INPLASY

Hemodynamic Variability in Patients Undergoing Decompressive Craniotomy or Craniectomy: A Scoping Review Protocol

INPLASY202560073

doi: 10.37766/inplasy2025.6.0073

Received: 17 June 2025

Published: 17 June 2025

Bhatt, O; Rizk, AA; Kumar, N; Goyal, K; Bindra, A; Singh, GP; Sokhal, N; Chowdhury, T.

Corresponding author:
Om Bhatt

om.bhatt1@medportal.ca

Author Affiliation:
Michael G. DeGroote School of Medicine, McMaster University, Hamilton, ON, Canada.

ADMINISTRATIVE INFORMATION

Support - N/A.

Review Stage at time of this submission - Preliminary searches.

Conflicts of interest - None declared.

INPLASY registration number: INPLASY202560073

Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 18 June 2025 and was last updated on 18 June 2025.

INTRODUCTION

Review question / Objective The primary objective of this scoping review is to comprehensively map the literature on temporal variability in cardiovascular parameters among patients undergoing decompressive craniotomy or craniectomy. We will consider all forms of heart rate and blood pressure variability over time, including heart rate variability (HRV), blood pressure variability (BPV), beat-to-beat fluctuations, pulse pressure changes, and related dynamic indices. The review will identify which variability measures have been studied in this patient population, how they have been quantified and analyzed, and whether they have been associated with clinical outcomes or management decisions. We will report pediatric and adult findings separately to account for any age-related differences in cardiovascular dynamics.

Background Decompressive craniotomy or craniectomy (DC) is a neurosurgical procedure performed to relieve refractory intracranial hypertension by removing a portion of the skull. Indications for DC include severe traumatic brain injury, malignant cerebral infarction with edema, and other causes of uncontrolled intracranial pressure. By expanding the intracranial compartment, DC can improve cerebral perfusion and reduce the risk of herniation, potentially improving survival and neurological outcomes. Patients undergoing DC are often critically ill and managed in intensive care or operative settings where continuous monitoring is routine. In these settings, heart rate and blood pressure are continuously recorded, and their fluctuations over time may carry important information beyond single measurements.

Heart rate variability refers to the natural fluctuation in the intervals between consecutive heartbeats. It is commonly quantified using time-domain measures (for example, the standard deviation of interbeat intervals or the root mean square of successive differences) and frequency-domain measures (for example, the power in low-frequency and high-frequency spectral bands). HRV is interpreted as a noninvasive marker of autonomic nervous system balance and cardiac adaptability. Blood pressure variability describes

spontaneous variations in systolic, diastolic, or pulse pressure over time, which can be expressed using statistical measures (such as standard deviation or coefficient of variation) or waveform analyses (such as beat-to-beat changes). These dynamic indices reflect cardiovascular regulatory mechanisms that are not captured by static averages.

In acute brain injury and neurosurgical patients, autonomic dysregulation is common. Traumatic brain injury or stroke can disrupt normal neurocardiac pathways, often leading to diminished HRV or labile blood pressure. Decompressive surgery itself may further alter these dynamics by abruptly lowering intracranial pressure and affecting cerebral blood flow. Although HRV and BPV have been studied in various critical care and neurological populations (often as prognostic indicators), the specific patterns of hemodynamic variability in patients after decompressive craniotomy/craniectomy are not well understood. Characterizing these patterns may provide insights into patient status and management needs in neurocritical care.

Rationale A scoping review is warranted because the existing evidence on hemodynamic variability in DC patients appears fragmented and diverse. Studies may exist in different clinical contexts (for example, traumatic vs. stroke cases) with varying methodologies, making it difficult to aggregate findings without a structured approach. By systematically mapping all relevant literature, we can clarify what has been studied - for instance, which specific HRV or BPV metrics have been used - and identify overarching themes or common findings. This broad overview is an important precursor to any more narrowly focused analysis or guideline development.

Importantly, this review will include all patient ages and all languages. Decompressive surgery is performed in both pediatric and adult populations, and baseline cardiovascular variability differs with age. For example, healthy children typically exhibit higher HRV than adults. By including studies of all ages and explicitly stratifying results for pediatric and adult groups, we can reveal whether certain variability measures or findings are age-specific or consistent across the lifespan. Additionally, including non-English studies ensures that regional or linguistic publication biases do not exclude relevant data.

