INPLASY

Incremental Clinical Benefit and Safety of Robotic-Assisted Compared With Non-Robotic Minimally Invasive Cardiac Surgery: A Systematic Review

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ADMINISTRATIVE INFORMATION

Support - None.

Review Stage at time of this submission - The review has not yet started.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 20 December 2025 and was last updated on 20 December 2025.

INTRODUCTION

Review question / Objective To evaluate the incremental clinical benefit and safety profile of robotic-assisted cardiac surgery (RACS) compared to standard non-robotic minimally invasive cardiac surgery (MICS).

Rationale Minimally invasive cardiac surgery (MICS) has become an established standard of care for a range of cardiac pathologies, offering well-documented advantages over conventional median sternotomy, including reduced surgical trauma, improved cosmetic outcomes, and faster postoperative recovery. Traditionally, non-robotic MICS is performed via mini-thoracotomy using long-shafted instruments under thoracoscopic visualization. Although effective, this approach is associated with notable technical challenges, such as restricted instrument maneuverability due to the fulcrum effect and reliance on two-dimensional imaging, which may limit surgical precision, particularly in anatomically complex repairs.

Robotic-assisted cardiac surgery (RACS) was developed to address these ergonomic and visualization constraints. Robotic platforms provide three-dimensional high-definition visualization, tremor filtration, and multi-articulated instruments that replicate the range of motion of the human wrist. In theory, these technological enhancements should facilitate greater surgical precision and enable more complex procedures to be performed through a minimally invasive, endoscopic approach.

Despite these theoretical advantages, evidence regarding the incremental clinical benefit of robotic assistance over well-performed non-robotic MICS remains conflicting. The existing literature compares robotic surgery with conventional sternotomy, a comparison that inherently favors robotic approaches due to the avoidance of sternotomy-related morbidity. In contrast, when

robotic-assisted surgery is directly compared with standard video-assisted MICS, the extent of its clinical benefit is less certain.
Accordingly, this systematic review aims to determine whether robotic-assisted cardiac surgery confers clinically meaningful improvements in safety outcomes, intraoperative blood loss, or intensive care unit length of stay compared with non-robotic MICS, and whether any such benefits justify the associated increases in operative duration and financial cost. Clarifying this trade-off is essential to support evidence-based decision-making by surgeons and healthcare institutions when considering the substantial resource investment required for robotic cardiac surgery programs.
There is conflicting evidence regarding whether the robotic platform adds "incremental value" over a non-robotic minimally invasive cardiac surgery. This review seeks to determine whether the addition of a robotic interface to minimally invasive cardiac surgery results in clinically meaningful improvements in safety, blood loss, or intensive care unit length of stay that justify the associated increases in operative duration and financial cost, compared with non-robotic minimally invasive cardiac surgery.

Condition being studied Surgical management of cardiac pathology amenable to minimally invasive approaches. Key domains include valvular heart disease, coronary artery disease and structural heart disease in adult.

METHODS

Participant or population Adult patients (age ≥18 years), elective cardiac surgery, studies reporting a direct comparison between robotic and non-robotic minimally invasive cardiac surgery.

Intervention Robotic-Assisted Cardiac Surgery (RACS): procedures where the surgeon utilizes a console-based robotic system to control instruments inside the chest cavity.

Comparator Non-Robotic minimally invasive cardiac surgery (MICS): Conventional endoscopic or direct-vision minimally invasive cardiac surgery performed through limited access incisions (e.g., right mini-thoracotomy for mitral valve, left mini-thoracotomy for MIDCAB) using standard long-shafted instruments and 2D/3D video assistance.

Study designs to be included Randomized Controlled Trials (RCTs). Observational studies (prospective or retrospective cohorts) with a control group. Propensity-score matched studies will be prioritized in the synthesis to minimize selection bias.

Eligibility criteria Inclusion criteria: 1.randomized controlled trials or observational studies with propensity-score matched analyses, 2.adult patients (≥18 years of age) requiring elective cardiac surgery, 3.direct comparison between RACS and MICS.
Exclusion criteria: 1.Hybrid procedure, 2.transcatheter intervention, 3.case series (single-arm studies without a control group).

Information sources PubMed, Embase, Scopus.

Main outcome(s) Hospital Length of Stay (LOS), Blood Product Utilization, 30-day or in-hospital all-cause mortality.

Additional outcome(s) Stroke or Transient Ischemic Attack (TIA), Re-exploration, Conversion Rate, Cardiopulmonary Bypass (CPB) Time, Aortic Cross-Clamp Time, Total Operative Time, Total hospital costs, Postoperative pain scores, Return to normal physical activity(or work).

Data management Two reviewers will independently screen titles/abstracts and full texts. Extraction: Data will include study design, sample size, baseline cardiac risk (EuroSCORE/STS score), operative technique, and perioperative outcomes.

Quality assessment / Risk of bias analysis RCTs: Cochrane Risk of Bias 2 (RoB 2). Non-RCTs: ROBINS-I tool (Risk Of Bias In Non-randomized Studies – of Interventions) version 2.

Strategy of data synthesis A meta-analysis is not planned due to the anticipated heterogeneity in study designs and reporting metrics.

Subgroup analysis Data will be grouped and presented primarily by procedure type to avoid combining physiologically distinct operations; valvular heart surgery, coronary revascularization, and other.

Sensitivity analysis Excluding studies assessed as having a high risk of bias and small sample size or underpowered dataset.

Language restriction No.

Country(ies) involved Thailand.

Keywords Robotic assisted; minimally invasive; cardiac surgery; benefit; clinical outcome; systematic review.

Dissemination plans Publication.

Contributions of each author

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