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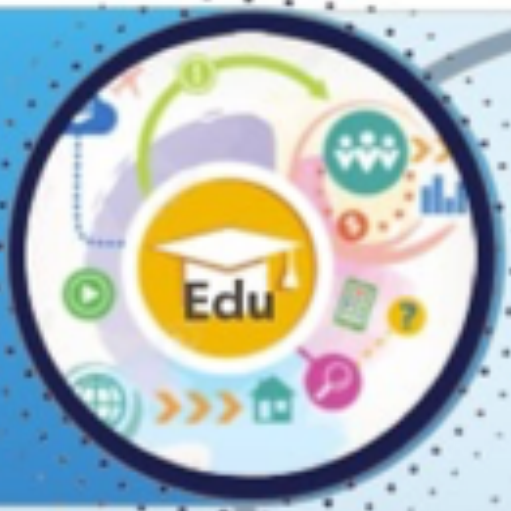

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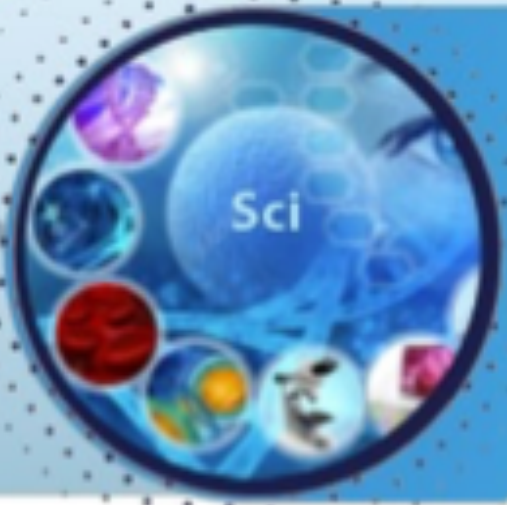

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Review Article

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Endovascular Treatment Strategies for Diabetic Foot Complications in Patients with Coexisting Coronary Artery Disease

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ABSTRACT

Background. *Diabetic foot syndrome (DFS), particularly in its ischemic and neuroischemic forms, is a major cause of amputation and mortality in patients with type 2 diabetes mellitus. When combined with coronary artery disease (CAD), the risks of poor outcomes increase substantially. Endovascular revascularization has emerged as a preferred approach for limb salvage, yet clinical results vary depending on cardiovascular status and timing of intervention.*

Methods: *This review summarizes the current literature on endovascular management of diabetic foot complications in patients with coexisting CAD. It focuses on treatment sequencing, procedural access, revascularization efficacy, and patient selection. Clinical challenges and future directions for personalized intervention algorithms are also discussed.*

Results: *Patients with advanced DFS and concomitant CAD often require careful risk stratification before revascularization. Factors such as ejection fraction, anatomical accessibility, ulcer staging, and coronary reserve influence outcomes. Studies support the efficacy of limb-first or heart-first strategies depending on individual risk profiles. Preprocedural planning and coordinated care are essential to reduce amputation rates, repeat interventions, and perioperative complications.*

Conclusion: *Endovascular treatment offers promising outcomes for patients with diabetic foot complications and CAD when applied within a structured, risk-oriented framework. Personalized decision-making, based on cardiac status and ischemic severity, should guide therapeutic priorities to maximize limb preservation and survival.*

Keywords: *Diabetic foot, endovascular intervention, limb ischemia, coronary artery disease, revascularization, personalized treatment, ischemic complications.*

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INTRODUCTION

Diabetic foot syndrome (DFS) remains a leading cause of hospitalization, limb loss, and reduced life expectancy among patients with type 2 diabetes mellitus (T2DM). The progression from peripheral arterial disease to critical limb ischemia and tissue necrosis is often accelerated by the metabolic and vascular disturbances characteristic of diabetes, including endothelial dysfunction, impaired angiogenesis, and chronic inflammation [1]. In recent decades, endovascular revascularization has emerged as a frontline therapeutic modality aimed at restoring perfusion, promoting wound healing, and preventing major amputations [2].

