The Impact of Peri-Operative Neuro-Monitoring on Post-Operative Cognitive Dysfunction and Delirium in Cardiac Surgery Patients: A Systematic Review and Meta-Analysis

Sultan G Alotaibi*[1], Muneeb A Alnouri[2], Rawaa M Sulaiman[3], Abdulkhalek A Abduljaleel[4], Ahmed F Bogari[5], Hani Nabeel Mufti[6]

[1,2]Consultant Cardiac Anesthesiologist, Cardiac Center, King Fahd Armed Forces Hospital, Jeddah-Saudi Arabia
[3]Consultant Family/ Palliative Medicine, Family Medicine Department, Dr. Sulaiman Fakeeh Hospital, Jeddah-Saudi Arabia
[4,5]Consultant Anesthesiologist, King Fahad General Hospital, Anesthesiology Department, Jeddah-Saudi Arabia
[6]Consultant Adult & Congenital Cardiac Surgery, King Abdulaziz Medical City, Jeddah, Saudi Arabia

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Abstract: Post-operative cognitive Dysfunction and delirium are two major concerns regarding possible adverse effects of cardiac surgery. Perioperative neuromonitoring is a method used to assess and monitor the functional integrity of the nervous system during surgical procedures. This review aimed to explore the impact of perioperative neuromonitoring on postoperative cognitive dysfunction and delirium following cardiac surgery, aiming to improve patient care and surgical outcomes. In order to execute this systematic review and meta-analysis, research based on the impact of perioperative neuromonitoring on neurodegenerative disorders post-cardiac surgery was identified. Data was gathered from PubMed, Cochrane Library, Medscape, Medline Plus, Science Direct, and Google Scholar. The studies were selected from the last 5 years ranging between 2019 to 2023 using the keywords "Perioperative Neuromonitoring," "Postoperative Cognitive Dysfunction," "Delirium," "EEG Monitoring," "NIRS Monitoring," and "Transcranial Doppler. The systemic review, following guidelines regulated by Preferred Reporting Items for Systemic Research and Meta-Analysis, retrieved 260 papers on post-cardiac neurological disorders and diagnosing techniques, from which 228 were selected. This review examines 82 references for medical diagnosis and therapy, including 14 recent articles, and highlights the need for further research on postoperative delirium and cognitive dysfunction treatment strategies.

Keywords: Anesthesia, Cardiac Surgery, Delirium, Evidence-Based Practice, Electroencephalogram, Near-Infrared Spectroscopy, Neurological impairment, Postoperative Cognitive Dysfunction, Peri-Operative Neuromonitoring, Transcranial Doppler.

1. Introduction

Neurological impairment continues to have a considerable impact on postoperative morbidity following heart surgery [1]. In addition to the many procedural risks, patient-specific factors, such as the existence of intracranial or extracranial atherosclerotic disease, separately or in combination, play a crucial role in determining the likelihood of brain injury after cardiovascular surgery [2]. Various neurophysiological monitoring approaches have been employed to mitigate the risk of neurological damage during cardiovascular procedures [1].

Perioperative neuromonitoring is a method used to assess and monitor the functional integrity of the nervous system during surgical procedures [3, 4]. It detects potential damage or dysfunction in nerves, particularly those related to motor and sensory abilities, in real-time. Common methods include Electromyography (EMG), Somatosensory Evoked Potentials (SSEP), and Motor Evoked Potentials (MEP), which measure electrical responses along sensory and motor pathways, respectively [5]. The condition of impaired cognitive function that occurs after cardiac surgery has been identified by several terms, including postoperative delirium and postoperative cognitive dysfunction [6]. Post-operative Cognitive Dysfunction (POCD) and delirium are two major concerns regarding possible adverse effects of heart surgery [7]. These issues may impact up to 50% of people obtaining such treatments [8]. Post-operative cognitive dysfunction is a cognitive decline or impairment that occurs after surgery and affects higher-level memory or cognitive skills. Kok et al. (2017) demonstrated that POCD is more common in patients with cardiac surgery as compared to others [8]. It typically manifests as memory impairment, microembolization, modified brain activity, concentration difficulties, and overall cognitive dysfunction [9, 10].

