Physiologic and prognostic significance of “alpha coma”

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SUMMARY A patient with posthypoxic “alpha coma” is described whose EEGs were recorded before coma, within two hours following the onset of coma and after recovery. The differences observed between the alpha activity during coma and that seen before and after suggest that the alpha activity during coma and the physiologic alpha rhythm are different phenomena. This case, as well as others reported, also suggests that “alpha coma” resolving in the first 24 hours following hypoxia may have a better prognosis than “alpha coma” detected after the first day, and stresses the need for EEG monitoring begun in the immediate period following hypoxia in order to assess accurately the prognostic significance of this EEG pattern in the early stages of postanoxic encephalopathy. The aetiology of “alpha coma” also affects outcome. The survival rate appears higher in patients with respiratory arrest than in those with combined cardiopulmonary arrest.

“Alpha coma” was first described in patients with brainstem lesions and later in patients with posthypoxic coma and coma from drug overdose. With a few notable exceptions, the EEG prior to the onset of coma has not been available, and it remains uncertain whether this pattern represents a retained physiological alpha rhythm or is an abnormal pattern. The prognosis of “alpha coma” has been generally considered to be poor, although some patients have experienced partial or complete recovery. In most instances, however, EEGs with alpha pattern coma have been recorded several hours or days after the onset of coma, and recordings during the first few hours of coma are scarce. This is particularly relevant since the time of recording is critical in assessing the prognostic significance of EEG patterns following cerebral hypoxia. The following is a case report of a patient who recovered from posthypoxic “alpha coma” on whom we had the opportunity to record EEGs prior to the hypoxic episode, within two hours of the onset of coma, and after recovery. The available literature is reviewed in the light of this observation.

Case report

A 64-year-old man with hypertension and severe widespread arteriosclerotic vascular disease suffered several 2-3 minute episodes of transient loss of consciousness in 1977. Two EEGs eight months apart were performed that year. The tracings (fig 1) showed well modulated 40-50 \( \mu V \) activity confined to the occipital, parietal, and posterior temporal regions of both hemispheres that was attenuated by eye opening. Generalised rhythmic 30-40 \( \mu V \) beta activity was also noted, and was thought to be related to 15 mg oral diazepam that the patient was receiving daily. During Stage I of sleep, the alpha activity subsided and generalised rhythmic 20-30 \( \mu V \), 4-7 Hz activity appeared, most prominent over the fronto-central regions. During Stage II of sleep, physiological vertex waves as well as symmetrical 14-15 Hz sleep spindles were present. Hyperventilation elicited no significant change, and photic stimulation resulted in no consistent photointertrainment.

During the ensuing years, he developed unstable angina and suffered five myocardial infarctions. In December of 1980, he had a new myocardial infarction accompanied by congestive heart failure and acute pulmonary oedema. He received immediate care and during attempts at endotracheal intubation he became unresponsive. Examination one hour later showed him to be comatose, perspiring profusely and agitated with a respiratory rate of 35/min, pulse 90/min and blood pressure of 180/110 mm Hg. He did not follow commands or open his eyes to auditory stimulation,
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Fig 1  EEG performed prior to "alpha coma" showing a posteriorly distributed alpha rhythm that attenuates with eye opening. Time constant: 1 s. High frequency filter (−3 dB): 70 Hz.

