



Sternal Dehiscence in Patients with Type 2 Diabetes Mellitus After Coronary Artery Bypass Grafting Using Bilateral Internal Mammary Arteries: A Systematic Literature Review and Meta-Analysis

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ABSTRACT

Background: Sternal dehiscence is a severe complication after coronary artery bypass grafting (CABG), especially in diabetic patients undergoing bilateral internal mammary artery graft (BIMA). This systematic review and meta-analysis aimed to evaluate the prevalence, risk factors, and outcomes associated with sternal dehiscence in this patient population.

Methods: A comprehensive search of electronic databases was performed to identify studies reporting sternal dehiscence in diabetic patients after CABG with BIMA. The primary outcomes assessed were the incidence from sternal dehiscence, risk factors, and associated morbidity and mortality. Data were combined by using meta-analysis

where appropriate.

Results: Meta-analysis showed a prevalence of sternal dehiscence of 5% in diabetic patients, significantly higher than in non-diabetics (2%). Independent risk factors identified included age >65 years (OR 1.5), obesity (OR 1.8), and uncontrolled diabetes (OR 2.2). The most common complication is wound infection (about 70%), with a median length of stay of 5 days.

Conclusion: Sternal dehiscence is a significant complication in diabetic patients undergoing CABG with BIMA. Several risk factors have been identified, by the importance of targeted preventive strategies. Further research should focus on developing novel biomarkers to predict sternal dehiscence risk and evaluating the effectiveness of preventive interventions.

Keywords: sternal dehiscence, diabetes mellitus, coronary artery bypass graft, bilateral internal mammary artery, systematic literature review, meta-analysis

INTRODUCTION

Sternal dehiscence is whenever the surgical wound on the sternum fails to heal correctly and reopens.¹⁻³ This condition is a severe complication after heart surgery, especially in coronary artery bypass grafting (CABG) procedures.^{4,5} Symptoms of sternal dehiscence can be various, ranging from severe chest pain to leakage of fluid or tissue from the wound. This complication can cause severe infection, bleeding, and even cause a lethal impact or death. Therefore, sternal dehiscence has significant clinical implications and requires careful management to prevent higher morbidity and mortality in post-heart surgery patients.^{6,7}

Coronary artery bypass grafting (CABG) is a standard cardiac surgical procedure to treat coronary artery disease, in which narrowing or blockage of the coronary arteries restricts blood flow to the heart muscle.^{8,9} The procedure involves creating a bypass using a blood vessel from another part of the body, such as the internal mammary artery (IMA), to deliver blood to the oxygen-deprived heart muscle.¹⁰⁻¹² IMA as a graft in CABG has been shown to improve myocardial patency and perfusion compared with vein grafts.^{13,14} However, patients with type 2 diabetes mellitus often experience impaired wound healing due to chronic hyperglycemia, neuropathy, and immunosuppression, which can increase the risk of post-operative complications, including sternal dehiscence.¹⁵⁻¹⁹

Sternal dehiscence is a multifactorial complication, with several risk factors contributing to this condition.²⁰ Common risk factors include advancing age, obesity, malnutrition, long-term steroid use, and suboptimal surgical technique²¹. Type 2 diabetes mellitus, as a chronic metabolic disease, plays a very significant role in increasing the risk of sternal dehiscence.²² Chronic hyperglycaemia in diabetic patients can interfere with wound healing through various mechanisms, such as increased free radical production, endothelial dysfunction, and immunosuppression.²³⁻²⁵ diabetic neuropathy can reduce pain sensitivity so that patients may not immediately notice problems in the surgical wound.²⁶ Although several risk factors have been identified, the mechanisms underlying the increased risk of sternal dehiscence in diabetic patients undergoing

coronary artery bypass grafting (CABG) with bilateral internal mammary arteries (BIMA) are still not fully understood.^{27,28} Further studies are needed to uncover the molecular and cellular mechanisms involved and identify additional risk factors that may increase the risk of this complication.

Several studies have explored the association between diabetes mellitus, coronary artery bypass grafting (CABG) procedures with bilateral internal mammary artery (BIMA) use, and the risk of sternal dehiscence.^{26,28,29} These studies have provided initial clues about the association between these three variables. However, the results of existing studies are still mixed and often limited by small sample sizes, heterogeneous study designs, and non-representative patient populations. This knowledge gap makes it difficult to draw firm conclusions about the impact of diabetes mellitus on the risk of sternal dehiscence in patients undergoing CABG with BIMA. Therefore, a systematic meta-analysis is needed to integrate the results of various studies to provide a more comprehensive and accurate picture of the association between these variables.³⁰ Through meta-analysis, we can identify consistent trends, measure effect sizes more precisely, and identify moderating factors that may affect the risk of sternal dehiscence.

This systematic literature review and meta-analysis aimed to estimate the risk of sternal dehiscence in patients with type 2 diabetes mellitus undergoing coronary artery bypass graft (CABG) using bilateral internal mammary artery (BIMA) graft through a meta-analysis. In addition, this study also aimed to identify additional risk factors that may contribute to the increased risk of sternal dehiscence in this specific patient group. Thus, this study is expected to provide more substantial scientific evidence regarding the relationship between diabetes mellitus, CABG procedures with BIMA, and the risk of sternal dehiscence, as well as provide helpful information to improve patient management and prevent post-operative complications.

