Correlation Between Diabetes Prevalence and ICU and Hospital Length of Stay Across Studies: A Systematic Review and Meta-Analysis

Keywords

diabetes mellitus;
cardiopulmonary bypass;
length of stay

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Abstract

Background: Diabetes mellitus elicits considerable concern regarding perioperative outcomes in cardiac surgery. This systematic review endeavors to elucidate the effect of diabetes on ICU and hospital length of stay (HLOS) after cardiopulmonary bypass (CPB) in cardiac surgery.

Methods: A comprehensive search of PubMed, Scopus, Embase, and the Cochrane Library was conducted, targeting clinical trials published between 2004 and 2024. The primary outcome assessed was the correlation between the proportion of diabetic patients and ICU length of stay. Secondary outcomes included the correlation between the proportion of diabetic patients and HLOS, as well as the relationships among the proportion of diabetic patients, ICU length of stay, mean age, sex distribution, and BMI. Weighted correlation analyses were used.

Results: Thirteen studies involving 1588 patients were included. The weighted correlation between the proportion of diabetic patients and ICU length of stay was −0.176 (P=0.57), indicating a weak and nonsignificant association. Nine studies involving 905 patients analyzed HLOS, revealing a weak but statistically significant negative correlation (−0.255, P=0.0020). The mean age of patients was 64.7 years, which did not significantly affect ICU length of stay (coefficient, 0.065; P=0.51). The sex distribution comprised 25.0% female and 75.0% male participants, with significant differences across studies (chi-square statistic, 38.764; P<0.01). BMI analysis showed a mean BMI of 27.2, which also did not significantly affect ICU length of stay (coefficient, −0.20549; P=0.7657).

Conclusions: Diabetes does not significantly affect ICU length of stay but is associated with shorter hospital stays. This unexpected finding warrants further investigation, particularly given the limited number of studies contributing data to the HLOS analysis. Significant differences in sex distribution across studies highlight the need to consider sex as a variable in future research. Although age and BMI were not significant factors in ICU length of stay, they remain important for postoperative outcomes. Future research should address these limitations to enhance the reliability of findings and improve postoperative care for diabetic patients.

Introduction

Cardiopulmonary bypass (CPB) is a critical technique in cardiac surgery, providing essential support to the heart and lungs during complex procedures.[1] Introduced into clinical practice in the 1950s,[2] CPB has revolutionized cardiac surgery by allowing operations that would otherwise be impossible. Despite its undeniable benefits, CPB is associated with a range of complications, including systemic inflammation, organ dysfunction, and coagulation disorders.[3]

Diabetic patients, who constitute a significant proportion of those undergoing cardiac surgery,[4] are particularly susceptible to the complications associated with CPB. Diabetes mellitus is a chronic disease characterized by persistent hyperglycemia, leading to vascular damage, an increased risk of infection, and inflammation.[5] In diabetic patients, the exacerbated inflammatory response during CPB can aggravate these conditions, resulting in higher risks of morbidity and mortality.[6]

One of the primary concerns for diabetic patients undergoing CPB is the length of stay in the intensive care unit (ICU). Prolonged ICU stays not only increase the risk of hospital-acquired complications, such as nosocomial infections, but also contribute to higher health care costs and socioeconomic burden.[7] Identifying the factors that prolong ICU stays in diabetic patients is crucial for developing management strategies that can improve clinical outcomes and reduce associated costs.

The existing literature on the effect of diabetes on ICU length of stay after CPB is extensive but presents conflicting results. Some studies suggest that diabetic patients have a significantly longer ICU stay than nondiabetic patients,[8,9] whereas others find no significant differences between the two groups.[10,11] These discrepancies may be attributable to differences in study designs, populations studied, and definitions of outcomes.

This systematic review aims to consolidate the existing evidence and provide a comprehensive assessment of the effect of diabetes on ICU length of stay after CPB. By pooling and analyzing data from multiple studies, we seek to answer the question: Is the proportion of diabetic patients in studies of cardiac surgery with CPB associated with a significant difference in ICU and hospital length of stay?

Overall, this systematic review seeks to fill a critical knowledge gap regarding the effect of diabetes on ICU length of stay after CPB, providing a comprehensive overview that can guide clinical practice and future research. By addressing this issue, we aim to improve the management and outcomes of diabetic patients undergoing cardiac surgery, ultimately contributing to better patient care and health care resource utilization.

