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Narrative Review Comparing the Effectiveness of Robotic-Assisted Coronary Artery Bypass Surgery Versus Conventional Coronary Artery Bypass Surgery: Perioperative and Mid-Term Results

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Abstract: Coronary artery bypass grafting (CABG) stands as a cornerstone in managing coronary artery disease (CAD), with robotic-assisted coronary artery bypass (RCAB) emerging as a promising alternative to traditional CABG methods. This narrative review evaluates perioperative and mid-term outcomes of RCAB compared to conventional CABG, incorporating diverse study designs and endpoints. Ten studies, encompassing prospective and retrospective analyses, randomized controlled trials, and observational studies, were included after a rigorous selection process. Findings reveal potential advantages of RCAB, including reduced perioperative morbidity, improved pain management, and enhanced postoperative recovery trajectories. Long-term survival rates and freedom from major adverse cardiac events also appear promising with RCAB. However, limitations such as study heterogeneity, small sample sizes, variable follow-up periods, and lack of standardization in surgical techniques and perioperative care protocols are noted.

Keywords: *Coronary Artery Bypass Grafting, Robotic-Assisted Coronary Artery Bypass, Conventional CABG, Perioperative Outcomes, Mid-Term Outcomes, Surgical Innovation.*

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I. INTRODUCTION

Coronary artery bypass grafting (CABG) is still a mainstay of the treatment regimen for individuals suffering from coronary artery disease (CAD), a common and dangerous cardiovascular ailment.[1] Traditionally, CABG procedures were predominantly conducted through conventional sternotomy techniques, facilitated by the utilization of cardiopulmonary bypass (on-pump).[2] However, the landscape of cardiac surgery has undergone notable transformations propelled by advancements in surgical methodologies. Off-pump treatments and minimally invasive techniques, such as minimally invasive direct coronary artery bypass (MIDCAB) and port-access coronary artery bypass (PA-CAB), have been made possible by the development of CABG techniques.[3,4] These techniques, aimed at reducing surgical trauma and enhancing patient recovery, have garnered considerable attention for their potential to mitigate postoperative morbidity and expedite rehabilitation.

A pivotal development in the realm of cardiac surgery has been the introduction of robotic surgical systems, most notably the da Vinci system. This cutting-edge technology has revolutionized surgical practice by enabling precise and minimally invasive procedures through enhanced visualization and dexterity.[5] The incorporation of robotics into CABG procedures has opened new frontiers in surgical innovation, offering novel approaches that hold promise for improved patient outcomes.[6] A thorough assessment of the safety and effectiveness of robotic-assisted coronary artery bypass (RCAB) in relation to conventional CABG techniques and other minimally invasive methods like MIDCAB and PA-CAB is urgently needed in light of this surgical innovation.[7-9] Although traditional CABG has long been regarded as the gold standard due to its well-established benefits, most notably the long-lasting advantages of the left internal mammary artery (LIMA)-to-left anterior descending artery (LAD) graft, the emergence of alternative strategies emphasizes the importance of weighing their relative merits.[10]

The evaluation of RCAB comprises a detailed analysis of its mid-to-long-term survival rates as well as its perioperative outcomes, such as death rates, perioperative morbidities, and anastomotic complications. Furthermore, in order to clarify the possible benefits and constraints of RCAB in the current context of cardiac surgery, comparisons with traditional CABG and other less invasive procedures are crucial.[11] By conducting a meticulous evaluation of RCAB, this assessment aims to inform clinical decision-making and guide the selection of optimal surgical approaches for patients with CAD.[12] Furthermore, it seeks to contribute to the ongoing discourse surrounding advancements in cardiac surgical interventions, paving the way for evidence-based practice and improved patient care in the field of cardiovascular medicine.

In the realm of cardiac surgery, the past two decades have witnessed remarkable advancements in minimally invasive techniques, revolutionizing the approach to complex cardiac procedures. These innovations have enabled surgeons to perform intricate interventions through smaller incisions, representing a paradigm shift from traditional sternotomy approaches.[13] By minimizing surgical trauma and reducing operative morbidity, minimally invasive surgery has emerged as a preferred option for select patients requiring cardiac interventions.

