J. appl. health sci. 2026; 12(2): 65-71

Pregledni rad

Near-death Experiences in Planned Circulatory Arrest During Cardiac Surgery: A Comprehensive Review

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Abstract

Near-death experiences (NDEs) are profound subjective events reported by individuals who have come close to death. In Western cultures, they often involve out-of-body perceptions (OBEs), feelings of peace, moving through a tunnel, and encountering lights or figures. While traditionally studied in unpredictable cardiac arrest or trauma, planned circulatory arrest during hypothermic cardiac surgery offers a unique, controlled model to investigate NDEs. This review summarizes definitions, incidence, typologies, and cultural variations of NDEs and OBEs, emphasizing cardiac arrest research. We describe the literature search methodology and synthesize findings: typical NDE features, which vary by culture, occur in roughly 10–20% of survivors, with OBEs in ~2%. Planned hypothermic circulatory arrest (e.g., aortic arch repair) precisely times cardiac arrest and reperfusion, enabling systematic observation and interview. We discuss limitations of prior studies (anaesthetic effects, recall bias) and how induced arrest may improve control over physiological and temporal variables. Emerging tools such as virtual reality (VR) simulations can help patients articulate NDE memories and reduce trauma. Including the medical staff's timeline and patient monitoring (ECG, blood gases, drug records) can corroborate subjective reports. We conclude that planned cardiac arrest settings could advance understanding of NDE mechanisms and support patient care particularly when an adequate number of patients are included.

Keywords: near-death experience, out-of-body experience, hypothermic circulatory arrest, cardiac surgery, aortic arch, consciousness

Article received: 03.09.2025.

Article accepted: 31.01.2026.

https://doi.org/10.24141/1/12/2/7

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Introduction

Near-death experiences (NDEs) are intense subjective psychological events of consciousness reported by people during situations very close to death or in a physical/emotional crisis, with transcendental and mystical elements (1).

They typically include a sense of detachment from the body (an out-of-body experience, OBE), a feeling of peace or bliss, traveling through darkness or a tunnel, seeing a bright light, a life review, or meeting deceased relatives or spiritual beings. OBEs are defined as a sensation in which one's center of awareness seems to be located outside the physical body. NDEs have been described across history and cultures, often leading to lasting personal changes (such as reduced fear of death, greater spirituality). Their phenomenology has been systematically analyzed: for example, Greyson's NDE Scale quantifies common features, and recent reviews classify NDE content qualitatively into cognitive, emotional, spiritual/religious, and supernatural categories (2).

Parnia et al. (2014) conducted the largest prospective study of NDEs in cardiac arrest survivors (the AWARE study) and identified recurring themes in patients' reported experiences. They categorized NDE content into seven types: fear; seeing animals or plants; bright light; violence or persecution; déjà-vu sensations; encounters with family; and post-arrest event recall. In that study, 9% of survivors reported experiences meeting NDE criteria, and 2% described veridical OBEs (accurate perceptions during unconsciousness) (3).

Other large studies have found similar incidence: for example, van Lommel et al. (2001) found that 18% of cardiac arrest survivors reported an NDE (12% describing a core NDE) (4).

Overall, the literature estimates NDE incidence in cardiac arrest survivors at roughly 10–20%, with higher percentages occurring in-hospital (5).

Reported OBE rates are lower (around 1–2%). These events most often occur after near-fatal events such as cardiac arrest, major surgeries, severe trauma, or hypoxia (3).

NDE phenomenology shows both universal and culture-specific elements. Core features, like peace, moving through darkness, and encountering beings, are widely reported. However, cultural context shapes the details: Westerners frequently describe Christian figures (e.g., Jesus) in tunnels with deceased relatives, whereas Thai Buddhist experiencers often meet Yama's messengers and rarely see a light (6). Greyson noted that Indian and Buddhist subjects commonly experience tunnel passages, whereas Thai subjects seldom do (7). Thus, NDE content depends on personal beliefs and culture, even as some aspects remain consistent across backgrounds.