Importantly, this study adopts an ecological, study-level approach, examining whether variation in the proportion of diabetic patients across published trials is associated with differences in mean ICU and hospital length of stay. As such, the analysis does not compare outcomes between individual diabetic and nondiabetic patients.

Methods

Search Strategy and Databases

To ensure a comprehensive and systematic review, we used a meticulous search strategy across multiple reputable scientific databases. The databases used for this review included PubMed, Scopus, Embase, and the Cochrane Library, chosen for their extensive coverage of medical and clinical research. We used a combination of keywords and Medical Subject Headings (MeSH) related to diabetes, cardiopulmonary bypass, cardiac surgery, and hospital length of stay. The primary search terms included "diabetes mellitus," "extracorporeal circulation," "cardiopulmonary bypass," "cardiac surgery," and "hospital length of stay." Boolean operators (AND, OR) were used to refine the search and ensure the inclusion of all pertinent studies. The search terms used were: ("Diabetes Mellitus" OR "Diabetes" OR "Diabetic patients" OR "Type 1 Diabetes" OR "Type 2 Diabetes" OR "T1D" OR "T2D") AND ("Extracorporeal Circulation" OR "Cardiopulmonary Bypass" OR "CPB" OR "Cardiac Bypass" OR "Heart-Lung Machine" OR "Heart-Lung Bypass" OR "Extracorporeal Life Support" OR "ECLS") AND ("Cardiac" OR "Heart" OR "Coronary") AND ("Surgery" OR "Operation" OR "Procedure").

The search strategy was applied to each database, specifically focusing on clinical trials from the past 20 years, without language restrictions. In addition, the reference lists of the identified articles were manually screened to uncover any studies that might have been missed in the initial search.

Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: (1) clinical trials published between January 1, 2004, and December 31, 2024; (2) involvement of patients who underwent CPB during cardiac surgery; (3) inclusion of both a control group and an intervention group; and (4) reporting of ICU length of stay and the number of diabetic patients in the control group. Studies were excluded if they were case reports, review articles, editorials, or conference abstracts, or if they exhibited significant methodological flaws or a high risk of bias, as determined during the quality-assessment phase.

Data Extraction Process

This systematic review uses an ecological, study-level design. Rather than performing patient-level comparisons between diabetic and nondiabetic individuals, we analyzed the proportion of diabetic patients reported in each study and examined its correlation with aggregate outcomes, including mean ICU and hospital length of stay. Data extraction was carried out independently by two reviewers to minimize bias and errors. A standardized data-extraction form was used to ensure consistency. For each included study, the following data were extracted: basic study information, including author names, publication year, country, and study design; participant characteristics, including number of participants, age, sex distribution, BMI, and diabetes status; surgical details, including type of cardiac surgery performed; and outcomes, including the primary outcome of ICU length of stay and the secondary outcome of hospital length of stay. Any discrepancies between the reviewers regarding data extraction were resolved through discussion, and a third reviewer was consulted if consensus could not be reached.

It is important to note that this study does not perform patient-level comparisons between diabetic and nondiabetic individuals. Instead, we used an ecological approach by analyzing the proportion of diabetic patients reported in each study and assessing its correlation with aggregate outcomes such as mean ICU length of stay and hospital length of stay.

In addition, information regarding the study setting — including the country of origin, number of participating centers, and time frame of data collection — was extracted to assess potential sources of institutional heterogeneity. Of the 13 included studies, 7 were conducted at a single center and 6 were multicenter trials, ranging from 2 to 25 institutions. Most multicenter studies reported standardized perioperative protocols; however, one explicitly stated that no uniform anesthetic or surgical practices were used across centers. Such variability may represent a significant confounding factor, because differences in institutional practices, discharge criteria, and postoperative management can independently affect outcomes such as ICU and hospital length of stay, regardless of diabetes status.

Information on diabetes status was extracted from the baseline-characteristics tables reported in each study. Although most studies classified patients as diabetic or nondiabetic, few provided specific diagnostic criteria such as glycemic thresholds, medication use, or HbA1c levels. In some cases, diabetic patients were described as having type 2 diabetes; in others, no additional details were provided. This heterogeneity in diabetes definition was considered a limitation of the analysis.