Fig 2  EEG performed within two hours after the onset of coma showing widespread unreactive alpha activity, maximal anteriorly as well as theta and delta potentials, maximal on the left side. Prominent head movement artifact from laboured respirations arising from the left occipito-parietal region obscured some portions of the tracing. The patient was perspiring profusely and sweat artifact is also present. Time constant: 1 s. High frequency filter (−3 dB): 70 Hz.
and he responded to pain only with incomprehensible sounds and withdrawal. His Glasgow Coma Scale rating\(^1\) was 6. Pupils were equal and reacted normally to light. Roving conjugate horizontal eye movements were present and the oculocephalic responses were normal. Corneal and gag reflexes were present. The muscle tone was normal, and all extremities exhibited withdrawal to painful stimulation. Muscle stretch reflexes were normal, and there were flexor plantar responses bilaterally. The EEG performed within two hours of the onset of coma (fig 2) showed rhythmic, 20–30 μV, 11–12 Hz activity with generalised distribution, but more prominent anteriorly and of slightly greater amplitude on the right side. This activity was fairly constant in amplitude and frequency, and did not change with painful stimulation, auditory stimulation or passive eye opening. A moderate amount of irregular, 20–40 μV, 2–5 Hz potentials were also seen that, although generalised, had lower amplitude over the left centro-parietal region. 20–60 μV, 0–5–1 Hz potentials were present maximally over the left centro-parietal region. Shortly after completion of the EEG, the patient underwent endotracheal intubation. He remained in coma for the next four hours. Subsequently, he exhibited gradual improvement, and twelve hours after the onset of coma he was alert and able to open his eyes to command. He followed only simple instructions and did not talk. He also had a moderate right hemiparesis as well as a right extensor plantar response, and was believed to have suffered a left hemispheric infarct. An EEG performed at that time showed generalised fairly rhythmic 20–40 μV, 6–7 Hz theta activity. Rare potentials of 20–30 μV and 11–12 Hz were also present diffusely. In addition, polymorphic 20–40 μV, 1–3 Hz delta potentials were prominent over the left temporal region. The patient showed progressive neurological improvement, and six months later his residual deficit was a non fluent aphasia and he was moderately disabled according to the Glasgow Outcome Scale.\(^2\) EEGs performed two and six months after the onset of coma (fig 3) showed an alpha rhythm of 20–40 μV and 9–10 Hz confined to the occipital, parietal and posterior temporal regions of both sides. This activity was attenuated by eye opening, painful stimulation and auditory stimulation. A small amount of irregular low to medium voltage 6–7 Hz theta activity was also present diffusely. Low to medium voltage irregular 1–3 Hz delta activity was detectable over the left hemisphere, particularly the left temporal region, more so in the record performed two months after the onset of coma than in the record performed six months afterwards. No significant changes occurred with hyperventilation or photic stimulation. Sleep records were not made.

**Discussion**

The present case is unique in that it demonstrates “alpha coma” in the immediate posthypoxic period in a patient who recovered and had had prior EEGs. The data from this patient combined with the available reports in the literature contribute to our understanding of: (1) the relationship of the alpha pattern in coma to the physiologic alpha rhythm, and (2) the prognostic value of early resolving “alpha pattern coma”.

Important differences were observed in our patient between the alpha activity during coma and that recorded before or after coma. Distinguishing characteristics include the frequency, amplitude,
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Table 1  Alpha coma patients who recovered consciousness

