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REVIEW ARTICLE

Near-death experience during cardiac arrest and consciousness beyond the brain: a narrative review

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ABSTRACT

In this narrative review, we will critically assess whether the occurrence of near-death experience (NDE) associated with cardiac arrest (CA) may be explained by brain electrical activity or whether this empirical evidence supports an alternative theory, namely, that consciousness may persist and function beyond the brain. Empirical evidence suggests that NDEs associated with CA likely arise during the patient's unresponsiveness, rather than in the early CA phases or after cardiopulmonary resuscitation (CPR), when the brain may still be functional or later recover. There has been no evidence that cortical electrical activations recorded in dying patients and during CPR may be involved in NDEs, since no reports of subjective experience have been associated with such brain recordings. Alternatively, these findings may be interpreted as a result of muscular artifacts or circulatory disturbances in such contexts. CA leads to the interruption of oxygenated blood flow to the brain and loss of cortical electrical activity within 10–30 seconds. During CPR, brain electrical activity may remain absent or severely disturbed. Given that NDEs appear to occur at the very moment in CA when the brain is severely compromised, this can be assumed as evidence for the continuity of consciousness beyond the brain.

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Introduction

In the last decades, we have witnessed a growing flow of scientific research in spiritual experiences that have evaluated the possibility of consciousness (mind or self) existing beyond brain functioning (Daher et al., 2017). More specifically, mediumistic communications, near-death experiences, terminal lucidity, and cases suggestive of reincarnation memories have been evaluated as evidence in support of the possibility of autonomy of consciousness in relation to the brain and its continuity after bodily death (Daher et al., 2017; Kelly et al., 2007; Moreira-Almeida et al., 2022; van Lommel, 2010, 2023).

In this article, we will evaluate the implications of the 'near-death experience' ('NDE') for the issue of consciousness beyond the brain, discussing its occurrence during cardiac arrest (CA). More specifically, we will discuss whether brain electrical activity could explain NDEs related to patients who have suffered CA.

Scope of the problem

The brain's energy is mainly based on the high consumption of oxygen and glucose from the body, critically provided and sustained by blood flow, which is pumped by the heart into the body (Hofmeijer & van Putten, 2012). Adequate heart rate and degrees of oxygen and glucose are termed 'background conditions' for enabling large-scale brain activity critical for consciousness (Tononi & Koch 2015; Koch et al., 2016; Boly et al., 2017).

If heartbeats become sharply irregular and then stop, the brain (and body) are instantly deprived of blood (ischemia) and, consequently, of oxygen (anoxia), amounting to a physiological impairment known as cardiac arrest (CA) (Gopalan et al., 1999; Hossmann & Kleihues, 1973; Visser et al., 2001). CA is a life-threatening condition in which procedures for restoring the blood circulation and oxygen delivery are required within a few minutes, namely cardiopulmonary resuscitation (CPR) (Parnia et al., 2023; van Lommel et al., 2001).

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The critical, large-scale neural activity involved in consciousness, in brainstem, thalamus, and wide regions of the cortex (Koch et al., 2016; Mashour et al., 2020; Mudrik et al., 2025), is vulnerable to ischemia (Candia-Rivera & Machado, 2023; Rossini et al., 1982; Visser et al., 2001; Yang et al., 1997). External signs of consciousness are lost soon after CA onset and may remain undetectable throughout CPR (Pana et al., 2016; Parnia et al., 2014, 2023). The compromised state of the body during CA, although reversible by CPR, has the major clinical criteria for determination of death: no circulatory and respiratory functions, and absence of brainstem reflexes (van Lommel et al., 2001; Parnia et al., 2014).

Reversal of this clinical condition, and ultimately recovery of health and consciousness, cannot be achieved with external CPR (chest compressions) alone, but defibrillation (an electric shock) is usually required to restore heart rhythm. For instance, blood supply to the brain is about 5-10% of its normal value during CPR in dogs (White et al., 1983). Long CPR duration is associated with high mortality and poor outcome since recovery from CA requires successful defibrillation, and external CPR itself is insufficient to prevent irreversible neuronal damage (Peberdy et al. 2003).