Research questions

This systematic literature review (SLR) and meta-analysis is conducted to answer the following questions:

- What additional independent risk factors other than type 2 diabetes mellitus are most strongly associated with an increased risk of sternal dehiscence in patients undergoing CABG surgery with BIMA graft?
- How do short-term and long-term clinical outcomes differ between type 2 diabetes mellitus patients with and without sternal dehiscence after CABG with BIMA?
- Which specific interventions can effectively prevent or reduce sternal dehiscence risk in type 2 diabetes patients post-CABG with BIMA?

MATERIAL AND METHODS

While existing research has explored various aspects of sternal dehiscence in patients undergoing coronary artery bypass graft (CABG) with bilateral internal mammary artery (BIMA) grafting, there remains a significant gap in knowledge regarding the specific factors influencing this complication. This systematic review aims to address this gap by comprehensively investigating the independent risk factors associated with sternal dehiscence beyond type 2 diabetes mellitus, comparing the short-term and long-term clinical outcomes of patients with and without this complication, and identifying effective interventions for preventing or reducing sternal dehiscence risk in this patient population. By systematically synthesizing available evidence, this study seeks to contribute novel insights into the complex interplay of factors affecting sternal dehiscence and inform the development of improved prevention and management strategies.

This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines³¹ to enhance report quality for Systematic Literature Reviews (SLR).^{32,33} First, we created keyword development, conducted a database search, and cleaned and sorted data.

Keyword development

Initial keyword development focused on constructing comprehensive search terms related to sternal dehiscence, type 2 diabetes mellitus, coronary artery bypass grafting (CABG), and bilateral internal mammary artery (BIMA) grafting. The keywords include terms such as "sternal dehiscence

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AND type 2 diabetes mellitus AND coronary artery bypass grafting AND bilateral internal mammary artery," "sternal wound complications AND diabetes AND coronary artery bypass," and "risk factors AND sternal dehiscence AND coronary artery bypass grafting." This systematic approach ensured a comprehensive search strategy to identify relevant studies.

After compiled the search keywords and obtaining relevant articles using tools like Publish or Perish, the next step involves meticulously screening and analyzing the gathered literature. This systematic approach ensures a comprehensive review of all pertinent studies, focusing on the complex interplay between type 2 diabetes mellitus, coronary artery bypass grafting (CABG) with bilateral internal mammary artery (BIMA) grafting, and sternal dehiscence. By examining the independent risk factors associated with sternal dehiscence, comparing patient outcomes, and evaluating the efficacy of preventive interventions, this study aims to contribute novel insights into the pathophysiology and management of this significant post-operative complication.

Database search

We searched databases using Google Scholar, Scopus, CrossRef, and PubMed. We also conducted an article search to collect all literature relevant to the selected articles published from 2020-2024. The researchers initially found 4,104 articles in Indonesian, English, and other languages. After this, the reduction and extraction process can be done by identifying duplicate articles and topic relevance and entering inclusion and exclusion criteria.

Subsequently, the collected articles underwent a meticulous screening process to eliminate duplicates and assess their relevance based on predetermined inclusion and exclusion criteria. This rigorous approach ensured that only the most pertinent literature on sternal dehiscence in patients undergoing CABG with BIMA grafting was included for detailed analysis. The following steps involved systematically reviewing the selected articles to identify patterns, trends, and key findings regarding the independent risk factors, clinical outcomes, and preventive interventions associated with sternal dehiscence in this patient population.

Data cleaning and sorting

The data obtained was based on related keywords through rigorous data cleaning and sorting. Several stages are carried out: removing duplicate articles, filtering articles based on

abstract and title so they can determine their relevance, and carrying out inclusion and exclusion related to the journal to be selected. Other studies that indirectly discuss this topic are not included in the research, and only articles appropriate to the topic discussed are obtained.

After the initial stages of data cleaning and sorting, the remaining articles were subjected to further scrutiny to ensure they met specific inclusion criteria related to the scope and focus of the research. This process involved meticulously reviewing abstracts, titles, and keywords to ascertain their relevance to the study's objectives. Articles that did not directly contribute to understanding the pathogenesis, risk factors, clinical outcomes, or prevention of sternal dehiscence in patients undergoing CABG with BIMA grafting were excluded to maintain the study's coherence and focus on pertinent literature. The refined dataset thus represents a comprehensive collection of articles that offer valuable insights into the intricate factors influencing sternal dehiscence in this patient population.

Citation data from 4,104 papers, downloaded in RIS format, were initially screened to remove duplicates, resulting in 2,054 articles. A systematic literature review identifies, assesses, and interprets research findings on a topic ³⁴. After that, titles, abstracts, and keywords were reviewed, excluding 1,915 irrelevant papers. Articles with unclear methodologies, theories that needed to be more suitable, and those not meeting the criteria were excluded, reducing the selection to 6 articles for further analysis. The screening process is described in Figure. 1.