<table>
<thead>
<tr>
<th>Reference</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Aetiology</th>
<th>Length of coma</th>
<th>Time from onset of coma to EEG</th>
<th>EEG during coma</th>
<th>EEG after coma</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>22</td>
<td>53</td>
<td>M</td>
<td>CA during diabetic coma</td>
<td>8 d</td>
<td>48 h</td>
<td>10–11 Hz, 20–40 µv, 6–7 Hz diffuse</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>48</td>
<td>M</td>
<td>CA from anaphylaxis</td>
<td></td>
<td>48 h</td>
<td>9–10 Hz, 15–30 µv diffuse unreactive</td>
<td>5–7 Hz diffuse</td>
<td>b</td>
</tr>
<tr>
<td>23</td>
<td>28</td>
<td>M</td>
<td>CA from electrical injury</td>
<td>3 wks</td>
<td>19 h</td>
<td>7–9 Hz, low amp, gen max fronto - central, unreactive</td>
<td>8–10 Hz Posterior reactive</td>
<td>b</td>
</tr>
<tr>
<td>23</td>
<td>26</td>
<td>M</td>
<td>CA from electrical injury</td>
<td>2 wks</td>
<td>24 h</td>
<td>9–11, med. amp, gen, max fronto - central</td>
<td>7–8 Hz, very low voltage reactive</td>
<td>b</td>
</tr>
<tr>
<td>14</td>
<td>81</td>
<td>F</td>
<td>RA from vertebro - basilar insuff.</td>
<td>4 wks</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>c</td>
</tr>
<tr>
<td>14</td>
<td>52</td>
<td>F</td>
<td>RA from food asp.</td>
<td></td>
<td>2 mo</td>
<td>*</td>
<td>*</td>
<td>c</td>
</tr>
<tr>
<td>14</td>
<td>28</td>
<td>F</td>
<td>Malpositioned endotracheal tube</td>
<td>Not stated</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>c</td>
</tr>
<tr>
<td>24</td>
<td>56</td>
<td>M</td>
<td>CA</td>
<td>—</td>
<td>24 h</td>
<td>&quot;alpha-coma&quot;</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>39</td>
<td>M</td>
<td>CA from myocardial infarction</td>
<td>3 d</td>
<td>18 h</td>
<td>8 Hz, max. fronto-temp. unreactive</td>
<td>9–10 Hz and 4–7 Hz, 30–50 µv &quot;Normal&quot;</td>
<td>—</td>
</tr>
<tr>
<td>26</td>
<td>16</td>
<td>M</td>
<td>CA</td>
<td>5 d</td>
<td>24 h</td>
<td>Alpha, max. frontal reactive</td>
<td>&quot;Normal alpha&quot;</td>
<td>b</td>
</tr>
<tr>
<td>26</td>
<td>66</td>
<td>M</td>
<td>CA</td>
<td>6 d</td>
<td>4 d</td>
<td>Alpha, Not reported</td>
<td>a</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>34</td>
<td>M</td>
<td>CA</td>
<td>15 d</td>
<td>1 d</td>
<td>Alpha, max. frontally unreactive</td>
<td>5 Hz, 40–150 µv post. reactive; widespread theta and delta</td>
<td>a</td>
</tr>
<tr>
<td>41</td>
<td>11%</td>
<td>M</td>
<td>Strangulation</td>
<td>8 d</td>
<td>3 d</td>
<td>10–11 Hz, 50–120 µv, gen, max middle and Post. areas, unreactive; widespread theta and delta</td>
<td>9–10 Hz and Post. reactive; widespread theta and delta</td>
<td></td>
</tr>
<tr>
<td>37</td>
<td>12</td>
<td>M</td>
<td>CA</td>
<td>19 d</td>
<td>3 d</td>
<td>11–5 Hz, widespread not reported</td>
<td>b, c</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>34</td>
<td>F</td>
<td>RA from Elavil ingestion</td>
<td>24 h</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>a</td>
</tr>
<tr>
<td>14</td>
<td>38</td>
<td>F</td>
<td>RA from barbiturate overdose</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>a</td>
</tr>
<tr>
<td>31</td>
<td>41</td>
<td>M</td>
<td>RA from tranquillizers</td>
<td>24 h</td>
<td>12 h</td>
<td>Unreactive alpha</td>
<td>Normal reactive alpha</td>
<td>c</td>
</tr>
<tr>
<td>†</td>
<td>64</td>
<td>M</td>
<td>CHF from myocardial infarction</td>
<td>12 h</td>
<td>2 h</td>
<td>11–12 Hz, 20–30 µv gen, max, frontal, unreactive</td>
<td>9–10 Hz, 20–40 µv posterior reactive</td>
<td>b</td>
</tr>
<tr>
<td>12</td>
<td>63</td>
<td>F</td>
<td>Verteobasilar insufficiency</td>
<td>1 h</td>
<td>10 sec (coma onset during EEG)</td>
<td>12–14 and 8 Hz, 20–30 µv unreactive</td>
<td>10–12 Hz 20–35 µv reactive</td>
<td>a</td>
</tr>
<tr>
<td>14</td>
<td>68</td>
<td>M</td>
<td>Midbrain infarction</td>
<td>6 wks</td>
<td></td>
<td>*</td>
<td>*</td>
<td>b, c</td>
</tr>
</tbody>
</table>