Given the profound implications of NDEs for consciousness research and patient care, a rigorous scientific approach is needed. Planned circulatory arrest in cardiac surgery (e.g. deep hypothermic circulatory arrest, DHCA, for aortic arch repair) offers a controlled model for studying NDEs (8). Unlike spontaneous arrests, surgeons deliberately induce a brief "clinical death" under monitored conditions. This setting allows for precise timing of arrest, controlled physiological parameters, and immediate postoperative interviews. To explore this topic, we systematically reviewed peer-reviewed literature on NDEs, focusing on cardiac arrest settings and induced arrest scenarios. This review synthesizes definitions, typologies, cultural factors, incidence data, and methodological considerations to assess the potential of studying NDEs during planned cardiac circulatory arrest.

Materials and methods

We conducted a structured literature search (up to April 2025) in PubMed and Google Scholar using keywords including "near-death experience," "out-of-body experience," "cardiac arrest," "circulatory arrest," "cardiac surgery," "hypothermic," "aortic arch," and combinations thereof. We included peer-reviewed articles (original studies, case reports, and reviews) in English that addressed NDE phenomenology, incidence, or mechanisms, particularly in relation to cardiac arrest or induced clinical death. We excluded non-peer-reviewed reports, conference abstracts, and articles focusing solely on non-medical NDE cases. References of key papers and review articles were screened for additional sources. Data were extracted on NDE definitions, typologies (e.g. Sam Parnia's categories), cultural compari-

sons, typical clinical contexts, incidence and OBE rates, study limitations, and the relevance of physiological monitoring. Emphasis was placed on controlled settings (elective circulatory arrest) and innovative methods (e.g. VR).

Results

Definitions and Phenomenology of NDEs and OBEs

NDEs are defined as conscious experiences occurring at the threshold of death. They are described as "deep psychic, conscious, semi-conscious, or recollected experiences of someone approaching or having temporarily begun dying" (2). In these events, individuals often feel detached from their bodies and may observe their surroundings from an external vantage point. Common elements include a sense of peace, out-of-body perception, passing through darkness or a tunnel, a panoramic life review, and encountering a brilliant light or beings. Greyson's scale and other instruments capture these features; scores above a threshold identify an experience as an NDE. OBEs, a frequent component of NDEs, are defined as episodes where one's "centre of consciousness" appears to exist outside the physical body. These perceptions can include seeing one's own body from above or perceiving events in the room while clinically unconscious (3).

In Parnia et al.'s 2014 study (the AWARE II study), NDE experiences were categorized into seven thematic groups. These included: fear, terror or panic during the event (3); encountering animals/plants (2); moving towards bright, colored or white light (4); violence/persecution or feelings of being punished or frightened by unseen forces (5); déjà vu (sensations of having lived the moment before) (9); meeting deceased loved ones (10) and post-cardiac recall of events (8). This typology highlights the diversity of NDE content and the overlap with OBEs (e.g. witnessing actual resuscitation efforts under an OBE state). In the AWARE II, 9% of cardiac arrest survivors reported experiences meeting NDE criteria, and 2% described explicit OBEs with verifiable awareness (3). These rates align with earlier findings: van Lommel et al. reported that 18% of resuscitated patients had some memory of the event, with 12% having a clearly defined NDE (4).

Cultural Variation in NDEs

Cross-cultural studies reveal both universal core NDE features and culturally specific imagery. In Western (European/North American) cohorts, NDE reports frequently include Christian religious figures, tunnels of light with greetings by deceased relatives, and life reviews. In contrast, studies in Thailand and India show distinct motifs: Thai Buddhists often begin NDEs with encounters with "Yama-dūtas" (death deities) and rarely report a light or tunnel, whereas Indian and other Buddhist NDErs commonly report tunnels and may see Hindu deities or other culturally relevant images. For example, one Thai NDEr reported a Yama-dūta pointing to a star identified as the Buddha (6). Overall, themes like feeling peace or unity are common everywhere, but specific religious symbols vary (3). Empirical reviews note that up to 85% of children and 43–48% of adults surviving severe illness report at least one component of an NDE (2). These differences underscore the influence of cultural and religious background on NDE interpretation.

Clinical Settings and Rationale for Planned Arrest Study

NDEs have been documented in various life-threatening medical contexts. Classically, patients who suffer cardiac arrest (out-of-hospital or in-hospital), receive resuscitation (CPR), and survive may later report NDEs. Other settings include near-drowning, severe trauma or bleeding, anaphylaxis, strokes, and complications of surgery (e.g. obstetric hemorrhage or anesthesia). However, these scenarios are unpredictable and often involve multiple confounders (such as intense drugs, chaos, and prolonged hypoxia), making systematic study difficult (3).

