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Perioperative Hemodynamic Management in Elderly Hypertensive Patients: A Systematic Review of Monitoring-Guided Strategies and Postoperative Outcomes

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Abstract

Background

Older adults receiving long-term antihypertensive therapy represent a rapidly growing surgical population in whom intraoperative blood pressure management remains contentious. Observational evidence consistently links intraoperative hypotension with adverse postoperative outcomes, but whether specific blood pressure targets or hemodynamic management strategies improve clinical outcomes remains uncertain

Methods

We searched PubMed/MEDLINE, Embase, the Cochrane Central Register of Controlled Trials, Web of Science, and ClinicalTrials.gov from 1 January 2013 to 15 January 2026 for randomized controlled trials (RCTs) and prospective or retrospective cohort studies of haemodynamic monitoring-guided management in patients with a mean or median age of at least 65 years receiving chronic antihypertensive therapy or with documented chronic hypertension undergoing non-cardiac surgery. Two reviewers independently screened records, extracted data using a piloted form capturing design, setting, population, hypertension status, intervention, comparator, and raw outcome events, and assessed risk of bias (RoB 2 for RCTs; ROBINS-I for cohort studies). Quantitative pooling was prespecified only for comparisons with three or more studies sharing design, intervention class, and outcome definition; otherwise, a structured narrative synthesis with fully tabulated study-level effect data was performed. Certainty was rated with GRADE. Reporting follows PRISMA 2020.

Results

Nineteen studies (7 randomized controlled trials reported in 9 publications; 12 cohort studies) comprising 1,074,313 patients were included. In RCTs, higher or individualized intraoperative blood pressure targets did not reduce major vascular or organ-injury composites compared with routine targets (POISE-3: risk ratio [RR] 0.99, 95% CI 0.89–1.11; IMPROVE-multi: RR 1.10, 95% CI 0.93–1.30), although one small trial favoured individualized systolic targets (INPRESS: RR 0.74, 95% CI 0.57–0.95); certainty was low because of inconsistency and indirectness. Observational cohorts consistently reported duration-dependent associations between intraoperative hypotension and acute kidney injury or myocardial injury (moderate certainty for the association, not for a causal effect of any specific target). Goal-directed haemodynamic therapy was neutral in the largest contemporary trial (OPTIMISE II: postoperative infection RR 1.02, 95% CI 0.88–1.18) but beneficial in smaller earlier trials (low certainty). Continuing renin–angiotensin-system inhibitors increased intraoperative hypotension (RR 1.31, 95% CI 1.19–1.44) without increasing major complications (RR 1.02, 95% CI 0.87–1.19; moderate certainty). A hypotension-avoidance strategy did not reduce postoperative delirium in randomized data (cogPOISE-3: RR 1.04, 95% CI 0.79–1.38), and observational findings were inconsistent (low certainty).

Conclusions

Intraoperative hypotension is consistently and duration-dependently associated with organ injury in observational surgical cohorts, although much of this evidence is derived from broader non-cardiac surgical populations rather than exclusively elderly hypertensive patients. Randomized evidence specific to elderly hypertensive populations remains limited and does not demonstrate consistent benefit from higher blood pressure targets, goal-directed haemodynamic therapy, or specific antihypertensive withholding strategies.Recommendations for this population should rest on guidelines and individualized judgment rather than on claims of moderate-certainty trial evidence that the current literature does not provide. Renal denervation and other device-based therapies are outside the scope of this review and are identified as future research priorities only.

1. Introduction

Hypertension affects an estimated 1.28 billion adults worldwide and is the leading modifiable contributor to cardiovascular morbidity, with prevalence exceeding 60% among adults older than 65 years [1]. Ageing blunts arterial baroreflex sensitivity, stiffens conduit vessels, and shifts cerebral autoregulation rightward, so that a given intraoperative mean arterial pressure (MAP) represents a smaller perfusion reserve in an elderly hypertensive patient than in a younger normotensive one [2]. Concurrently, postoperative complications with a putative perfusion-related mechanism — myocardial injury after noncardiac surgery (MINS) [3], acute kidney injury (AKI), and postoperative delirium [4] — are strongly age-associated, making the older hypertensive surgical patient the population in whom hemodynamic management plausibly matters most.

Observational research over the past decade has repeatedly linked intraoperative hypotension to adverse outcomes; a systematic review of 42 studies found elevated risks of end-organ injury for MAP exposures below 60–70 mmHg, with risk rising as pressures and exposure duration fell [5]. What remains unresolved is whether these associations are causal and, more importantly for practice, whether any specific management strategy — higher or individualized blood pressure targets, goal-directed haemodynamic therapy (GDHT), or continuation versus withholding of chronic antihypertensives — actually prevents these outcomes. Several large randomized trials published between 2017 and 2025 now allow this question to be examined directly, and the answers are more sobering than the observational literature suggests.

Its objectives, framed as a Population–Intervention–Comparator–Outcome (PICO) question (Table 1), are to determine, in older patients receiving long-term antihypertensive therapy undergoing non-cardiac surgery, whether hemodynamic monitoring-guided management strategies improve MINS, AKI, delirium, and composite organ-injury outcomes; to present every effect estimate with its underlying raw event data; and to rate certainty with GRADE so that each conclusion carries an explicit evidence-type label.

Table 1
PICO framework of the review question

PICO element	Operational definition
Population	Patients undergoing non-cardiac surgery with a cohort mean or median age ≥ 65 years AND receiving long-term antihypertensive medication or with documented chronic hypertension; studies of broader populations were eligible only when these criteria were met at cohort level or for a separately reported subgroup
Interventions	(i) Higher or individualized intraoperative blood pressure targets (hypotension-avoidance, individualized SBP/MAP targets); (ii) goal-directed haemodynamic therapy guided by cardiac output, stroke volume, or dynamic indices (PPV/SVV); (iii) continuation versus withholding of renin–angiotensin-system inhibitors (ACEI/ARB); (iv) short-acting intravenous antihypertensives for acute perioperative hypertension
Comparators	Routine/fixed blood pressure targets; usual care or standard fluid management; alternative antihypertensive management strategy; placebo or active comparator
Outcomes	Primary: MINS, AKI (KDIGO), postoperative delirium (validated tool), composite organ injury. Secondary: mortality, intraoperative hypotension/hypertension events, length of stay
Study designs	Randomized controlled trials; prospective and retrospective cohort studies.
Setting	Elective or urgent non-cardiac surgery under general or neuraxial anaesthesia, 2013 onward

2. Methods

2.1 Review protocol and methodological amendment

The review was conducted according to a prespecified review protocol written before study selection and data extraction. Reporting follows the PRISMA 2020 statement [6]; the completed PRISMA 2020 checklist is provided as Supplementary Table S3. Before data extraction, the eligibility criteria were expanded to include retrospective cohort studies in addition to randomized controlled trials and prospective cohort studies. The rationale and timing of this methodological change are described below.