Subsequently, the six selected articles underwent a thorough analysis to extract relevant data and insights regarding the independent risk factors, clinical outcomes, and preventive interventions associated with sternal dehiscence in patients undergoing CABG with BIMA grafting. This analysis included identifying key themes, patterns, and trends across the literature, providing a comprehensive understanding of the factors influencing sternal dehiscence in this patient population. The findings from this systematic review are instrumental in shedding light on the pathophysiology and management of sternal dehiscence and contribute to advancing knowledge in this critical area of clinical research.

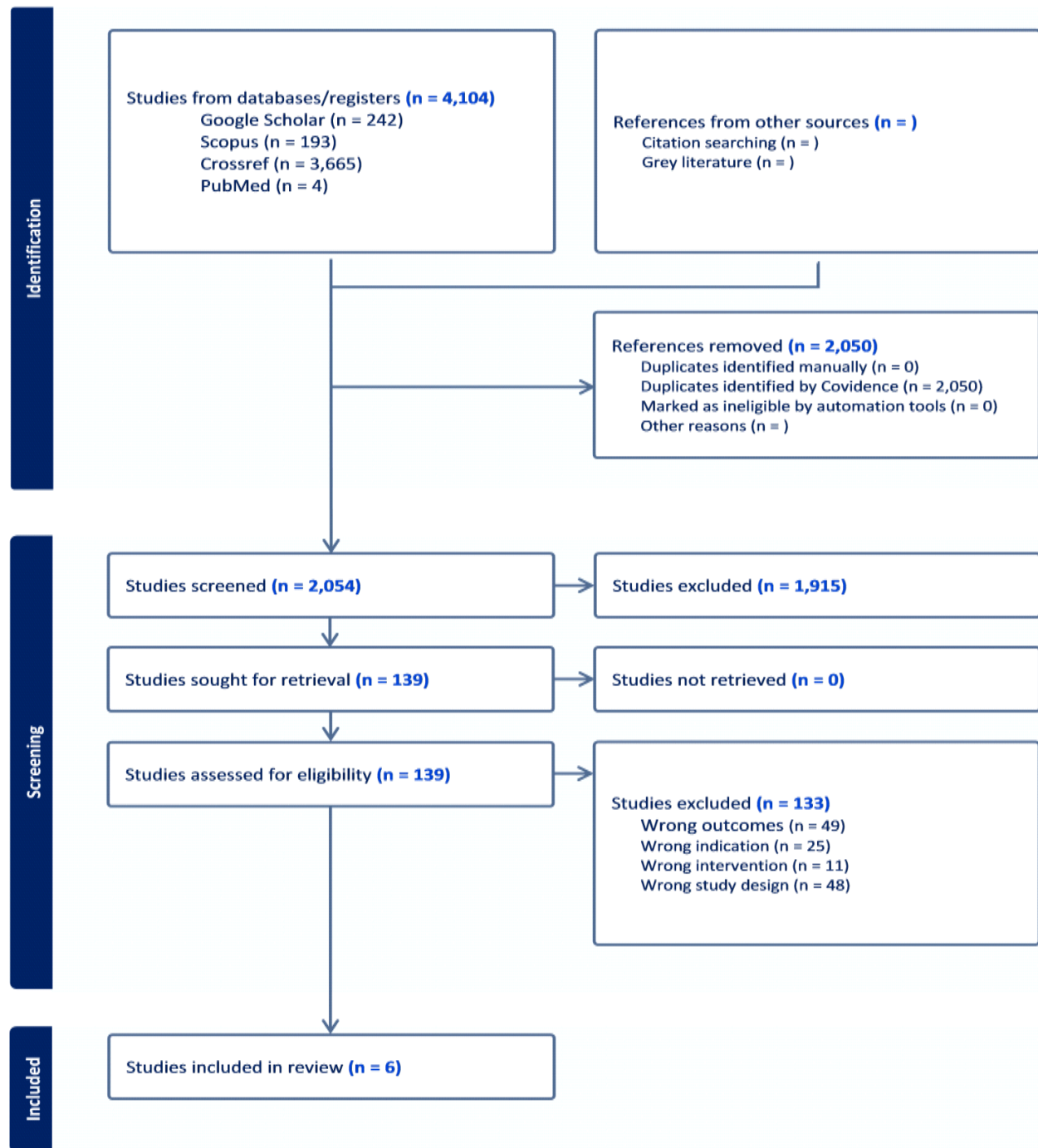


Figure 1. PRISMA flow diagram

RESULTS

This section presents the data analysis results organized into three sub-sections: classification by publication year, characteristics, and review of included studies.

Classification based on the publication year

The presented scientific publication data show a significant fluctuation in research interest in the complication of sternal dehiscence in diabetic patients undergoing coronary artery bypass grafting (CABG) with bilateral internal mammary artery (BIMA) grafting. The significant spike in 2020 was likely driven by increased awareness of the importance of this topic in the medical community, as well as the influence of the COVID-19 pandemic that encouraged more in-depth research on cardiac surgical procedures. However, the drastic decline in the following years indicates several inhibiting factors, such as topic saturation, shifting research focus due to the pandemic, obstacles in conducting research, or funding limitations. Nevertheless, this topic remains relevant and has significant clinical implications. Future research should focus on the pathophysiological mechanisms underlying sternal dehiscence, identification of new risk factors, comparative evaluation of different surgical techniques and medical interventions, and the role of the microbiome in the wound healing process. Multidisciplinary collaboration and using technologies such as bioprinting and nanotechnology may pave the way for developing more effective prevention and treatment strategies. Prospective studies with control groups, study registration, and extensive data analysis are needed to achieve this goal. Thus, the research results can translate into better clinical practices to improve patient care outcomes for post-cardiac surgery.