Quality Assessment of Included Studies

The quality and risk of bias of the included studies were assessed with validated tools appropriate for the study designs. Randomized, controlled trials were evaluated with the Cochrane Risk of Bias 2 (ROB 2) tool, which assesses potential biases in randomization, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result. Each study was independently assessed by two reviewers. The studies were categorized as having a low, moderate, or high risk of bias on the basis of the assessment criteria.

Reporting and Registration

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure transparency and rigor in reporting. The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) to promote transparency and prevent duplication of efforts.

Statistical Analysis

The primary statistical analysis focused on establishing the weighted correlation between the proportion of diabetic patients and length of stay in the ICU. The weighted correlation coefficient was calculated, considering the number of participants (N) in each study to ensure that studies with larger sample sizes had a proportionately greater influence on the results. Secondary analyses were conducted to assess HLOS and the relevance of mean age, sex distribution, and body-mass index (BMI) across the included studies.

Therefore, for the primary outcome, we analyzed the control groups from 13 clinical trials,[12–24] encompassing a total sample size of 1588 patients. Furthermore, a weighted correlation analysis was performed to examine the relationship between the proportion of diabetic patients and HLOS. For the HLOS analysis, studies with missing data on hospital length of stay were excluded, resulting in 9 studies,[12,14–18,22–24] with a total sample size of 905 patients being included in this analysis.

To evaluate the age distribution, the weighted mean age was calculated, again using the number of participants as the weight. For this analysis, studies with missing age data were excluded, resulting in a total of 12 studies,[12–15,17–24] with a combined sample size of 1564 participants. The sex-distribution differences across the studies were assessed with a weighted chi-square test, with 11 articles[12–19,21,23,24] included, resulting in a total sample size of 1405 participants. For the BMI analysis, the weighted mean BMI was calculated. Studies without BMI data were excluded, resulting in 7 studies[12–17,21] with a combined sample size of 1039 participants. To understand the potential effect of age and BMI on ICU length of stay, a weighted least-squares (WLS) regression analysis was performed, including the mean age and mean BMI as predictors, weighted by the number of participants in each study.

Results

The search strategy identified a total of 613 articles across the three databases. After duplicates were removed, 481 unique articles remained. These articles were screened on the basis of titles and abstracts, resulting in 64 articles deemed potentially relevant. Full-text reviews of these articles were conducted, leading to the exclusion of 51 articles that did not meet the inclusion criteria. Ultimately, 13 studies were included in the systematic review, providing data on ICU length of stay and the number of diabetic patients.