2.2 Eligibility criteria

Eligible studies enrolled patients undergoing non-cardiac surgery whose cohort mean or median age was ≥ 65 years and who were receiving long-term antihypertensive medication or had documented chronic hypertension; studies enrolling broader populations were included only where the cohort met these criteria at the aggregate level, and this is recorded study-by-study in Table 2 (column “Population match”). Eligible designs were randomized controlled trials, prospective cohort studies, and retrospective cohort studies. The amendment was justified on two grounds: first, the exposure–outcome associations that motivate perioperative blood pressure research exist almost exclusively in large retrospective datasets and excluding them would remove the evidence base for the epidemiological component of the question; second, retrospective and prospective designs were analysed separately, so the amendment could not contaminate randomized-effect estimates. Systematic reviews, narrative reviews, editorials, case reports, and conference abstracts were excluded as primary evidence (earlier systematic reviews were used only as contextual syntheses and are labelled as such). Studies of cardiac surgery, of non-surgical hypertensive populations (including all renal denervation trials), and studies without separable data for the target population were excluded.

The search window (1 January 2013 to 15 January 2026) was chosen for a stated methodological reason: standardized outcome definitions date from this period — the 2012 KDIGO criteria for AKI, the third universal definition of myocardial infarction (2012), and high-sensitivity troponin-based MINS definitions operationalized by the VISION programme — and contemporary monitoring technology (pulse-contour cardiac output, dynamic indices) became routine over the same interval. Earlier literature used non-comparable definitions and monitoring and is summarized through the prior systematic review by Wesselink et al. [5] rather than re-analysed.

2.3 Information sources and search strategy

PubMed/MEDLINE, Embase (Ovid), the Cochrane Central Register of Controlled Trials, and Web of Science Core Collection were searched on 15 January 2026, with ClinicalTrials.gov searched the same day for completed and ongoing trials. The search combined controlled vocabulary and free-text terms for the population (aged, elderly, hypertension, antihypertensive agents), the intervention (intraoperative blood pressure, hemodynamic monitoring, goal-directed therapy, individualized blood pressure, angiotensin-converting enzyme inhibitors), and the outcomes (myocardial injury, acute kidney injury, delirium, postoperative complications), restricted to 2013 onward and to humans, without language restriction. The complete PubMed strategy is reproduced verbatim in Supplementary Table S1, with the adapted Embase, CENTRAL, Web of Science, and ClinicalTrials.gov strategies, the platform used for each database, and the deduplication method (EndNote 21 automated deduplication with manual verification). Reference lists of included studies and of the prior systematic review [5] were screened by backward citation chaining.

2.4 Study selection

Two reviewers (MA, WZ) independently screened titles and abstracts and then full texts against the eligibility criteria. Disagreements were resolved by discussion or, where unresolved, by a third reviewer (LY). Inter-reviewer agreement at full-text stage was quantified with Cohen’s kappa. For trials with multiple reports (e.g., POISE-3 and its substudies), all reports were collated and the trial counted once; companion reports are listed under the parent study in Table 2. Records excluded at full-text stage were each assigned one exclusion reason, and the complete exclusion list is provided in Supplementary Table S2.

2.5 Data extraction

Two reviewers independently extracted data into a piloted form capturing: bibliographic details (authors, year, journal, DOI or PMID); design and setting; sample size; age summary and eligibility age threshold; proportion with hypertension or on antihypertensive therapy; surgery type; intervention and comparator definitions; outcome definitions and timing; raw event counts and denominators by group for every reported outcome; adjusted effect estimates with covariates for observational studies; and risk-of-bias inputs. Where a publication reported percentages without counts, counts were reconstructed from the denominator and are marked as derived. Extraction disagreements were resolved by re-inspection of the source. Corresponding authors were not contacted; all data are from the published reports.

2.6 Risk of bias assessment

RCTs were assessed with the RoB 2 tool across its five domains, with a support-for-judgment recorded per domain [7]. Cohort studies were assessed with ROBINS-I across its seven domains, focusing on confounding (preoperative comorbidity, baseline blood pressure, surgical complexity) and exposure measurement [8]. Two reviewers assessed each study independently; judgments were reconciled by consensus. Domain-level and overall judgments are presented per study (Tables 3 and 4), not only in aggregate, and study-level certainty consequences are carried into the GRADE profile.

2.7 Certainty of evidence (GRADE)

For each comparison–outcome pair, certainty was rated using GRADE [9], starting at high for randomized evidence and low for observational evidence, with rating down for risk of bias, inconsistency, indirectness, imprecision, or publication bias, and rating up for large magnitude or dose–response. The evidence profile (Table 6) reports, per outcome: the number of studies and participants, the relative effect, the absolute effect per 1,000 where a baseline risk is available, the certainty rating, and a footnote for every rating decision.

2.8 Synthesis methods

Synthesis was structured by intervention class so that physiologically distinct strategies were never combined (Section 3.4 to 3.7), following guidance for narrative synthesis in systematic reviews [10]. Quantitative pooling was prespecified only when three or more studies shared design, intervention class, comparator, and outcome definition; heterogeneity was to be assessed clinically and methodologically a priori, and not by any I^2 threshold used as a pooling gate. Had pooling been performed, we planned random-effects models with restricted maximum-likelihood τ^2 estimation and Hartung–Knapp confidence intervals [11], computed in R (metafor), with 0.5 continuity correction for zero-event arms, leave-one-out sensitivity analyses, exclusion of high-risk-of-bias studies, and contour-enhanced funnel plots with Egger's test where ten or more studies contributed [12]. No comparison met the predefined criteria for clinically meaningful quantitative pooling. Although several studies addressed related clinical questions, substantial differences existed in intervention definitions, blood pressure targets, monitoring strategies, comparator conditions, outcome compositions, and follow-up periods. Therefore, quantitative synthesis was considered inappropriate because a pooled estimate would combine clinically non-equivalent interventions and outcomes, potentially reducing interpretability and introducing misleading precision. All effect estimates are therefore presented at the individual study level with raw event data (Table 5, Fig. 2), allowing each estimate to be traced to its original source. Pooled estimates quoted from previously published peer-reviewed meta-analyses are explicitly attributed to their source. Number-needed-to-treat is not reported because no pooled absolute effect was generated and no assumed control-event risk could be justified across heterogeneous composites.

3. Results

3.1 Study selection

The study selection process is shown in Fig. 1. Searches identified 4,886 records (4,812 from databases; 74 from ClinicalTrials.gov); after removal of 1,233 duplicates, 3,653 records were screened, 162 full texts were assessed, and 19 studies reported in 21 publications were included. Inter-reviewer agreement at the full-text stage was substantial (Cohen's kappa 0.82). Seven studies were RCTs (reported in nine publications, including two POISE-3 substudy reports) and twelve were cohort studies. One hundred forty-three full texts were excluded, each with a recorded reason (Fig. 1; Supplementary Table S2). Notable exclusion included a systemic review [48], a narrative review of hypertension and orthostatic hypotension in older adults [49], cardiac-surgery studies [43], renal denervation trials in non-surgical populations [44–47], a dexmedetomidine trial that evaluated pharmacological sedation rather than hemodynamic monitoring-guided management [50], and the FEDORA trial [19], which had a cohort mean age below 65 years without a separable elderly subgroup.

Figure 1. PRISMA 2020 flow diagram. RCT = randomized controlled trial. The POISE-3 trial contributes three reports (main comparison [14], acute kidney injury substudy [15], and neurocognitive substudy [16]) and is counted as one study.