However, the presence of coexisting coronary artery disease (CAD) adds substantial complexity to the management of DFS. CAD is prevalent in over 70% of patients with DFS and often remains undiagnosed until acute events occur or surgical risk assessment reveals latent myocardial dysfunction [3]. The combined burden of DFS and CAD is associated with higher rates of treatment failure, perioperative complications, and mortality, particularly when revascularization is pursued without appropriate cardiovascular evaluation [4].

Traditional approaches to treating DFS have focused primarily on local limb salvage, frequently neglecting systemic perfusion adequacy and myocardial reserve. Yet recent studies have highlighted the bidirectional relationship between cardiac function and limb hemodynamics: insufficient cardiac output may impair peripheral revascularization success, while critical limb ischemia may trigger cardiac decompensation through inflammatory and neurohumoral pathways [5,6].

Despite these observations, clinical practice remains fragmented. Endovascular procedures for lower-limb ischemia are typically performed without synchronized cardiologic assessment, and vice versa. The lack of consensus regarding procedural sequencing—whether to prioritize revascularization of the limb or the myocardium—further contributes to therapeutic inconsistency. While "limb-first" strategies may be justified in the presence of gangrene or ulcer infection, "heart-first" approaches may reduce intraoperative risk in patients with advanced CAD and reduced ejection fraction [7].

Recent evidence suggests that individualized algorithms, integrating cardiac, vascular, and metabolic parameters, may improve outcomes by tailoring intervention sequence and intensity to patient-specific profiles [8]. However, such approaches are still underutilized, particularly in low-resource settings or where multidisciplinary coordination is limited. Moreover, there is a paucity of prospective data comparing different endovascular strategies in this complex patient population.

This review aims to synthesize current evidence regarding the role of endovascular interventions in the management of DFS among patients with coexisting CAD. Emphasis is placed on risk stratification, procedural planning, treatment sequencing, and the implementation of personalized therapeutic models. By consolidating available data and identifying existing gaps, the discussion seeks to inform future clinical pathways that prioritize both limb preservation and cardiovascular survival.

MAIN PART

Pathophysiological Basis and Technical Considerations

The therapeutic rationale for endovascular revascularization in patients with diabetic foot syndrome (DFS) rests on the urgent need to restore perfusion in ischemic tissues to prevent infection, facilitate wound healing, and avoid amputation. In patients with type 2 diabetes mellitus, peripheral arterial disease is often advanced, multilayered, and characterized by distal vessel occlusion, calcification, and impaired autoregulation of blood flow [1]. These features limit the effectiveness of conservative therapy and necessitate mechanical intervention.

At the same time, the co-presence of coronary artery disease (CAD) introduces additional systemic constraints. Reduced myocardial contractility and compromised cardiac output, frequently observed in patients with CAD, impair distal perfusion even after technically successful lower-limb revascularization. Furthermore, procedural stress during endovascular intervention may precipitate ischemic cardiac events in patients with latent or uncorrected coronary pathology [2].

Pathophysiologically, both DFS and CAD share a common substrate in endothelial dysfunction, chronic low-grade inflammation, and enhanced thrombogenicity. In diabetic patients, these mechanisms contribute to a diffuse, multivessel pattern of vascular injury, involving the coronary circulation, the aortoiliac axis, and the infrainguinal arteries [3]. In the lower extremities, medial calcification and tibial artery involvement are particularly prevalent and pose significant technical challenges during angioplasty or stenting [4]. The presence of gangrene or deep infection further complicates revascularization by increasing the risk of thrombosis, embolization, and vessel spasm.

From a procedural perspective, the selection of vascular access, device choice, and target vessel strategy must be individualized based on anatomical and functional parameters. Ipsilateral antegrade femoral access is often preferred for tibial interventions due to improved catheter control, yet may be contraindicated in patients with proximal femoral disease or obesity. Cross-over contralateral access is commonly used in such cases, though it carries higher technical complexity and may require longer procedural time [5].

Moreover, the choice between balloon angioplasty alone and stent deployment depends not only on lesion morphology but also on systemic risk factors such as platelet reactivity, renal function, and prior anticoagulant use. In patients with coexisting CAD, antiplatelet strategies must be coordinated to balance hemorrhagic and thrombotic risks. This is especially relevant in the context of dual antiplatelet therapy (DAPT) for recently implanted coronary stents, which may interfere with perioperative planning for foot surgery or wound debridement [6].

