# SLEEP VS COMA

**By Quentin Noirhomme, Steven Laureys and Mélanie Boly**

What are the differences between coma and sleep? Can patients in coma and related states have self-awareness or dreamlike experiences as can be encountered in sleep? Behaviorally, a coma may resemble deep sleep – the major difference being that comatose patients will never open the eyes, not even when intense or noxious stimuli are applied. Patients evolving from a coma to a vegetative state may, in turn, be compared to sleepwalkers – only showing reflex or automatic behavior, but not command following (Laureys, 2005). In addition, electroencephalography (EEG) shows similarities between coma (or the vegetative state) – classically showing diffuse slowing of the brain's basic rhythms – and deep (stage 3-4) sleep. EEG spindle activity (the hallmark of stage 2 sleep) can also be observed in some comatose or vegetative patients and seems to be a predictor of good outcome. Whereas coma patients will never show the EEG characteristics of REM sleep, it remains controversial whether vegetative patients may present periods of REM sleep. The very unstructured and slow waking EEG encountered in the vegetative state makes it utterly difficult to identify possible REM sleep other than by the presence of muscular atonia and eye movements – note that nocturnal penile erections have been convincingly shown in vegetative patients (Cologan et al., in press).

The brain's metabolic activity in a coma, as measured by fluorodeoxyglucose positron emission tomography or FDG-PET, decreases to about half of normal waking values, and to ~40-50% of normal values in the vegetative state. These massive decreases in cortical metabolism are comparable to what is observed in deep sleep (~60% of waking values) but much lower than what is seen in REM sleep (where overall cerebral metabolism is comparable to normal wakefulness). The areas that are the most dysfunctional in coma and vegetative states are the frontoparietal associative cortices, also known to show the lowest metabolism in sleep (and in sleepwalking) (Laureys, 2005).

In response to external stimulation, functional magnetic resonance imaging (fMRI) and event related potential (ERP) studies have shown residual activation of "lower order" primary sensory cortices (but not of "higher order" frontoparietal associative networks) in coma and vegetative states, similar to what has been observed in sleep (Owen et al., 2009). In clinical practice, the absence of primary cortex activation, as measured by somatosensory ERPs, is a strong indicator of bad outcome in coma. Recent research is employing fMRI to study the brain's so called "resting state" or "default" activity (where in the normal waking state mind wandering, inner speech and mental imagery are occurring in the absence of any external stimulation). Preliminary results show some partially preserved cerebral default network connectivity in both coma and vegetative states and in non-REM sleep – but it remains to be shown whether this truly reflects conscious cognitive activity or some residual structural (thought-independent) connectivity (Boly et al., 2009).

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Functional neuroimaging techniques have only recently begun to probe for residual consciousness in coma and sleep. fMRI and ERP studies are now uncovering undeniable signs of awareness in some clinically vegetative or minimally conscious coma survivors (Schnakers et al., 2008). The logical next step is to employ these novel real-time fMRI or EEG-based brain-computer interfaces to permit these exceptional, but very challenging patients, to communicate their possible inner thoughts (Sorger et al., 2009), inaccessible even to the most detailed behavioral assessments.


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