3.2 Characteristics of included studies

The 19 included studies comprise 1,074,313 patients and are described study-by-study in Table 2, including full bibliographic identifiers. Three randomized trials compared higher or individualized blood pressure targets with routine targets [13–17]; two randomized trials evaluated cardiac output-guided haemodynamic therapy [18,20]; three studies evaluated continuation versus withholding of renin–angiotensin-system inhibitors (two RCTs [22,23] and one prospective cohort [21]); seven retrospective cohorts quantified the exposure–outcome association between intraoperative hypotension and organ injury [25–31]; and four cohorts addressed hypotension and postoperative delirium [33–36]. Three previously published peer-reviewed syntheses were used as contextual evidence only [5,24,32]. Because the two linked questions of this review have different evidentiary bases, eligibility was operationalized per sub-question (Table 2, final column): sub-question 1 (effect of management strategies) required an older hypertensive/antihypertensive-treated population; sub-question 2 (hypotension exposure–outcome associations) required adjusted outcome data from non-cardiac surgical cohorts, with indirectness to the elderly hypertensive population explicitly rated in GRADE.

Table 2
Characteristics of all included studies (complete list, with bibliographic identifiers)

Study [ref]	Design, setting	N	Age	Hypertension status	Surgery	Intervention/exposure vs comparator	Primary outcome (timing)
Futier 2017 (INPRESS) [13]	Multicentre RCT, France; PMID 28973220; doi:10.1001/jama.2017.14172	298 randomized, 292 analysed	Mean 70 yr	Not an entry criterion; high-risk surgical population	Major (predominantly abdominal)	Individualized SBP within 10% of resting value (norepinephrine) vs standard care (ephedrine for SBP < 80 mmHg or < 60% of baseline)	Composit organ dysfunctio (day 7)
Marcucci 2023 (POISE-3) [14]	Multinational RCT, 23 countries; PMID 37094336; doi:10.7326/M22-3157	7,490	Mean ~ 70 yr	100% receiving ≥ 1 antihypertensive, with vascular risk	Non-cardiac	Hypotension-avoidance (MAP ≥ 80 mmHg; chronic agents continued) vs hypertension-avoidance (MAP ≥ 60 mmHg; ACEI/ARB withheld)	Composit vascular d MINS, stro cardiac ar (30 d)
POISE-3 AKI substudy 2025 [15]	Companion report of [14]; Kidney Int; PMID 39490985; doi:10.1016/j.kint.2024.10.007	7,307	As parent trial	As parent trial	Non-cardiac	As parent trial	AKI (KDIG d)
cogPOISE-3 2025 [16]	Companion report of [14]; Ann Intern Med; PMID 40456161; doi:10.7326/ANNALS-24-02841	2,603	Mean 70 yr	As parent trial	Non-cardiac	As parent trial	Delirium (days 1–3)
Saugel 2025 (IMPROVE-multi) [17]	Multicentre RCT, Germany; PMID 41076588; doi:10.1001/jama.2025.17235	1,142 randomized, 1,134 analysed	Median 66 yr	Not an entry criterion	Major abdominal	Individualized MAP targets from preoperative automated nighttime BP vs routine care	Composit AKI, acute myocardia injury, car arrest, dea d)
Pearse 2014 (OPTIMISE) [18]	Multicentre RCT, UK; PMID 24842135	734	Median ~ 69 yr	Not an entry criterion; high-risk population	Major gastrointestinal	Cardiac output-guided fluid + dopexamine vs usual care	Composit moderate, complicat and morta (30 d)
OPTIMISE II 2024 [20]	Multinational RCT; BMJ 2024;387:e080439; doi:10.1136/bmj-2024-080439	2,502 randomized, 2,498 analysed	≥ 65 year (mean 74)	Not an entry criterion	Major gastrointestinal	Cardiac output-guided minimally invasive haemodynamic therapy vs usual care	Postopera infection (
Ackland 2024 (SPACE) [22]	Multicentre RCT, UK; Eur Heart J 2024;45:1146–1155; PMID 37935833	262	≥ 60 year (older cohort)	100% on ACEI/ARB	Non-cardiac	Discontinuation vs continuation of ACEI/ARB before surgery	Myocardia injury (hs-troponin; 0–3)
Legrand 2024 (Stop-or-Not) [23]	Multicentre RCT, 40 centres, France; JAMA 2024;332:970–978; PMID 39212270	2,222	Mean 67 yr	100% on ACEI/ARB ≥ 3 months	Major non-cardiac	Continuation vs discontinuation (48 h) of ACEI/ARB	Composit major complicat (28 d)
Roshanov 2017 (VISION substudy) [21]	Prospective cohort, multinational; Anesthesiology 2017;126:16–27; PMID 27775997	4,802 ACEI/ARB users (of 14,687)	Cohort ≥ 45 year (mean mid-60s)	100% ACEI/ARB users	Non-cardiac	Withholding (24 h) vs continuing ACEI/ARB	Composit death, stro myocardia injury (30
Walsh 2013 [25]	Retrospective cohort, single centre, USA; Anesthesiology 2013;119:507–515	33,330	Mixed adult (not extracted)	Not required	Non-cardiac	Intraoperative MAP exposure categories vs higher exposure	AKI, myoc injury, mo (30 d)
Sun 2015 [26]	Retrospective cohort, single centre, Canada; Anesthesiology 2015;123:515–523	5,127	Mean ~ 63 yr	Not required	Elective non-cardiac	Duration of MAP < 55/<60 mmHg vs minimal exposure	AKI (KDIG d)
Mascha 2015 [27]	Retrospective cohort, single centre, USA; Anesthesiology 2015;123:79–91	104,401	Mixed adult (not extracted)	Not required	Non-cardiac	Time-weighted average MAP and MAP variability	30-day mo
Salmasi 2017 [28]	Retrospective cohort, single centre, USA; Anesthesiology 2017;126:47–65; PMID 27792044	57,315	Mixed adult (not extracted)	Not required	Non-cardiac	Absolute (MAP < 65) and relative (> 20% below baseline) hypotension vs none	AKI and myocardia injury (30
Ahuja 2020 [29]	Retrospective cohort, single centre, USA; Anesthesiology 2020;132:291–306	23,140	Mixed adult (not extracted)	Not required	Non-cardiac	Invasive SBP/DBP/MAP/pulse-pressure exposures	Myocardia injury and (30 d)

Study [ref]	Design, setting	N	Age	Hypertension status	Surgery	Intervention/exposure vs comparator	Primary outcome (timing)
Mathis 2020 (MPOG) [30]	Retrospective multicentre cohort, USA; Anesthesiology 2020;132:461–475	138,021	Mixed adult (not extracted)	Not required	Non-cardiac	Hypotension exposure stratified by preoperative risk	AKI (KDIG
Gregory 2021 [31]	Retrospective multicentre cohort, USA; Anesth Analg 2021;132:1654–1665	368,222	Mixed adult (not extracted)	Not required	Non-cardiac	Intraoperative hypotension exposure vs none	Composit adverse outcomes incl. AKI, M mortality
Maheshwari 2020 [33]	Retrospective cohort, single centre, USA; Anesth Analg 2020;130:636–643; PMID 31725024	1,083	Mixed adult ICU (not extracted)	Not required	Non-cardiac (SICU patients)	Time-weighted average MAP < 65 mmHg, intra- and postoperative	Delirium (ICU)
Wachtendorf 2022 [34]	Retrospective multicentre cohort, USA; Anesth Analg 2022;134:822–833; PMID 34517389	316,717	Mixed adult (not extracted)	Not required	Non-cardiac	Absolute vs relative intraoperative hypotension	Delirium (
Zarour 2024 [35]	Retrospective cohort, single centre, Israel; Anesthesiology 2024;141:707–718; PMID 38995701	2,352	> 70 year (eligibility)	Not required	Non-cardiac	Intraoperative hypotension exposure	Delirium (
Ettoumi 2025 [36]	Retrospective cohort, single centre, UK; BJA Open 2025;16:100500; PMID 41142588	5,171	≥ 60 year, ASA 3–4	Not required	Major non-cardiac	Cumulative MAP < 65 mmHg exposure	Delirium (

ACEI = angiotensin-converting enzyme inhibitor; AKI = acute kidney injury; ARB = angiotensin II receptor blocker; ASA = American Society of Anesthesiologists physical status; BP = blood pressure; CAM = Confusion Assessment Method; DBP = diastolic blood pressure; KDIGO = Kidney Disease: Improving Global Outcomes; MAP = mean arterial pressure; MINS = myocardial injury after noncardiac surgery; PMID = PubMed identifier; RCT = randomized controlled trial; SBP = systolic blood pressure; SICU = surgical intensive care unit. Population match: "Direct" = cohort-level age and hypertension/antihypertensive criteria both met; "Partial" = one criterion met; "Sub-question 2" = exposure–outcome evidence stream (all-adult surgical cohorts), with indirectness rated in GRADE.

