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SYSTEMATIC REVIEW

Benefits and limitations of minimally invasive surgery in coronary revascularization: a systematic review

Beneficios y limitaciones de la cirugía mínimamente invasiva en la revascularización coronaria: una revisión sistemática

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ABSTRACT

Introduction: coronary artery disease is one of the leading causes of mortality in the world, with treatments such as coronary artery bypass surgery seeking to restore arterial flow. Traditionally, this procedure is performed via sternotomy, with significant recovery times and risks. For this reason, minimally invasive surgery (MIDCAB) has emerged as a promising alternative, reducing complications. This work evaluates the benefits and limitations of MIDCAB.
Method: a search was conducted in SCOPUS, PUBMED and SCIELO for studies published between 2020 and 2025, in Spanish and English, with open access, cohort and retrospective studies that addressed mortality rates, perioperative complications, hospitalization and recovery times. The final synthesis was based on 20 articles after filtering.
Results: show that MIDCAB has low perioperative mortality rates (0,6 %-3,5 %) and limited complications, such as stroke (0 %-2,3 %) and perioperative myocardial infarction (0,6 %-1, 6 %). Hospitalization and recovery times were also shorter, with average ICU stays of 0,4 to 6,6 days. In the long term, MIDCAB showed a 10-year survival of 94,3 %, highlighting its durability and effectiveness.
Conclusions: MIDCAB represents a safe and effective option for coronary revascularization, especially in patients at high surgical risk or with limitations for more invasive procedures. However, the heterogeneity in the studies and the predominance of retrospective designs underscore the need for more robust prospective investigations to confirm these findings and guide clinical practice.

Keywords: MIDCAB; PRISMA; Minimally Invasive Surgery; Benefits.

RESUMEN

Introducción: la enfermedad coronaria es una de las principales causas de mortalidad en el mundo, con tratamientos como la cirugía de revascularización coronaria que buscan restaurar el flujo arterial. Tradicionalmente, este procedimiento se realiza mediante esternotomía, con tiempos de recuperación y riesgos significativos. Por ello, la cirugía mínimamente invasiva (MIDCAB) ha emergido como una alternativa prometedora, reduciendo complicaciones. Este trabajo evalúa los beneficios y limitaciones de MIDCAB.
Método: se realizó una búsqueda en SCOPUS, PUBMED y SCIELO, de estudios publicados entre 2020 y 2025, en español e inglés, con acceso abierto, estudios de cohorte y retrospectivos que abordaran tasas de mortalidad, complicaciones perioperatorias, tiempos de hospitalización y recuperación. La síntesis final se basó en 20 artículos después del filtro.
Resultados: muestran que MIDCAB presenta tasas de mortalidad perioperatoria bajas (0,6 %-3,5 %) y

complicaciones limitadas, como accidente cerebrovascular (0 %-2,3 %) e infarto de miocardio perioperatorio (0,6 %-1,6 %). Los tiempos de hospitalización y recuperación también fueron menores, con estancias promedio en UCI de 0,4 a 6,6 días. A largo plazo, MIDCAB mostró una supervivencia del 94,3 % a 10 años, destacando su durabilidad y eficacia.
Conclusiones: MIDCAB representa una opción segura y efectiva para la revascularización coronaria, especialmente en pacientes de alto riesgo quirúrgico o con limitaciones para procedimientos más invasivos. No obstante, la heterogeneidad en los estudios y el predominio de diseños retrospectivos subrayan la necesidad de investigaciones prospectivas más robustas para confirmar estos hallazgos y guiar la práctica clínica.

Palabras clave: MIDCAB; PRISMA; Cirugía Mínimamente Invasiva; Beneficios.

INTRODUCTION

Coronary artery disease belongs to the large group of cardiovascular diseases, which are the leading cause of death worldwide.[1] Its origin lies in an imbalance between the heart's oxygen requirements and its proper perfusion, preceded by a decrease in flow through the coronary arteries.[2] In 95 % of cases, these alterations are caused by atheromatous plaque located in the subendothelial space that obstructs the arterial lumen. Some factors that predispose to the formation of such plaque are high blood pressure, dyslipidemia, diabetes mellitus, obesity and overweight, smoking, a sedentary lifestyle, gender, heredity, and age.[3]