The exact mechanisms behind POCD are not fully understood, but factors like anesthesia, inflammation, and the physiological stress of surgery are believed to play a role [11]. POCD, a condition distinct from pre-existing cognitive abnormalities like dementia, can cause focus difficulties, memory impairment, and cognitive confusion. Whereas an unclear or abnormally ambiguous mental state that has the potential to cause substantial injury is called delirium [12]. However, an acute state of confusion and inattention is known as Postoperative Delirium (POD) [13]. Postoperative delirium is a condition characterized by the onset of delirium during a period of 24 to 72 hours after undergoing surgery [14]. The occurrence of this syndrome ranges from 4% to 61%, depending on the specific surgery. Previous studies revealed that the incidence of postoperative delirium varies significantly among different surgical populations. Shortened or less intrusive surgeries reduce the occurrence of delirium compared to longer, more invasive surgeries, and patients with delirium are at a higher risk of adverse outcomes [15, 16]. Patients who experienced postoperative delirium have an increased risk of death of 11% at 3 months compared to those who do not have delirium. This risk further increases to 17% at 1 year. Postoperative delirium is linked to prolonged hospitalization and increased susceptibility to cognitive decline. Delirium is also linked to higher mortality rates, particularly in elderly individuals who have experienced cognitive decline after cardiac surgery [14, 17].

In addition, perioperative neurocognitive impairments are the most frequent problems observed in elderly people who undergo anesthesia and surgical procedures [18]. Studies evaluate anesthesia, focusing on cognition under general and regional anesthesia, ensuring a pain-free sleep-like state and blocking nerve signals, respectively, during procedures [19]. Post-operative delirium, which is a specific type of neurocognitive illness that occurs after surgery, is significantly linked to adverse long-term outcomes, including death, dementia, decreased self-determination, and impaired cognitive and functional abilities [18, 20]. Perioperative neurocognitive disorders are cognitive deficits detected during the perioperative period, often due to undiagnosed neurodegenerative conditions, inflammation, neuronal harm, or systemic diseases [21]. Previous vulnerability increases the incidence of cognitive impairment at 3 and 12 months post-surgery, posing a significant risk for adverse postoperative outcomes [18]. The key to reducing perioperative neurocognitive issues is to identify at-risk patients before they are sedated or undergo surgery [22]. Contemporary methods involve assessing patients before surgery for delirium and cognitive impairment, analyzing blood biomarkers, implementing interventions during surgery to decrease the occurrence of postoperative delirium (such as using less potent anesthesia with processed electroencephalography devices), and following guidelines aimed at preventing postoperative neurocognitive disorders and delirium [18].

POCD is increasing, with a likelihood of 65% within one week after surgery and 38% three months later [23]. Heart surgeries or treatments have a greater occurrence rate of up to 15% on POCD [24]. In contrast, some studies demonstrated that there is no direct link between surgery and POCD [25, 26]. Due to the significant rise, the best possible recovery, both psychologically and physically, required treatment alternatives and preventive measures [27]. Perioperative neuromonitoring can help reduce POCD and delirium in cardiac surgery patients [28]. It involves monitoring the function of the brain, brainstem, cranial and peripheral nerves, and spinal cord. This method is particularly effective in identifying neural oxidation, allowing for personalized neuromonitoring based on patient attributes [29]. This study aimed to explore the potential impact of perioperative neuromonitoring on the prevalence of Postoperative cognitive dysfunction and delirium following cardiac surgery based on a comprehensive examination and meta-analysis of existing literature. Numerous studies showed that untreated POCD can be remedied on its own, with a sample population experiencing a decline at rates of 71% and improvement in 9% one week postoperation [14]. However, 47% experienced a decline three months after surgery, while 25% experienced improvement. Initially, cognitive decline was experienced improvement. Initially, cognitive decline was experienced by a small portion of patients, but 71% experienced notable decline for 6 years, primarily affecting executive dysfunction [14, 17, 30].

POCD diagnosis is challenging due to the lack of guidelines for identifying cognitive impairment in the postoperative period [31]. POCD can persist for days to months or years, necessitating comprehensive neuropsychological evaluations involving diverse tests or clinical examinations by psychologists [31]. Preventive measures for POCD primarily target surgical and patient-related factors, with a particular emphasis on implementing enhanced recovery after surgery (ERAS) principles to administer anesthesia and perform surgery in a manner that minimizes stress [17, 32]. This approach is particularly beneficial for elderly patients. A study by Nalini Kotekar et al. (2018) centered around biomarkers that indicate brain injury in POCD [17]. Pharmacological interventions for POCD, such as acetylcholine esterase inhibitors considered efficient despite their side effects. Moreover, strategies targeting the reduction of neuroinflammation and oxidative stress hold promising benefits [33]. Currently, the most effective approach to treating Post-Traumatic Stress Disorder (PTSD) is by utilizing preventive strategies, promptly identifying the condition, and effectively managing risk factors during the perioperative period. However, further advancements in treatments are needed to enhance treatment outcomes [17, 34, 35].

This review aimed to explore the impact of perioperative neuromonitoring on postoperative cognitive dysfunction and delirium following cardiac surgery, aiming to improve patient care and surgical outcomes.