At the forefront of this surgical evolution stands robotic-assisted surgery, exemplified by the da Vinci Surgical System. This state-of-the-art technology offers surgeons enhanced precision, dexterity, and visualization, thereby facilitating the execution of minimally invasive procedures with unparalleled accuracy.[14] The da Vinci system's robotic arms mimic the movements of the surgeon's hands with remarkable precision, allowing for delicate maneuvers in confined spaces within the body.[15,16] Despite the immense potential of robotic-assisted surgery in cardiac interventions, there exists a notable gap in the literature regarding the clinical outcomes of robotic coronary artery bypass (RCAB) procedures. While anecdotal evidence and small-scale studies have demonstrated promising results, a dearth of robust clinical data hampers a comprehensive understanding of the efficacy and safety of RCAB. This review primarily focuses on perioperative mortality as the major goal, with perioperative morbidities, anastomotic complications, and long-term survival serving as additional outcomes. This review aims to clarify the relative efficacy of RCAB in comparison to conventional and other minimally invasive procedures by thoroughly analyzing these endpoints. This systematic review seeks to influence future research paths in the field of coronary artery bypass surgery and to enhance clinical decision-making by offering insights into the safety profile and clinical results of RCAB. Moreover, the objective is to function as an invaluable asset for medical professionals, scholars, and politicians, promoting evidence-based approaches and progressions in cardiac surgery procedures.

By closely examining the perioperative and mid-term results of RCAB procedures—which include TECAB with cardiopulmonary bypass (TECAB on-pump), TECAB with totally endoscopic coronary artery bypass (TECAB off-pump), and robotic-assisted LIMA harvesting followed by off-pump manual anastomosis of LIMA-to-LAD through MIDCAB—this systematic review seeks to close this evidence gap.

II. MATERIALS AND METHODOLOGY

- *Literature Search Strategy*

For the narrative review titled "Comparing the Effectiveness of Robotic-Assisted Coronary Artery Bypass Surgery Versus Conventional Coronary Artery Bypass

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Surgery: Perioperative and Mid-term Results," a rigorous electronic search strategy was employed across multiple databases, including Ovid Medline, EMBASE classic, EMBASE, and all EBM Reviews, from their inception dates to July 2020. The search strategy encompassed a comprehensive combination of relevant search terms to ensure the identification of all potentially pertinent studies. The search terms utilized were carefully selected to encompass the key concepts of interest. Specifically, the terms "Robotic-Assisted Coronary Artery Bypass Surgery" and "Conventional Coronary Artery Bypass Surgery" were included to delineate the interventions under investigation. Additionally, broader terms such as "neoadjuvant*" and "surgery" were incorporated to capture studies examining various aspects of surgical treatment for coronary artery disease (CAD). Furthermore, a range of specific surgical procedures relevant to the topic were included as search terms, such as "resect*," "lobectomy," "VATS," and "thoracic surgery, video-assisted." This comprehensive approach aimed to identify studies examining a spectrum of surgical techniques and interventions pertinent to the comparison between robotic-assisted and conventional coronary artery bypass surgery.

Both MeSH terms and keywords were employed to maximize the sensitivity of the search strategy and capture relevant literature. The search was not limited by language or publication status, ensuring the inclusion of studies irrespective of these factors. Following the electronic search, the reference lists of retrieved articles were meticulously reviewed to identify additional relevant studies not captured through the initial database search. This supplementary approach aimed to enhance the comprehensiveness of the literature review and minimize the risk of overlooking potentially pertinent studies. Subsequently, all identified articles underwent systematic assessment using predefined selection criteria to determine their eligibility for inclusion in the review. The selection criteria were established a priori to ensure consistency and objectivity in the screening process. Only studies meeting the predetermined criteria were included in the systematic review, thereby maintaining the integrity and rigor of the analysis.