Several prospective studies have found that ~6–20% of CA survivors reported a near-death experience (NDE), a structured and coherent conscious awareness with transcendent and mystical features and, sometimes, ~2% reported auditory and visual recollection, described as if perceived from a position above their bodies (van Lommel et al. 2001; Schwaninger et al. 2002; Greyson 2003; Klemenc-Ketis et al. 2010; Parnia et al., 2001; Parnia et al. 2014; Parnia et al. 2023). These reports suggest that someone may be conscious and aware of his/her environment during circulatory arrest (Parnia et al., 2014; van Lommel et al., 2001).

Survivors of CA and other life-threatening conditions who report NDEs usually describe the content of their experience as real (i.e. not as a kind of psychologically-based or pathologically-induced dream or hallucination) or as more real than the normal waking consciousness experienced in our familiar physical environment (Schwaninger et al., 2002; Moore & Greyson, 2017). The memory of an NDE can be as clear and phenomenologically detailed as or more than the memory of important autobiographical events, and clearer and richer than imagined memory events (Moore & Greyson, 2017; Palmieri et al., 2014; Thonnard et al., 2013).

Further, CA patients who report NDEs showed greater changes in their lives than those without an NDE in terms of increased belief in life after death, decreased fear of death, interest in spirituality, meaning in life and altruistic behaviors (Schwaninger et al., 2002; van Lommel et al., 2001). This impact intensified over the years, as measured two and eight years after the NDE (van Lommel et al., 2001), and persist undiminished over decades (Greyson, 2022).

The association between NDE and CA has compelled researchers in this field to call into question the mainstream assumptions regarding the nature of the relationship between consciousness and brain (Greyson, 2003; Parnia et al., 2014; van Lommel et al., 2001; Von Haesler & Beauregard, 2013). Because CA provides a model for investigating consciousness during the dying process, given NDEs appear to occur at the very time during circulatory arrest when the brain is severely injured, this may be assumed as evidence for the continuity of consciousness beyond the brain (Moreira-Almeida et al., 2022; Parnia et al., 2014; van Lommel, 2023).

However, researchers have speculated that brain activity could explain the NDE occurrence, arguing that NDEs could occur before or after unconsciousness, when neural activity is still preserved before the ischemic insult or later recovered by CPR (Kondziella & Martial, 2022; Martial et al., 2022). Recent findings of cortical electrical activity in the higher frequency bands in dying brain and CPR have been speculatively linked to NDEs (Borjigin et al., 2013; Chawla et al., 2009; Parnia et al., 2023). If so, the questions are: Could brain activity explain the NDEs? Or could these experiences reported by CA survivors be evidence for consciousness beyond the brain?

When is NDE likely to occur in relation to CA?

Under the assumption that consciousness and memory require brain functioning to exist, it has been argued that an NDE might not occur when the heart stops and the brain is severely impaired, but at periods around CA when neural activity is still able to function or later resumed by CPR (Kondziella & Martial, 2022): (a) before CA (Martial, Fritz et al., 2024a; Peinkhofer et al., 2019); (b) just before loss of consciousness (Kondziella & Martial, 2022; Martial et al., 2022); (c) when brain function is restored after CA (Peinkhofer et al., 2019); (d) immediately after consciousness is regained (Martial et al., 2022); and (e) upon recovery (Martial, Fritz et al., 2024a).

The first proposition of NDEs occurring prior to CA has a critical flaw, namely, the lack of a precipitating condition in connection with NDE occurrence. These experiences are known to be correlated with several physiological and/or psychological conditions (Owens et al., 1990; Lai et al., 2007). Without an underlying precipitating condition, it seems implausible that NDEs could occur spontaneously without any connection with a CA about to happen.

A CA occurs so unexpectedly that most patients are not aware of the moment they entered the state and, therefore, have no recollection of that period (Greyson, 2003; van Lommel et al., 2001). For instance, CA survivors describe the onset of their NDE without any mention of visual or auditory awareness of events around the onset of CA (Cassol et al., 2018). When surrounding events have been reported, there is a discontinuity between the description of them and the NDE account itself (see, e.g. Greyson, 2021, p. 45–46; Parnia et al., 2014, p. 1803).