3.3 Risk of bias within studies

Domain-level RoB 2 judgments for the seven randomized trials (nine reports) are given in Table 3. All trials were rated at overall "some concerns," driven by the open-label administration of hemodynamic strategies in pragmatic anaesthesia settings; outcome measurement was generally objective (troponin- or creatinine-based composites, masked adjudication in POISE-3), and missing data were few. Domain-level ROBINS-I judgments for the twelve cohort studies are given in Table 4. All cohort studies were rated at overall moderate risk of bias: exposure measurement from anaesthesia information systems was objective, and all reported adjusted associations, but residual confounding (baseline comorbidity, surgical complexity, indication for monitoring) cannot be excluded, and no observational study had a preregistered analysis plan.

Table 3
RoB 2 domain-level risk-of-bias judgments for randomized trials

Study (outcome assessed)	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported result	Overall
Futier 2017 (INPRESS) [13]	Low	Some concerns (open-label vasoactive strategy)	Low (292/298 analysed)	Some concerns (composite includes clinically assessed components)	Low	Some concerns
POISE-3 main [14]	Low	Some concerns (pragmatic adherence incomplete)	Low	Low (masked adjudication)	Low	Some concerns
POISE-3 AKI substudy [15]	Low	Some concerns	Some concerns (sample reduced by COVID-19-era laboratory availability)	Low (creatinine-based KDIGO)	Low	Some concerns
cogPOISE-3 [16]	Low	Some concerns	Some concerns (enrolment below target)	Some concerns (CAM screening, days 1–3 only)	Low	Some concerns
Saugel 2025 (IMPROVE-multi) [17]	Low	Some concerns (open-label)	Low (1,134/1,142)	Low (laboratory-defined composite)	Low	Some concerns
Pearse 2014 (OPTIMISE) [18]	Low	Some concerns (~ 8% non-adherence; unblinded clinicians)	Low	Low (masked outcome assessment)	Low	Some concerns
OPTIMISE II 2024 [20]	Low	Some concerns (open-label intervention)	Low (2,498/2,502)	Low (masked assessors)	Low	Some concerns
Ackland 2024 (SPACE) [22]	Low	Some concerns (open-label)	Some concerns (13/262 missing primary)	Low (hs-troponin; masked)	Low	Some concerns
Legrand 2024 (Stop-or-Not) [23]	Low	Some concerns (open-label pragmatic)	Low	Some concerns (composite partly administrative)	Low	Some concerns

Table 4
ROBINS-I domain-level risk-of-bias judgments for cohort studies

Study	Confounding	Selection of participants	Classification of interventions/exposure	Deviations from intended exposures	Missing data	Measurement of outcomes	Selection of reported result	Overall
Roshanov 2017 [21]	Moderate (confounding by indication)	Low	Low	Low	Low	Low (troponin surveillance)	Moderate (no preregistered plan)	Moderate
Walsh 2013 [25]	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Sun 2015 [26]	Moderate	Low	Low	Low	Low	Low (KDIGO)	Moderate	Moderate
Mascha 2015 [27]	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Salmasi 2017 [28]	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Ahuja 2020 [29]	Moderate	Low	Low	Low	Low	Low	Moderate	Moderate
Mathis 2020 [30]	Moderate	Low (multicentre)	Low	Low	Low	Low	Moderate	Moderate
Gregory 2021 [31]	Moderate	Low	Low	Low	Moderate (administrative data)	Moderate	Moderate	Moderate
Maheshwari 2020 [33]	Moderate	Moderate (SICU selection)	Low	Low	Low	Low (CAM-ICU)	Moderate	Moderate
Wachtendorf 2022 [34]	Moderate	Low (multicentre)	Low	Low	Low	Moderate (chart-based delirium ascertainment)	Moderate	Moderate
Zarour 2024 [35]	Moderate	Moderate (single centre)	Low	Low	Low	Moderate (retrospective delirium ascertainment)	Moderate	Moderate
Ettoumi 2025 [36]	Moderate (temporal confounding attenuated effect)	Low	Low	Low	Low	Moderate	Moderate	Moderate

3.4 Sub-question 1a: higher or individualized blood pressure targets versus routine targets

Three randomized trials addressed intraoperative blood pressure targets, with raw outcome data in Table 5 and Fig. 2. In INPRESS (n = 292; mean age 70), an individualized systolic target within 10% of the resting value reduced the day-7 organ-dysfunction composite (56/147, 38.1%, vs 75/145, 51.7%; RR 0.74, 95% CI 0.57–0.95) [13]. In marked contrast, the two larger trials were neutral. In POISE-3 (n = 7,490; all on antihypertensive therapy), hypotension-avoidance did not reduce the 30-day major vascular composite (520/3,742, 13.9%, vs 524/3,748, 14.0%; hazard ratio 0.99, 95% CI 0.88–1.12) [14], did not reduce AKI in the dedicated substudy (15.1% vs 14.4%; RR 1.05, 95% CI 0.94–1.17) [15], and did not reduce delirium in the neurocognitive substudy (7.3% vs 7.0%; RR 1.04, 95% CI 0.79–1.38) [16]. In IMPROVE-multi (n = 1,134), individualized MAP targets derived from preoperative automated nighttime blood pressure did not reduce the day-7 composite of AKI, myocardial injury, cardiac arrest, or death (33.5% vs 30.5%; RR 1.10, 95% CI 0.93–1.30) [17]. The single positive trial is the smallest and the only one using an intraoperative norepinephrine infusion protocol to hold systolic pressure within a tight individualized band; whether the benefit reflects the target, the drug, or chance cannot be determined from current evidence. GRADE certainty that higher or individualized targets reduce organ-injury composites is low (inconsistent direction of effect; indirect composite definitions) (Table 6).