➢ *Selection Criteria and Data Extraction*

As detailed in Figure 1, the systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria to guarantee methodological rigor and transparency throughout the review process. A thorough methodology was utilized for the selection of studies and the extraction of data, with predetermined criteria serving as a guide. The purpose of the inclusion criteria was to find research that directly compared, in terms of perioperative and mid-term outcomes, the efficacy of robotically aided coronary artery bypass surgery (RCAB) to conventional coronary artery bypass surgery (CABG). Randomized controlled trials (RCTs), non-randomized comparative studies (such as cohort and case-control studies), and observational studies with suitable control groups were all considered eligible for inclusion. Furthermore, pertinent outcome metrics including perioperative mortality, perioperative morbidities, anastomotic complications, and long-term survival rates had to be reported by the research. Studies that only focused on descriptive or qualitative analyses, case series, case reports, editorials, letters, commentaries, or conference abstracts without enough data for analysis, on the other hand, were omitted if they did not match the predetermined inclusion criteria. Research that did not directly compare RCAB with traditional CABG or that did not provide sufficient information on the outcome measures were also disregarded.

Several electronic databases, from their launch dates until July 2020, were included in the systematic search, including Ovid Medline, EMBASE classic, EMBASE, and all EBM Reviews. The search approach, which made use of a combination of pertinent search phrases and Boolean operators, was created to find all pertinent studies contrasting RCAB and traditional CABG. To find potentially relevant research, two independent reviewers first screened abstracts and titles. After that, full-text publications from the chosen studies were obtained, and their eligibility was independently evaluated in accordance with the predetermined inclusion and exclusion criteria. To guarantee agreement, disagreements between reviewers were settled by conversation or by consulting a third reviewer.

A standard data extraction form was used to extract data, which included pertinent outcome measures as detailed in Table 1, key study characteristics (e.g., study design, sample size, patient demographics), specifics of surgical interventions (e.g., type of CABG procedure, use of robotic assistance), and details of surgical interventions. A second reviewer double-checked the extracted data to make sure it was accurate and comprehensive. A methodical evaluation of the overall quality of the evidence was conducted, considering variables such study design, bias risk, consistency of outcomes, and directness of the evidence.

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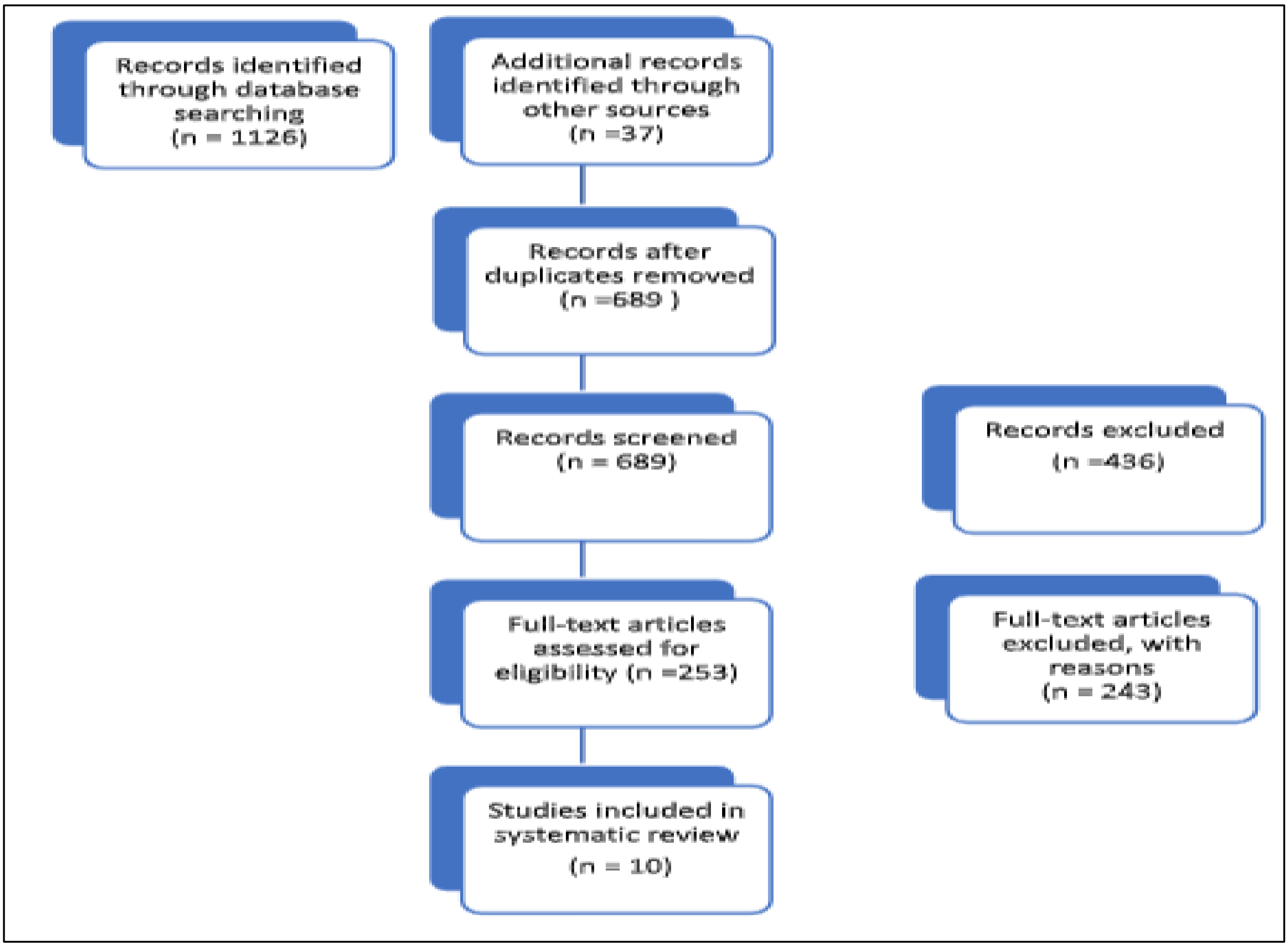