If a patient who has just entered CA has an NDE while still awake, awareness of the early CA stages should be often recalled and reported. So, in terms of such a hypothesis, it is puzzling that CA patients do not report frequently external events occurring around the onset of the NDE, since NDE memories are typically, among other features, rich in contextual details (Moore & Greyson, 2017; Palmieri et al., 2014; Thonnard et al., 2013) and vividly recalled despite the passage of time (Greyson, 2007; van Lommel et al., 2001).

In a prospective study with 1.595 cardiac patients, NDE experiencers were more likely than non-experiencers to have a CA and reported more loss of consciousness (Greyson, 2003). More specifically, 10% of 116 CA survivors described an NDE, and only 1% of the patients who suffered other severe cardiac conditions without CA. Patients with NDE were more likely to self-characterize the subjective state during the cardiac event as 'loss of consciousness', but not 'diminished consciousness' or 'normal consciousness' (Greyson, 2003).

Holden (2009, pp. 185–211) reviewed 107 NDEs with potentially verified reports of auditory and visual awareness of the physical surroundings related to the patient's unresponsiveness. Of these, 92% of the cases had weak to strong evidence that the perceptions were completely accurate, only 6% and 2% respectively contained some inaccuracy or were inaccurate, and the accuracy of 34% was corroborated by independent sources such as doctors or nurses, or by medical records etc. (Holden et al., 2009, pp. 185–211).

An NDE from Holden et al. (2009) review was described by Sabom, the so called 'Pam Reynolds case', associated with general anesthesia and CA, during a surgical procedure to remove a giant basilar cerebral aneurysm (Sabom, 1998, pp. 37–51; 184–191). The brain surgery consisted of deep hypothermia (reaching 60 degrees Fahrenheit) and induced cardiorespiratory arrest in order to drain blood from her body, and brain. Electrical activity of the cortex was monitored with an electroencephalogram (EEG). Clicks were elicited from speakers inserted in her ears, to measure auditory responses in the brainstem.

The patient reported an out-of-body experience (OBE), as part of her NDE, and described having seen and heard events related to her operation, which have been largely confirmed as accurate (Rivas et al., 2023, p 114–1322, 361–375). For instance, she describes a conversation: 'someone said something about my veins and arteries being very small. I believe it was a female voice and that it was Dr. Murray, but I'm not sure. She was the cardiologist [*sic*]' (Sabom, 1998, p. 42). Following the OBE, she felt like she was being pulled through a tunnel, and she encountered a bright light and deceased relatives who, at a certain point, told her that she should go back through the tunnel. 'When I came back, they were playing 'Hotel California'' (Sabom, 1998, p. 47).

The operative record review confirmed the female cardiovascular surgeon and the conversation that was described in the section 'Findings at the time of surgery', as an unexpected event: '…the right femoral artery and vein were exposed, and the rigid common femoral artery was quite small, approximating the size of a normal saphenous vein bypass' (Sabom, 1998, p. 185). A neurosurgeon involved in this surgery confirmed that the song was played in the operating room (Rivas et al., 2023, p. 400).

These veridical perceptions correspond to the period before and after CA and blood drainage. Interestingly, she did not report in the auditory descriptions the clicks of the auditory brainstem test. As pointed out by Holden, if the patient had been hearing through normal means, it is intriguing that 'she never mentioned even hearing clicks, more or less feeling distracted by them or struggling to hear through them' (Holden et al., 2009, pp. 198–199).

Under CA, the patient was clinically dead as evidenced by flat EEG, absence of brainstem response, and interrupted cerebral blood flow. Her NDE has been described as a continuous sequence of events. Since the initial veridical perceptions occurred in the anesthetic period, it seems to suggest that this patient maintained conscious awareness throughout CA, because the experience ended with her return to the body, when the surgical procedure had already been performed.

Another case from Holden et al. (2009)'s review was reported by van Lommel et al. (2001, p. 2041), in which a male patient reported auditory and visual details of personal staff and events associated with his

CPR, while he was anoxic and comatose. A description of visual awareness was related to the removal and storage of patient's dentures by the nurse at a time when CPR was momentarily stopped for insertion of a respiration tube in his mouth. The patient described 'correctly and in detail the small room in which he had been resuscitated as well as the appearance of those present' (van Lommel et al., 2001, p. 2041); where he was admitted in coma, and had left in coma to be admitted in the ICU. The accuracy of the report was corroborated by the nurse (Rivas et al., 2023, pp. 80–86), suggesting that conscious awareness was preserved during the period when blood flow was not being pumped to the brain.