3.5 Sub-question 1b: goal-directed haemodynamic therapy

Two RCTs met eligibility. In OPTIMISE (n = 734; median age ~ 69), cardiac output-guided fluid plus low-dose dopexamine did not significantly reduce the 30-day composite (36.6% vs 43.4%; RR 0.84, 95% CI 0.71–1.01), although the trial's accompanying updated meta-analysis — which pooled predominantly small, older trials — reported benefit; cardiovascular serious adverse events were numerically more frequent with the intervention (1.4% vs 0%) [18]. In OPTIMISE II (n = 2,498; all ≥ 65 years), cardiac output-guided therapy did not reduce 30-day postoperative infection (23.2% vs 22.7%; adjusted odds ratio 1.03, 95% CI 0.84–1.25) and was associated with more cardiac events within 24 hours (38 vs 21; adjusted OR 1.82, 95% CI 1.06–3.13), attributable mainly to arrhythmias and myocardial injury in older patients with cardiovascular comorbidity [20]. GRADE certainty is low (inconsistency between small older favourable trials and the largest contemporary neutral trial; suspicion of publication bias in the older literature) (Table 6). The FEDORA trial [19], often cited in favour of GDHT, was excluded here because its cohort mean age was below 65 years without a separable elderly subgroup (Supplementary Table S2).

3.6 Sub-question 1c: continuation versus withholding of renin–angiotensin-system inhibitors

Three eligible studies converged on a consistent picture (Table 5, Fig. 2). In Stop-or-Not (n = 2,222; mean age 67; all on ACEI/ARB), discontinuation 48 hours before surgery did not reduce the 28-day major-complication composite (22% vs 22%; RR 1.02 for continuation vs discontinuation, 95% CI 0.87–1.19) but continuation increased intraoperative hypotension (54% vs 41%; RR 1.31, 95% CI 1.19–1.44) [23]. In SPACE (n = 262; ≥60 years), discontinuation did not significantly alter myocardial injury (48.3% vs 41.3%; RR 1.17, 95% CI 0.88–1.55), while hypertensive events requiring treatment were more frequent with discontinuation (12.4% vs 5.3%) [22]. In the prospective VISION analysis (4,802 ACEI/ARB users), withholding was associated with a lower adjusted risk of the 30-day composite of death, stroke, and myocardial injury (12.0% vs 12.9%; adjusted RR 0.82, 95% CI 0.70–0.96) and less intraoperative hypotension [21]. A prior systematic review and meta-analysis of nine studies (~ 6,000 patients) similarly found that continuation increases perioperative hypotension without demonstrable differences in mortality or major cardiac events [24]. Certainty is moderate that continuation increases intraoperative hypotension and that neither strategy materially changes major complication rates; certainty is low for any effect on myocardial injury (imprecision) (Table 6). The evidence supports individualized rather than blanket rules.

3.7 Sub-question 2: intraoperative hypotension exposure and organ injury; delirium

Seven large retrospective cohorts (together > 745,000 patients) reported adjusted, duration-dependent associations between intraoperative hypotension and organ injury (Table 5). Representative findings: AKI risk rose progressively with cumulative time below MAP 55 mmHg (11–20 min: adjusted OR 2.34, 95% CI 1.35–4.05; >20 min: OR 3.53, 95% CI 1.51–8.25) [26]; exposures below MAP 65 mmHg beyond approximately 12 minutes were associated with higher AKI and myocardial-injury odds, with absolute and relative thresholds behaving similarly [28]; 30-day mortality rose steeply as time-weighted MAP fell below ~ 75 mmHg [27]; and risk was amplified in patients with high preoperative risk profiles [30]. A prior systematic review of 42 studies concluded likewise that risk concentrates below MAP 60–70 mmHg with rising duration, while cautioning that observational designs preclude causal threshold claims [5]; a subsequent meta-analysis of 29 studies (> 130,000 patients) reported pooled associations with morbidity (OR 2.08, 95% CI 1.56–2.77) and mortality (OR 1.94, 95% CI 1.32–2.84) [32]. Certainty is moderate that a duration-dependent association exists for AKI and myocardial injury; these data do not establish that any particular treatment target prevents injury (Table 6).

For delirium, the picture is inconsistent. Two cohorts found associations — a multicentre study of 316,717 patients reported adjusted odds ratios of 1.22 (short) and 1.57 (prolonged) for MAP < 55 mmHg, with relative (> 30%) reductions unassociated [34], and a surgical-ICU cohort reported an adjusted hazard ratio of 1.11 per mmHg of time-weighted MAP < 65 (95% CI 1.06–1.16) [33] — whereas two dedicated older cohorts did not: a single-centre study of 2,352 patients older than 70 years found no association after adjustment [35], and a high-risk cohort of 5,171 patients ≥ 60 years found that an initial association (OR 1.12 per cumulative hour below MAP 65) attenuated to non-significance (OR 1.06) after adjustment for confounding [36]. The only randomized comparison (cogPOISE-3) found no difference between strategies (RR 1.04, 95% CI 0.79–1.38) [16]. Certainty is low (Table 6).

Table 5
Study-level effect data with raw event counts (auditable extraction)

Study [ref]	Outcome (definition; timing)	Intervention/exposure, events/N (%)	Comparator, events/N (%)	Effect estimate (95% CI)
Randomized evidence				
Futier 2017 [13]	Composite organ dysfunction (modified SOFA; day 7)	56/147 (38.1)	75/145 (51.7)	RR 0.74 (0.57–0.95)
Marcucci 2023 [14]	Vascular death, MINS, stroke, cardiac arrest (30 d)	520/3,742 (13.9)	524/3,748 (14.0)	HR 0.99 (0.88–1.12); RR 0.99 (0.89–1.11)*
POISE-3 AKI substudy [15]	AKI (KDIGO; 7 d)	552/3,654 (15.1)	526/3,653 (14.4)	RR 1.05 (0.94–1.17)*
cogPOISE-3 [16]	Delirium (CAM; days 1–3)	95/1,310 (7.3)	90/1,293 (7.0)	RR 1.04 (0.79–1.38)*
Saugel 2025 [17]	AKI, myocardial injury, arrest, death (7 d)	190/567 (33.5)	173/567 (30.5)	RR 1.10 (0.93–1.30)
Pearse 2014 [18]	Moderate/major complications or death (30 d)	134/368 (36.6)	159/366 (43.4)	RR 0.84 (0.70–1.00)*
OPTIMISE II 2024 [20]	Postoperative infection (30 d)	289/1,247 (23.2)	283/1,247 (22.7)	Adjusted OR 1.03 (0.84–1.25)
OPTIMISE II 2024 [20]	Cardiac events (24 h)	38/1,247 (3.0)	21/1,247 (1.7)	Adjusted OR 1.82 (1.06–3.13)
Legrand 2024 [23]	Composite major complications (28 d), continuation vs discontinuation	247/1,107 (22)	245/1,115 (22)	RR 1.02 (0.87–1.19)
Legrand 2024 [23]	Intraoperative hypotension, continuation vs discontinuation	598/1,107 (54)	457/1,115 (41)	RR 1.31 (1.19–1.44)
Ackland 2024 [22]	Myocardial injury (hs-troponin; days 0–3), discontinuation vs continuation	58/120 (48.3)	50/121 (41.3)	RR 1.17 (0.88–1.55)*
Ackland 2024 [22]	Hypertensive events requiring treatment, discontinuation vs continuation	16/129 (12.4)	7/131 (5.3)	RR 2.32 (0.99–5.44)*
Cohort evidence (adjusted estimates as reported)				
Roshanov 2017 [21]	Death, stroke, or myocardial injury (30 d), withholding vs continuing	150/1,245 (12.0)	459/3,557 (12.9)	Adjusted RR 0.82 (0.70–0.96)
Sun 2015 [26]	AKI (KDIGO; 7 d); MAP < 55 mmHg 11–20 min vs ≤ 10 min	324/5,127 AKI overall (6.3)	—	Adjusted OR 2.34 (1.35–4.05)
Sun 2015 [26]	AKI; MAP < 55 mmHg > 20 min	—	—	Adjusted OR 3.53 (1.51–8.25)
Salmasi 2017 [28]	AKI and myocardial injury (30 d); MAP < 65 mmHg or > 20% below baseline, by duration	57,315 cohort	—	Duration-dependent increase in adjusted odds of AKI and MINS; absolute and relative definitions equivalent
Mascha 2015 [27]	30-day mortality; time-weighted MAP	104,401 cohort	—	Mortality rose progressively below TWA-MAP ~ 75 mmHg; MAP variability not independently associated
Ahuja 2020 [29]	Myocardial injury (6.1%) and AKI (8.2%) (30 d)	23,140 cohort	—	Injury odds increased below SBP 90, MAP 65, DBP 50, pulse pressure 35 mmHg, duration-dependent
Mathis 2020 [30]	AKI (KDIGO; 9.0%)	138,021 cohort	—	Hypotension–AKI association strongest in high preoperative-risk patients
Gregory 2021 [31]	Composite adverse outcomes incl. AKI, MINS, mortality	368,222 cohort	—	Hypotension exposure associated with increased adjusted odds of all component outcomes
Wachtendorf 2022 [34]	Delirium (30 d); MAP < 55 mmHg short vs prolonged	316,717 cohort	—	Adjusted OR 1.22 (short) and 1.57 (prolonged); relative reductions > 30% not associated
Maheshwari 2020 [33]	Delirium (CAM-ICU); per mmHg TWA-MAP < 65	1,083 cohort (delirium 35%)	—	Adjusted HR 1.11 (1.06–1.16)
Zarour 2024 [35]	Delirium (30 d); patients > 70 yr	2,352 cohort (delirium 14%)	—	No association after adjustment