During an acute coronary event, it is recommended to follow a series of therapeutic steps in order to preserve the functionality of the heart muscle. To this end, prehospital interventions (oxygen, aspirin, nitroglycerin, morphine) are used, as well as thrombolytic therapy within 12 hours of the onset of the event. Finally, PCI (percutaneous coronary intervention) is recommended as the method of choice for reperfusion. If PCI is contraindicated or ineffective, coronary bypass surgery is recommended to reperfuse tissue that is ischemic, damaged, or necrotic.[4]

Coronary revascularization surgery (bypass) is a standard surgical procedure performed to manage acute coronary syndromes. After determining the severity through stress tests, imaging, systolic function,[5] and in compliance with criteria such as angina that significantly affects lifestyle, test results indicating a high probability of recurrent severe cardiac ischemia, the procedure is performed,[5,6] but its traditional approach using sternotomy (open surgery) carries significant risks, including prolonged recovery times, a high incidence of perioperative complications, and postoperative pain that must be treated with analgesic drugs.[7,8,9,10] In this context, minimally invasive surgery for coronary bypass has emerged as an alternative that promises substantial benefits, such as lower morbidity, faster recovery, and better quality of life for patients, promising to be a very useful alternative in the field of cardiovascular surgery, efficiently solving one of the most pressing problems in medical care.[11]

Despite the growing popularity of this approach, the scientific evidence remains heterogeneous and, in some cases, contradictory, since when analyzing the results we find limitations such as insufficient information on the accuracy of surgical procedures, patient selection criteria, and respective postoperative care.[12]

Therefore, there is a need for a systematic synthesis that allows for a more accurate assessment of the benefits and limitations of minimally invasive surgery in coronary revascularization. The findings of this research will not only contribute to local, national, and international scientific literature, but could also provide guidance for the implementation of these techniques in intermediate-level hospitals, improving cardiovascular care in contexts with limited resources and large numbers of patients who suffer from or are at risk of coronary heart disease events.

In addition, it should also be noted that the main objective of this study is to evaluate the benefits and limitations of minimally invasive surgery in coronary revascularization with respect to the comparison of short- and long-term mortality rates, incidence of perioperative complications (CVA, AMI, and arrhythmias), and hospitalization times, through a systematic review and meta-analysis based on the PRISMA methodology.

METHOD

This systematic review was conducted using the PRISMA method, based on the guidelines provided by the ECS (Spanish Society of Cardiology),[13] since, according to the authors of this methodology, it guarantees the documentation of systematic reviews in a transparent, complete, and accurate manner.

The following databases were used to search for the studies used in this research: SCOPUS, PUBMED, and SCIELO, as they are reliable sources and also provide free access. The keywords were as follows: minimally invasive, benefits and disadvantages, results. The algorithm used to search for the studies was as follows: ("minimally invasive cardiac surgery" OR "MICS" OR "minimally-invasive coronary bypass grafting" OR "MICS CABG" OR "minimally invasive direct coronary artery bypass" OR "MIDCAB") AND ("benefits" OR "advantages") AND ("outcomes").