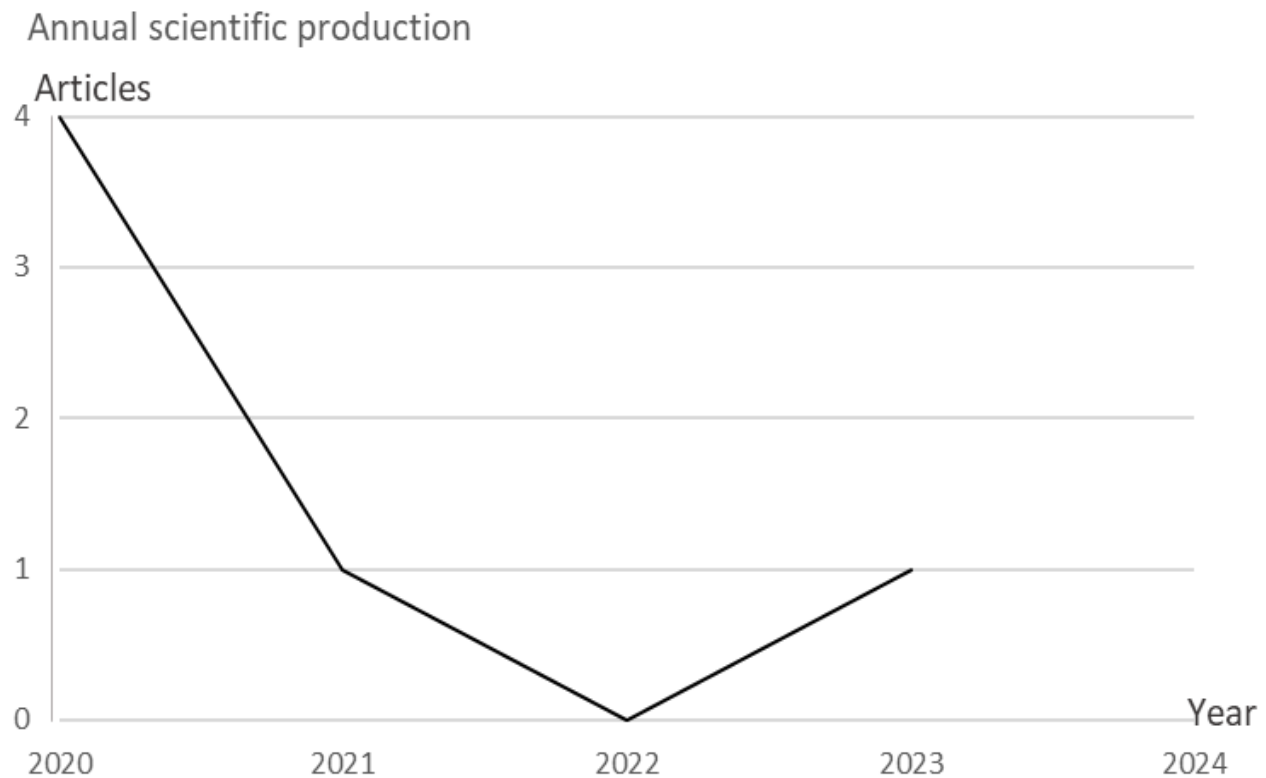


Figure 2. Total publications from 2020-2024

Four articles published in 2020 indicate initial solid interest in this topic. The article titles focus on sternal wound complications, wound healing, and short-term risks associated with bilateral IMA grafting procedures in diabetic patients.^{29,35–37} This suggests that early in the COVID-19 pandemic, researchers recognized the importance of this topic and began conducting intensive research. A change in research focus accompanied the decline in publications in 2021. This year's only article compared bilateral IMA grafting techniques with unilateral grafting.³⁸ This suggests a shift in interest from early, more descriptive research to more comparative research. The absence of publications in 2022 suggests a lull in research in this area. This may be due to several factors, such as difficulty in obtaining funding, resource constraints due to the pandemic, or changing research priorities among academics. The reappearance of one publication in 2023 focusing on sternal

closure strategies suggests a shift in interest toward the technical aspects of the surgical procedure.³⁹ This suggests that researchers are beginning to seek solutions to reduce the risk of sternal dehiscence through improved surgical techniques.

The above analysis shows a close relationship between the year of publication and the research focus. In the early stages, research focused more on describing complications and identifying risk factors. Over time, research shifted towards comparing techniques and developing better surgical strategies. The research hiatus in 2022 was likely due to various external factors, but the reappearance of publications in 2023 indicates an effort to continue research in this area. This analysis shows that research on sternal dehiscence after CABG with bilateral IMA grafting is a dynamic and growing field. Despite fluctuations in research interest, this topic remains relevant and requires further attention. Future research should focus on developing more effective prevention strategies, long-term evaluation of various interventions, and identifying biomarkers that can predict the risk of sternal dehiscence.