Mapping the evidence can also highlight clinical implications and research gaps. If the review finds that certain variability profiles (such as persistently reduced HRV or elevated BPV) are consistently linked to worse outcomes after DC, this could suggest targets for monitoring or intervention. Conversely, if we find few studies or inconsistent results, that will underscore the need for further standardized research. In sum, this scoping review will create a comprehensive picture of what is known and unknown about hemodynamic variability in decompressive craniotomy/craniectomy patients, thereby guiding clinicians and future researchers.

METHODS

Strategy of data synthesis We will synthesize extracted data descriptively and thematically. Findings will be organized by category of variability measure. For example, one part of the synthesis will address heart rate variability measures (including time-domain and frequency-domain indices), another will address blood pressure variability metrics (such as systolic BP standard deviation or coefficient of variation), and a third part will cover any other relevant indices (for example, pulse pressure variation or baroreflex sensitivity measures).

Within each category, we will describe how the measures were obtained and analyzed. This includes the monitoring modality (e.g., continuous ECG versus intermittent blood pressure readings, invasive arterial line versus noninvasive cuff), the duration of recording, and the analytic method (for example, which software or algorithm was used). We will tabulate which specific metrics were reported (for example, SDNN or RMSSD for HRV; standard deviation or coefficient of variation for BPV) and how many studies used each.

We will also summarize any associations between these metrics and clinical outcomes. For example, if several studies report an association between low HRV and poor neurological recovery, we will synthesize these findings qualitatively, noting consistency or divergence. We will describe what outcomes or physiological variables were studied in relation to variability (such as intracranial pressure levels, neurological outcome scales, length of ICU stay, or mortality) and summarize the reported relationships in narrative form.

All results will be stratified by age group. We will separately present findings for pediatric patients and for adults. This stratification will highlight developmental differences; for instance, if a certain metric behaves differently in children than in adults, that will be noted. In tables and text, we will clearly label whether results apply to pediatric or adult cohorts.

Throughout the synthesis, we will integrate an appraisal of study quality. We will note how many studies of each finding come from high- or low-quality designs (based on our bias assessments). For example, if most evidence for a given

association comes from small retrospective series, we will mention that limitation. We will also discuss whether key confounders (such as sedation, mechanical ventilation, or vasoactive drug use) were accounted for in the analyses. By weaving these considerations into the narrative, we will contextualize the strength of the evidence for each finding.

No quantitative meta-analysis will be attempted due to expected heterogeneity in measures and outcomes. Instead, we will provide descriptive summaries. For example, we may report the number or proportion of studies that found a significant association for a particular metric. The primary goal is to create an evidence map – indicating what has been studied and what the main findings were – rather than to generate pooled estimates.

Sample search: (((((((craniotomy, decompressive[MeSH Terms]) OR (decompressive craniotomy[MeSH Terms])) OR (craniotomy[MeSH Terms])) OR (decompressive craniectomy[MeSH Terms])) OR (decompressive craniectomies[MeSH Terms])) OR (((((("decompressive craniotom*"[Title/Abstract]) OR ("decompressive craniectom*"[Title/Abstract])) OR ("decompressive surger*"[Title/Abstract])) OR (hemicraniectom*[Title/Abstract])) OR (craniotomy[Title/Abstract])))) AND (((heart rate[MeSH Terms]) OR (control, heart rate[MeSH Terms])) OR ((((((((((((((((((((("heart rate variability"[Title/Abstract]) OR ("HRV"[Title/Abstract])) OR ("heart rate monitor*"[Title/Abstract])) OR ("cardiac autonomic"[Title/Abstract])) OR ("heart rate chang*"[Title/Abstract])) OR ("heart rate"[Title/Abstract])) OR ("R-R interval"[Title/Abstract])) OR ("Beat-to-beat variability"[Title/Abstract])) OR ("heart rate fluctuation*"[Title/Abstract])) OR ("autonomic variability"[Title/Abstract])) OR ("blood pressure variability"[Title/Abstract])) OR ("BPV"[Title/Abstract])) OR ("Heart rate normalization"[Title/Abstract])) OR ("blood pressure chang*"[Title/Abstract])) OR ("baroreflex"[Title/Abstract])) OR ("BP variability"[Title/Abstract])) OR ("blood pressure fluctuations"[Title/Abstract])) OR ("blood pressure lability"[Title/Abstract])) OR ("hemodynamic variability"[Title/Abstract])) OR ("physiological variability"[Title/Abstract])) OR ("autonomic dysfunction"[Title/Abstract])) OR ("blood pressure monitor*"[Title/Abstract])) OR ("blood pressure*"[Title/Abstract]))))) AND ((((((((((traumatic brain injuries[MeSH Terms]) OR (tbi traumatic brain injuries[MeSH Terms])) OR (tbi traumatic brain injury[MeSH Terms])) OR (tbis traumatic brain injuries[MeSH Terms])) OR (acute stroke[MeSH Terms])) OR (acute strokes[MeSH Terms])) OR (intracranial hypertension[MeSH Terms])) OR (cerebral edema[MeSH Terms])) OR (acute brain injuries[MeSH Terms])) OR (acute brain injury[MeSH Terms])) OR (middle cerebral artery infarction[MeSH Terms])) OR (((((((("traumatic brain injur*"[Title/Abstract]) OR (TBI[Title/Abstract])) OR ("malignant infarction"[Title/Abstract])) OR (Stroke*[Title/Abstract])) OR ("intracranial hypertension"[Title/Abstract])) OR ("cerebral edema"[Title/Abstract])) OR ("Acute brain injur*"[Title/Abstract])) OR ("malignant middle cerebral artery infarction"[Title/Abstract]))).

