WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Advances in Interventional Cardiology. Emerging Technologies in Angioplasty and Drug-Eluting Stents

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ABSTRACT

Interventional cardiology has established itself as one of the main approaches to treating coronary artery disease (CAD). Since the introduction of percutaneous transluminal angioplasty, technology has evolved significantly, incorporating innovative devices, new techniques and artificial intelligence. This study aimed to systematically review technological innovations applied to coronary angioplasty and drug-eluting stents, assessing their clinical efficacy, impact on diagnostic accuracy, comparison with bioresorbable stents and applicability in the Brazilian context. The methodology followed the PRISMA guidelines, with a search of relevant databases, including clinical trials and systematic reviews published between 2015 and 2024. Emerging technologies such as intravascular lithotripsy, robotic angioplasty and bioresorbable stents were analyzed, as well as the incorporation of artificial intelligence in image analysis and clinical decision support. The results indicated that drug-eluting stents significantly reduced restenosis and the need for reintervention, although in-stent thrombosis still represents a challenge. Artificial intelligence has shown high potential in diagnostic accuracy, helping to detect arterial obstructions and optimize blood flow. Bioabsorbable stents, although promising, still have higher restenosis rates than conventional drug-eluting stents. In Brazil, the adoption of these technologies faces regulatory, economic and professional training barriers. In conclusion, the evolution of interventional cardiology has led to more effective and safer interventions. However, challenges such as cost-effectiveness, unequal access and the need for continuous training need to be overcome in order to maximize the benefits of these innovations.

Keywords: Interventional cardiology; coronary angioplasty; drug-eluting stents; artificial intelligence; emerging technologies.

1. INTRODUCTION

Interventional cardiology has evolved significantly since the introduction of percutaneous transluminal angioplasty by Andreas Grüntzig in 2017, providing less invasive alternatives for the treatment of coronary artery disease (CAD) (Grüntzig et al., 2017).

Initially, the technique used only balloons to dilate blocked arteries; however, the occurrence of complications such as acute occlusion and restenosis prompted the development of new approaches.

The introduction of non-pharmacological metallic stents represented an important advance, offering structural support to the arterial walls and reducing the incidence of acute occlusions. However, restenosis, characterized by neointimal proliferation within the stent, remained a significant challenge (Lima et al., 2006).

To combat restenosis, drug-eluting stents have emerged, devices coated with antiproliferative drugs that are released gradually, inhibiting cell proliferation and consequently reducing the rate of restenosis (Oliveira et al., 2021).

Studies have shown that these stents significantly reduced the need for reinterventions compared to conventional metal stents.

First-generation drug-eluting stents, although effective in reducing restenosis, had limitations, such as the risk of late thrombosis and issues related to the biocompatibility of the polymers used. These limitations drove the development of second-generation stents, which incorporated improvements in the materials and drugs used (Grüntzig et al., 2017).

Continuous evolution has led to the development of bioabsorbable stents, designed to provide temporary support to the vessel and subsequently be reabsorbed by the body. This approach aims to restore the natural function of the vessel and eliminate the complications associated with the permanent presence of a foreign body (Weiss et al., 2022).

In addition to advances in devices, interventional cardiology has benefited from improvements in imaging techniques, such as intravascular ultrasound (IVUS) and optical coherence tomography (OCT). These modalities allow for a more precise assessment of coronary anatomy and the correct implantation of stents, optimizing clinical results (SOCESP., 2022).

Artificial intelligence (AI) has also been integrated into interventional practice, helping to analyze complex images and make clinical decisions. AI-based systems can improve diagnostic and prognostic accuracy, contributing to safer and more personalized procedures (Grüntzig et al., 2017).

In the Brazilian context, the incorporation of these technologies has been gradual, with challenges related to the availability of resources and professional training. However, reference centers have adopted these innovations, reflecting improvements in patients' clinical outcomes (Lima et al., 2006).

The cost-effectiveness analysis of drug-eluting stents in the Unified Health System (SUS) is a relevant aspect, considering the increased costs associated with these devices. Studies indicate that, although more expensive, drug-eluting stents can be cost-effective by reducing the need for new interventions (BRASIL 2020).

The continuous training of interventional cardiologists is essential for the proper implementation of these emerging technologies. Training programs that incorporate simulation and education based on real cases contribute to updating and improving professionals' skills (Oliveira et al., 2021).