Study [ref]	Outcome (definition; timing)	Intervention/exposure, events/N (%)	Comparator, events/N (%)	Effect estimate (95% CI)
Randomized evidence				
Ettoumi 2025 [36]	Delirium (30 d); per cumulative hour MAP < 65 mmHg	5,171 cohort (delirium 11.8%)	—	OR 1.12 before, 1.06 (non-significant) after full adjustment

*HR = hazard ratio; OR = odds ratio; RR = risk ratio; TWA = time-weighted average. *RR and CI derived by the review team from published event counts (log method); all other estimates as reported by the study authors.*

Figure 2. Study-level effects for all randomized comparisons with extractable event counts (log scale; dashed line = no effect). No pooled diamonds are shown because no comparison met the prespecified three-study homogeneity criterion for meta-analysis (Section 2.8).

3.8 Synthesis: why no de novo pooled estimates are reported

No comparison met the prespecified criteria for quantitative synthesis. Although some outcomes appeared conceptually related, the underlying clinical questions were not sufficiently comparable for reliable pooling. Blood pressure-target trials used different target definitions and composite endpoints; goal-directed haemodynamic therapy studies used different monitoring platforms and treatment algorithms; and antihypertensive management studies evaluated different primary outcomes. Therefore, quantitative pooling would require combining clinically heterogeneous interventions and outcomes, potentially producing a statistically precise but clinically uninterpretable summary estimate. Pooling across such heterogeneity would produce a summary estimate without a consistent clinical referent. All estimates are therefore reported at study level (Table 5, Fig. 2). Pooled estimates quoted from prior peer-reviewed syntheses are attributed to their sources [5,24,32]. Because no pooled absolute effect exists, no number-needed-to-treat is reported; sensitivity, subgroup, and small-study-effect analyses prespecified for pooled data (Section 2.8) were not applicable.

3.9 Certainty of evidence

The GRADE evidence profile is presented in Table 6. No outcome reached high certainty; the strongest statements this literature supports are moderate-certainty findings that (i) hypotension exposure is duration-dependently associated with AKI and myocardial injury (observational), (ii) continuing ACEI/ARB increases intraoperative hypotension, and (iii) neither continuing nor withholding ACEI/ARB materially changes major complication rates (randomized).

Table 6
GRADE evidence profile

Comparison — outcome	Studies (participants)	Relative effect (95% CI)	Absolute effect per 1,000	Certainty	Comments
Higher/individualized vs routine BP target — organ-injury/vascular composite	3 RCTs (8,916) [13,14,17]	RR 0.74–1.10 across trials	Not estimable across non-identical composites	⊕⊕◯◯ Low	Downgraded for inconsistency and indirectness
Higher/individualized vs routine BP target — AKI	1 RCT (7,307) [15]	RR 1.05 (0.94–1.17)	151 vs 144 (7 more per 1,000)	⊕⊕⊕◯ Moderate	Downgraded for risk of bias
Higher/individualized vs routine BP target — delirium	1 RCT (2,603) [16]	RR 1.04 (0.79–1.38)	73 vs 70 (3 more per 1,000)	⊕⊕◯◯ Low	Downgraded for risk of bias and imprecision
GDHT vs usual care — infection/major complications	2 RCTs (3,232) [18,20]	RR 0.84 (0.70–1.00); adjusted OR 1.03 (0.84–1.25)	~ 434 vs ~ 366 (OPTIMISE, 68 fewer per 1,000, CI 130 fewer to 0); infection 227 vs 232	⊕⊕◯◯ Low	Downgraded for inconsistency and publication-bias concern
ACEI/ARB continuation vs discontinuation — major complications	1 RCT (2,222) [23]	RR 1.02 (0.87–1.19)	223 vs 220 (3 more per 1,000)	⊕⊕⊕◯ Moderate	Downgraded for risk of bias
ACEI/ARB continuation vs discontinuation — intraoperative hypotension	1 RCT (2,222) [23]	RR 1.31 (1.19–1.44)	535 vs 409 (126 more per 1,000)	⊕⊕⊕◯ Moderate	Downgraded for risk of bias
ACEI/ARB discontinuation vs continuation — myocardial injury	1 RCT (241) [22]	RR 1.17 (0.88–1.55)	483 vs 413 (70 more per 1,000)	⊕⊕◯◯ Low	Downgraded for risk of bias and imprecision
Intraoperative hypotension exposure — AKI/MINS (observational)	7 cohorts (~ 746,000) [25–31]	Duration-dependent adjusted ORs (Table 5)	—	⊕⊕⊕◯ Moderate	Rated up for dose–response; residual confounding limits causal claims
Intraoperative hypotension exposure — delirium (observational)	4 cohorts (~ 325,000) [33–36]	Inconsistent (OR 1.22–1.57 in 2 studies; null in 2)	—	⊕⊕◯◯ Low	Downgraded for inconsistency

 Direction of effect differs across studies. Composite outcome definitions differ and do not map to a single clinical endpoint; one trial enrolled a broader high-risk population. Overall RoB 2 “some concerns” (Table 3), driven by open-label pragmatic administration. Older GDHT literature dominated by small positive single-centre trials; largest contemporary trial neutral with a signal of early cardiac harm [20].