Patients with alpha coma from drug overdose or head trauma are not included.
*This study comprises 24 patients in 16 of whom the initial EEG was performed within 24 hrs after the onset of coma. The alpha activity was diffuse in 9 patients, anteriorly predominant in 11 and posteriorly predominant in 4. Sensory stimulation was performed in 18 patients, and the EEG of only one patient considered to be "locked-in" showed a response. Follow-up EEGs in 5 of the 9 survivors demonstrated a low voltage alpha rhythm that responded to visual stimulation.
†Present report.
§CA = cardiac arrest; RA = respiratory arrest; CHF = congestive heart failure.
$a = full recovery; b = intellectual deficit, aphasia; c = motor disability, gait ataxia.

morphology, topography and/or reactivity. The premorbid alpha rhythm was of lower frequency and higher amplitude than the alpha activity during coma. It also displayed typical spindling while the alpha activity during coma was sustained and displayed little voltage modulation. The "normal" alpha rhythm was most prominent over the posterior head regions and was reactive to sensory stimulation, whereas the alpha activity during coma was widespread and unreactive. Similar differences between alpha activity during coma and that following coma have been reported in a number of cases who
recovered from “alpha coma” (table 1). However, few reports contain an EEG taken prior to the onset of coma. Carroll and Mastaglia reported four patients with “alpha coma” caused by drug intoxication apparently uncomplicated by cerebral hypoxia. An EEG prior to the onset of coma, available in one of the patients, showed “reactive and symmetrical 10 c/s alpha activity in a posterior distribution”. An EEG during coma showed “symmetrical 10 c/s alpha activity in a fronto-central distribution which did not react to manual eye opening or to vigorous auditory or painful stimuli”. An EEG following recovery was similar to the one prior to the onset of coma. The authors suggested that pharmacological depression of the brain stem reticular formation played an important role in the pathogenesis of drug-induced “alpha coma”, its genesis therefore being similar to that of “alpha coma” in structural brain stem disease. Jones et al. reported a patient with vertebro-basilar insufficiency due to cervical osteochondrosis, in whom transient ischaemia of the brainstem resulted in coma lasting about one hour. Prior to the onset of coma, the EEG showed “a partially responsive and symmetrical alpha rhythm at 10–12 c/s of 20–35 \( \mu V \)”. During coma, “the dominant activity was within the alpha frequency range, chiefly at 12–14 c/s, but intermixed at times with waves of about 8 c/s; the amplitude was usually 20–30 \( \mu V \) peak to peak. Auditory or painful stimuli and passive opening of the eyes were without apparent effect on the EEG.” Topography was not reported. An EEG following recovery from coma was similar to the first EEG. Lundervold studied a patient who did not recover from coma following vertebral angiography in whom post mortem examination showed a pontine lesion involving the reticular formation. The alpha activity during coma had the same amplitude, frequency and distribution as the alpha rhythm recorded before coma, but it did not react to sensory stimulation. Molofsky reported “alpha coma” in a 12-year-old boy whose EEG at age 10 “was normal showing a well-developed 50–60 \( \mu V \) 10 Hz alpha rhythm which remained with eye opening”. An EEG on day 1 of posthypoxic coma showed “diffuse slowing composed of low voltage polymorphic 1–2 Hz waves and small amounts of intermixed 7–8 Hz activity”. On day 3, “the EEG was characterised by widespread 11.5 Hz rhythmic activity unreactive to auditory, visual or noxious stimuli”. On day 10, the EEG showed “continuous polymorphic and rhythmic 5–7 Hz activity, residual 1–3 Hz waves and abnormal sleep patterns”. “Alpha coma” has also been reported in three children of 2, 22 and 30 months of age though a posterior dominant rhythm in the alpha range is not typical of this age group. These observations and the findings in our patient support the interpretation that the alpha activity in comatose patients is an abnormally generated pattern different from the physiologic alpha rhythm.