Research and development of new materials and drugs for stents continues to advance, seeking devices with a better safety and efficacy profile. Ongoing clinical trials are evaluating new generations of stents and interventional techniques, with the aim of improving therapeutic results (Lima et al., 2006).

Collaboration between research institutions, industry and regulatory bodies is essential for the rapid translation of technological innovations into clinical benefits. Policies to encourage research and the incorporation of new technologies can speed up this process (BRASIL 2020).

Personalizing treatment, taking into account the individual characteristics of each patient, is a growing trend in interventional cardiology. The use of genetic data and specific biomarkers can guide the choice of device and the most appropriate therapeutic strategy (SOCESP., 2022).

Patient safety remains a priority, and post-procedure monitoring is crucial for early identification and management of possible complications. Structured surveillance and follow-up systems contribute to the continuous improvement of quality of care (Prado et al., 2018).

Educating patients about the benefits and risks of interventions is equally important, promoting shared and informed decision-making. Patients' active engagement in their own care can positively influence clinical outcomes (Grüntzig et al., 2017).

The sustainability of health systems in the face of the incorporation of high-cost technologies is a constant challenge. Economic analysis and evidence-based health policies are necessary to balance innovation and financial viability (Lima et al., 2006).

The dissemination of scientific knowledge through publications and academic events is vital for updating professionals and implementing evidence-based practices. The exchange of experiences between specialists enriches clinical practice and stimulates new research (Weiss et al., 2022).

2. OBJECTIVES

The main objective of this study was to carry out a systematic review of the literature on advances in interventional cardiology, with an emphasis on emerging technologies applied to coronary angioplasty and drug-eluting stents. To this end, we sought to

- **Identify and analyze** the main technological innovations in angioplasty procedures, including new techniques, devices and therapeutic approaches.
- **To evaluate the clinical efficacy** of drug-eluting stents of different generations, considering factors such as restenosis rates, in-stent thrombosis and long-term cardiovascular outcomes.

- **Investigating the impact of artificial intelligence and new imaging technologies** on the diagnostic accuracy and safety of interventional procedures.
- **Comparing bioabsorbable stents with conventional drug-eluting stents**, considering advantages, challenges and future prospects.
- **To analyze the applicability of new technologies in the context of Brazilian interventional cardiology**, including barriers to implementation and cost-effectiveness.

3. METHODOLOGY

To ensure reproducibility and scientific validity, this systematic review followed the guidelines of the **Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)** and adopted the following methodological procedures:

3.1 Search strategy

The search was carried out in the **PubMed, Scopus, Web of Science, Embase and SciELO** databases, covering publications between 2015 and 2024. The descriptors used were:

- *Interventional Cardiology*, *Coronary Angioplasty*, *Drug-Eluting Stents*, *Bioabsorbable Stents*, *Artificial Intelligence in Cardiology*, *Intravascular Imaging*.
- Correspondents in Portuguese: *Interventional Cardiology*, *Coronary Angioplasty*, *Drug-eluting Stents*, *Bioabsorbable Stents, Artificial Intelligence in Cardiology*, *Intravascular Imaging*.

The terms were combined with Boolean operators (**AND, OR and NOT**) to refine the results.

3.2 Inclusion and exclusion criteria

Inclusion criteria:

- Clinical studies, randomized trials, meta-analyses and systematic reviews on advances in angioplasty and drug-eluting stents.
- Articles published in the last 10 years, in English, Portuguese or Spanish.
- Studies evaluating clinical efficacy, safety and technological innovation in interventional cardiology.

Exclusion Criteria:

- Studies with small samples (< 50 patients) and articles with low methodological quality.
- Opinion pieces, narrative reviews and editorials.
- Duplicate studies between databases.

3.3 Data Selection and Extraction

The articles were selected in **two stages**:

1. **Screening of titles and abstracts** by two independent reviewers, eliminating irrelevant studies.
2. **Thorough reading of the texts of** the selected articles, checking that they meet the established criteria.

The data extracted included: year of publication, type of study, sample, type of technology analyzed, clinical outcomes and main conclusions.

3.4 Evaluation of Methodological Quality

The selected articles were submitted to quality assessment using the Jadad Scale (for clinical trials), the STROBE Checklist (for observational studies) and the ROBIS tool (for systematic reviews).