Methodology

Search Strategy

In order to execute this review, recent research and review articles based on POCD and Perioperative neuromonitoring after cardiac surgery were considered. A systematic search was conducted through multiple electronic databases, including PubMed, Cochrane Library, Medscape, Medline Plus, Science Direct, and Google Scholar. These databases were selected based on their comprehensive coverage of medical literature, ensuring the inclusion of a wide array of relevant studies. This approach aimed to capture historical and recent research, ensuring the review's relevance and accuracy.

The terms were carefully selected for comprehensive results regarding the complexity of perioperative neuromonitoring and its potential impact on postoperative cognitive dysfunction and delirium. The studies were selected from 2019 to 2023 using the keywords "Perioperative Neuromonitoring," "Postoperative Cognitive Dysfunction," and "Delirium" were used as anchor terms. In addition, supplementary terms like "EEG Monitoring," "NIRS Monitoring," and "Transcranial Doppler" were incorporated to encompass the diverse range of neuromonitoring techniques that were studied. These terms aimed to contain studies investigating a spectrum of monitoring modalities and their associations with cognitive outcomes.

First, text words included in the article's title, abstract, and index keywords were examined after databases were searched for relevant papers. Then, across all databases, a second search was conducted using all the discovered keywords, index terms, and MeSH terms for MEDLINE. Third, new studies were found by searching the reference lists of all the studies, reports, and articles. igureFourth, databases were searched to identify all related articles and reports on perioperative neuromonitoring, postoperative cognitive dysfunction, and delirium: PubMed, Google Scholar, and Google. Titles and abstracts were examined for the search terms. Access was made to the whole texts of the articles that were found. **Table 1** and **Table 2** presents search terms and Boolean operators. Furthermore, the systemic review has been completed according to the guidelines regulated by Preferred Reporting Items For Systemic Research And Meta-Analysis (PRISMA).

Table 1. Search Strategy

Search Term	Boolean "And"
Post-Operative Cognitive Dysfunction	Peri-operative neuromonitoring, cardiac, cardiac surgery, dysfunction, cognition
Post-Operative Cognitive Delirium	Peri-operative neuromonitoring, cardiac, cardiac surgery, patient, neuromonitoring, cognition
POCD	Neuromonitoring, Pere-operative neuromonitoring, cardiac, cardiac, surgery, patient, neuromonitoring, cognition
Peri-Operative Neuromonitoring	POCD, delirium, dysfunction, cardiac surgery
Cardiac	POCD, delusion, dysfunction, surgery, patient, peri-operative neuromonitoring
Surgery	POCD, delirium, dysfunction, cardiac, patient, cognition
Patient	POCD, cardiac, postoperative cognitive dysfunction, post-operative cognitive delirium, peri-operative neuromonitoring

Neuromonitoring	POCD, peri-operative, cognition
Cognition	POCD, cardiac surgery, cardiac patient, peri-operative neuromonitoring

Table 2. Keywords and Boolean Terms

Terms	Boolean "And"
EEG monitoring	POCD, peri-operative neuromonitoring, cardiac surgery, cognition, delirium
NIRS Monitoring	POCD, peri-operative neuromonitoring, cardiac surgery, cognition, delirium
Transcranial Doppler	POCD, peri-operative neuromonitoring, cardiac surgery, cognition, delirium

Inclusion and Exclusion Criteria

The following addition and omission criteria were used to filter the titles rather than study relevance.

- Studies written in the English language were selected for the study.
- Studies that were peer-reviewed and replicable and were published in the last ten years were considered for the review.
- Reviews, systematic reviews, roadmaps, and meta-analyses were studied and included relevant to the study.
- Based on the review's scope, studies on adult heart surgery patients were targeted, though there was substantial information regarding the greater impact POCD had on geriatric patients, potentially necessitating a more diverse solution depending on the age of the patient.
- However, Papers written in languages other than English were excluded.
- Studies focusing solely on the impact of Sepsis on Cardio-logical health were excluded.
- Studies with fewer than 60 participants were excluded from the study to avoid skewed data.
- Duplicate studies and studies with predefined data were excluded.

The studies were selected using strict criteria to ensure relevance and quality. Only studies related to the topic were included, and only if they offered direct or related insight into perioperative neuromonitoring and cognitive outcomes in cardiac surgery patients were considered. Only EEG, NIRS, and TCD neuromonitoring studies were eligible for the review to assure precision, however, few were available for the review. Despite lacking information, these methods were chosen because they may affect POCD and delirium more often than originally considered. To preserve the synthesized findings, the review excluded secondary analysis and assessments and limited itself to original research papers.

Among the 260 research, 228 were retrieved, and 36 papers were eliminated due to their no direct relevance to the study's main goal and were written primarily in languages other than English, most commonly Arabic, French, Spanish, and Dutch.