Databases include: MEDLINE (via PubMed), EMBASE, Cochrane CENTRAL, CINAHL, and Web of Science.

Eligibility criteria For inclusion, studies must meet all of the following criteria. Population: patients of any age (neonate, child, adult, etc.) who have undergone decompressive craniotomy or craniectomy, for any underlying indication (trauma, stroke, tumor, infection, etc.). Concept: the study reports quantitative analysis of cardiovascular dynamics over time. In other words, it includes at least one measure of heart rate variability, blood pressure variability, beat-to-beat fluctuation, pulse pressure change, or a similar dynamic index. To be included, a study must report some data on heart rate and/or blood pressure beyond a single static measurement - i.e., it should analyze variability, changes over time, or differences between time points or patient groups. For instance, a paper that reports mean heart rate before and after surgery, or correlates blood pressure fluctuations with outcomes, would be included; on the other hand, a paper that only reports a one-time heart rate measurement without any notion of variability or change would not meet our concept criterion. Context: any clinical setting is eligible, including intraoperative monitoring, intensive care, or ward care, and no geographic or language restrictions will be imposed. We will include all primary research designs (observational cohorts, case-control studies, clinical trials, case series > 10 patients, etc.). We will exclude reviews, commentaries, editorials, and animal or laboratory studies. Studies that report only static hemodynamic values (for example, mean arterial pressure without any time-series analysis) will also be excluded.

No date or language limits will be applied. This broad inclusion will ensure capture of all relevant evidence on hemodynamic variability in DC patients.

Source of evidence screening and selection The literature search will be conducted in collaboration with a health sciences librarian. We will search multiple electronic databases from inception to the present, including MEDLINE (via

PubMed), EMBASE, Cochrane CENTRAL, CINAHL, and Web of Science. The search strategy will combine controlled vocabulary (MeSH/Emtree) and keywords related to decompressive neurosurgery. The full strategy will be documented in an appendix. We will also search gray literature sources such as trial registries (e.g., ClinicalTrials.gov), relevant conference proceedings, and reference lists of included studies. No language restrictions will be applied; for non-English reports we will seek translations.

Screening will be carried out in two phases by two independent reviewers. In the first phase, titles and abstracts of all retrieved records will be reviewed for relevance. Studies that clearly do not meet the eligibility criteria will be excluded. In the second phase, full texts of all remaining articles will be assessed against the inclusion criteria. A standardized screening form will be used to guide both phases. Disagreements between reviewers will be resolved by discussion or by consulting a third reviewer. We will document and report the reasons for exclusion at the full-text stage (for example, wrong patient population or no variability measures reported). The overall selection process will be illustrated with a PRISMA-ScR flow diagram.

Data management Data will be extracted using a standardized charting table. Two reviewers will independently extract information from each included study, and any discrepancies will be resolved by discussion or consensus. We will record study identifiers (authors, year, journal, country), study design, and setting. We will capture patient population details such as sample size, age distribution (mean or median age and range), the proportion of pediatric versus adult patients, sex distribution, and clinical diagnoses or indications for DC. Details of the surgical procedure (type of DC, timing relative to injury or admission) and care setting (e.g., ICU type) will also be noted.

Crucially, we will extract specifics of how hemodynamics were monitored and analyzed. This includes the method of heart rate measurement (e.g., ECG leads, pulse oximeter) and blood pressure measurement (e.g., invasive arterial catheter, noninvasive cuff), the duration of data recording, and the sampling or averaging interval. For each variability metric reported, we will record its name, how it is defined or calculated (for example, SDNN – standard deviation of NN intervals in milliseconds; or coefficient of variation of systolic blood pressure), and the units. We will also note any analytic tools or software mentioned.