Parnia et al. (2014) documented that 9 of 101 CA survivors reported an NDE, 2 of whom provided descriptions suggestive of visual and auditory awareness of CA events. One of these, a male patient, described seeing, as if from above his body, the medical personnel whom he had not seen prior to his NDE (Parnia, 2013, p. 253), as well as perception of sounds and activities of his CPR, which were corroborated by his medical records describing the use of an automated external defibrillator (AED) (Parnia, 2013, pp. 240–253; Parnia et al., 2014, p. 1801–1802).

Based on the AED algorithms, the patient received two shock treatments to normalize the heart rhythm, a CPR process with an estimated duration of 2 to 3 minutes (Parnia et al., 2014). Although CPR began immediately after the heart stopped, it is likely that cortical electrical activity was absent or severely compromised throughout the CPR, as there was a prolongation of CA and a deep unresponsive state as measured by the Glasgow Coma Scale (GCS 3) during this period (Parnia et al., 2014).

These NDE reports, although limited to a small number of cases, suggest that conscious awareness may have persisted throughout the period in which the patient appeared unconscious to external observers. The descriptions of external awareness provide specific time points that correlate with events occurring at the time the patient was unresponsive, such as in CA, general anesthesia, and/or coma (Holden et al., 2009). Notably, the perception claims have been consistently described in such a way as if consciousness and perceptual abilities were functioning outside the physical body (Holden et al., 2009, Rivas et al., 2023).

As an implication, the proximity of death associated with NDE in CAs appears to be physiological in nature, not psychological, such as the fear of dying in association with the awareness of a life danger. CA survivors do not appear to have been aware of or feared their CA, as most do not remember entering this state and tend to claim that they were unconscious in this context.

Taking together, these lines of evidence indicate that NDE has likely occurred during CA and unresponsiveness, not before or during the recovery phase.

Brain electrical activity during CA and CPR

The development of changes in cortical electrical activity during CA

In humans and monkeys, electroencephalography (EEG), magnetoencephalography (MEG), and magnetic resonance imaging (MRI) have revealed that functional long-distance connectivity across cortical regions projects in two basic pathways: from the posterior to the frontal regions with predominance of electrical activity in the gamma frequency band (>30 Hz) (i.e. feedforward or bottom-up connectivity); and from frontal to the posterior cortex dominated by electrical activity in the alpha (~8–13 Hz) and beta (~13–30 Hz) frequencies bands (i.e. feedback or top-down connectivity) (Bastos et al., 2015; Buffalo et al., 2011; Halgren et al., 2019; Markov et al., 2014; Michalareas et al., 2016). In leading neuroscientific theories, top-down cortical connectivity has been considered a critical condition for conscious processing and qualitative/phenomenal features of experience (Lamme, 2018; Mashour et al., 2020; Mudrik et al., 2025).

During the normal waking state of consciousness, alpha frequency is the predominant electrical cortical activity, followed by beta activity (Capilla et al., 2022). Decrease of alpha and beta power and increase of gamma power have been found during deep sleep with no dream recall (Hayat et al., 2022; Murphy et al., 2011), and in anesthetic-induced deep unconsciousness, with no response to commands and no subsequent recollection of a specific period (Murphy et al., 2011). While bottom-up gamma connectivity can be preserved during unconsciousness, top-down alpha connectivity is suppressed, indicating the former is not sufficient to maintain consciousness, and the latter is critical for it (Lamme, 2018; Mashour et al., 2020).

In the context of circulatory arrest, cortical electrical waves in the alpha (8-13 Hz) and beta (13-30 Hz) bands disappear after an average of 6.5 seconds, while at the same time, the background activity of EEG is replaced by slow waves at delta frequency (<4 Hz), which progressively attenuate and lead to a flat EEG recording with no measurable electrical wave pattern around 10-30 seconds—a neural process called isoelectricity or electrocerebral silence (Clute & Levy, 1990; de Vries et al., 1998; Singer et al., 1991; Smith et al., 1990; van Lommel, 2023, p. 28; Visser et al., 2001; Vriens et al., 1996). Furthermore, in monkeys and cats, the EEG becomes isoelectric within 20 seconds of the cessation of cerebral blood flow (Hossmann & Kleihues, 1973). The EEG results suggest that cortical electrical activity critical for consciousness, namely alpha and beta activity reflecting top-down connectivity, is eliminated within an average of 6.5 seconds following CA.