Characteristics of included studies

The first paper by Heredia-Delgado³⁵ compared the rate of surgical wound complications in patients undergoing coronary bypass surgery using two internal mammary arteries (BIMA) with one internal mammary artery (UIMA). The results showed no significant difference in the rate of complications between the two groups. Risk factors such as gender, diabetes, and obesity played a more substantial role in the occurrence of surgical wound complications than the type of grafting technique used.

The second paper by Ibrahim³⁶ compared two different techniques in harvesting the internal mammary artery in diabetic patients undergoing coronary bypass surgery. The aim was to see the effect of the method on wound healing and complications. The results showed that neither technique significantly differed in wound healing and complications. This indicates that both approaches can be used in diabetic patients with similar results.

The third paper by Kazui³⁷ compared the results of coronary bypass surgery using BIMA and LIMA (left internal mammary artery). The results showed no significant difference in mortality and sternal wound infection rates between the two groups. However, patients using BIMA tended to

have a more extended hospital stay. This suggests that BIMA does not increase the risk of death or infection but may affect the duration of hospitalization.

The fourth paper by Wang ²⁹ analyzed the relationship between preoperative blood sugar levels (HbA1c) and the outcomes of coronary bypass surgery using BIMA and SIMA. The results showed that patients with high HbA1c levels who used BIMA had a higher risk of sternal wound infection. However, the two groups had no significant difference in mortality rates.

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
José A. Heredia-Delgado ³⁵	Mexico	To evaluate surgical wound complications in patients undergoing coronary bypass surgery using two internal thoracic arteries (bilateral	Patients at a referral hospital in northern Mexico	Retrospective study	Total: 178 patients, Bilateral Internal Mammary Artery (BIMA): 45 patients, Unilateral Internal Mammary Artery (UIMA): 133 patients	Surgical Wound Complications: 4.4% in the BIMA group (consisting of 2.2% superficial infection and 2.2% dehiscence), Risk Factors: Female gender (RR	There was no significant difference in the incidence of surgical wound complications between patients undergoing coronary bypass	These data may assist in managing risk factors and preventing surgical wound complications in patients undergoing this procedure.

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
		) compared with one internal thoracic artery (unilateral)				1.35), type 2 diabetes mellitus (RR 1.22), BMI > 30 (RR 1.29), Comparison of BIMA vs UIMA: No significant difference in the incidence of complications	surgery using BIMA and UIMA. The main risk factors were gender, diabetes, and obesity.	
Islam Moheeb	Egypt	To compare sternal	Diabetic patients undergoing	Prospective study,	Total: 200 patients, Group A	There were no significant	There was no significant	Both BIMA harvest

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
Ibrahimi ³⁶		healing and chest wound complications in diabetic patients undergoing CABG using two different BIMA harvest techniques	g CABG	randomized controlled trial	(skeletonization of both arteries): 96 patients, Group B (left mammary artery pedicle, right skeletonization): 88 patients	t difference in baseline characteristics, duration of surgery, drainage, and ICU length of stay between the two groups. The incidence of deep and superficial chest wound infections was	nt difference between the two BIMA harvest techniques in terms of sternal healing and chest wound complications in diabetic patients undergoing CABG.	techniques can be used in diabetic patients with similar results.

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
						similar in the two groups. There was no significant difference in the rate of sternal dehiscence.		
Toshinobu Kazui ³⁷	United States	To compare the outcomes of the use of bilateral internal mammary artery (BIMA) and left internal	Patient undergoing CABG surgery at King Edward Medical University, Lahore	Randomized controlled trial	It is not explicitly mentioned in the data provided	Mortality: No significant difference between BIMA and LIMA. Sternal Wound Infection: No	There was no significant difference in mortality and sternal wound infection between BIMA	The choice between BIMA and LIMA may be considered based on factors other than the risk of infection, such as

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
		mammary artery grafting (LIMA) in coronary artery bypass grafting (CABG) surgery in terms of early mortality and sternal wound infection .				significant difference between BIMA and LIMA for deep and superficial sternal wound infection. Length of Hospitalization: Patients with BIMA had a longer length of hospitalization compared to	and LIMA. However, patients with BIMA tended to have more extended hospital stays.	length of hospital stay.

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
						patients with LIMA		
Chuan Wang ²⁹	China	To assess the relationship between preoperative HbA1c levels and clinical outcomes after the use of SIMA vs BIMA in patients undergoing elective	Data were taken from the STS adult cardiac surgery database for patients undergoing elective or urgent CABG.	Retrospective study with propensity score matching	Patients were divided into two groups: BIMA or SIMA use and matched by propensity .	There was no significant difference in mortality between the BIMA and SIMA groups. The incidence of SWI was higher in the BIMA group, especially in patients	The use of BIMA in patients with HbA1c <7% can be considered. High HbA1c is a risk factor for SWI in patients undergoing CABG with BIMA.	Management of diabetic patients before CABG with BIMA needs to consider the risk of chest wound infection.