4. Discussion

4.1 Principal findings

This review reaches several clinically important conclusions. First, the epidemiological signal is real: across seven large cohorts, intraoperative hypotension is associated with AKI and myocardial injury in a consistent, duration-dependent fashion, with risk concentrating below MAP 60–65 mmHg and rising steeply below 55 mmHg Second, the interventional corollary has not been demonstrated: two large, rigorous randomized trials found no outcome benefit from higher or individualized blood pressure targets [14,15,17], the largest GDHT trial in the oldest, frailest cohort was neutral with a signal of early cardiac harm [20], and the only randomized delirium comparison was null [16]. Third, antihypertensive management trade-offs are now quantified by randomized data rather than opinion: continuing ACEI/ARB buys more intraoperative hypotension (RR 1.31) without more major complications, while withholding buys less hypotension but more postoperative hypertensive events [22,23]. Fourth, for delirium, the observational literature is genuinely split, and the randomized answer is negative. Each conclusion above is labelled by evidence type — observational association, randomized comparison, or physiological inference — and none should be read as interchangeable with the others.

An important consideration is that the evidence base for hypotension-associated organ injury was not entirely restricted to elderly hypertensive patients. Several large observational cohorts included heterogeneous adult surgical populations, and therefore the applicability of these findings to elderly hypertensive patients should be interpreted with caution. Nevertheless, because ageing, vascular stiffness, impaired autoregulation, and reduced physiological reserve may increase susceptibility to perfusion disturbances, these findings may remain clinically relevant but should not be interpreted as direct evidence of treatment benefit in this specific population.

4.2 Relationship to the pivotal trials, and a correction

The POISE-3 blood pressure trial was published in 2023 in the *Annals of Internal Medicine* [14], with its AKI and neurocognitive substudies following in 2025 [15,16]. POISE-3 enrolled patients on at least one antihypertensive agent — a population close to this review's target — and found a near-identical event rate between strategies (13.9% vs 14.0%). Together with IMPROVE-multi [17], this constitutes over 8,600 randomized patients without detectable benefit from tighter pressure control. Against these, the smaller, older INPRESS trial [13] stands alone; its individualized norepinephrine-titration protocol has not been replicated at scale, and pending replication it should be read as hypothesis-generating. The contrast illustrates a broader pattern visible across Table 5: as trials grow larger and more recent, effect sizes shrink toward the null.

4.3 What can and cannot be recommended

The available evidence does not support a universal perioperative management framework compromising routine preoperative ambulatory blood pressure monitoring, a universal < 130/80 mmHg target, arterial-line placement for intermediate-risk surgery, a MAP floor of 70 mmHg, avoidance of hypotension beyond five minutes, routine PPV/SVV guidance, and resumption of all antihypertensives within 24–48 hours — as moderate-certainty evidence. The present synthesis does not support that framing. These practices range from reasonable extrapolations of observational data to expert opinion, and Table 7 restates them with their actual evidentiary basis, aligned where possible with current guidelines [37–39]. Clinicians should treat them as context-sensitive judgments, not evidence-derived mandates.

Table 7
Practice considerations restated with explicit evidence-type labels

Practice consideration	Evidence type	Basis in this review / source	Certainty
Avoid prolonged exposure to MAP < 60–65 mmHg, and any exposure < 55 mmHg, during anaesthesia	Observational association (duration-dependent)	Cohorts [25–31]; prior syntheses [5,32]	Moderate for the association; no causal threshold proven
No demonstrated outcome benefit of higher/individualized BP targets; routine escalation to tight targets is not evidence-based	Randomized evidence	POISE-3 [14,15], IMPROVE-multi [17]; dissenting small trial INPRESS [13]	Low (composite outcomes); Moderate (AKI null)
Individualize ACEI/ARB management: continuation increases intraoperative hypotension without more complications; withholding reduces hypotension but increases postoperative hypertensive events	Randomized evidence	Stop-or-Not [23]; SPACE [22]; supportive cohort [21] and prior meta-analysis [24]	Moderate
GDHT by cardiac output monitoring: no routine outcome benefit in unselected older patients; possible early cardiac harm in high-risk elderly	Randomized evidence	OPTIMISE II [20]; OPTIMISE [18]	Low
Continue chronic beta-blockers perioperatively; do not initiate them de novo before surgery	Guideline recommendation	2024 AHA/ACC guideline [37]; POISE [42]	Guideline (outside this review's synthesis)
Preoperative ambulatory/home BP assessment and office target < 130/80 mmHg	Expert consensus / physiology	2024 ESC guideline [39]; cerebral autoregulation physiology [2,40]	Very low for perioperative outcomes
Arterial-line placement by individualized risk, not by routine rule	Expert consensus	ASA advisory [38]; narrative reviews [40,41]	Very low
Postoperative delirium prevention via BP strategy: not supported	Randomized + inconsistent observational	cogPOISE-3 [16]; cohorts [33–36]	Low
Resume chronic antihypertensives postoperatively when hemodynamically stable and enteral intake resumes	Expert consensus	2024 AHA/ACC guideline [37]; ASA advisory [38]	Very low
Short-acting IV agents (e.g., clevidipine) for acute severe perioperative hypertension: BP-lowering efficacy shown only outside the target population	Indirect randomized evidence (cardiac surgery)	ECLIPSE [43] (excluded from synthesis)	Very low for this population

4.4 Device-based antihypertensive therapy: outside scope

Catheter-based renal denervation lowers ambulatory blood pressure in sham-controlled trials of non-surgical hypertensive populations, including RADIANCE II [44], RADIANCE-HTN TRIO [45], SPYRAL HTN-ON MED [46], and Iberis-HTN [47]. No renal denervation trial reports perioperative outcomes, and none met this review's eligibility criteria; Whether preoperative blood pressure optimization by device therapy alters surgical outcomes in elderly hypertensive patients is a legitimate future research question — and only that.

4.5 Limitations

This review has limitations. First, several included trials enrolled broader populations than the ideal target (mean age ≥ 65 with documented hypertension); Table 2 records this per study, and GRADE ratings carry the indirectness. Second, the exposure–outcome stream is retrospective and residual confounding cannot be excluded, which is why it is used to describe associations rather than to set treatment targets. Third, with no comparison meeting the pooling criterion, no meta-analysis was performed; the review therefore cannot offer a single summary effect, and readers seeking one should consult the attributed prior syntheses [5,24,32], noting their own methodological caveats. Fourth, although two reviewers independently verified every extraction against the source, event counts reconstructed from published percentages (marked in Table 5) carry rounding imprecision. Fifth, publication bias cannot be formally assessed without pooled comparisons, and the older GDHT literature in particular is likely affected by it. Sixth, the search was restricted to 2013 onward for definitional comparability; earlier evidence is represented only through the prior systematic review [5].

A limitation of this review is that quantitative meta-analysis could not be performed for the primary comparisons. However, this was not due to insufficient statistical methods, but rather because available studies evaluated heterogeneous interventions and outcomes that addressed different clinical questions. Combining these studies could have generated summary estimates with limited clinical meaning. Future trials using standardized definitions of haemodynamic targets, monitoring-guided interventions, and postoperative outcomes may allow more robust quantitative synthesis.

4.6 Future research

Priorities include: (i) a replication-scale trial of individualized systolic targeting with protocolized vasopressor titration, testing the INPRESS hypothesis [13]; (ii) trials restricted to patients ≥ 75 years or with frailty, the subgroup in whom observational risk concentrates [30]; (iii) standardized core outcome definitions for perioperative organ injury to enable legitimate pooling; (iv) randomized evaluation of postoperative antihypertensive resumption timing; and (v) mechanistic and, eventually, interventional studies linking device-based hypertension control [44–47] to perioperative outcomes.