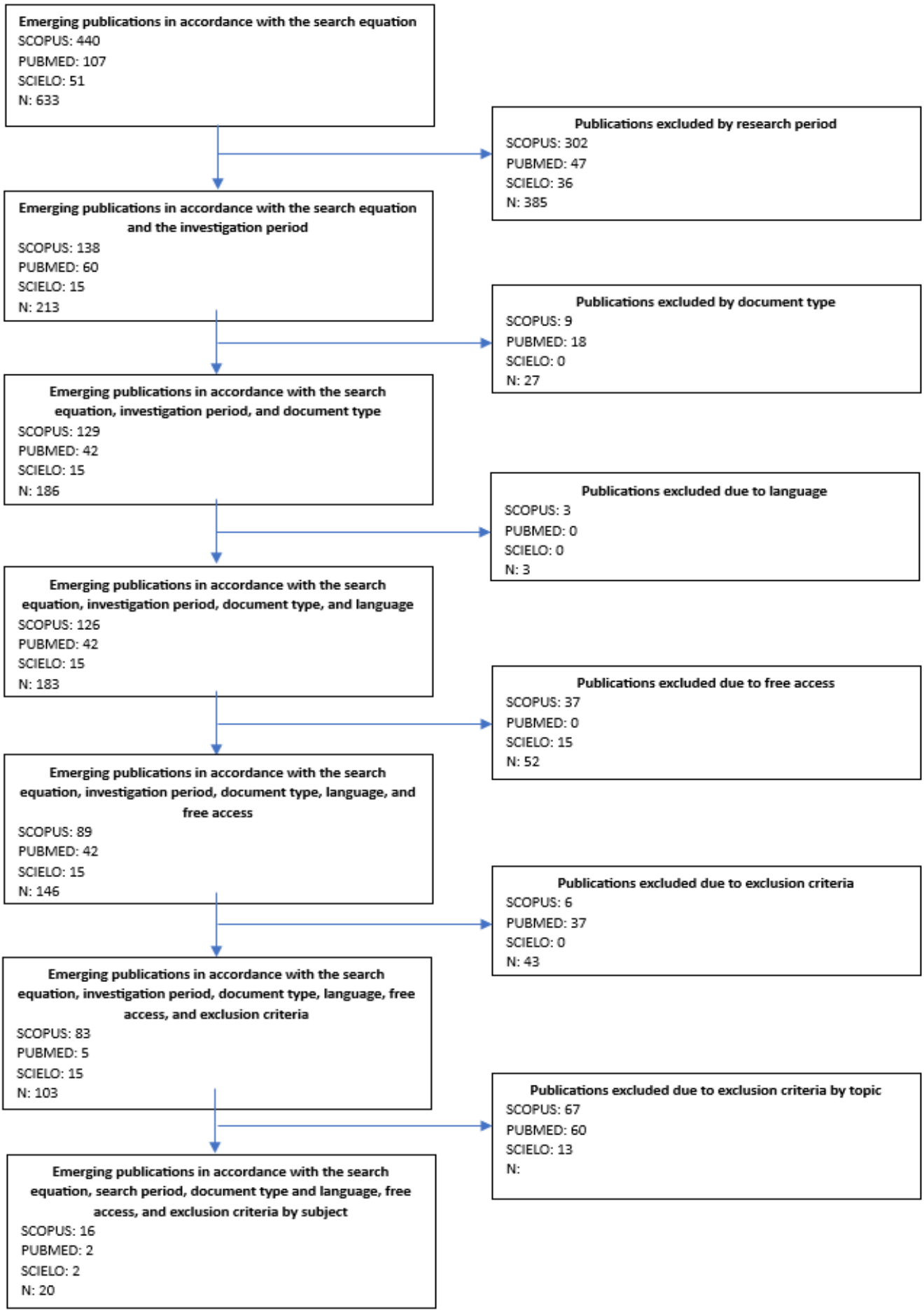

Figure 1. PRISMA flow diagram of the systematization process

The inclusion criteria for the studies included in this paper comparing the benefits and limitations of minimally invasive surgery in coronary revascularization procedures were as follows:

- Study period: 2020–2025
- Type of study: cohort studies, case-control studies,
- Language: spanish and english
- Access: free and/or open

The exclusion criteria indicate the elimination of studies that do not have a specific focus or are not related to revascularization surgery, including animal studies, studies associated with robotic surgery, and in vitro studies.

The studies were grouped for synthesis based on the initial database search. After importing them into the Zotero platform, duplicate articles were eliminated. The next step was to review the articles, focusing on the title, and to quickly read the abstract and make a manual selection. Finally, the extracted data were loaded into Excel, including necessary information such as author name, year of publication, type of study , sample size, complications (infections, thromboembolic events, arrhythmias), hospitalization times, and recovery times. All of this data were attached, depending on the availability of each article.