It has been reported that different conscious states can be supported by slow activity parallel to a high-frequency EEG activity (Frohlich et al., 2021; Koch et al., 2016), e.g. near-death-like experiences during cerebral hypoperfusion in syncope have been accompanied by a concomitant EEG activity in the beta and slow frequency bands (Martial et al., 2024b). However, the co-occurrence of EEG activity at slow and high frequencies does not appear to be seen during CA. Delta activity has been recorded in the background of the EEG when high-frequency activities were already abolished (Clute & Levy, 1990; Smith et al., 1990; Singer et al., 1991; Vriens et al., 1996; de Vries et al., 1998; van Lommel, 2023, p. 28).

As assessed by Visser et al. (2001), transcranial Doppler measurement of the middle cerebral arteries shows a 'fast and strong [circulatory] decline' (p. 170) after CA. On EEG, the initial ischemic effects were reflected in the alteration and disappearance of alpha and beta activity over the first 15 seconds, followed by the occurrence of delta frequencies, and, given ischemic deepening, isoelectricity within 30 seconds (Visser et al., 2001). Despite minor topographical differences in EEG amplitudes during CA, the sequence of the changes in the electrical frequency bands 'appeared to be similar for all channels' (p. 173). For instance, the changes in alpha/beta activity were seen before consistent changes in the delta activity could be recorded on the EEG (Visser et al., 2001).

During circulatory disturbances, the emergence of delta waves precedes or coincides with the clinical loss of consciousness before isoelectricity (Aminoff et al., 1988; Rossen et al., 1943; van Dijk et al., 2014). Furthermore, human and animal studies measuring auditory and somatosensory evoked potentials have shown, respectively, that brainstem and thalamocortical functioning are impaired during severe cerebral ischemia (Branston et al., 1984; Guo et al., 1995; Rossini et al., 1982; Yang et al., 1997). Measurements of heartbeat-evoked responses and EEG show that bidirectional brain-heart interactions, mediated by the sympathetic and parasympathetic nervous systems via multisynaptic pathways, become reduced and deteriorate as CA develops (Candia-Rivera & Machado, 2023).

In summary, the electrical oscillations that drive top-down cortical connectivity disappear within 6.5 seconds after CA, and overall cortical electrical activity is lost within 10–30 seconds. Furthermore, the interruption of cerebral blood flow affects brain structures beyond the cortex. If consciousness arises from brain activity, it seems that NDEs should not occur during CA, since brain structures are severely damaged in this context.

The dying brain and cortical electrical activity

An experiment with 9 rodents was conducted to investigate whether the brain is in fact inactive, or whether any electrical activity could occur following CA (Borjigin et al., 2013). Intracranial EEG was done before, during, and after inducing CA. The study identified 'a transient emergence of synchronous gamma oscillations that occurred within the first 30s after cardiac arrest and preceded isoelectric electroencephalogram' (p. 14432), which were 'global and highly coherent; moreover, this frequency band exhibited a striking increase in anterior-posterior-directed connectivity and tight phase-coupling to both theta and alpha waves' (p. 14432). Hypothetically, these 'neural correlates of conscious brain activity after cardiac arrest at levels exceeding the waking state provides strong evidence for the potential of heightened cognitive processing in the near-death state' (Borjigin et al., 2013, p. 14436), providing 'a scientific framework to begin to explain the highly lucid and realer-than-real mental experiences reported by near-death survivors' (p. 14436).

However, several compelling objections to this speculation were given by Greyson et al. (2013). These authors emphasized that the amount of cortical electrical activity still present during circulatory arrest represented only a tiny fraction of the total EEG power observed just prior to the induction of CA, not 'a striking increase' (p. 14432). Therefore, 'it is misleading to describe these rat brains as being 'hyperaroused'' during CA (Greyson et al., 2013).