Another important technical consideration is the role of hybrid approaches that combine open debridement or minor amputation with staged or simultaneous endovascular procedures. This approach has demonstrated promising results in limb salvage, particularly when infection control is prioritized and revascularization is timed appropriately [7]. Nevertheless, such interventions require close coordination between surgical, interventional, and cardiologic teams, highlighting the importance of a multidisciplinary framework.

Despite advancements in device technology and procedural techniques, outcomes remain suboptimal in patients with both DFS and CAD, unless systemic and local factors are addressed simultaneously. High rates of restenosis, re-occlusion, and delayed healing continue to challenge clinicians, particularly in the setting of advanced comorbidity, poor glycemic control, and delayed presentation [8].

Sequencing Strategies, Clinical Coordination, and Personalized Risk Assessment

The question of optimal sequencing in the treatment of patients with diabetic foot syndrome (DFS) and coexisting coronary artery disease (CAD) remains clinically controversial. Two main strategic models have emerged: the "limb-first" approach, in which endovascular revascularization of the lower extremity is prioritized to halt progression of ischemia and prevent amputation; and the "heart-first" approach, where coronary evaluation and potential intervention are performed prior to any vascular procedure to minimize perioperative cardiac risk [1].

Each strategy has its rationale and limitations. The "limb-first" approach is often indicated in patients presenting with critical limb-threatening ischemia (CLTI), where tissue viability and infection control are time-sensitive. Delaying revascularization in this setting may lead to irreversible tissue necrosis and sepsis. However, proceeding with limb intervention without cardiological clearance in patients with undiagnosed CAD may expose them to major perioperative events such as myocardial infarction, arrhythmia, or hemodynamic collapse [2].

Conversely, the "heart-first" approach is supported in patients with unstable angina, severely reduced left ventricular ejection fraction, or a history of recent acute coronary syndromes. In such cases, coronary angiography and revascularization may reduce intraoperative risks and improve systemic perfusion before proceeding to limb salvage. Yet, this strategy is often limited by logistical delays and may not be feasible in the presence of infected gangrene or progressing necrosis [3].

Recent studies emphasize the importance of patient-specific risk profiling to guide sequencing decisions. Factors such as coronary anatomy, ventricular function, ulcer depth, Wagner stage, and Fontaine classification have been incorporated into predictive models that assist clinicians in stratifying patients according to the likelihood of amputation or mortality [4]. Tools that integrate these parameters have shown promise in retrospective validation, but prospective multicenter trials are still needed for widespread adoption.

Hybrid or staged interventions have emerged as a practical solution in selected patients. In these scenarios, minimally invasive coronary stenting is performed first, followed by peripheral endovascular treatment once cardiovascular stability is ensured. Alternatively, a single-session procedure may be performed in specialized centers with cardiac and peripheral expertise, though this approach requires careful monitoring and resource availability [5].

Multidisciplinary care models are crucial to implementing such individualized strategies. Coordination between vascular surgeons, cardiologists, diabetologists, and wound care specialists allows for synchronized therapeutic decision-making, preoperative optimization, and continuity of care. Unfortunately, these models are not universally adopted, especially in resource-limited settings where compartmentalized care remains the norm [6].

Furthermore, the timing of revascularization in relation to debridement or amputation procedures must be carefully planned. Revascularization performed prior to surgical intervention may improve healing potential and reduce the extent of tissue loss, provided that infection is adequately controlled. In contrast, performing limb surgery without prior or simultaneous revascularization may result in poor wound healing and higher rates of stump revision [7].

Ultimately, the management of patients with DFS and CAD requires an integrated algorithm that balances the urgency of limb ischemia against the stability of coronary perfusion. Decision-making should be based not on rigid procedural hierarchies but on individualized risk assessment and the availability of multidisciplinary support. Personalized sequencing strategies, guided by validated clinical tools and supported by team-based care, offer the best opportunity to improve outcomes in this high-risk population [8].