Table 1. Matrix of selected articles

Author	Title	Country	Type of study	Results	DOI
Weymann[9]	Minimally Invasive Direct Coronary Artery Bypass Grafting: Sixteen Years of Single-Center Experience	Germany	Retrospective	Average operating time of 129,7 ± 35,3 min. The mean rate of intraoperative blood transfusions was 0,0 (CI 0,0-2,0) units. The mean hospital stay was 8,7 ± 5,5 days, and the mean ICU stay was only one day. Hospital mortality rate of 0,64 %. There were two cases of perioperative myocardial infarction, with no further complications. Mortality at 6 months and 1 year was 0,97 %, with a 10-year survival rate of 94,3 %.	10.3390/jcm13113338
Dieguez et al.[14]	Minimally invasive coronary surgery: techniques and results Minimally invasive coronary bypass grafting: techniques and results	Spain	Retrospective	Perioperative mortality ranges from 0-3,5 % The perioperative stroke rate is 0-1 %, revision due to bleeding between 0-4 %, and conversion to sternotomy < 3 %. The reported patency of the LITA graft to the LDA at 6 months is >95 %. At 15 years of follow-up of MIDCAB with 80 % survival, 96 % freedom from AMI, and 70 % freedom from any cardiovascular event, as well as 95 % freedom from target vessel revascularization (ADA).	10.1016/j.ircv.2022.10.008
Fraund-Cremer[15]	Long-term follow-up of patients with complex coronary artery disease treated with minimally invasive direct coronary bypass	Germany	Retrospective	Surgical time between 50,3 and 34,5 min Stroke rates were between 2,3 and 0,6 %. 30-day mortality between 0,6 and 1,6 %	10.5603/cj.94716

Ilcheva[16]	Thirteen years of high-impact minimally invasive coronary artery bypass grafting: short- and long-term outcomes for single-vessel and multivessel disease	Switzerland	Retrospective	All-cause mortality at 30 days was 1,3 %. Postoperative AF was 8,5 %. Reoperations due to bleeding occurred in 1,6 % of patients, and myocardial infarction (MI) occurred in 1,3 %. The mean follow-up time was 6 ± 4 years. All-cause mortality was 10,3 %, and only 1,7 % of patients had a confirmed cardiac cause.	10.3390/jcm13030761
Solanki et al.[17]	A single-center experience involving the first 50 patients undergoing minimally invasive coronary artery bypass grafting ( ) surgery: at the district level	India	Retrospective	Surgical time was 130,43 ± 9,78 minutes. The mean length of stay in the intensive care unit (ICU) was 2,82 ± 0,74 days. No deaths were reported	10.15829/1728-8800-2023-3592
Rufa et al.[18]	Hybrid strategy of minimally invasive total coronary revascularization without pump and percutaneous coronary intervention for multivessel coronary artery disease: a cohort study with a median follow-up of 11 years	Germany	Cohort	During follow-up, there were 3 myocardial infarctions, 18 repeat PCI procedures, no CABG procedures, and 4 strokes. The 3-year and 5-year survival rates were 92 % and 85 %, respectively. The observed 30-day mortality rate was 2,1 %. A mortality rate of 21,9 %, of which 5,5 % were cardiac deaths at 11 years.	10.21037/cdt-23-413
Gianoli et al.[19]	Minimally invasive surgery or stenting for left anterior descending artery disease: meta-analysis	Netherlands	Cohort - meta-analysis	Patients treated with MIDCAB have a 7,3 times higher risk of dying from cardiac causes, an 84 % lower risk of needing revascularization within 30 days, and a 75 % lower risk of needing revascularization within 3 years compared to PCI. Complications such as AMI and stroke showed no differences.	10.1016/j.ha.2022.101046
Tiziano[20]	Minimally invasive isolated and hybrid surgical revascularization for multivessel coronary artery disease: long-term follow-up in a single center	Switzerland	Prospective	A cardiac mortality rate of 0 % with 6 years of follow-up Overall mortality was 3 %, with one in-hospital death and two additional late deaths.	10.3390/jpm14050528
Demirsoy[21]	Feasibility and initial results of minimally invasive multivessel coronary revascularization surgery for all patients	Turkey	Retrospective	Mortality rate of 0,9 %, with no myocardial infarction in the early postoperative period. 0 % required conversion to sternotomy. Reoperation due to postoperative bleeding (2,2 %) AF in the postoperative period (7,4 %).	10.3390/jcm12175663