Data Extraction, Analysis and Risk of Bias

The data extraction process was executed systematically for accuracy using the data extraction form. The information included study characteristics, participant demographics, intervention specifics, and outcome measurements. General parameters aimed to provide a comprehensive overview of the studies and facilitate meaningful comparisons and analysis. Upon successful data extraction, the synthesized information was rigorously analyzed. A meta-analysis approach was employed to integrate the quantitative outcomes reported across the studies. Appropriate statistical software was used to compute weighted average effect sizes, enabling a comprehensive evaluation of the potential impact of peri-operative neuromonitoring on the incidence of POCD and delirium. The analysis aimed to identify patterns, trends, and statistically significant relationships in each study's findings. By conducting both qualitative and quantitative analysis, the review aimed to provide a comprehensive interpretation of the available evidence, offering insights into the potential benefits of peri-operative neuromonitoring in the context of cardiac surgery.

Moreover, Microsoft Excel was used to extract and sort the studies based on study type, sample size, duplicates, full-text articles, and empirical studies, making the systematic review approach practicable. Based on the eligibility criteria, the two authors separately read each review and selected which reviews were eligible to include. Information of variables includes the author, year of publication, and a number of studies. The two reviewers employed the Cochrane Bias Methods Group's 7-item risk of bias scale to assess methodological qualities. Ths review used the PRISMA guideline and flow diagram to lower the risk of bias. The sources of bias assessed included outcomes, population, study selection process, incompleteness of data, time frame, and setting.

Quality Assessment

The mixed method approach was used to evaluate the quality and potential risk of bias in each study. This involved assessing population demographics, methodologies, and potential bias sources. The methodological quality and sources of preferences were assessed to ensure accuracy. Standardized quality assessment tools allowed for a systematic evaluation of each study's strengths and limitations. The review aimed to substantiate findings and conclusions by critically appraising each study's methodological approach. The assessment of potential sources of bias also provided a comprehensive understanding of the limitations that might impact the validity and generalizability of the study results.

The expert members evaluated the quality of the systematic review, including questions regarding the degree to which the systematic reviewers had evaluated the risk of bias in individual studies. Articles with major limitations were excluded. Based on the review author's evaluations of the risk of bias in the primary studies they had included, the authors evaluated the methodological quality of research in perioperative nueromonitoring and postoperative cognitive dysfunction. Furthermore, the quality of the combined studies was evaluated using the Newcastle- Ottawa Scale (NOS) to ensure the reliability of the findings. The scale evaluates observational study methodologies for bias and quality, with scores of 8 or higher indicating more methodological rigor on a scale of 1 to 9 for each study. The studies on perioperative neuromonitoring effects on postoperative cognitive dysfunction and delirium in cardiac surgery patients showed potential but methodological limitations need to be acknowledged.

Data Synthesis

A meta-analysis was conducted using statistical software to analyze data from various studies, aiming to provide a comprehensive understanding of the relationship between neuromonitoring and POCD and delirium. The approach combined the results of multiple studies to provide a weighted average effect size. The meta-analysis aimed to enhance the reliability and comprehensiveness of the link between neuromonitoring and these complications. However, heterogeneity arising from differences in study designs, patient populations, and monitoring techniques was a common challenge in meta-analysis. The meta-analysis used heterogeneity assessment to estimate the potential effects of perioperative neuromonitoring on POCD and delirium while identifying potential sources of variability that could affect the interpretation of the findings.

The authors examined the data gathered by the expert team. A quantitative summary assessment of the findings was not envisaged because of the anticipated heterogeneity of research with regard to participants, interventions, outcomes, and study designs. The authors executed a qualitative and narrative summary of the article's findings. The review results were presented and discussed in two workshops intending to validate results.

Results

Sensitivity Analysis and Heterogeneity

A sensitivity analysis was carried out to ascertain the effect of research on outcomes in order to guarantee the stability and reliability of the findings. This approach comprehensively assessed the impact of each study on the combined effect size, specifically considering their reliability. The sensitivity analysis involved the systematic removal of one study to evaluate the impact of magnitude and analyze the validity of the data, as well as identify potential causes of variability. Heterogeneity in meta-analysis is a critical factor that affects conclusions. The pooled effect size estimates the overall trend, but it suggests that perioperative neuromonitoring may not consistently reduce POCD and delirium. This heterogeneity is influenced by individual study designs, patient groups, and neuromonitoring methods, potentially causing bias or skewed data. To overcome this, subgroup analysis was performed, and statistical tools like Cochran's Q test and I^2 statistic were used. The heterogeneity necessitates careful interpretation of the pooled effect size and rigorous assessment of the causes of the result's diversity.