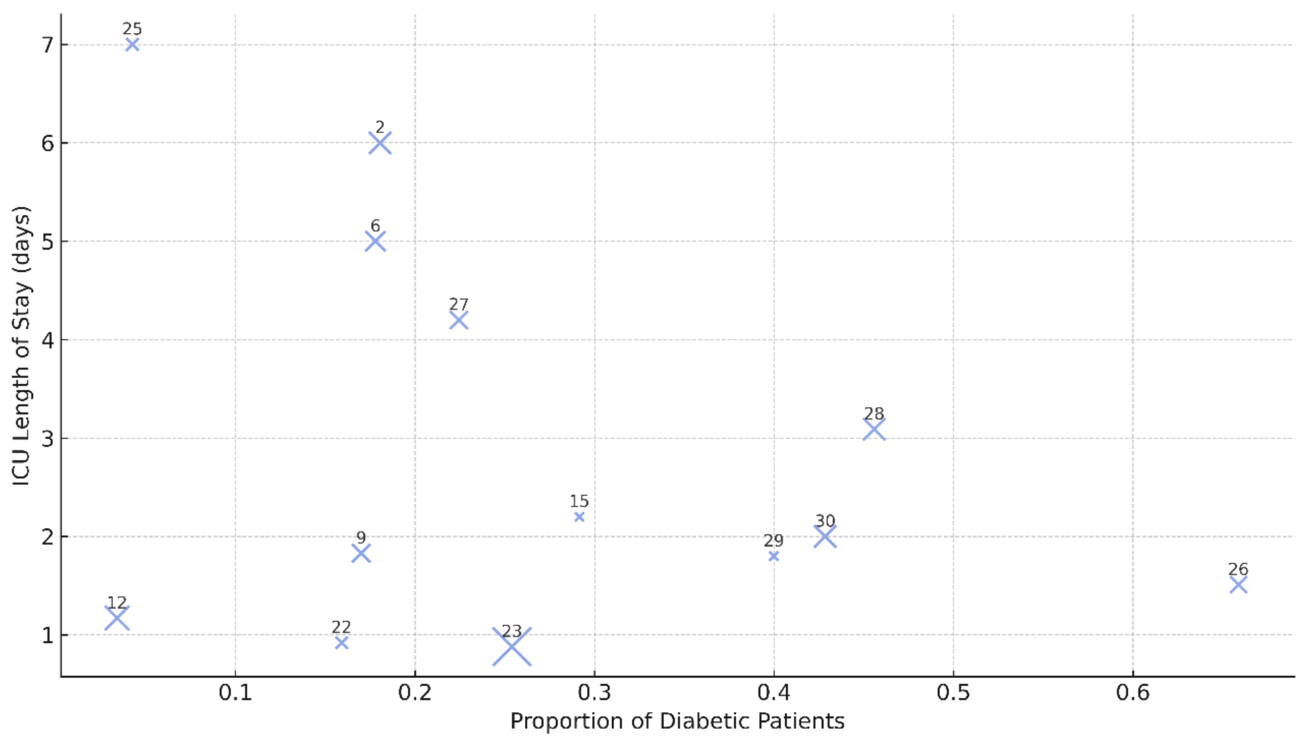
Study Characteristics

The 13 included studies were published between 2004 and 2024 and collectively enrolled 1588 patients. Sample sizes ranged from 24 to 433 participants. The studies reported on various types of cardiac surgery, including coronary-artery bypass grafting (CABG), valve replacement, and mixed cardiac procedures. The proportion of diabetic patients in the studies ranged from 3% to 66%.

Primary Analysis: ICU Length of Stay

The primary analysis examined the weighted correlation between the proportion of diabetic patients and ICU length of stay. The weighted correlation coefficient was −0.176 (P=0.57), with a mean ICU length of stay of 2.6 days, indicating a weak negative correlation that was not statistically significant.