Planned deep hypothermic circulatory arrest (DHCA) in cardiac surgery offers a unique, controlled equivalent of temporary clinical death. In aortic arch repair and complex cardiac operations, surgeons intentionally cool the patient and stop blood circulation (often for tens of minutes) while protecting the brain with hypothermia. This controlled interruption of perfusion is one of the few "reversible" models of clinical death. Because the arrest is elective, investigators know exactly when consciousness ceases and returns. Physiological data (including ECG, oxygenation, blood pressure, blood gases, and drug administration) are continuously recorded. Immediately after surgery, patients can be systematically interviewed using standardized NDE questionnaires (e.g., Greyson scale). This design overcomes key limitations

of retrospective cardiac arrest research: unknown timing of events, severe brain injury, and memory gaps due to sedation (10).

Gray et al. found that induced arrests under anesthesia produced no reported NDEs, likely because patients expected safety and often received amnestic sedatives. They argued, however, that a truly "controlled near-death setting" (with high perceived risk and minimal memory-suppressing drugs) could yield observable NDE phenomena (11). The DHCA model approximates this: the threat of death is real, but the outcome is survival by design (10).

Cardiac Procedures Involving Planned Arrest

Elective procedures requiring DHCA include open surgical repair of the thoracic aorta, especially the aortic arch. Major aortic arch aneurysms or dissections often involve circulatory arrest for surgical access. Published series reports hundreds of arch cases using "straight" DHCA as the sole cerebral protection method. In these cohorts, the mean arrest time was ~30 minutes at bladder temperatures below 20°C, with low stroke rates when DHCA was limited to <50 minutes (12). Hypothermia is key: cooling greatly reduces cerebral metabolism, permitting a safe interval without flow. Other surgeries occasionally use planned arrest, such as complex congenital heart repairs in infants (e.g., the Norwood procedure) or neurosurgical aneurysm clipping under deep hypothermia (10). For this review we focus on aortic procedures, since they are well described in the literature. In summary, the principal indication is aortic arch intervention, where DHCA enables a bloodless field.

Limitations of Prior Cardiac Arrest Research

Traditional NDE research in cardiac arrest faces several methodological challenges. First, the exact time of brain oxygen cessation is often unknown. In out-of-hospital arrests, bystanders delay CPR, and even in-hospital arrests occur unpredictably. Planned arrest eliminates this uncertainty. Second, most studies interview survivors well after recovery (weeks to years later), introducing recall bias and distortion. Indeed, one review noted that patients often recount NDEs 5–10 years post-event, precluding accurate capture of physiological correlates (2). Planned arrest studies can schedule interviews in the ICU or surgical ward immediately post-operation, minimizing memory decay. Third, sedative and analgesic medications blur consciousness and memory. In voluntary induced-arrest studies, the sedative Midazolam caused profound amnesia, likely preventing NDE recall. In cardiac surgery, anaesthetic agents are routinely used, posing a similar problem. However, protocols could be adjusted (e.g. minimizing amnestic premedication) to enhance recall. Fourth, patients who die in cardiac arrest cannot be interviewed, potentially underestimating NDE incidence. In surgical arrest, by definition all patients survive the arrest period, ensuring interview eligibility. Parnia et al. also pointed out that many survivors might have unreported NDE memories erased by brain injury or drugs (3). Planned arrest with careful patient selection and monitoring could reduce brain injury (via controlled cooling) and allow investigation of "veridical" perceptions. Indeed, Parnia's team emphasized the importance of including objective measurements (ECG, oxygen, neurophysiology) to interpret NDE claims. They reported one case of a survivor who correctly described events during a 3-minute flatline period, underscoring the value of staff and monitor data in validating subjective reports (3).

Incidence of NDEs and OBEs in Cardiac Arrest

The expected frequency of NDE and OBE recollections among cardiac arrest survivors is modest. Van Lommel et al. found that 18% had any NDE memories, and 12% had a "core" NDE (4). Parnia et al. (the AWARE II study) reported 9% with NDEs and 2% with veridical OBEs (3). Meta-analyses and reviews suggest a broad range: some studies cite 6–23% NDE incidence. The scoping review by Kovoor et al. found that NDE rates varied widely (6.3–39.3% (2)) across studies, depending on location (in-hospital vs out-of-hospital) and methodology (5). OBEs are consistently rarer (~1–2%) than other NDE features. It is plausible that induced arrest in surgery might produce higher observed rates (3). First, the arrest is controlled and brief, possibly yielding clearer NDE signals. Second, patients might undergo less hypoxic injury (due to hypothermia) than in chaotic CPR, preserving consciousness capacity. Third, knowing that the arrest is reversible (physicians' expectation) might paradoxically lower patient anxiety and increase recall (11).