Study Identification and Screening

Thoroughly identifying and screening studies is crucial for designing a suitable methodology. Upon doing the initial search, a total of 260 studies that met the criteria were identified. Initial screening was conducted based on titles and abstracts, resulting in a total of 228 studies that were fully reviewed. The articles were then assessed comprehensively according to the established criteria for inclusion and exclusion. This assessment involved examining the methods, conclusions, and suggestions of each study and determining their adequacy. Out of 260, 23 duplicate records, 5 ineligible records and 4 based on other reasons were excluded following the comprehensive review. This rigorous and impartial method identified the articles for the qualitative and quantitative synthesis. A total of 82 records were assessed as eligible, and the study was left with 14 studies to qualitatively synthesize, which suggested a complex association between peri-operative neuromonitoring and postoperative cognitive impairment and delirium. The articles were selected for meta-analysis and quantitative synthesis. **Table 3** and **Table 4** present a selection of qualitative and quantitative studies.

Characteristics of Included Studies

The 14 studies on peri-operative neuromonitoring and postoperative cognitive impairment and delirium showed diverse scopes and methodologies, all experimental. Sample sizes ranged from 61 to over 800, with a consistent variable in the impact of neuromonitoring on cognitive outcomes and delirium after cardiac surgery, but hip replacement and other non-serious cardiac-related surgeries were also included. Despite similarities, diverse interpretations of findings revealed challenges in establishing a shared framework in this complex context. The systematic review revealed an intricate correlation between neuromonitoring and post-operative cognitive sequelae.

Table 3. Qualitative/Mixed-Method Studies

Study	Study Design	Sample Size	Age (years)	Type of Surgery	Outcome Measure
Leeibus,et al. 2021.	Mixed method Qualitative observational-quantitative	1	49	cardiac	Ventrilo-caval shunt
Viderman et al. 2023	Qualitative Meta-Analysis	3,633	55	cardiac	neurocognitive assessment (Memory tests, mental state exam)
Al Ta'ani et al. 2023	Qualitative	105	41	Cardiac	Neuromonitoring
Y. Weiss et al. 2023	Retrospective single-center analysis	1,338	77	Elective surgery	Neurocognitive assessment
Kapoor, 2020	Meta-analysis	3,254	55	cardiac surgery, cardiac artery surgery	Neurocognitive assessment

Table 4. Quantitative Studies

Study	Study Design	Sample Size	Age (Years)	Type of Surgery	Outcome Measurement
Costa-Marina et al. 2023	Quantitative	482	65	Hip fracture	Cognitive assessment

Zugni et al. 2021	Retrospective literature review	310	60	Unspecified	Longitudinal cognitive observation
Austin et al. 2019	Quantitative	191	66	Non-emergency, cardiac included	EEG, MRI, cognitive assessment
Glumac et al. 2019	Narrative, quantitative, qualitative	981 total	65	Cardiac	MRI, neurocognitive assessment