Fig 1 Prisma Flow Chart Detailing the Literature Search Process for Included Studies

The determination of inclusion and exclusion criteria was guided by the aspects of Study design, Participants, Interventions, Comparisons, and Outcomes (SPICO).

Table 1 PICO Criteria

Population	**Individuals Diagnosed with Coronary Artery Disease.**
Intervention	Patients underwent either robotic CABG based on surgeon's decision and the availability of robotic equipment.
Comparision	Conventional CABG
Outcome	Post-operative mortality, complications, blood loss, freedom from major adverse cardiac and cerebral events.
Study Design	Cohort studies, case-control studies, and randomized controlled trials (RCTs).

III. RESULTS

A comprehensive search across several electronic databases was conducted before the systematic review began, producing a total of 1126 records. The original pool of records was increased to 1163 when 37 more were found from various sources. There were 689 distinct records left for screening after duplicates were eliminated. After careful examination of each of these data, 253 full-text publications were evaluated for eligibility. 243 items were eliminated based on predetermined criteria after a thorough review process, with justifications provided for each exclusion. In the end, ten papers were found to have satisfied the rigorous inclusion requirements and were incorporated into the systematic review. This allowed for a thorough examination of the relative efficacy of robotically aided coronary artery bypass surgery and traditional coronary artery bypass surgery.

A viable substitute for traditional CABG methods in the quest to improve surgical results for CAD is R-CABG. A single-centre prospective analysis comparing the outcomes of robotic and traditional CABG cohorts was carried out by Kofler et al on patients in need of elective CABG. Researchers found that, as compared to traditional CABG recipients, the mean age of robotic CABG patients was much lower (61 vs. 66 years). Primarily, the objectives were to ensure long-term survival and avoid significant adverse

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cardiac and cerebral events. The secondary outcomes included the necessity for revascularization and the results of the surgery. An important insight into the relative effectiveness of different interventions over time was offered by the mean follow-up period of 6.6 ± 3.2 years.[17]

