

Immediate Day 1-2 Day 3-7

SSEP

Long-Term Support

Immediate Exam

Severe Cerebral Edema

No Cortical Response

Light Coma

Immediate Day 1-2

SEEE
**Immediate**

- *CT*
  - Severe Cerebral Edema

**Day 1-2**

- *EEG*
  - Continuous
  - Burst – Suppression
  - NCSE
  - MSE

**Day 3-7**

- *Awaken*
  - Light Coma
  - SSEP
  - N20 Present
  - N20 Absent

**Long-Term Support**

- No Cortical Response

**Persistent Vegetative State**

**Initial Exam**

- Brain Death
MRI for Persistent Coma after Cardiac Arrest

Patients with MRI obtained for persistent coma 3-10 days post-CPR (DWI images shown)
MRI Patterns versus Outcome

**Widespread Cortical Damage**
- Eyes open = “Wakefulness”
- No verbal response
- No apparent communication or understanding
- “Vegetative”

**Subcortical Damage**
- Recovers wakefulness in ~6 days with tremors x weeks
- Normal cognitive recovery and return to work
- Subtle clumsiness.
Extent of Restricted Diffusion on DWI versus Survival

- None: n=21
- 1 to 2: n=12
- 3 to 4: n=7
- >5: n=16
Clinical Example (6)

- On day 4, check MRI
  - Reading is “Early ischemic changes in medial occipital lobes bilaterally.”
Test #6 - MRI for Persistent Coma

Pretest
Comatose and gets MRI on day 3-14

Survival 27% (15/56)

Posttest

MRI with DWI and FLAIR

Normal; 37% (21/56)
57% (12/21) survive

Focal Abnormalities; 36% (20/56)
30% (6/20) survive

Diffuse Injury; 27% (15/56)
7% (1/15) survive
Brain Death

CT: Persistent Vegetative State
EEG: Continuous Burst-Suppression
NCSE: No Cortical Response
MSE: N20 Absent
MRI: N20 Present

Immediate
Initial Exam: Severe Cerebral Edema

Day 1-2
Convulsive State

Day 3-7
Awaken

Light Coma
SSEP: N20 Present
Long-Term Support

ImmtEDIATE
Brain Death
Persistent Vegetative State
Brain Death

Initial Exam
- CT: Severe Cerebral Edema
- EEG: Continuous, Burst-Suppression, NCSE, MSE
- MRI: Normal, Focal, Diffuse
- SSEP: N20 Present, N20 Absent

Immediate

Day 1-2
- Awaken

Day 3-7
- Long-Term Support

Persisted Vegetative State

Immediate Day 1-2 Day 3-7

Light Coma
- No Cortical Response

Nonawakened
- No Cortical Response

Brain Death
Brain Death

CT EEG

Persistent Vegetative State

Continuous Burst – Suppression NCSE MSE

Awaken

MSE

MRI

No Cortical Response

Light Coma

Focal Diffuse

SSEP

N20 Present

N20 Absent

Immediate

Day 1-2

Day 3-7

Initial Exam

Severe Cerebral Edema

Immediate Day 1-2 Day 3-7

Light Coma

Long-Term Support

Brain Death

Persistent Vegetative State

Normal

Immediate

Initial Exam

Severe Cerebral Edema

Immediate Day 1-2

Light Coma

Long-Term Support

Brain Death

Persistent Vegetative State
Clinical Example (7)

• Clinical Exam is unchanged for a week
  – Primary team, neurology and we advise that recovery is unlikely
  – Daughter states “This is my mom. I am just can’t handle pulling the plug.”
  – Palliative care meets with family, but goals remain the same

• PEG and Trach on Day 14
Clinical Example (8)

- Patient moves to stepdown with trach mask on day 15
  - Awaiting SNF nearer to home
  - Has insurance issues that delay discharge

- PT / OT involved for passive range of motion, splints

- Trial of stimulants
  - Goal is to increase “arousal”
  - Methylphenidate start 10 mg twice per day
  - Amantadine start 100 mg once-twice per day
  - These are associated with higher rates of awakening (*Reynolds 2013, Resuscitation*)
Clinical Example (9)

• After 29 days, patient awakens!
  – Recalls going into kitchen to wash dishes, then nothing for 1 month

• Weak and drowsy, but improves daily
  – Reverses DNR status
  – Consents for implantable defibrillator (ICD)

• PM&R takes to inpatient TBI Rehab –
  – Starts on day 42 (after ICD)
  – “Alert, oriented to person, place, year but not exact date...weak voice...recalls 3/3 items at 1 minute; 1/3 at 5 minutes...”
Functional Neurologic Outcomes Change Over the First 6 Months After Cardiac Arrest

Julia T. Tong, BA¹; Irina Eyngorn, MD¹; Michael Mlynash, MD¹; Gregory W. Albers, MD²; Karen G. Hirsch, MD²

Crit Care Med 2016; 44:e1202–e1207
Clinical Example (10)

• Anticonvulsants tapered off during rehab

• PM&R discharge on day 47
  – Assist for transfers.
  – Ambulates 300 feet with wheeled walker
  – Supervision for stair climbing of 12 stairs
  – Independent grooming
  – Assistance for other ADLs

  – Some visual limitations (occipital ischemia on DWI!)
Conclusion

• Use multiple modalities over a sufficient period of time to determine prognosis after cardiac arrest
  – Each test result *alters estimated probability* of outcome
  – *No single test* or exam absolutely guarantees (FPR=0%) bad outcome: need better studies!
  – *Multiple tests* provide more certainty
  – Consider *waiting longer* in patients who are indeterminate
  – Recovery *continues over weeks and months* after ICU
  – Consider *long-term support* in absence of “devastatingly bad” findings