Thus, while the literature suggests that approximately 10% of cardiac arrest (CA) survivors report NDEs and ~2% report OBEs, we hypothesize that well-designed induced-arrest studies could reveal higher rates or at least capture previously hidden experiences.

Assuming an expected 15% incidence of NDE in DHCA patients versus 2% in controls with $\alpha = 0.05$, a sample of approximately 100 patients per group provides 90% power to detect this difference. This sample size also allows estimation of a 15% incidence with a 95% confidence interval of roughly ± 4%. Therefore, enrolling around 200 DHCA patients and 100 controls ensures ≥ 90% power and sufficiently precise confidence intervals for both NDE and OBE rates.

Use of Virtual Reality and Staff Observations

Emerging technologies offer new ways to study and support patients with NDEs. Immersive virtual reality (VR) can simulate common NDE elements (such as OBE, tunnel, light) to help patients articulate their experiences. For instance, a PLOS One study immersed participants in a VR "island" where they witnessed virtual companions dying and experienced an OBE-like sequence with a tunnel and light. Participants reported positive life-attitude changes afterward (13). Such VR paradigms can serve as communication aids: after surgery, a patient could experience a similar VR scenario to help identify parallels with their memory, potentially improving reporting accuracy and reducing distress. Additionally, VR exposure therapy is an established tool for anxiety and PTSD and could be adapted to desensitize patients who have traumatic NDE components (e.g. fear or persecution themes) (13).

Crucially, any subjective report must be interpreted alongside objective data. Medical staff observations (charts, EEG, ECG, conversations) provide context for an NDE claim. If a patient reports hearing voices or seeing events, cross-checking with monitor logs or staff recall is essential. For example, Parnia et al. rigorously collected eyewitness accounts and vital signs during resuscitation to evaluate NDE claims (3). In surgical arrest, ICU nurses and surgeons can note the exact timing of cooling, bypass, and stimuli. If a patient claims an OBE during a specific minute of HCA, one can examine monitors to confirm EEG silence or perfusion stops. This triangulation distinguishes true anomalies (awareness with no detectable brain activity) from confabulations.

Discussion

This review highlights that NDEs and OBEs are complex, culturally influenced phenomena with significant neuroscientific and clinical interest. Planned circulatory arrest during cardiac surgery is an underutilized opportunity to study NDEs systematically. The controlled context addresses many prior research gaps: timing is exact, physiology is monitored, and interviews can be conducted immediately. Moreover, since surgeries routinely measure ECG, arterial blood gases (pH, PaO_2, $PaCO_2$), anesthesia dosages, and even near-infrared spectroscopy, researchers can correlate NDE reports with precise physiologic states. For example, Klemenc-Ketis et al. found that higher arterial CO_2 and potassium levels were associated with NDE occurrence (9). In DHCA patients, tracking pH and oxygenation during arrest might reveal whether acidosis or hypoxia are NDE triggers (10).

Studying NDEs in this unique cohort also has practical implications. If NDE recollections are confirmed, patients may need psychological support for integration. Using VR tools could be especially helpful in post-operative care. Simulated NDE experiences might normalize patients' reports and reduce isolation or fear (14). VR could also serve in clinician training: immersive simulations of NDE features may prepare staff to sensitively discuss these events with patients (13).

Nonetheless, challenges remain. Anesthesia management must balance patient comfort with the need to preserve memory. Ethical considerations arise in consent and whether to prime patients about potential experiences. The negative result of Mauduit et al. suggests that simply having a circulatory arrest is not sufficient; depth of hypothermia, duration of arrest, and anaesthetic regimen all influence recall (10). Future studies should optimize protocols (e.g. minimize benzodiazepines, ensure normocapnia or mild hypercapnia) as suggested by both clinical findings and NDE theories. Inclusion of a control group (similar surgery without arrest) is also essential to isolate the effect of circulatory cessation.