Building on this base, Gofus et al. evaluated the perioperative and mid-term outcomes of minimally invasive direct CABG using both robotically aided and conventional procedures in retrospective observational research. Their results, which were based on a single-centre cohort, highlighted how crucial it is to assess preoperative features, postoperative results, and survival rates in order to determine the relative benefits of various surgical techniques. With follow-up periods ranging from 1.5 to 15.8 years, the study offered a thorough picture of results that extended past the first postoperative phase.[18]

Leyvi et al. conducted a nonrandomized comparison analysis in which 10 recipients of traditional CABG were compared with 28 patients getting robotically assisted minimally invasive CABG. In this instance, the focus was on explaining cytokine levels in conjunction with pre- and post-operative results. Among the robotically assisted CABG sample over a 2-year period, the comparison study showed a significant reduction in cytokine release, namely for IL-6, IL-10, TNF, and CRP levels.[19] Through an observational study focusing on patients with left main illness, Su et al. provided insightful information. The study provided insight into in-hospital mortality and long-term survival rates by comparing the results of various revascularization methods, such as robotic CABG, traditional CABG, and percutaneous coronary intervention (PCI). The findings highlighted a significantly lower total death rate in the robotic CABG group compared to both conventional CABG and PCI cohorts during the period from January 2005 to November 2013.[20]

An observational, retrospective, comparative analysis with 2088 patients undergoing CABG procedures using both robotically aided and conventional approaches was carried out by Leyvi et al. Clinical outcomes, such as complication rates, mortality, length of stay, and readmission rates, were the main focus of their analysis. Notable results highlighted the potential advantages of robotic-assisted approaches: the robotic CABG group experienced more early discharges and a reduced NY State complication composite rate.[21] Through prospective observational research involving patients undergoing CABG at a single institution, Raad et al. contributed to the body of evidence. Between January 2007 and March 2012, the robotic CABG group required less total morphine equivalent dose, according to their analysis of intraoperative and postoperative data.[22]

Ezelsoy et al. conducted a prospective observational study with 250 patients to gain additional insights about robotic assisted minimally invasive direct CABG. Study findings on the safety and effectiveness of robotically assisted surgeries were greatly enhanced by looking at graft patency rates, surgical technique, clinical outcomes, and demographic variables.[23] A retrospective observational study by Zaouter et al. focused on patients who were going to have a left anterior descending artery transplant to the left internal mammary artery. Their comparison of whole endoscopic CABG with a beating heart and standard CABG highlighted variations in anesthetic administration, clinical outcomes, and operating parameters, offering important new insights into the development of surgical methods.[24]

Poston et al. used a prospective observational analysis with 100 consecutive patients to provide insights on mini-CABG operations using the da Vinci S robot. The study examined recovery measures, comorbidities, preoperative variables, and demographics to identify possible benefits of mini-CABG, despite its higher initial costs.[25] Finally, a prospective randomized controlled trial evaluating several CABG techniques was conducted by Bucerius et al., which added to the body of knowledge. Their examination of the preoperative and postoperative course, the degree of pain, and the efficiency of pain management techniques yielded important information about patient outcomes and recovery paths.[26]

IV. DISCUSSION

An examination of studies comparing standard CABG with R-CABG provides important information on the perioperative and mid-term results of these procedures. A prospective research comparing the outcomes of robotic and traditional CABG cohorts was carried done by Kofler et al. Based on a single-center dataset, their results showed that patients undergoing robotic CABG had a much lower mean age than those undergoing traditional CABG. Notably, the primary outcomes highlighted the potential advantages of robotically assisted procedures over conventional methods by focusing on long-term survival and freedom from major adverse cardiac and brain events.[17] Through a retrospective observational study evaluating the perioperative and mid-term outcomes of minimally invasive and robotically assisted direct CABG, Gofus et al. added to the conversation. Their thorough examination, which included survival rates, perioperative results, and baseline characteristics, offered insightful information about the relative merits of traditional and robotically assisted procedures. With follow-up periods ranging from 1.5 to 15.8 years, the study provided a sophisticated insight of results after surgery.[18]