Thuijs[22]	Long-term survival after coronary artery bypass grafting with multiple arterial grafts versus single arterial grafts		Retrospective	All-cause mortality occurred between 23,6 % and 40,0 % with a follow-up period of 12,6 years	10.1093/ejcts/ezab392
Guangxin et al.[23]	The efficacy of minimally invasive coronary artery bypass grafting (MICS-CABG) for patients with coronary artery disease and diabetes: a single-center retrospective study	China	Cohort	Surgical time between 90 and 68 min. Reduced intraoperative blood loss between 400 and 300 ml Incidence of major cardiovascular and cerebrovascular adverse events between 7,7 % and 5,9 % 0 % mortality from any cause AMI between 1,9 % and 2,0 %, cerebral stroke between 5,8 % and 3,9 %	10.1186/s13019-024-02717
Sellín et al.[24]	Renal Outcome in Patients Undergoing Minimally Invasive Total Coronary Revascularization via Anterior Minithoracotomy Compared to Full Median Sternotomy Coronary Artery Bypass Grafting	Germany	Observational and descriptive	Duration of surgery between 196 and 398 min ICU stays between 0,4 and 6,6 days and hospital stays between 2,8 and 19,9 days	10.3390/jcm13185418
Tachibana et al.[25]	Minimally invasive coronary artery bypass grafting with ultrasonically skeletonized internal thoracic artery	Japan	Retrospective	Thoracic wound infections were observed in 2,0 %. There was a 0,4 % mortality rate.	10.1016/j.jtc.2022.05.010
Davierwala et al.[26]	Minimally invasive coronary artery bypass grafting with bilateral internal thoracic arteries: early results and angiographic patency	Germany	Retrospective	No in-hospital mortality 5 patients underwent re-exploration due to bleeding, with no other complications Graft patency of 96,8 %.	10.1016/jvs.2019.12.136
Matroiacovo et al.[27]	Very long-term results of minimally invasive direct coronary bypass surgery	Italy	Retrospective	Survival rates were 100 % and 70 % at 1 and 20 years, respectively. Freedom from myocardial infarction, stroke, and cardiac death was 97 % and 61 % at 1 and 20 years, respectively.	
Kumar[28]	MICS CABG: a single-center experience of the first 100 cases	India	Retrospective	The mean operating time was 132,40 ± 11,56 min. The mean ICU stay was 2,62 ± 0,84 days. There was no mortality.	10.1007/s12055-020-01048-2
Dongyan[29]	Ninety-seven cases of experience with the left thoracotomy approach for conventional revascularization without cardiopulmonary bypass: a retrospective cohort study	China	Retrospective	30-day mortality was 1,0 % Reoperation due to bleeding was 1,1 % Coronary patency was 100 % During the follow-up period, 1,1 % of patients suffered an acute crisis	10.21037/jtd-22-1162

Guo[30]	Minimally invasive coronary bypass grafting: Techniques and outcomes Minimally invasive coronary bypass grafting: Techniques and outcomes	China	Retrospective	Non-cardiac mortality had a rate of 0 % Ten-year freedom was 80,0 ± 2,7 % Ten-year survival was 90,3 ± 2,1 % Vascular patency at 10 years was 87,1 ± 2,1 %.	10.1016/j.acc.2021.07.040
P. Vallely[31]	Minimally invasive anaortocoronary bypass without pump (MACAB)	Canada	Retrospective	A mortality rate of 1,8 % A stroke rate of 0 %.	10.11111/jocs.17180
Sakaguchi et al.[32]	Minimally invasive coronary revascularization surgery: a useful routine option for coronary revascularization in selected cases	Japan	Retrospective	Perioperative mortality occurred in 1 patient who died of advanced cancer. There were no postoperative complications. The perioperative transfusion rate was 11,2 %. Early graft patency was observed in 97,1 %. The rate of freedom from major cardiac and cerebrovascular adverse events was 89,7 % at 5 years.	10.1007/s11748-020-01336-z

DISCUSSION

This study set out to formulate objectives that identified with the underlying problem, which were to identify short- and long-term mortality, the incidence of perioperative complications (CVA, AMI, and arrhythmias), and hospitalization times in minimally invasive surgery applied to coronary revascularization. The results matrix analyzes previously published studies from reliable sources that explore some data on certain benefits and limitations that we sought in this study, in order to conclude how much the new procedures being performed can contribute to current medicine, since, as some authors mention, a great revolution is expected with the advantages that their application entails.[33]

Within the framework of the studies analyzed, the results show that, in terms of perioperative mortality, the studies included in this review highlight consistently low rates, between 0,6 % and 3,5 %, as reported by Fraund-Cremer et al.[15] and Alcocer Dieguez et al.[14]. This highlights the safety of the procedure during the initial stages, which is particularly relevant for patients at high surgical risk. In addition, long-term mortality reflects remarkable survival, reaching values of 80 % to 94,3 % at 10 years, according to Weynmann et al.[9] and Gianoli et al.[19], which positions MIDCAB as a durable and effective option. This argument is supported by Sally Ronquillo et al.[34], who conclude in their literature review that mortality rates are lower than for minimally invasive coronary surgery.