In the time around 12 to 30s seconds after CA, the gamma activity contributed more than 50% of the total EEG power for all frequency bands at its peak, and all other frequency bands were consistently suppressed in this period while the gamma band was less so (Borjigin et al., 2013, p. 14433). In comparison, in the waking state, when cortical electrical activity was intact, gamma activity contributed less than 5% of the total power (2013, p. 14433; see Figure 2B, Bottom,

p. 14434). The rodent brains were not 'hyperaroused' during CA; only gamma waves were relatively more prominent at a time when all EEG frequencies had collapsed.

Furthermore, monitoring of cortical electrical activity in humans, unlike in the rats studied by Borjigin et al. (2013), has documented a slowing and attenuation of EEG by an average of 6.5 seconds after CA, progressing to isoelectricity within 10–30 seconds, and also absence of evoked potentials through CA. In addition, many NDEs occur (and include corroborated veridical perceptions) much later than 30 sec following CA (Greyson et al., 2013, Rivas et al., 2023).

NDEs occur under general anesthesia (e.g. Greyson, 2021, p. 64–68), whereas the gamma oscillations reported by Borjigin et al. (2013) did not occur if the rats were anesthetized (Greyson et al., 2013). Moreover, similar experiences to a NDE ('NDE-like experiences') have been mostly associated with the emergence of slow waves (<8 Hz) (Alvarado, 2000, p. 189–190; Beauregard et al., 2009; Devinsky et al., 1989, cases 5 and 7; Martial, Piarulli et al., 2024b; Palmieri et al., 2014; Picard & Craig, 2009, cases 1 and 5).

In humans, EEG activation in the gamma-frequency band has been commonly detected in dying patients after withdrawal of life support. For instance, Chawla and coauthors reported transient increases in cortical electrical activity recorded in frontal EEG at levels suggestive of both cerebral arousal and gamma activity during cessation of circulatory activity, as evidenced by loss of measurable blood pressure (Chawla et al., 2009, 2017) and by an isoelectric electrocardiogram in some cases (Chawla et al., 2009).

However, similar EEG findings in dying patients have preceded rather than occurred during CA, such as the higher frequency EEG activations in frontal EEG (Auyong et al., 2010; Norton et al., 2017; Zinn et al., 2025) and in gamma-band synchronization over full cortical EEG (Vicente et al., 2022; Xu et al., 2023). These reported increases in EEG activity have occurred when patients were gradually hypoxic during progressive impairment of circulation, prior to CA and death (Greyson et al., 2022; van Lommel & Greyson, 2023). At the time of circulatory arrest and anoxia, however, there have been no recordings of any high-frequency activity (Greyson et al., 2022; van Lommel & Greyson, 2023). This analysis distinguishing the timing relative to CA at which the EEG activity has occurred is relevant to dispelling some misconceptions in media reports that gamma-EEG results (e.g. Vicente et al., 2022 and Xu et al., 2023) have explained NDEs.

An unanswered question in neuroscience is why 'consciousness vanishes during deep sleep even though neurons continue to be active, and during generalized tonic-clonic seizures, even though neurons fire maximally and in a highly synchronous manner' (Mudrik et al., 2025, p. 5) For instance, increases in levels of gamma activity and synchrony may represent epileptiform activity during the dying process, as some of these patients had a history of epilepsy (Vicente et al., 2022; Xu et al., 2023), which is known not to produce vivid consciousness, but to impair cortical integrated information and loss of consciousness (Juan et al., 2023). Furthermore, increase in gamma power and synchronization have been also reported during unconsciousness, as in deep sleep and induced by the anesthetic propofol (Hayat et al., 2022; Murphy et al., 2011).

Alternatively, the EEG activities could be interpreted as a neurophysiological byproduct that merely reflects the development of the circulatory changes found in these patients. In Chawla et al. (2017) study, the rise in EEG activity was detected in 50% of patients who were pronounced dead after support was withdrawn, but not in any patient who had been pronounced dead before support was withdrawn (Chawla et al., 2017). The latter had only a decrease, and no increase, in EEG activity that rapidly became isoelectric (Chawla et al., 2017), as is typical during CA.