In a nonrandomized comparison trial, Leyvi et al. compared 10 conventional CABG patients with 28 robotically assisted CABG patients. Promising findings were obtained from their examination of cytokine levels and pre- and post-operative outcomes; cytokine release was shown to be lower in the robotically assisted CABG group. This implies that robotically aided techniques may have immunological advantages, which calls for more investigation in subsequent research.[19] Su et al.'s observational study, which concentrated on patients with left main illness, yielded insightful information. The study shown that robotic CABG is superior to conventional CABG and percutaneous coronary intervention (PCI) in terms of both in-hospital mortality and long-term survival rates. This was achieved by comparing the outcomes of these three revascularization modalities. These results highlight the

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therapeutic benefits that robotically aided techniques may have for certain patient populations.[20]

Leyvi et al. performed a retrospective, observational, comparative analysis with a sizable patient cohort undergoing CABG surgeries using both traditional and robotically assisted methods. Clinical outcomes analysis showed that the robotic CABG group had better outcomes, with more early discharges and a lower NY State complication composite rate. These results point to possible advantages of robotically assisted CABG in terms of postoperative recovery and resource usage.[21] A prospective observational research by Raad et al. that concentrated on intraoperative and postoperative parameters expanded the body of evidence. The robotic CABG group required less total morphine equivalent dose, according to their analysis, which may have enhanced pain management and postoperative recovery. This demonstrates the many advantages of robotically aided techniques that go beyond just improved surgical results.[22]

Ezelsoy et al. conducted a prospective observational analysis with a large patient cohort to shed additional light on robotic assisted minimally invasive direct CABG. The safety and effectiveness of robotically assisted surgeries were demonstrated by their examination of demographic traits, surgical technique, and clinical outcomes; high graft patency rates were noted during long-term follow-up.[23] A retrospective observational research comparing routine CABG with beating-heart complete endoscopic CABG was carried out by Zaouter et al. Their analysis of anesthetic management, clinical outcomes, and surgical parameters identified prospective benefits of minimally invasive procedures, such as fewer transfusion needs and shorter hospital stays. These results highlight how crucial it is to consider changing surgical methods while treating coronary artery disease.[24]

Through a prospective observational study, Poston et al. provided perspectives on mini-CABG operations utilizing robotic assistance. Shorter intubation times and fewer problems were among the possible advantages of mini-CABG that were highlighted by their examination of patient demographics, surgical details, and recovery measures. These results imply that robotic support might enable less intrusive surgical techniques, improving patient outcomes and recuperation times.[25] Through a prospective randomized controlled experiment comparing various CABG techniques, Bucerius et al. added to the conversation. Their analysis identified subtle variations in the preoperative and postoperative courses, pain control, and recovery paths among various surgical specialties. The significance of customized treatment strategies in enhancing the results of CABG surgeries for patients is highlighted by these findings.[26]

While the systematic review provides valuable insights into the comparative effectiveness of RCAB versus CABG, several limitations should be considered. Firstly, the included studies varied in design, with a mix of prospective and retrospective observational studies, as well as randomized controlled trials (RCTs). This heterogeneity in study designs may introduce biases and limit the generalizability of findings. Secondly, the sample sizes in some studies were relatively small, which could affect the statistical power and precision of estimates. Additionally, the follow-up periods across studies varied, ranging from short-term to long-term, which may influence the assessment of mid-term outcomes and long-term survival rates. Furthermore, the lack of standardization in surgical techniques and perioperative care protocols across different centres may introduce variability in outcomes. Moreover, while efforts were made to conduct a comprehensive literature search, it is possible that some relevant studies may have been missed, potentially impacting the comprehensiveness of the review. Lastly, the majority of included studies were single-centre studies, which may limit the generalizability of findings to broader patient populations and clinical settings. Overall, while the systematic review offers valuable insights, these limitations should be taken into account when interpreting the results and guiding clinical practice.