Figure 1. Proportion of Diabetic Patients versus ICU Length of Stay.



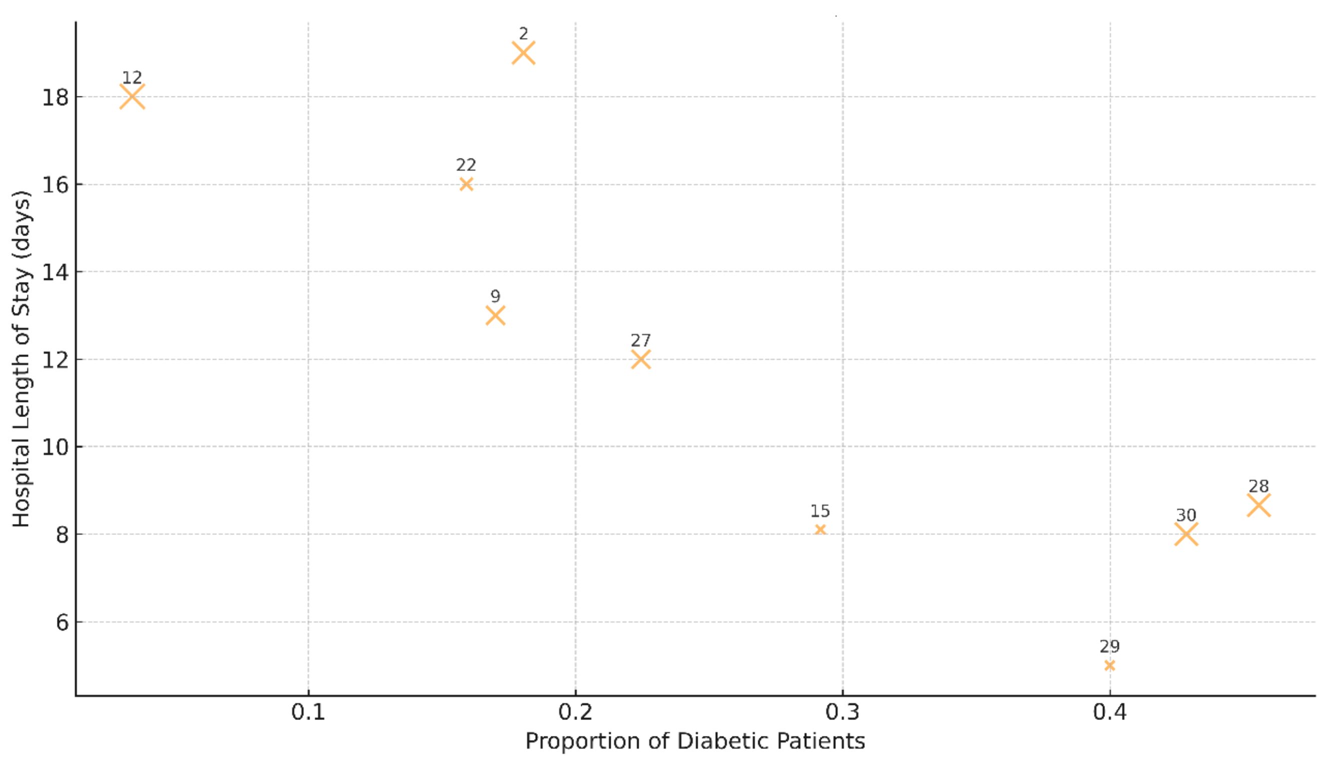
Scatter plot illustrating the relationship between the proportion of diabetic patients in each study on the x axis and the corresponding mean ICU length of stay, in days, on the y axis. Each point represents one of the 13 included studies. The size of each point is proportional to the total number of patients (N) in the respective study. Study codes are displayed above each data point for reference. Source: self-authored. ICU LOS denotes intensive care unit length of stay, DM diabetic patients, and N total number of patients.