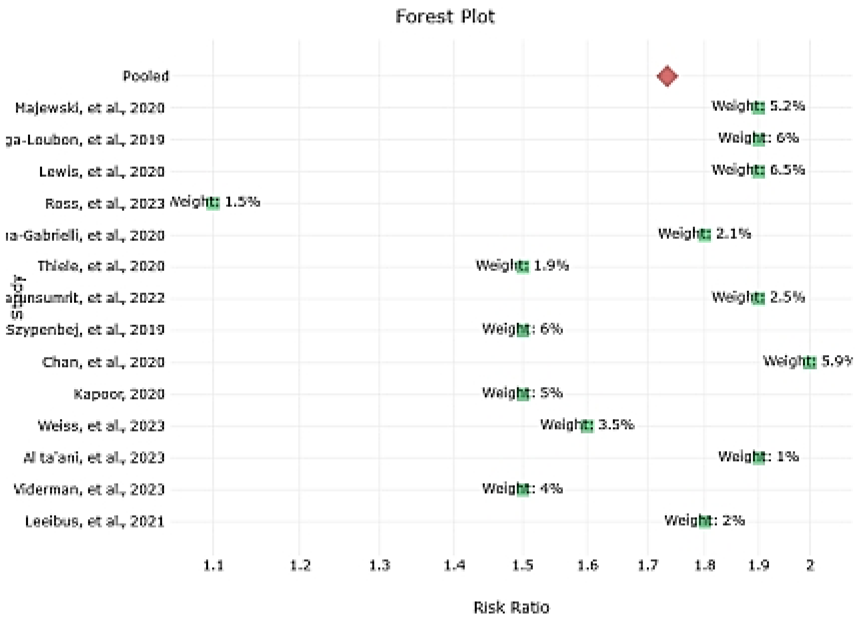

Figure 1. Forest Plot for Qualitative Studies

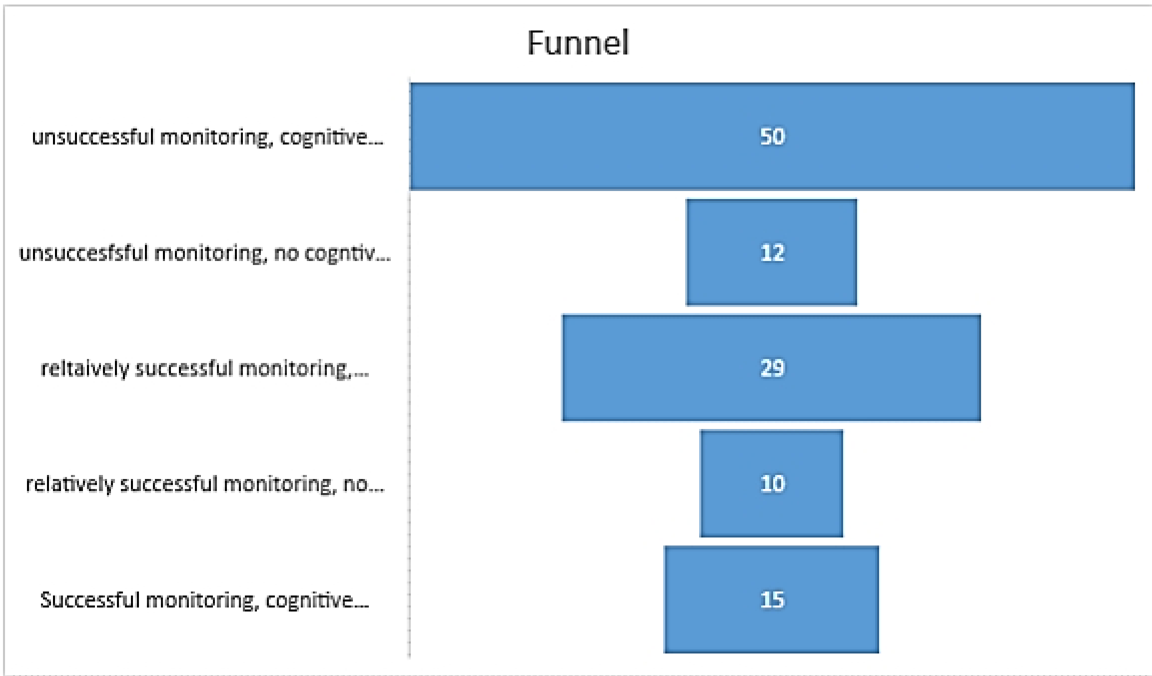

Figure 2. Funnel Chart

The initial search for publications concerning the significance of perioperative neuromonitoring on postoperative delirium and postoperative cognitive dysfunction yielded 260 papers, from which 228 were selected. The reviews' articles were further analyzed to ensure they were pertinent to assessing the impact of perioperative neuromonitoring technique on postoperative delirium and cognitive dysfunction treatment. Around 82 references were examined for their potential applicability to the medical field as a treatment. A total of 14 articles were included, with preference given to those published during the last 5 years. **Figure 3** illustrates the Preferred Reporting Items for Systemic Research and Meta-Analysis guidelines (PRISMA) flowchart of article identification, displaying the many stages of the systematic review applied in identifying studies.