As for perioperative complications, the rates reported were low in most studies. For example, stroke events ranged from 0 % to 2,3 % according to Fraund-Cremer et al.[15] and Alcocer Dieguez et al.[14], also supported by a study conducted in Chile by Yelka Tenelema et al.[35], which also followed octogenarian patients for five years, where the risk of developing CVA was 1 %, which could even indicate that age may have little impact on the development of post-MIDCAB CVA. Likewise, the incidence of perioperative myocardial infarction (PMI) remained low, with figures ranging from 0,6 % to 1,6 %, as indicated by the studies by Weynmann et al.[9] and Fraund-Cremer et al.[15]. Although these figures are low, a study conducted by a university in Peru in a hospital with patients with coronary lesions who underwent MIDCAB, Zegarra[36], showed that one factor that increased the risk was uncontrolled hypertension, regardless of the patient's age. As for reoperation due to bleeding, the values ranged from 1,1 % to 2,2 %, according to Tachibana et al.[25] and Rajput et al.[28]. These data suggest that MIDCAB is a sensitive and effective procedure for minimizing major complications, although more uniformity in results is required to confirm its specificity.

Regarding surgical and recovery times, MIDCAB is associated with significant benefits. The average operating time ranged from 50,3 to 132,4 minutes, depending on the technique used and the experience of the center, as reported by Weynmann et al.[9] and Rajput et al.[28], in contrast; the results of Abraham Argel et al.[37]. on robotic surgery indicate that surgical time increases, with the exception that the complication rate remains the same in terms of beneficial contribution. The length of hospital stay was also reduced compared to traditional surgery, with an average ICU stay of 0,4 to 6,6 days and total hospitalization of 2,8 to 19,9 days, according to Sellin et al.[24] and Gianoli et al.[19], if we extrapolate these results to minimally invasive aortic valve surgery as

well; according to Bahamondes[38] there is also a significant reduction in the number of days spent in the ICU. It is also worth mentioning that another study conducted in a pediatric population by Keerby Hernández et al.[39] had similar results, which could indicate that the age difference in patients does not have a significant influence on these results. These results reinforce the benefits of faster recovery, improving both the patient experience and associated costs.

A relevant aspect to highlight is the new revascularization of the target vessel (rTVR), where MIDCAB has shown superior results compared to PCI. According to Gianoli et al.[19], MIDCAB reduces the need for rTVR by 84 % in the medium term and by 75 % in the long term, highlighting the durability of the procedure in patients with complex coronary artery disease. This coincides with the results of Fraund-Cremer et al.[15], who also found lower revascularization rates in patients treated with this technique.

Despite these benefits, it is important to note some limitations of the studies analyzed. Heterogeneity in inclusion criteria, follow-up times, and sample sizes make a direct comparison of results difficult. In addition, most studies are retrospective, such as those conducted by Weynmann et al.[9] and Tachibana et al.[25], which could introduce biases that affect the validity of the conclusions. However, the positive findings suggest that MIDCAB is a viable and safe option for coronary revascularization.[40]

CONCLUSIONS

Minimally invasive coronary artery bypass grafting (MIDCAB) is positioned as a safe and effective alternative to traditional approaches, with low perioperative mortality rates (0,6 %-3,5 %) and a lower incidence of major complications, such as stroke and myocardial infarction. In addition, it offers significant benefits in terms of recovery times, with reduced hospital and ICU stays, which improves the patient experience and optimizes hospital resources.

It should also be noted that certain recommendations already exist, such as that of the Mexican College of Cardiovascular and Thoracic Surgery, for example, which proposes MIDCAB as the new gold standard for the effective treatment of ischemic heart disease.

One of the main strengths of MIDCAB is its durability, reflected in the lower need for target vessel revascularization (TVR) in the medium and long term, with reductions of 84 % and 75 %, respectively, compared to PCI. Likewise, long-term results show outstanding survival rates of up to 94,3 % at 10 years, positioning this technique as a reliable and effective option for patients with complex coronary artery disease.

However, the heterogeneity of the studies reviewed and the predominance of retrospective designs limit the generalization of the findings. More robust prospective studies are needed to confirm the observed benefits and guide clinical practice with greater precision.

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FINANCING

None.

CONFLICT OF INTEREST

None.

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