Secondary Analysis

Hospital Length of Stay

For the HLOS analysis, 9 studies with a total of 905 patients were included after those with missing data were excluded. The weighted mean HLOS was 13.1 days, and a weak but statistically significant negative correlation was found between the proportion of diabetic patients and HLOS (correlation coefficient, −0.255; P=0.0020). This suggests that a higher proportion of diabetic patients was associated with shorter hospital stays. However, only 9 studies contributed data to this analysis, which limits the precision and robustness of the estimated association and warrants cautious interpretation. The WLS regression analysis showed a high proportion of explained variance (R^2=0.768; F statistic, 23.16; P=0.002194), but these results should be interpreted as exploratory given the small number of studies.

Figure 2. Proportion of Diabetic Patients versus Hospital Length of Stay.



Scatter plot illustrating the relationship between the proportion of diabetic patients and mean hospital length of stay (HLOS) across the included studies. Each data point represents one study. The x axis denotes the proportion of diabetic patients, and the y axis represents the corresponding mean HLOS, in days. The size of each point is proportional to the total number of patients in the respective study (N). Study codes are labeled next to each point for identification. Source: self-authored on the basis of extracted data from included trials.

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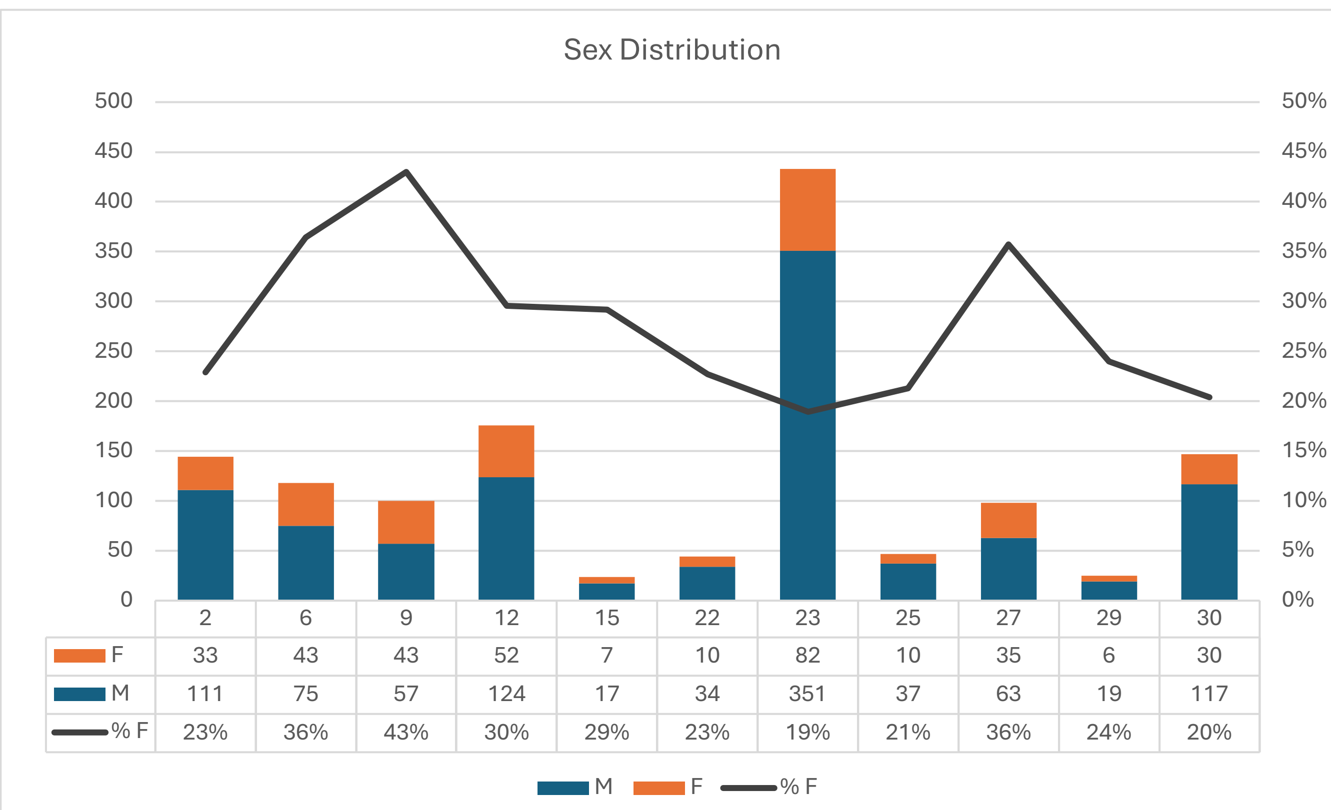
Mean Age

The age distribution across the studies was assessed with the weighted mean age. The weighted mean age was determined to be 64.7 years. To evaluate the effect of age on ICU length of stay, a WLS regression analysis was performed. The regression model included mean age as a predictor, weighted by the number of participants in each study. The regression analysis revealed that mean age did not have a statistically significant effect on ICU length of stay (coefficient, 0.065; P=0.51).

Sex Distribution

Sex-distribution differences across the studies were assessed. The total number of female participants was 351 (25.0%), and the total number of male participants was 1054 (75.0%). A weighted chi-square test revealed a chi-square statistic of 38.764, with a P value of less than 0.01, indicating a significant difference in sex distribution across the studies. This suggests that the variation in the proportion of female and male participants across the studies is nonrandom and should be considered when interpreting the results.

Figure 3. Sex Distribution across Included Studies.



Bars represent the absolute number of male (M) and female (F) participants in each study, and the line represents the percentage of female participants (%F). Numbers along the x axis correspond to study identification codes, which match the studies listed in Annex I. Source: self-authored. N denotes total number of patients, M number of male patients, F number of female patients, and ICU LOS intensive care unit length of stay.

BMI Analysis

The BMI analysis involved calculation of the weighted mean BMI, resulting in a value of 27.2 kg/m². A WLS regression analysis was conducted to understand the potential effect of BMI on ICU length of stay. The regression model included mean BMI as a predictor, weighted by the number of participants in each study. The regression analysis revealed that mean BMI did not have a statistically significant effect on ICU length of stay (coefficient, −0.20549; $P=0.7657$). The R^2 value was 0.021, indicating a very low proportion of variance in ICU length of stay explained by BMI.

Quality Assessment

The quality and risk of bias of the included studies were assessed with the Cochrane Risk of Bias 2 (ROB 2) tool. Overall, most included studies were judged to be at low risk of bias across all assessed domains. One study (Diab et al.[12]) was rated as having a moderate risk of bias due to protocol deviations, representing approximately 9% of the total pooled sample. No study was classified as having a high risk of bias.