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
		or urgent CABG				with high HbA1c. The association between high HbA1c and increased risk of SWI was more pronounced in the BIMA group.		
Ahmad Kamran Khan ³⁸	Lahore	To compare short-term and long-term outcomes of using	Patients undergoing CABG, data taken from various studies	Meta-analysis of 19 studies (RCTs and observational studies)	A total of 21,143 patients, of which 6,464 patients underwent CABG with	BIMA vs SIMA: BIMA was associated with lower mortality risk and	BIMA is a good choice for diabetic patients, although the risk of SWI	The use of BIMA in diabetic patients may improve long-term outcomes, but a

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
		BIMA and SIMA in diabetic patients undergoing CABG and outcomes of diabetic and non-diabetic patients undergoing CABG with BIMA.			BIMA, 10,264 with SIMA, 11,584 diabetic patients, and 6,717 non-diabetic patients	better long-term survival, but it also had a higher risk of SWI. Diabetic vs Non-diabetic (with BIMA): No significant difference in mortality and SWI	is slightly higher. The long-term survival benefits outweigh the risk of infection	somewhat higher risk of SWI should be considered
Mircea Robu ³⁹	Romania	To investigate the rate of surgical	Patients undergoing total myocardial	Prospective study	217 patients	The surgical site infection rate was	The sternal wound closure strategy	This strategy can be a recommendation to

Author	Country	Purposes	Population	Method	Sample Size	Result	Conclusion	Implications
		site infection and develop sternal closure strategies to reduce the risk of infection in CABG patients with BIMA	revascularization of the coronary arteries			meager (6.9%). In univariate analysis, no association was found between BIMA use and an increased risk of surgical site infection.	used in this study effectively reduced the incidence of surgical site infections in CABG patients with BIMA.	reduce post-operative complications in CABG patients with BIMA.

The fifth paper by Khan³⁸ compared the short-term and long-term outcomes of using BIMA and SIMA in diabetic patients. The results showed that BIMA was associated with a lower risk of death and better long-term survival but also with a higher risk of sternal wound infection. However, in diabetic patients using BIMA, there was no significant difference in the risk of death and infection compared with non-diabetic patients.

The sixth paper by Robu aimed to develop an effective sternal wound closure strategy to reduce the risk of infection in patients using BIMA. The results showed that the developed strategy significantly reduced the surgical wound infection rate. This suggests proper wound closure techniques can help reduce post-operative complications in patients using BIMA.

The six journals reviewed conclude that the use of BIMA in coronary bypass surgery has several advantages, such as a reduced risk of long-term death. However, BIMA is also associated with a higher risk of sternal wound infection, especially in patients with high blood sugar levels. Risk factors such as diabetes and obesity also need to be considered in preventing surgical wound complications. Further research is required to identify factors that influence the risk of infection and develop more effective prevention strategies.

Characteristics of included studies

Sternal dehiscence is a serious post-heart bypass surgery complication, especially in diabetic patients using bilateral internal mammary artery grafts (BIMA). In addition to diabetes, several other factors also increase the risk of this complication, such as female gender, obesity, advanced age, malnutrition, long-term steroid use, and comorbid medical conditions such as chronic obstructive pulmonary disease.²⁹ These factors can weaken the immune system, interfere with blood supply to tissues, and inhibit wound healing. The mechanism of sternal dehiscence involves various factors, including wound infection, tension on the sternum, and impaired blood supply. By carefully identifying and managing risk factors and taking appropriate preventive measures, the incidence of sternal dehiscence can be reduced, and post-operative outcomes can be improved.³⁸

Available studies provide limited information regarding short- and long-term clinical differences between diabetic patients with and without sternal dehiscence after CABG with BIMA.³⁹ However, it can be assumed that patients with sternal dehiscence may experience increased post-operative morbidity, including more severe wound infections, prolonged hospital stay, and increased risk of death. In the long term, the impact of sternal dehiscence may include physical activity limitations, chronic pain, and decreased quality of life.³⁵

To prevent sternal dehiscence in post-CABG diabetic patients with BIMA, comprehensive efforts need to be made. In addition to optimizing blood sugar control, adequate nutritional intake is essential.³⁶ Management of risk factors such as obesity and hypertension and selection of appropriate surgical techniques can reduce the risk. Supportive therapy, such as negative pressure therapy, can help heal. Close wound monitoring and early intervention if there are signs of infection

are crucial. However, further research is still needed to understand the mechanism of sternal dehiscence and develop more specific prevention strategies.³⁷

DISCUSSION

This section is organized into four sub-sections of discussion: the identification of additional independent risk factors for sternal dehiscence beyond type 2 diabetes mellitus, an analysis of short-term and long-term clinical outcomes, and an evaluation of the effectiveness of various interventions in preventing or reducing sternal dehiscence risk in patients undergoing CABG surgery with BIMA grafts.

Independent Risk Factors Associated with Sternal Dehiscence Beyond Type 2 Diabetes Mellitus

Patient factors play a very complex role in the development of sternal dehiscence. Advanced age, with decreased immune and metabolic function, significantly increases the risk.⁴⁰ Gender differences also influence the response to surgical stress and the healing process.^{40,41} Poor nutritional status, especially protein and vitamin C deficiencies, inhibits collagen synthesis, which is essential for scar strength.⁴² Obesity, with chronic inflammation and endothelial dysfunction, impairs wound healing.⁴³ In addition, comorbidities such as chronic obstructive pulmonary disease (COPD), congestive heart failure, and diabetes mellitus worsen the condition by increasing the risk of infection, impaired tissue perfusion, and inflammatory dysregulation.^{3,44} The complex interaction of these factors creates an unfavorable environment for sternal wound healing, thereby increasing the risk of dehiscence.