In interpreting any reported NDE, investigators must consider physiological parameters. An ECG flatline, arterial blood gases showing severe hypercapnia or acidosis, or high-dose sedatives can inform understanding of the patient's state. Conversely, a surprising NDE memory coinciding with minimal stimuli would be more

intriguing. A holistic analysis of NDE requires merging patient narrative with empirical data —staff notes, imaging, and monitors – to discern any discrepancies.

Finally, cultural and personal context should be considered when exploring NDEs. Surgeons and researchers should be aware that patients' descriptions may be framed according to their own worldview. Thus, study interviews should allow open-ended narration and avoid imposing interpretation. Including chaplains or cultural liaisons might help some patients articulate experiences that are difficult to describe in medical terms (Figure 1).

Conclusion

Near-death experiences, including OBEs, represent a fascinating intersection of consciousness and physiology. In the setting of planned circulatory arrest during cardiac surgery, researchers can capitalize on a rare model of reversible clinical death with extensive monitoring and control. This environment allows for precise correlation of subjective experiences with objective data (ECG, blood parameters, anesthesia drugs). Although prior studies suggest that only a minority of patients report NDEs (~10%) and even fewer OBEs (~2%) after spontaneous arrest, induced arrests under carefully managed conditions might reveal a higher incidence or novel insights. Incorporating virtual reality techniques and staff observations into the investigative protocol can enhance understanding and patient support. Given the potential to illuminate the nature of consciousness, future prospective studies of NDE in cardiac surgery are justified. Designing such studies will require interdisciplinary collaboration (including anesthesiology, cardiac surgery, neurology, psychiatry, and psychology) and rigorous methodology, but the controlled setting may finally answer longstanding questions about how and when these extraordinary experiences occur.

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ISKUSTVA BLISKE SMRTI TIJEKOM PLANIRANOG CIRKULACIJSKOG ZASTOJA U KARDIOKIRURGIJI: SUSTAVNI PREGLED

Sažetak

Iskustva bliske smrti (engl. *near-death experiences*, NDE) intenzivna su subjektivna iskustva koja opisuju osobe koje su bile u neposrednoj životnoj ugrozi. U zapadnim kulturama često uključuju izvantjelesna iskustva (engl. *out-of-body experiences*, OBE), osjećaj mira, prolazak kroz tunel te susrete sa svjetlošću ili osobama. Iako su se tradicionalno proučavala u kontekstu nepredvidivog srčanog zastoja ili traume, planirani cirkulacijski zastoj tijekom hipotermijske kardiokirurgije jedinstven je kontrolirani model za istraživanje NDE-a.

Ovaj pregledni rad donosi prikaz definicija, učestalosti, tipologije i kulturnih varijacija NDE-a i OBE-a, s naglaskom na istraživanja u kontekstu srčanog zastoja. Opisana je metodologija pretraživanja literature te su sintetizirani dostupni nalazi: tipične značajke NDE-a, koje variraju ovisno o kulturi, javljaju se u približno 10 do 20 % preživjelih, a OBE-i se bilježe u oko 2 % slučajeva. Planirani hipotermijski cirkulacijski zastoj (npr. tijekom operacija luka aorte) omogućuje precizno vremensko određivanje srčanog zastoja i reperfuzije, čime se omogućuje sustavno praćenje i intervjuiranje bolesnika.

Razmatraju se ograničenja dosadašnjih istraživanja (učinci anestetika, pristranost prisjećanja) te mogućnosti koje inducirani zastoj pruža u boljoj kontroli fizioloških i vremenskih varijabli. Novi pristupi, poput primjene virtualne stvarnosti (VR), mogu olakšati bolesnicima verbalizaciju iskustava NDE-a i pridonijeti smanjenju psihološke nelagode. Uključivanje vremenskog slijeda postupaka medicinskog osoblja i podataka kontinuiranog praćenja bolesnika (elektrokardiogram, plinovi u krvi, terapijski zapisi) može doprinijeti objektivizaciji subjektivnih iskaza.

Zaključno, planirani uvjeti srčanog zastoja mogu unaprijediti razumijevanje mehanizama NDE-a te pridonijeti unaprjeđenju skrbi za bolesnike, uz uvjet uključivanja dostatnog broja ispitanika.

Ključne riječi: iskustvo bliske smrti, izvantjelesno iskustvo; hipotermijski cirkulacijski zastoj, kardiokirurgija, luk aorte, svijest