V. CONCLUSION

In conclusion, the evolution of CABG techniques has led to the emergence of robotic-assisted surgery as a promising alternative to traditional methods. The systematic review presented herein highlights the comparative effectiveness of RCAB surgery versus conventional CABG, shedding light on perioperative and mid-term outcomes. Key findings suggest that RCAB may offer advantages such as reduced perioperative morbidity, improved pain management, and enhanced postoperative recovery trajectories compared to conventional CABG. Furthermore, RCAB demonstrates promising results in terms of long-term survival rates and freedom from major adverse cardiac events, underscoring its potential as a viable option for select patients with coronary artery disease. However, it is important to acknowledge the limitations of the included studies, including variations in study design, sample sizes, follow-up periods, and surgical techniques. Despite these limitations, the collective evidence presented in this review contributes to the ongoing discourse surrounding advancements in cardiac surgical interventions, informing clinical decision-making and guiding future research directions. Moving forward, continued efforts to standardize surgical protocols, expand patient cohorts, and conduct rigorous clinical trials will be essential to further elucidate the role of robotic-assisted coronary artery bypass surgery in the contemporary landscape of cardiac surgery. By fostering evidence-based practice and facilitating informed decision-making, this systematic review aims to enhance patient care and outcomes in the field of cardiovascular medicine.

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Table 2 Data Extraction Sheet

Study	**Population**	**Type of study**	**Mean age of patients**	**Parameters checked**	**Intervention**	**Comparison**	**Outcome**	**Time period**
Kofler et al., 2017	Individuals diagnosed with coronary artery disease who required elective coronary artery bypass grafting for the first time.	Single-centre, prospective study	Mean age for robotic CABG patients: 61 years; traditional CABG patients: 66 years.	preoperative risk factors (such as hypertension, dyslipidemia, diabetes mellitus), and postoperative outcomes (such as mortality, myocardial infarction, stroke, need for repeat revascularization).	Patients underwent either robotic CABG or traditional CABG based on the surgeon's decision and the availability of robotic equipment.	Study compared outcomes between patients who received robotic CABG and those who underwent traditional CABG.	Primary outcomes: long-term survival, freedom from major adverse cardiac and cerebral events. Secondary outcomes: perioperative results, need for revascularization.	mean follow-up duration was 6.6 ± 3.2 years
Gofus et al., 2022	Patients underwent minimally invasive and robotically assisted direct coronary artery bypass grafting since 2005 and 2018, respectively.	Retrospective observational single-centre study.	Not mentioned	Baseline characteristics, perioperative results, post-operative mortality, complications, blood loss, ventilation time, hospital stay, survival rates.	minimally invasive direct coronary artery bypass grafting and robotically assisted minimally invasive direct coronary artery bypass grafting procedures for coronary artery bypass grafting.	Comparison between conventional MIDCAB and RA-MIDCAB techniques.	Post-operative mortality, complications, blood loss, ventilation time, hospital stay, survival rates.	Post-operative follow-up ranged from 1.5 to 15.8 years.
Leyvi et al., 2014	28 robotically CABG patients versus 10 conventional CABG patients	Nonrandomized comparative study	RCAB - 61.6 ± 10.8 years, C-CABG - 61.8 ± 8.1 years	Pre- and post-operative outcomes, cytokine levels	r-CABG (robotically assisted minimally invasive direct coronary artery bypass grafting)	c-CABG (on-pump conventional coronary artery bypass grafting)	Cytokine release in the rCABG group was comparatively less for IL-6, IL-10, TNF and CRP levels.	Time period is 2 years.
Su et al., 2018	Patients with angiographically proven left main (LM) disease	Observational study	RCAB - mean age of 66 years; C-CABG - 70 years	Baseline characteristics, in-hospital and long-term outcomes, predictors of mortality	Revascularization procedures: R-CABG, C-CABG, PCI (percutaneous coronary intervention)	Comparison of outcomes among patients undergoing different revascularization modalities	In-hospital mortality: Lowest in R-CABG group, no significant difference between C-CABG and PCI groups Total death rate:	Time period from January 2005 to November 2013