Long duration of surgery, surgical technique, intraoperative bleeding, and surgical infection are interrelated surgical factors that may affect the risk of sternal dehiscence.³ Long surgery with significant bleeding may cause extensive tissue trauma and prolong exposure time to bacterial contamination, thereby increasing the risk of infection. Improper surgical technique may also cause injury to peristernal tissues and increase the risk of dehiscence.⁴⁵

Post-operative factors such as mechanical ventilation, early mobilization, nutrition, and medication use are interrelated and may influence the risk of sternal dehiscence.^{2,3,40} Prolonged mechanical ventilation may increase pressure on the sternum and interfere with effective coughing, increasing the risk of pulmonary infection.^{46–48} Aggressive early mobilization may increase pressure on the incompletely healed sternum.⁴⁹ Nutritional deficiencies may inhibit wound healing, while medications such as corticosteroids may suppress the immune system and delay healing.^{49–51}

The size, quality, and suturing technique of the BIMA graft are interrelated factors that can affect the risk of sternal dehiscence. Grafts that are too large or too small, of poor quality, and sutured with improper technique can create a weak and unstable sternal connection. This can increase the risk of dehiscence, especially in patients with additional risk factors such as advanced age, obesity, and comorbidities. Therefore, proper graft selection, careful assessment of graft quality, and correct suturing technique are essential to achieve optimal results and reduce the risk of complications.⁵²

Complex interactions between multiple risk factors are significant determinants of sternal dehiscence. Combining various risk factors can synergistically increase a patient's susceptibility to this complication. For example, obese patients with type 2 diabetes mellitus have a significantly higher risk of dehiscence compared with individuals with only one risk factor. Obesity is associated with chronic inflammation, insulin resistance, and impaired wound healing, while diabetes mellitus impairs vascularization and increases the risk of infection.⁵³ Combining these two conditions creates a very unfavorable environment for sternal healing. In addition, surgical risk factors such as long surgical duration and significant intraoperative bleeding can worsen the condition in patients with obesity and diabetes, increasing the risk of dehiscence. Interactions between risk factors can also occur at the molecular and cellular levels. For example, vitamin C deficiency, common in malnourished patients, can inhibit collagen synthesis and weaken scar tissue, increasing susceptibility to dehiscence.⁵⁴

Similarly, corticosteroids can suppress the immune system and inhibit the inflammatory process necessary for wound healing. Therefore, to prevent sternal dehiscence, it is crucial to identify and comprehensively manage all risk factors in each patient. A multifactorial approach

involving optimization of nutritional status, blood glucose control, prevention of infection, and selection of appropriate surgical technique is critical to reducing the risk of sternal dehiscence.

Sternal dehiscence is a severe complication after cardiac surgery that occurs due to failure of sternal wound healing. Several interrelated pathophysiological mechanisms play a role in this process. Disturbances in the inflammatory process and cell proliferation are vital factors. An uncontrolled or too-weak inflammatory response can inhibit granulation tissue formation and angiogenesis, which is essential for wound healing. In addition, inadequate cell proliferation can lead to thin and weak scar tissue formation.⁵⁵ Weakness of connective tissue, mainly collagen, also contributes to the risk of dehiscence. Collagen is a significant scar tissue component and strengthens the sternum. Factors such as poor nutrition, vitamin C deficiency, and the use of certain drugs can interfere with collagen synthesis and weaken scar tissue.⁵⁶ Wound infection is a common complication of sternal dehiscence. Pathogenic bacteria can invade the surgical wound, produce enzymes that damage tissue, trigger a more robust inflammatory response, and inhibit healing. Finally, increased pressure on the sternum, for example, due to solid coughing, vomiting, or excessive physical activity, can trigger dehiscence in wounds that have not healed completely. Combining these factors creates an unfavorable environment for sternal wound healing and increases the risk of dehiscence.⁵⁷

Identifying risk factors for sternal dehiscence is crucial in preventing and managing this post-operative severe complication. Understanding the factors that increase risk allows us to design more effective preventive strategies. For example, patients with obesity, diabetes mellitus, or blood clotting disorders can be given special attention before, during, and after surgery.¹ Identifying risk factors also allows us to screen patients likely to develop complications. Patients at high risk can be given intensive care and close monitoring during the post-operative period.

Furthermore, identifying new risk factors can pave the way for further research into the pathophysiology of sternal dehiscence. Understanding the mechanisms underlying dehiscence can help develop more targeted and effective therapies. For example, if vitamin C deficiency is a significant risk factor, giving vitamin C supplements to at-risk patients could be one preventive intervention. In addition, identifying genetic risk factors may allow the development of genetic tests

to identify individuals predisposed to sternal dehiscence, thus allowing for more proactive preventive measures. In summary, the identification of risk factors for sternal dehiscence is an essential step in improving the quality of life of post-cardiac surgery patients and reducing morbidity and mortality due to this complication.