All extracted data will be entered into a secure electronic spreadsheet or database. We will track any missing or unclear data fields and attempt to contact study authors for clarification if needed. However, we will not exclude studies based on missing data; instead, missing elements will be noted in our report as limitations.

We will conduct a risk-of-bias assessment for each study. For non-randomized studies, we will use the ROBINS-I tool to appraise potential biases in domains such as confounding (for example, whether the analyses accounted for factors like sedation or vasoactive drug use), selection of participants and so on.

Reporting results / Analysis of the evidence The results will be presented as an evidence map through descriptive summaries and tables. We will first describe the study selection process using a PRISMA-ScR flow diagram, reporting the number of records identified, screened, included, and excluded (with reasons). We will then summarize the characteristics of the included studies (for example, study designs, sample sizes, patient demographics, and settings) in overview tables and narrative form.

The core synthesis will be organized by type of variability measure. In each subsection (e.g., HRV time-domain measures, HRV frequency-domain measures, systolic BPV, etc.), we will report how many studies evaluated that measure and describe their main findings. For example, we might state that “N studies calculated HRV time-domain indices (such as SDNN, RMSSD); among these, X studies reported that lower HRV was associated with worse neurological outcomes.” We will summarize the reported associations with outcomes or interventions for each measure.

No quantitative meta-analysis will be conducted. We may use simple descriptive statistics (like counts or ranges) to summarize the literature (for example, the number of studies reporting a significant association versus not). The emphasis will be on mapping the scope of evidence and summarizing patterns rather than on pooling data.

Finally, we will identify research gaps revealed by the evidence. We will explicitly note areas where studies are lacking (for example, no data on BPV in pediatric DC patients) or where methodology is inconsistent (such as varying definitions of the same metric). These observations will help highlight priorities for future investigation.

Presentation of the results The results will be presented in tables and figures to facilitate understanding. We will include a PRISMA-ScR flow diagram showing the selection process. Tables will be used to summarize data systematically. For example, one table will list each included study with columns for reference, study design, patient population (age group, diagnosis), and main

variability findings. Another table will catalog each variability metric identified, its definition and units, and the studies reporting it. In all tables, pediatric and adult data will be clearly delineated (for example, via separate sections or labels).
Figures will illustrate patterns where useful. For instance, a bar chart might display the number of studies by category of variability metric (HRV vs BPV vs other), stratified by age group. A timeline chart could show publication counts over time. If appropriate, a conceptual diagram may depict links between variability measures and outcomes as reported in the literature. All figures will have clear labels and legends, and age groups will be indicated. Additional details, such as the full search strategy or extended data tables, will be provided in appendices. The presentation will adhere to PRISMA-ScR guidance to ensure clarity and completeness.

Language restriction No.

Country(ies) involved Canada, India.

Keywords decompressive craniotomy; decompressive craniectomy; hemodynamic variability; heart rate variability; blood pressure variability; autonomic nervous system; neurocritical care; pediatric; adult.

Dissemination plans We will disseminate this protocol and its findings broadly. The protocol will be registered on the INPLASY platform, and the completed scoping review will be submitted to a peer-reviewed journal in neurocritical care, neurosurgery, or critical care medicine. We will present the results at relevant conferences (for example, neurosurgical and neurocritical care meetings) to reach clinical and research audiences. In addition, we will follow open science practices by sharing our data extraction forms and, if permitted, anonymized extracted data or summary tables in an open-access repository. We may prepare summary materials (slides or infographics) to share key findings with clinical teams. By publishing in academic outlets and making materials accessible, we aim to inform practice and guide future research on hemodynamic monitoring in patients undergoing decompressive cranial surgery.

Contributions of each author

Author 1 - Om Bhatt.
Email: om.bhatt1@medportal.ca
Author 2 - Abramo Rizk.
Email: abramorizk@gmail.com
Author 3 - Niraj Kumar.
Email: drnirajaiims@gmail.com
Author 4 - Keshav Goyal.
Email: keshavgoyalster@gmail.com
Author 5 - Ashish Bindra.
Email: drashishbindra@gmail.com
Author 6 - Gyaninder Singh.
Email: drgpsingh.aiims@gmail.com
Author 7 - Navdeep Sokhal.
Email: drnavdeepsokhal@gmail.com
Author 8 - Tumul Chowdhury.
Email: tumul.chowdhury@uhn.ca