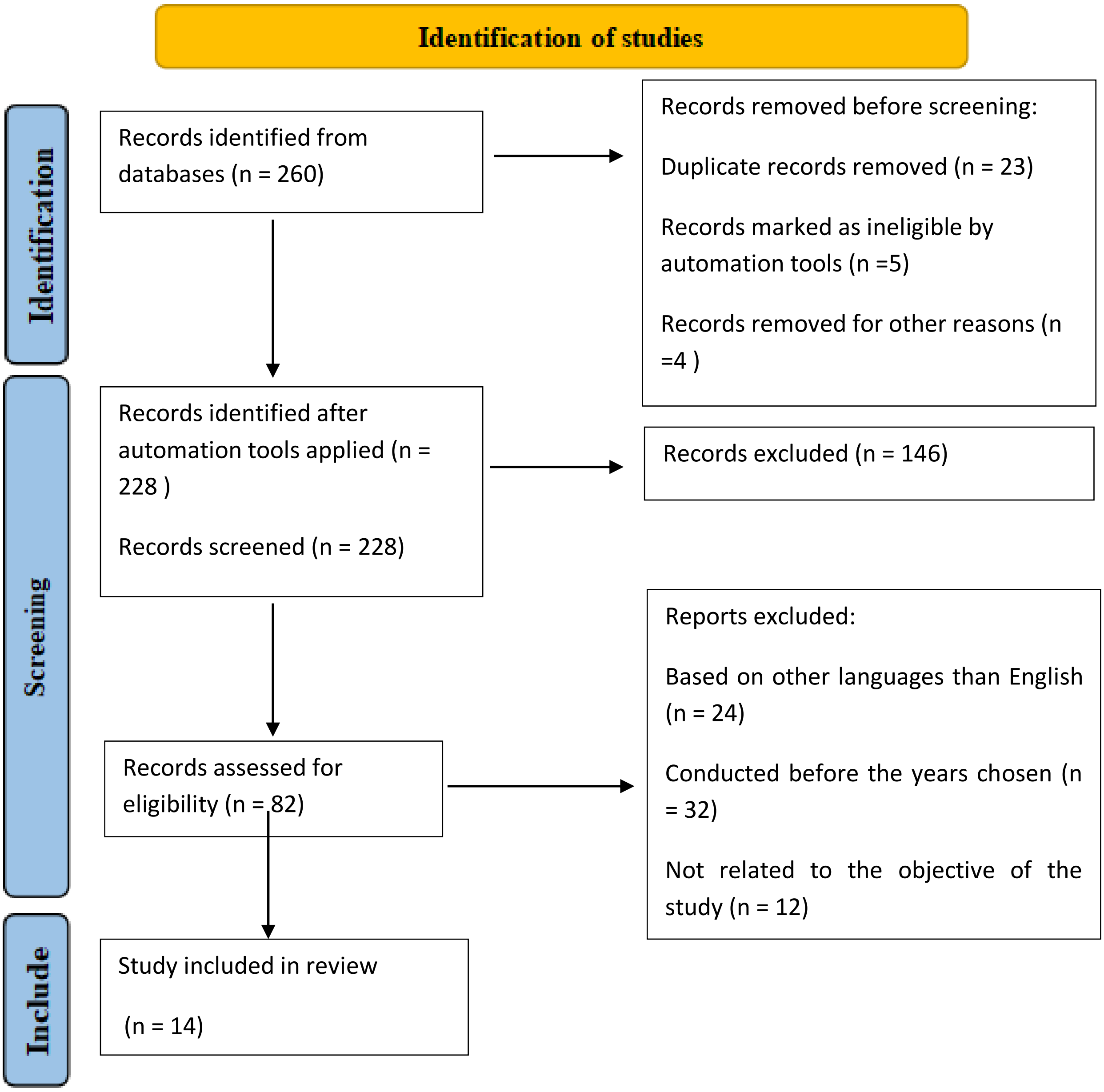

Figure 3. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses

Discussion

Delirium, or acute brain impairment, is characterized by irregular cognitive disturbances in surgical patients, with 40-50% experiencing cognitive impairment [36]. Delirium is a condition that is defined as an organ failure of the brain [12]. Notably, perioperative delirium patients are misdiagnosed in as much as two-thirds of cases occurred after 24 to 72 hours of surgery [37]. Predisposing factors linked to patient susceptibility events, or unpleasant experiences that trigger delirium, are part of the complicated etiology of delirium [38]. These factors can occur before, during, or after surgery and are influenced by treatment quality, homeostatic condition, and other factors [39]. These factors build complex connections and contribute to the patient's overall condition. Perioperative delirium is associated with various negative consequences, including an increased likelihood of falls, admission to the intensive care unit, longer hospital stays, higher rates of readmission, cognitive and functional decline, institutionalization, reduced quality of life, morbidity, mortality, and greater utilization of healthcare services, resulting in higher costs [40, 41]. An association exists between higher rates of illness, longer-lasting cognitive loss, and decreased ability to function independently after undergoing surgery [30].

However, effective management is crucial for preventing 40% of perioperative delirium cases by minimizing exposure to risk factors. Proactive discussions with ortho-geriatricians and anesthesiologists can address delirium through precise procedures and multifactorial optimization [42]. Implementing preventive measures and evaluating risk variables is essential. Fostering social, emotional, cognitive, and functional well-being in a supportive environment is recommended for a comprehensive healing process [36, 43]. A study by Nicola Zugni et al. (2021) stated that the prevalence of delirium varies significantly, ranging from 20% to 40% [27]. Most instances occur in elderly individuals after undergoing major surgeries, particularly cardiac surgeries [19]. Processed electroencephalography is a useful tool for assessing the degree of anesthesia, providing consciousness and preventing burst suppression episodes [27]. However, the cessation of brain activity was linked to the beginning of delirium. Near-infrared spectroscopy (NIRS), a noninvasive monitoring technique, was employed to detect cerebral tissue hypoxia by assessing regional oxygen saturation. While there was no evident connection between a decrease in this factor and the occurrence of POD, there was an association with POCD [27].