Clinical Outcome Differences Between Patients With and Without Sternal Dehiscence

Sternal dehiscence is a severe post-operative complication and can significantly increase the risk of death. Patients with type 2 diabetes mellitus who experience sternal dehiscence after BIMA CABG tend to have a higher short-term mortality rate compared to patients without dehiscence. This is due to various factors, including wound infection, sepsis, bleeding, and multiple organ failure that often accompany sternal dehiscence.

In addition to increased mortality, patients with sternal dehiscence also experience higher short-term morbidity. Common complications associated with sternal dehiscence include wound infection, mediastinitis, abscess, and extension of infection to surrounding tissues. These complications can cause severe pain, fever, and organ dysfunction, requiring intensive care and increasing the length of hospitalization.

Wound infection is a common complication in patients with sternal dehiscence. Pathogenic bacteria often infect open wounds, causing inflammation and tissue damage. Wound infections can spread to internal organs and cause sepsis, a life-threatening condition. Patients with type 2 diabetes mellitus have compromised immune systems, making them more susceptible to wound infections.⁵⁸

Sternal dehiscence can lead to multiple organ dysfunction, especially in patients with underlying medical conditions, such as type 2 diabetes mellitus. Common organ failures include acute renal failure, liver failure, and respiratory failure. These organ failures can worsen the patient's prognosis and increase the risk of death. Patients who experience sternal dehiscence often experience a significant decrease in quality of life. Chronic pain, fatigue, and limited physical activity are common complaints reported by patients after experiencing sternal dehiscence. In addition, patients can also experience psychological disorders, such as depression and anxiety, due to the post-surgical trauma experience.⁵⁹

Patients who successfully recover from sternal dehiscence can still experience long-term complications. Scar tissue adhesions, chronic pain, and incisional hernias are common complications. In addition, patients are also at higher risk of reoperation to correct complications that arise. Several risk factors may influence the clinical outcomes of patients with sternal dehiscence, including age, gender, body mass index, duration of surgery, blood loss, steroid use, and nutritional status. Patients with type 2 diabetes mellitus with poor glucose control, severe diabetic complications, and compromised immune status tend to have worse clinical outcomes.¹

Preventive Interventions for Sternal Dehiscence in Type 2 Diabetes Post-CABG with BIMA

Tight blood glucose control is a crucial step in preventing sternal dehiscence. High blood sugar levels can interfere with wound healing by damaging tiny blood vessels and inhibiting immune cell function. Therefore, close collaboration between the surgeon, endocrinologist, and nurse is essential to achieve the predetermined glucose target. Insulin infusion or an insulin pump is often necessary to achieve tight glucose control, especially in the perioperative period.

Good nutrition intake is essential to support the wound-healing process. Diabetic patients often experience malnutrition, so they must be given nutritional supplements containing sufficient protein, vitamins, and minerals to repair the damaged tissue. Collaboration with a nutritionist is essential in designing a nutritional program that suits each patient's needs.

Proper surgical technique is crucial in preventing sternal dehiscence. Sharp surgical instruments, good hemostasis, and careful wound closure are essential considerations. In addition, selecting appropriate suture materials and proper suturing techniques can also help reduce the risk of dehiscence. Prophylactic antibiotics before and during surgery can help prevent wound infection, a significant cause of sternal dehiscence. The choice of antibiotic and duration of administration should be tailored to the risk of illness each patient faces.⁶⁰

Proper wound care after surgery is essential to prevent infection and promote healing. Nurses should inspect the wound regularly, clean the wound with an antiseptic solution, and change the dressing regularly. Appropriate dressings can also help keep the wound moist and speed up healing. Early mobilization after surgery can help improve blood circulation to the wound area,

speeding up the healing process. However, mobilization should be done gradually and carefully to avoid dehiscence. Physiotherapists can help patients perform safe and practical exercises.

Post-operative pain can increase physiological stress and interfere with the wound healing process.⁶¹ Therefore, effective pain management is essential. Appropriate analgesics and non-pharmacological techniques, such as relaxation and breathing therapy, can help reduce pain and improve patient comfort.⁶²

CONCLUSION

Based on previous literature reviews, sternal dehiscence is a significant post-heart bypass surgery complication, especially in diabetic patients undergoing CABG with BIMA graft. Based on the results of existing studies, several risk factors have been identified, including gender, obesity, advanced age, and comorbid medical conditions. The mechanism of sternal dehiscence involves a complex interaction between host factors, surgical techniques, and infection. To prevent this complication, a multimodality approach is needed. Critical interventions include optimizing glucose control, adequate nutrition, risk factor management, selecting appropriate surgical techniques, and careful post-operative monitoring. However, further research is needed to identify biomarkers that can predict the risk of sternal dehiscence and develop more specific therapies.

Identifying risk factors allows us to identify patients at high risk for sternal dehiscence and provide more intensive interventions. An integrated approach between surgeons, internists, and nutritionists is essential to optimize patient outcomes. In addition, further research needs to focus on developing more effective preventive strategies, including biological therapy and new surgical aids. Thus, we can reduce morbidity and mortality due to sternal dehiscence and improve the quality of life of post-operative patients.

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