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							Significantly lower in R-CABG group compared to C-CABG and PCI groups	
Leyvi et al., 2016	2088 patients undergoing coronary artery bypass grafting (CABG) procedures, including robotically assisted and conventional CABG	Observational, retrospective, comparative study	RCAB 64.7 ± 12.8 years; C-CABG (on) 64.4 ± 9.9 years	Co-morbidities (e.g., diabetes, chronic obstructive pulmonary disease, cerebral vascular disease) Clinical outcomes (complication rates, mortality, length of stay, readmission rate)	Robotically assisted CABG	Conventional CABG	Lower NY State complication composite rate in robotic group, More early discharges in robotic group, Lower blood transfusion rate in robotic group.	Time period from January 2007 to March 2012
Raad et al., 2016	Patients undergoing coronary artery bypass grafting (CABG) at a single institution	Prospective observational study	RCAB 64.2 ± 12.6 years; C-CABG 63.9 ± 10.3 years.	Intraoperative: Blood transfusion, intubation time. Postoperative: Stroke, wound infection, renal failure, prolonged intubation, reoperation, readmission (30 days), pain.	Robotic CABG, including robotic LIMA mobilization, pericardiotomy, and vessel identification, with hand-sewn anastomosis on the beating heart through a directed minithoracotomy	Conventional CABG	Robotic group had lower total morphine equivalent dosing (MED) requirement from start of procedure to postoperative day 3	January 2007 to March 2012
Ezelsoy et al., 2015	250 patients underwent robotic-assisted MIDCAB.	Prospective observational study	Mean age of patients: 57.9 ± 9.7 years.	Demographic characteristics, operative technique, clinical outcomes, graft patency.	Robotic-assisted MIDCAB procedures using the da Vinci standard system.	Postoperative angiography (catheter or MCT) for graft patency.	Total operative time: 165.9 ± 19.5 min. Ventilation time: 5.8 ± 3 h. Hospital stay: 5.5 ± 1.7 days. Graft patency rate: 94.3%. Time to re-intervention: 55.5 ± 10.4 months.	April 2004 to February 2012.

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Zaouter et al., 2015	Patients scheduled to receive left internal mammary artery graft to the left anterior descending artery.	Retrospective observational study.	RCAB 64 ± 10 years C- ABG 67 ± 11 years	Operative parameters, anesthetic management, surgical management, cardiac intensive care management, clinical outcomes, transfusion data, length of ICU stay, length of hospital stay, morbidity, mortality.	Comparison between standard coronary artery bypass graft with fast-track cardiac anesthesia and beating-heart totally endoscopic coronary artery bypass graft combined with enhanced recovery after surgery pathway.	Standard CABG group versus TECAB group.	Standard CABG: Extubation within 3 hours, longer anesthesia, higher troponin, more transfusions, longer ICU, hospital stays. TECAB: Operating table extubation, shorter stays, less transfusions.	From September 2011 to March 2014.
Poston et al., 2008	100 consecutive mini-CABG cases using IMA grafting and coronary stenting.	Prospective, observational study	Mean age of patients in mini-CABG group was 61.8 years	Demographics, preoperative factors, comorbidities, medications, surgical details, complications, recovery metrics, satisfaction, and cost analysis.	MiniCABG using da Vinci S robot	OPCAB via median sternotomy	MiniCABG: shorter intubation, less blood loss, fewer complications. Lower MACCE, pain duration, and return to work. Higher initial costs.	From January 2005 to June 2007
Bucerius et al., 2002	Patients from two subsets: MIDCABG-endo (n=24), MIDCABG-conv (n=73), and CABG-conv (n=93).	Prospective randomized controlled trial	MIDCABG-endo: 65.3 ± 6.6 years MIDCABG-conv: 61.6 ± 9.9 years CABG-conv: 63.9 ± 9.0 years	preoperative and postoperative course, pain intensity, character, change over time, localization, occurrence in relation to activities, additional pain medication, effectiveness of pain medication.	MIDCABG-endo: Endoscopic computer-enhanced ITA dissection using da Vinci telemanipulation system. MIDCABG-conv: ITA takedown performed under direct vision.	Comparison between MIDCABG-endo, MIDCABG-conv, and CABG-conv groups.	Intubation and ICU stay shorter in MIDCABG-conv, while chest tube and hospital stay shorter in MIDCABG-endo. Pain decreased post-op.	Not mentioned