Clinical Guidelines, Technological Advancements, and Future Perspectives

The growing recognition of the interplay between diabetic foot syndrome (DFS) and coronary artery disease (CAD) has prompted calls for integrated treatment algorithms in leading clinical guidelines. International consensus documents now advocate for early cardiovascular screening in patients presenting with lower-limb ischemia, particularly those with advanced or recurrent ulceration. Echocardiographic assessment, electrocardiographic monitoring, and selective coronary angiography are recommended prior to major limb intervention in patients with known or suspected CAD [1].

In terms of limb-focused intervention, the angiosome-directed approach has gained popularity in recent years. This method prioritizes revascularization of the artery directly supplying the ischemic tissue, improving targeted perfusion and promoting wound healing. While anatomically sound, the angiosome strategy may be limited by the extent of occlusion or the presence of severe calcification. In patients with multilevel disease and coronary comorbidity, achieving complete revascularization remains a technical and physiological challenge [2].

Technological advancements in balloon and stent design, drug-eluting devices, and re-entry tools have expanded the therapeutic arsenal in endovascular care. Drug-coated balloons and bioresorbable scaffolds, in particular, offer benefits in maintaining vessel patency and reducing restenosis rates in complex tibial lesions. These innovations are especially valuable in diabetic patients, who often exhibit aggressive neointimal hyperplasia following standard angioplasty [3].

Moreover, non-invasive hemodynamic monitoring and imaging techniques are being increasingly utilized to guide therapy. Tools such as transcutaneous oxygen pressure ($TcPO_2$), skin perfusion pressure (SPP), and indocyanine green angiography provide real-time feedback on tissue perfusion and procedural success. Although not universally available, these technologies offer promising avenues for improving procedural planning and monitoring therapeutic response [4].

In parallel, machine learning and predictive modeling have begun to inform clinical decision-making. Algorithms trained on large datasets encompassing demographic, hemodynamic, metabolic, and procedural variables have demonstrated potential in stratifying risk and forecasting outcomes in patients with DFS and CAD. These digital tools may eventually serve as adjuncts to traditional scoring systems, enhancing the precision and efficiency of individualized care [5].

Despite these advances, several challenges remain. First, disparities in access to multidisciplinary care and advanced technology limit the universal application of best practices. Second, evidence from large randomized controlled trials comparing sequencing strategies and procedural techniques is still limited. Third, adherence to guideline-based care is often compromised by system-level barriers, including fragmented referral pathways, delayed diagnostics, and lack of coordination between specialties [6].

To address these gaps, future research should focus on the validation of integrated care models that combine cardiovascular risk stratification with peripheral intervention planning. Trials comparing heart-first, limb-first, and hybrid approaches in well-characterized diabetic populations are urgently needed. Additionally, health systems should prioritize the development of multidisciplinary teams capable of delivering timely and coordinated care, supported by evidence-based protocols and continuous outcome monitoring [7].

In conclusion, endovascular intervention in patients with DFS and CAD represents a complex but increasingly navigable therapeutic frontier. Technological innovation, growing clinical awareness, and the evolution of multidisciplinary care paradigms are converging to offer improved outcomes. However, continued efforts are required to translate these developments into standardized practice, ensuring that all patients benefit from timely, safe, and personalized vascular treatment.

CONCLUSION

The management of diabetic foot syndrome (DFS) in patients with coexisting coronary artery disease (CAD) requires a nuanced, multidisciplinary approach that reflects the complex pathophysiological, anatomical, and procedural challenges posed by this dual pathology. Endovascular therapy has become an indispensable tool in limb salvage, but its success depends not only on technical execution, but also on careful preprocedural risk assessment and personalized sequencing strategies.

Whether revascularization should begin with the limb or the myocardium remains a matter of clinical judgment, ideally informed by objective cardiac and peripheral vascular parameters. In this context, validated risk models and coordinated care pathways offer a structured framework for tailoring intervention to individual patient profiles. Procedural planning should account for systemic hemodynamics, ulcer severity, and the likelihood of adverse cardiovascular events.

Technological innovations—ranging from drug-coated balloons to advanced imaging and decision-support algorithms—are enhancing procedural safety and efficacy. Yet their full benefit will only be realized within systems that support timely diagnosis, inter-specialty collaboration, and evidence-based practice.