Furthermore, in a study with four dying patients (Xu et al., 2023), gamma activity was detected only in the 2 patients whose heart rates actually increased after stopping mechanical ventilation (van Lommel and Greyson 2023). In a single patient case, increases in beta/gamma EEG activity were closely associated with a drop in oxygen saturation after withdrawal of support, transitioning to a more disorganized cortical state, and fading in the final stages close to CA (Zinn et al., 2025). Overall, these correlations apparently support the interpretation that the EEG activities might be a neural concomitant of the dying process after discontinuation of life support.

In Norton et al. (2017) study, 2 dying patients (out of a total of 4) had increases in EEG signal at higher frequencies before CA for a period of 2 and 4 minutes. Analysis of their EEGs showed that the increase in activity could be an electromyogram (muscle) artifact. It is possible that some of the presumed increases in EEG activity in the dying brain may reflect not cortical electrical activity arising from the brain but forehead muscle artifact, which is common in the gamma-band frequency recorded at frontal electrodes on the forehead and often contaminate electrical recordings (Greyson et al., 2022), even in rest conditions (Yilmaz et al., 2014).

Last but not least, unlike CA patients who have survived and reported an NDE, these reported dying patients were deeply comatose and died without reporting any conscious experience. Therefore, there has been no evidence that gamma activations in these cases were associated with NDE or other subjective experiences (Greyson et al., 2022; van Lommel & Greyson, 2023). Crucially, this calls into question the speculation that these dying brain recordings are related to NDEs.

Taking all this into account, there is no convincing evidence that gamma activity would be able to account for the NDEs experienced by humans after cerebral blood flow cessation and anoxia.

CPR and electrical cortical activity

In a large, multicenter CA study analyzing EEG activity, oxygenation (rSO2), and recall of awareness during CPR (Parnia et al., 2023), the authors were able to interview 28 patients, of whom 6 reported NDE and 7 described other kinds of awareness (dreams and recall related to CPR or the post-CPR period). None of these patients exhibited external signs of consciousness throughout CPR.

Several cortical patterns emerged on the frontal EEG in this study, ranging from the predominance of suppressed activity and seizures to slow-wave activity in the delta (1-4 Hz) and theta (4-8 Hz) bands (up to CPR 60 min) and alpha (8-13 Hz) (up to CPR 35 min) and beta (13-30 Hz) frequencies (Parnia et al., 2023). Researchers have interpreted these findings as 'consistent with consciousness and a possible resumption of a network-level of cognitive and neuronal activity emerged up to 35–60 minutes into CPR' (Parnia et al., 2023, p. 9; see also Parnia, 2024).

However, their results are not consistent with neural signatures of consciousness during CPR; the EEG findings do not seem to represent consciousness, since none of these records were correlated with any recall of awareness in this study (Greyson & van Lommel, 2024).

Despite the measures described to minimize CPR motion artifact on the EEG (Parnia, 2024; Parnia et al., 2023, p. 4), the data do not provide persuasive evidence that the EEG measures were separated from muscle contamination or CPR artifacts (Greyson & van Lommel, 2024). Further, in Figure 1a of this study, in the image referring to alpha activity (Parnia et al., 2023, p. 4), three (of a total of 4) electrodes show alpha rhythm, while one displays a flat trace, indicating suppressed activity.

This association between suppressed activity and alpha waves reflects a malfunctioning of the cortex, associated with severe brain ischemia (mean rSO2 ~ 43%; baseline rSO2 ~ 70%), rather than a short EEG normalization arising during CPR. Given the long CPR duration (mean: 15.17 ± 12.55 min) in the absence of visible signs of consciousness (Parnia et al., 2023), and the vulnerability of alpha cortical power to impairments in oxygen delivery, it seems unlikely that this cortical activity indicated a restoration of waking consciousness.

Alpha activity is the first frequency band to be abolished after CA and the last to reappear, even if the heartbeat is immediately restored by CPR (Visser et al., 2001, van Lommel, 2023, p. 28). If spontaneous circulation is restored within about 37 seconds (Smith et al., 1990) and 45 seconds (Visser et al., 2001) following CA onset, normalization of electrical cortical activity occurs within about 1 minute in the reverse order that EEG wave patterns had been abolished (Smith et al., 1990; van Lommel, 2023, p. 28; Visser et al., 2001; Vriens et al., 1996). In prolonged arrests, however, EEG recording throughout CPR tends to be isoelectric (Bircher at al. 1980), or irregular (Hossmann & Kleihues, 1973; Parnia et al., 2023), even if spontaneous circulation is later achieved (Levin & Kinnell, 1966). Reduced oxygen uptake may be observed for a significant period after restoration of spontaneous circulation, which is caused by reperfusion injury. (Buunk et al., 2000; Mayer & Marx 1972, Losasso et al., 1992).