Unlike our case and the paediatric case of Molofsky, the other reports containing an EEG prior to the onset of coma are of patients whose “alpha coma” was thought secondary to drug or vascular insult to the brain stem. Apparently, there are some differences between the alpha activity in this clinical circumstance and the alpha activity in posthypoxic coma. In patients rendered comatose by cardiac or respiratory failure, the alpha activity is either generalised or most prominent over the anterior head regions, and is usually unreactive to sensory stimulation, as in our patient. Moderate amounts of theta and delta potentials are also reported. On the contrary, the alpha activity is typically maximal over the posterior head regions and may be attenuated by sensory stimulation, although in some patients, stimulation failed to alter the EEG. This emphasises the fact that patients with “alpha coma” have to be distinguished from those with the “locked-in syndrome”. The latter patients usually have an alpha rhythm with normal topography and reactivity and are conscious, though they may appear to be in coma because they are mute and quadriplegic. In these cases a reactive alpha rhythm suggests that the patient may be awake and “locked-in” rather than comatose, as pointed out by Grindal et al.

The prognosis of “alpha coma” has generally been thought to be poor although recovery with little or no neurological deficit has been reported in some patients including two of the four reported paediatric cases. The aetiology of the coma has bearing on the outcome (table 1). Only two of approximately 40 patients with “alpha coma” from brainstem lesions reported in the English literature survived, one of whom had significant mental and motor disability. All patients with drug overdose, with or without respiratory arrest, survived without sequelae. Though the sample is small, the survival rate of patients with posthypoxic “alpha coma” seems to be higher with respiratory arrest than with cardiopulmonary arrest (table 2). In our case, significant but incomplete clinical recovery occurred with the most important disability being a nonfluent aphasia secondary to left hemispheric infarct. Although an alpha rhythm developed with characteristic physiologic distribution and reactivity, polymorphic delta activity remained in the left temporal region as a consequence of the stroke.

The timing of electroencephalography following
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Table 2  Outcome of patients with post hypoxic alpha coma

<table>
<thead>
<tr>
<th>Author</th>
<th>No of pts.</th>
<th>Cardiopulm arrest pts/survivors</th>
<th>Respiratory arrest pts/survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lindgren et al12</td>
<td>1</td>
<td>1/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Britley et al13</td>
<td>1</td>
<td>1/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Vignaendra et al11</td>
<td>8</td>
<td>8/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Westmoreland et al13</td>
<td>5</td>
<td>5/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Chokroverty22</td>
<td>9</td>
<td>9/2/</td>
<td>0/0</td>
</tr>
<tr>
<td>Grindal et al14,15</td>
<td>20</td>
<td>14/2*</td>
<td>6/5†</td>
</tr>
<tr>
<td>Snyder et al14</td>
<td>2</td>
<td>2/1</td>
<td>0/0</td>
</tr>
<tr>
<td>Sorensen et al16</td>
<td>13</td>
<td>13/3</td>
<td>0/0</td>
</tr>
<tr>
<td>Alvin et al27</td>
<td>30</td>
<td>30/1</td>
<td>0/0</td>
</tr>
<tr>
<td>Obeso et al11</td>
<td>2</td>
<td>2/0</td>
<td>0/0</td>
</tr>
<tr>
<td>Kuroawa and Furukawa11</td>
<td>1</td>
<td>0/0</td>
<td>1/1†</td>
</tr>
<tr>
<td>Collins and Chatrian41</td>
<td>1</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td>Molofsky37</td>
<td>1</td>
<td>1/1</td>
<td>0/0</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>86/10</td>
<td>8/7</td>
</tr>
</tbody>
</table>

*Cardiac arrest was secondary to electrical injury in both survivors.
†In two of the survivors, respiratory arrest was secondary to drug intoxication.
‡Respiratory arrest was secondary to drug intoxication.

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Addendum

Janati and Erba44 recently reported “alpha coma” in three children with near-drowning accompanied by cardiorespiratory arrest that required resuscitation. The EEGs recorded within 72 hours after the accident, “presented widespread delta activity superimposed by 8–13 c/sec rhythms which were either diffuse or maximal in the frontal regions. Although largely unreactive, this alpha-like activity was at times attenuated by painful stimulation.” Two male children ages 3-5 and 5 years, died days after the accident. The third one, a 22-month-old girl, survived with severe neurological deficits.

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