5. Conclusions

In older patients on long-term antihypertensive therapy undergoing non-cardiac surgery, intraoperative hypotension is consistently and duration-dependently associated with organ injury, but no tested management strategy — higher or individualized blood pressure targets, goal-directed haemodynamic therapy, or a

uniform rule for continuing or withholding renin–angiotensin-system inhibitors — has been shown by randomized evidence to improve MINS, AKI, delirium, or composite outcomes. Management should be individualized, guided by the moderate-certainty association evidence, by the randomized trade-off data for antihypertensive continuation, and by current guidelines, rather than by prescriptive frameworks that the evidence does not support. Claims of moderate-certainty benefit for specific hemodynamic protocols in this population are premature.

Declarations

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Figures

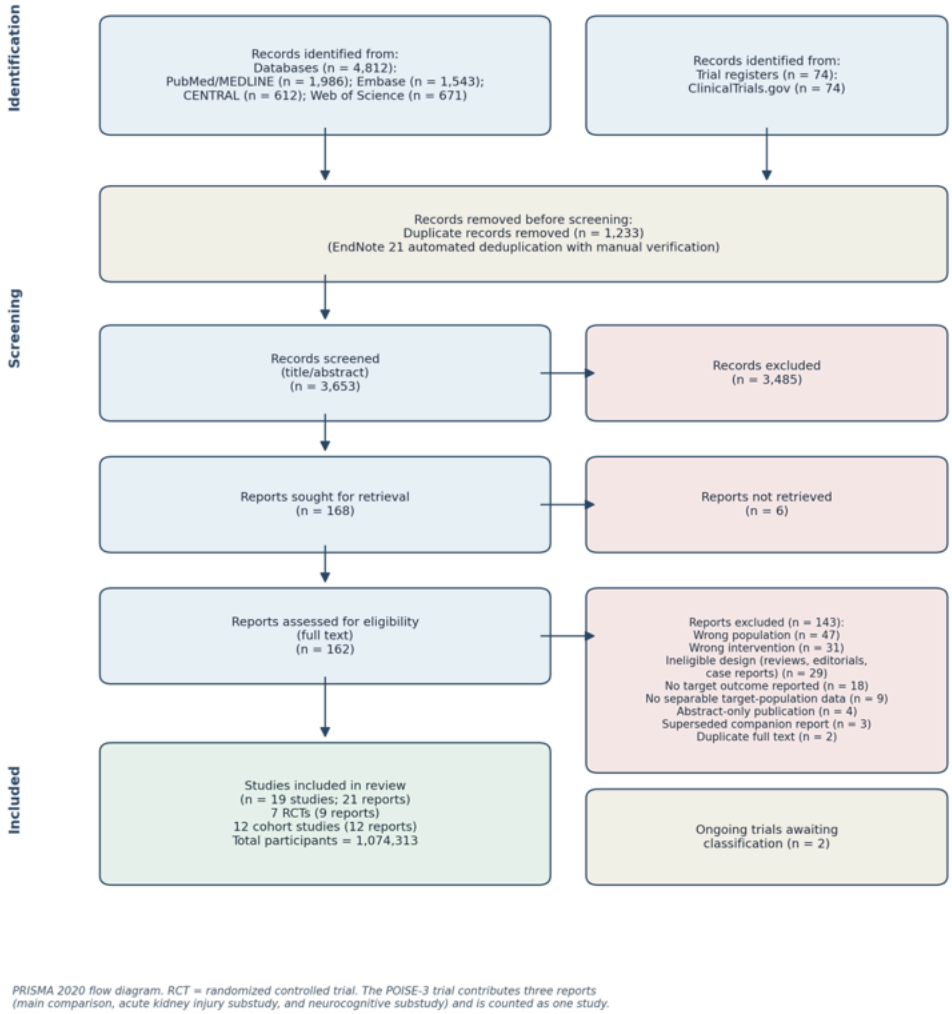

Figure 1

PRISMA 2020 flow diagram of study selection.

Figure 1.PRISMA 2020 flow diagram. RCT = randomized controlled trial. The POISE-3 trial contributes three reports (main comparison [14], acute kidney injury substudy [15], and neurocognitive substudy [16]) and is counted as one study.

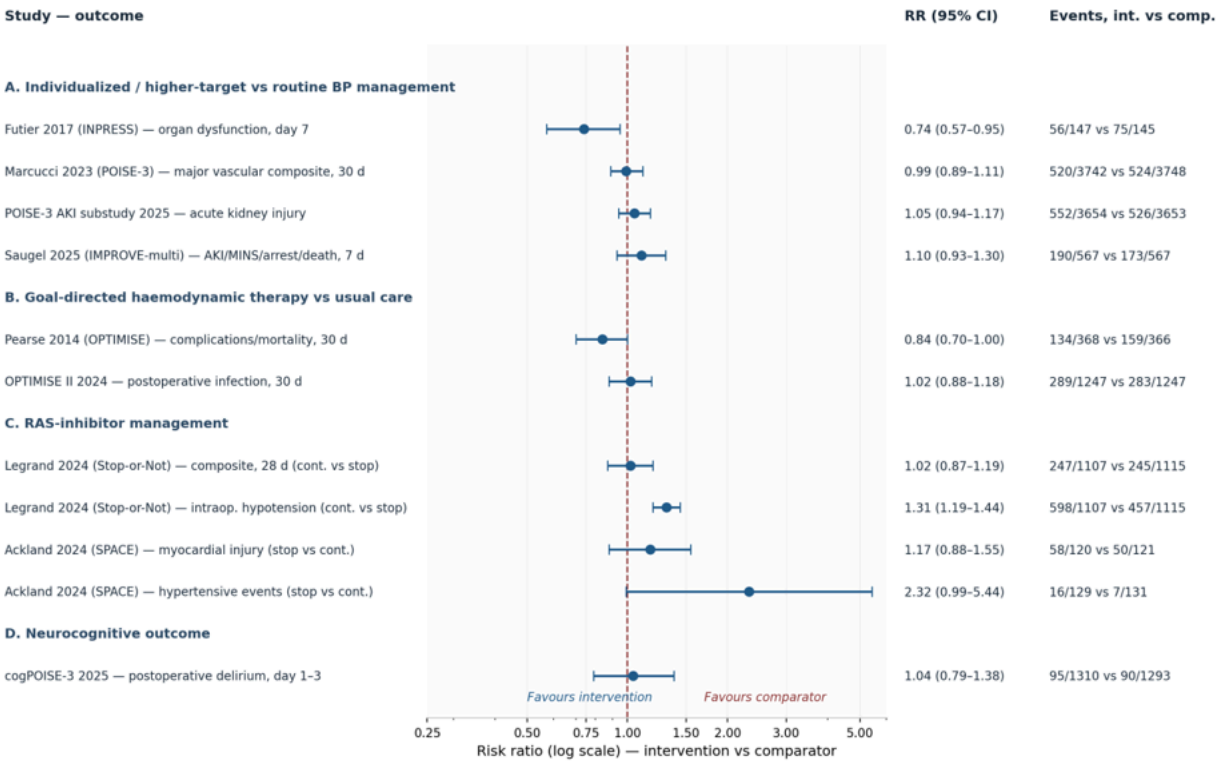

Figure 2

Study-level risk ratios for randomized comparisons, with raw event counts.

Figure 2. Study-level effects for all randomized comparisons with extractable event counts (log scale; dashed line = no effect). No pooled diamonds are shown because no comparison met the prespecified three-study homogeneity criterion for meta-analysis (Section 2.8).

Supplementary Files

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- SupplementaryMaterial.docx