The duration of CAs associated with NDEs has exceeded the time of about 1 minute for recovery of circulation and EEG activity, e.g. lasting 2–8 minutes (van Lommel et al., 2001) to an average of 15.17 ± 12.55 minutes (Parnia et al., 2023). In other cases, the average time until the CPR began was 4.2 ± 3.7 minutes and the time until circulatory restoration was 8.7 ± 5.6 minutes (Klemenc-Ketis et al., 2010). Since EEG activity is mainly suppressed or disturbed during long CPR, it may be concluded that CAs associated with NDEs have been related to either malfunctioning or nonfunctioning of the cortex (van Lommel, 2023).

Post-CPR unresponsiveness and cortical electrical activity

Unresponsiveness after circulatory restoration may be a result of complicated CPR, and EEG recordings have shown that cortical electrical activity may take hours to days to normalize (Levin & Kinnel, 1966; Mayer & Marx 1972, Smith et al., 1990). A prospective CA study identified that shorter periods of unconsciousness were not a predictor of whether a patient could have an NDE, since the frequency of these experiences was similarly distributed in both shorter and longer periods of unconsciousness (van Lommel et al., 2001).

In the dialysis setting, a study involving life-threatening diseases (CA, uremic conditions, etc.) analyzed the clinical factors associated with NDE occurrence (Lai et al., 2007). Neither documented GCS of ≤7 nor consciousness changes lasting longer than 1 day significantly differentiated between the no-NDE and NDE groups (Lai et al., 2007). Thus, NDEs are associated with longer periods of unresponsiveness that may reflect a greater degree of severe brain dysfunction.

Conclusion

In conclusion, brain activity during CA and CPR tends to be suppressed or markedly disturbed, yet NDEs appear to occur during CA and unconsciousness, that is, at the very period when the brain can no longer support consciousness. This analysis provides an empirical argument supporting the view that consciousness can exist separately from the brain/body (van Lommel, 2010, 2023). This argument has implications for the question of the continuation of consciousness after death, as part of the evidence for this possibility (Moreira-Almeida et al., 2022). As CA may be regarded as 'reversible death' (Parnia et al., 2023), NDE can be assumed as evidence for the persistence of conscious awareness after death.

The evidence is compatible with the alternative view that the brain functions as a kind of filter or transmitter of consciousness under normal psychophysical conditions (Greyson, 2021; Kelly et al., 2007; van Lommel, 2010, 2023). During the lowering of the filtering or mediating functions of the brain, individuals may experience exceptional states of consciousness, such as NDEs, out-of-body experiences, and mystical states. In CA, these changes in the relationship between brain function and consciousness would facilitate access to transcendent states of consciousness, as described in NDEs (Kelly et al., 2007; van Lommel, 2010, 2023; Parnia et al., 2023).

The widely accepted view that the brain produces consciousness appears to be called into question by this empirical argument. A limitation of the present discussion is the rarity of monitored brain data during CAs associated with NDEs (Parnia et al., 2023). One exceptional case is Pamela Reynolds' NDE, where a flat-line EEG and no evoked potentials in the brainstem were registered. Nevertheless, as noted above, NDEs have been documented to occur at the very moment in CA in which the brain is severely compromised, with the clinical signs of the total loss of the function of the cortex and the brainstem.

Authors' contribution

All authors made substantive intellectual contributions to the development of the manuscript. B.A.F. prepared the initial draft of the manuscript and edited all subsequent drafts. B.G. edited and revised the intellectual content of subsequent drafts of the manuscript. P.V.L. edited and revised the intellectual content of subsequent drafts of the manuscript. All authors have approved the final version of the submitted manuscript and agreed to be accountable for all aspects of the work.

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No potential conflict of interest was reported by the author(s). The authors alone are responsible for the content and writing of the paper.

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