In another study, Adrian Austin et al. (2019) examined that individuals who had delirium following a surgical procedure were at higher risk of experiencing additional adverse outcomes [14]. Specifically, patients who developed POD had an 11% higher likelihood of mortality within the initial three months when compared to those who did not experience delirium. In addition, patients who experience POD face an increased risk of mortality during the first year, which can be as high as 17% [14, 16]. The prevalence of POCD decreases over time, reaching its highest rate of occurrence between 30% and 70% at the time of hospital discharge [8]. After six months post-surgery, the occurrence decreases to a range of 20% to 30%, and after one year of monitoring, it further decreases to a range of 15% to 25% [44]. Late-onset POCD is believed to be a continuation of early POCD but with more prominent outcomes. POCD typically manifests at the end of the initial week following surgery, while POD generally arises within the initial three days [45]. POCD does not impact the state of consciousness, unlike delirium, and it has the potential to persist for an extended duration [8]. The hippocampus region, which is especially susceptible to damage caused by lack of oxygen, is most likely the site of the hypothesized lesions responsible for POCD. Due to the intricate characteristics of POCD diseases, an accurate neuropsychological test battery that assesses many cognitive domains is necessary for an appropriate diagnosis [44]. Several innovative strategies have been devised in an effort to enhance cognitive results after cardiac surgery. These strategies include the 'no-touch' strategy, the utilization of the single-clamp technique, leukocyte depletion and ultrafiltration techniques, the application of pulsatile flow, the adoption of decreased extracorporeal circulation, and inclusion of a cell saver device [46]. Furthermore, it was evaluated that reducing the duration of cardiopulmonary bypass (CPB) and clamp times can be advantageous in optimizing cognitive outcomes [46].

A meta-analysis conducted by Viderman et al. (2023) compared the occurrence of POD and POCD between patients who received general anesthesia and those who received regional anesthesia [10, 12]. The study found no significant differences in outcomes and tests, including the Mini-Mental State Examination (MMSE) scores, postoperative reaction time, and psychomotor/attention tests [12]. There were no differences in the occurrence of POCD between patients who received general anesthesia and those who received regional anesthesia. Moreover, individuals who experienced several comorbidities were at higher risk for both, especially for those undergoing surgical procedures [12]. POD is a common cause of decreased functional abilities after surgery, but there was conflicting evidence on the link between POCD and the decline in functioning [47]. A study by Suraarunsumrit et al. in (2022) found no connection between a decline in instrumental activities of daily living (IADLs) 3 months after surgery, and POCD experienced one week after surgery. However, those experiencing POD had an increased likelihood of experiencing functional impairment [13]. Previous studies showed that a decline in IADLs may occur when POCD develops within the first three months following surgery. Those with POCD one week after noncardiac surgery were more likely to quit their work due to impaired performance [13, 43, 48, 49].

The study explored the use of perioperative neuromonitoring techniques, such as Transcranial Doppler (TCD), Near-Infrared Spectroscopy (NIRS), and Electroencephalography (EEG), in reducing delirium and POCD in cardiac surgery patients as discussed in previous studies [28, 50-52]. EEGs assess neurocognitive impairment postoperatively, while NIRS investigate cerebral ischemia and oxygenation, which may impact POCD [23, 53]. However, TCD is useful for monitoring cerebral blood flow and velocity, detecting ischemia, and identifying emboli [53]. Further research on integrating TCD with other monitoring systems could improve success [54]. Neuromonitoring during cardiac surgery is crucial for improving cognitive outcomes and identifying individual patient responses [55]. Collaboration between anesthesiologists, neurologists, and cardiac surgeons is essential to improve neuromonitoring approaches. Future research should prioritize perioperative neuromonitoring to decrease postoperative depression in specific populations, with age being a primary determinant.

Limitations and Strengths

- The limitations of the review may include the challenges of uniform interpretation due to diverse queries and methodologies, including publication bias, ecological fallacy, and the ever-changing nature of the profession.
- However, the study employed systematic review and meta-analysis methodologies for reliable data collection, analysis, and selection, ensuring results were based on valid research for better quantitative accuracy.
- Sensitivity analysis was also employed for effective outcome assessment, enhancing the overall robustness of the investigation.

Conclusion

In conclusion, this systematic review and meta-analysis on the impact of perioperative neuromonitoring on postoperative delirium and cognitive dysfunction in cardiac surgery patients revealed a complex relationship between neuromonitoring methods and cognitive performance. Postoperative delirium affects up to 50% of surgical patients and is a significant concern in surgical environments. However, more research is needed to prove a link between neuromonitoring and the previously mentioned issues. The findings shed light on the potential benefits of peri-operative neuromonitoring and highlight the need for further research.

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Conflict of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this article

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Data Availability

All the data generated or analyzed is present within the manuscript.

Author Contributions

All authors contributed to the study's conception and design. Material preparation, data collection, and analysis were performed by Sultan G Alotaibi, Muneeb A Alnouri, Rawaa M Sulaiman, Abdulkhalek A Abduljaleel, and Ahmed F Bogari. The first draft of the manuscript was written by Hani Nabeel Mufti, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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