Discussion

The primary objective of this systematic review was to determine the effect of diabetes on ICU and hospital length of stay after cardiac surgery with CPB. Our findings indicate that the proportion of diabetic patients within a study population does not significantly influence ICU length of stay, as evidenced by the weak and nonsignificant negative correlation (weighted correlation coefficient, −0.176; $P=0.57$). This finding contrasts with the common paradigm that diabetes is associated with longer ICU stays after cardiac surgery,[25] suggesting that our analysis provides a new perspective on this relationship.

However, our secondary analysis revealed a statistically significant but weak negative correlation between the proportion of diabetic patients and HLOS, with a weighted correlation coefficient of −0.255 and a P value of 0.0020. This unexpected finding contrasts with the prevailing understanding that diabetes is generally associated with worse postoperative outcomes. Previous studies have commonly reported prolonged hospital stays among diabetic patients.[8] One possible explanation is that study populations with a higher prevalence of diabetes may be managed with more standardized or intensive perioperative protocols, potentially influencing discharge practices. It is important to note that this secondary analysis was based on a small number of studies with available HLOS data. As emphasized by Button et al.,[26] analyses based on small sample sizes or limited numbers of studies are particularly prone to unstable effect estimates and reduced reproducibility. Accordingly, this finding should be interpreted cautiously and viewed as exploratory rather than confirmatory. Further research is needed to explore this hypothesis and identify the specific factors contributing to this outcome.

Although our analysis did not find significant effects of age or BMI on ICU length of stay, these factors are well documented in the literature as important determinants of postoperative outcomes.[27,28] In addition, our analysis revealed significant differences in sex distribution across studies, which may have influenced outcomes. In cardiac surgery populations, female patients have been shown to differ from male patients in baseline risk profiles, comorbidity burden, and physiological responses to CPB, including differences in body size, vascular anatomy, inflammatory response, and susceptibility to postoperative complications such as bleeding, renal dysfunction, and prolonged recovery. These sex-related factors may contribute to variability in ICU and hospital length of stay across studies.[29] Therefore, age, BMI, and sex distribution should continue to be considered in future studies to ensure a comprehensive understanding of factors influencing ICU length of stay.

Strengths and Limitations

This systematic review has several strengths, including a comprehensive search strategy, the use of multiple databases, and rigorous assessment of study quality. However, there are limitations that must be acknowledged. One included study was assessed as having a moderate risk of bias due to protocol deviations, accounting for approximately 9% of the total pooled data. Although this may slightly influence the reliability of the findings, the overall low risk of bias across the remaining studies supports the robustness of the primary conclusions. In addition, the exclusion of studies with missing data may have introduced selection bias, and the significant difference in sex distribution across the studies, as indicated by the weighted chi-square test, highlights the importance of considering sex as a variable in the analyses.

Therefore, although diabetes does not appear to significantly affect ICU length of stay, it may be associated with shorter hospital stays after cardiac surgery with CPB. These findings underscore the need for further investigation into the specific care practices and management strategies that may benefit diabetic patients postoperatively. In addition, future research should aim to address these methodological limitations to provide more robust and reliable findings.

Another potential limitation is the heterogeneity in health care systems and postoperative care protocols across centers. Differences in institutional practices may influence outcomes such as ICU and hospital length of stay independently of diabetes status. As such, variations between single-center and multicenter studies may confound the observed associations.

Furthermore, institutional variability across studies, particularly between single-center and multicenter trials with differing perioperative protocols and health care delivery models, may have introduced confounding effects. These differences underscore the importance of accounting for interinstitutional variability when interpreting aggregate outcomes in systematic reviews.

An important limitation of this review is the lack of standardized definitions of diabetes mellitus across the included studies. Although a few studies described diabetic patients as having type 2 diabetes mellitus, most did not provide diagnostic criteria or clarify whether diabetes status was based on clinical history, pharmacologic treatment, or laboratory markers such as HbA1c. This inconsistency limits the ability to evaluate the effect of diabetes severity or control on postoperative outcomes. In addition, no study provided data on glycemic control or stratified diabetic patients by disease severity. This heterogeneity limits the ability to assess how the metabolic status of patients may have influenced ICU or hospital length of stay.