Future progress in this field will depend on generating high-quality comparative data, expanding access to multidisciplinary vascular care, and embedding risk-based algorithms into daily clinical workflows. In doing so, healthcare providers can improve not only limb-related outcomes, but also cardiovascular survival in a population that remains among the most vulnerable in modern medicine.

Ethical Approval:

This article is a narrative literature review and did not involve human or animal subjects. Ethical approval was therefore not applicable.

Conflict of Interest:

The author declares no conflict of interest.

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Kamalov S.T.: Conceptualization, literature review, manuscript drafting, and critical revision.

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KORONAR YURAK KASALLIGI BILAN BIRGA KECHUVCHI DIABETIK OYOQ SINDROMI BO‘LGAN BEMORLARDA ENDOVASKULYAR DAVOLASH STRATEGIYALARI

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ANNOTATSIYA

Diabetik oyoq sindromi (DOS) qandli diabetning og‘ir asoratlaridan biri bo‘lib, ayniqsa yurak ishemik kasalligi (YIK) bilan birga kechganda, amputatsiya va o‘lim xavfi sezilarli darajada ortadi. Endovaskulyar revaskulyarizatsiya oxirgi yillarda oyoqni saqlab qolishning asosiy usullaridan biriga aylandi. Biroq bemorning yurak holati, miokard rezervi va davolanish ketma-ketligi klinik natijalarga kuchli ta’sir qiladi. Ushbu adabiy tahlil endovaskulyar davolash strategiyalarini, ularning texnik xususiyatlarini, yurak va oyoq revaskulyarizatsiyasi o‘rtasidagi muvofiqlashtirishni va individual qaror qabul qilishning ahamiyatini ko‘rib chiqadi. Tadqiqotlar shuni ko‘rsatadiki, bemorlar uchun “yurak birinchi” yoki “oyoq birinchi” yondashuvlar tanlanishi, ularning individual xavf darajasiga asoslanishi kerak. Shaxsga yo‘naltirilgan, ko‘p tarmoqli strategiyalar DOS + YIK bo‘lgan bemorlar uchun amaliy natijalarni sezilarli darajada yaxshilashi mumkin.

Kalit so‘zlar: Diabetik oyoq, yurak ishemik kasalligi, endovaskulyar davolash, revaskulyarizatsiya, individual yondashuv, xavf stratifikatsiyasi.

ЭНДОВАСКУЛЯРНЫЕ СТРАТЕГИИ ЛЕЧЕНИЯ ОСЛОЖНЕНИЙ СИНДРОМА ДИАБЕТИЧЕСКОЙ СТОПЫ У ПАЦИЕНТОВ С ИШЕМИЧЕСКОЙ БОЛЕЗНЬЮ СЕРДЦА: СОВРЕМЕННЫЕ ПОДХОДЫ И ПЕРСПЕКТИВЫ

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АННОТАЦИЯ

Синдром диабетической стопы (СДС) в сочетании с ишемической болезнью сердца (ИБС) представляет собой тяжёлую клинико-патофизиологическую комбинацию, сопряжённую с высоким риском ампутации, повторных вмешательств и летальности. Эндоваскулярная реваскуляризация в настоящее время рассматривается как один из приоритетных методов восстановления перфузии у таких пациентов. Однако клинические результаты напрямую зависят от точной стратификации риска, выбора тактики вмешательства (поэтапной или комбинированной), оценки кардиального резерва и наличия мультидисциплинарной координации. Обзор освещает современные данные по эффективности стратегий «сначала сердце» и «сначала конечность», обсуждает технические аспекты доступа и применения инновационных устройств, включая ангиосомно-ориентированную терапию. Подчёркивается необходимость разработки персонализированных алгоритмов, основанных на интеграции кардиологических, сосудистых и метаболических параметров, как основного направления повышения эффективности лечения пациентов с сочетанием СДС и ИБС.

Ключевые слова: Синдром диабетической стопы, ишемическая болезнь сердца, эндоваскулярное лечение, реваскуляризация, стратификация риска, персонализированный подход.