The results of this systematic review help clarify discrepancies previously reported in the literature and may serve as a foundation for clinical practice and future research. Understanding how variation in diabetes prevalence across study populations correlates with ICU and hospital length of stay may inform the development of targeted interventions and contribute to optimizing perioperative care for diabetic patients. Moreover, the findings may support health policy decisions aimed at improving resource allocation and care delivery in cardiac surgery settings.

Conclusion

This systematic review used an ecological, study-level approach to examine whether variation in diabetes prevalence across cardiac surgery trials involving CPB is associated with differences in ICU and hospital length of stay. Across 13 studies, no significant association was observed between the proportion of diabetic patients and ICU length of stay. A weak inverse association was identified between diabetes prevalence and hospital length of stay; however, this finding was based on a small number of studies and should be interpreted cautiously.

These results should be viewed in light of important limitations, including the ecological design, the limited number of studies contributing hospital-length-of-stay data, missing outcome information, and heterogeneity in study populations and perioperative practices. Consequently, the observed association with hospital length of stay is exploratory and hypothesis-generating rather than confirmatory.

Future research should prioritize adequately powered, patient-level analyses that account for diabetes severity, glycemic control, and perioperative management strategies to better clarify the relationship between diabetes and postoperative resource utilization after cardiac surgery.

Annex I. Systematic Review Table

COD	AUTHOR	YEAR	STUDY	N	DM	% DM	ICU LOS	HLOS	AGE	IMC	SEX F	SEX M
2	DIAB	2022	Cytokine Hemoadsorption During Cardiac Surgery Versus Standard Surgical Care for Infective Endocarditis (REMOVE)	144	26	18%	6,00	19	69	27,5	33	111
6	BARBA-NAVARRO	2017	The Effect of Spironolactone on Acute Kidney Injury After Cardiac Surgery	118	21	18%	5,00		54	26,8	43	75
9	RUJIROJINDAKUL	2014	Safety and efficacy of intensive intraoperative glycaemic control in cardiopulmonary bypass surgery	100	17	17%	1,83	13	54	23,3	43	57
12	HAASE	2013	Prophylactic Perioperative Sodium Bicarbonate to Prevent Acute Kidney Injury Following Open Heart Surgery	176	6	3%	1,17	18	64,6	27,5	52	124
15	MIRMOHAMMADSADEGHI	2020	Sleep Quality after Coronary Artery Bypass Graft Surgery: Comparing Pulsatile and Nonpulsatile Pump Flow	24	7	29%	2,20	8,1		25,3	7	17
22	BREUER	2006	Preoperative oral carbohydrate administration to ASA III-IV patients undergoing elective cardiac surgery	44	7	16%	0,92	16	64	27,5	10	34
23	VIDLUND	2012	GLUTAMICS-a randomized clinical trial on glutamate infusion in 861 patients undergoing surgery for acute coronary syndrome	433	110	25,4%	0,88		68	27	82	351
25	KNEZEVIC	2014	The effects of levosimendan on renal function early after heart transplantation: results from a pilot randomized trial	47	2	4%	7,00		49		10	37
26	SHER-I-MURTAZA	2012	Is there any benefit of preoperative oral trimetazidine in coronary artery bypass graft?	85	56	66%	1,51		54,8			
27	COGLIATI	2007	Fenoldopam Infusion for Renal Protection in High-Risk Cardiac Surgery Patients: A Randomized Clinical Study	98	22	22%	4,20	12	69,6		35	63
28	LAZAR	2007	Beneficial effects of complement inhibition with soluble complement receptor 1 (TP10) during cardiac surgery: Is there a sex difference?	147	67	46%	3,09	8,66	67,4			
29	COUTURE	2007	Milrinone enhances systolic, but not diastolic function during coronary artery bypass grafting surgery	25	10	40%	1,80	5	70		6	19
30	BURNS	2005	Perioperative N-acetylcysteine to prevent renal dysfunction in high-risk patients undergoing CABG surgery: A randomized controlled trial	147	63	43%	2,00	8	69.2	30	30	117
				1588	**414**	**26%**	**2,64**	**13,10**	**64.7**	**27.2**		

BMI denotes body-mass index, CABG coronary artery bypass grafting, DM diabetic patients, HLOS hospital length of stay, ICU intensive care unit, IMC body-mass index, and LOS length of stay.

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