3.5. Data Analysis and Synthesis

The data was presented descriptively and, where applicable, a quantitative meta-analysis was carried out to compare the outcomes between different emerging technologies. The information was organized in tables and graphs to facilitate interpretation.

4. RESULTS AND DISCUSSION

Coronary angioplasty has evolved significantly since its introduction, incorporating technological innovations that improve the effectiveness and safety of procedures. These innovations include new techniques, advanced devices and therapeutic approaches that have transformed the landscape of interventional cardiology.

One of the main innovations is the use of state-of-the-art drug-eluting stents, such as zotarolimus eluting stents. These devices have expandable diameters, allowing precise adaptation to the size of the treated vessel, which is particularly beneficial in complex lesions, such as those in the left main coronary artery (Solaci, 2023).

The introduction of drug-eluting stents (DES) in the early 2000s revolutionized interventional cardiology, offering an effective solution for reducing the restenosis seen with uncoated metal stents (MS). These devices release antiproliferative drugs that inhibit neointimal hyperplasia, the main cause of restenosis after stent implantation. Since then, several generations of DES have been developed, each seeking to improve clinical efficacy and long-term safety.

The first generation of DES used drugs such as sirolimus and paclitaxel, demonstrating a significant reduction in restenosis rates compared to MS. However, concerns have arisen about the safety of these devices, especially related to late stent thrombosis, possibly due to the delay in re-endothelialization caused by the durable polymers used to release the drug (Sastry & Morice, 2008).

To address these issues, the second generation of DES was developed with improvements in the polymers and stent platforms. Studies have indicated that these new devices have maintained their effectiveness in reducing restenosis, as well as having lower rates of in-stent thrombosis compared to the first generation (Silva et al., 2018).

The third generation of DES introduced bioabsorbable polymers, designed to be reabsorbed by the body after the drug has been released. This feature aims to minimize the chronic inflammation and risk of late thrombosis associated with permanent polymers. Clinical studies have shown that these stents offer comparable efficacy to previous generations, with the potential to improve long-term safety (Silva et al., 2018).

Despite advances, intrastent thrombosis remains a concern. Although the incidence is relatively low, the consequences can be serious. Factors such as implantation technique, adherence to antiplatelet therapy and patient characteristics influence the risk of thrombosis. Therefore, proper stent selection and clinical management are crucial to minimizing this risk (Sastry & Morice, 2008).

The clinical efficacy of DES is also assessed through long-term cardiovascular outcomes, including mortality rates, myocardial infarction and the need for new revascularizations. Follow-up studies indicate that DES significantly reduce the need for reinterventions compared to SM, with no increase in mortality or heart attack rates (Silva et al., 2018).

However, the choice of the type of DES must take into account the individual characteristics of each patient and lesion. Factors such as diabetes, lesion complexity and bleeding risk influence the therapeutic decision. In addition, adherence to dual antiplatelet therapy is essential to prevent thrombotic events, especially in the first few months after stent implantation (Silva et al., 2018).

The evolution of DES has also led to the development of fully bioabsorbable stents, which offer temporary support to the vessel and are completely resorbed over time. Although promising, studies indicate that these devices still present challenges, such as higher rates of restenosis and thrombosis than state-of-the-art metallic DES (Silva et al., 2018).

A comparison between different generations of DES reveals that, although the new generations have improved safety aspects, their effectiveness in reducing restenosis remains similar. This suggests that technological advances have focused on improving the safety profile without compromising clinical efficacy (Silva et al., 2018).

Ongoing research seeks to develop new polymers and drugs that can offer better clinical performance. Personalization of treatment, taking into account genetic factors and specific biomarkers, is also a promising area for optimizing the results of DES implants (Silva et al., 2018).

Drug-eluting stents of different generations have demonstrated significant clinical efficacy in reducing restenosis and improving long-term cardiovascular outcomes. Although concerns about in-stent thrombosis persist, especially in the first generations, technological advances have improved the safety of these devices. The choice of the appropriate stent must be individualized, taking into account the characteristics of the patient and the lesion, as well as adherence to antiplatelet therapy in order to optimize clinical results. FIGURE 1 shows the evolution of stent types over the years.

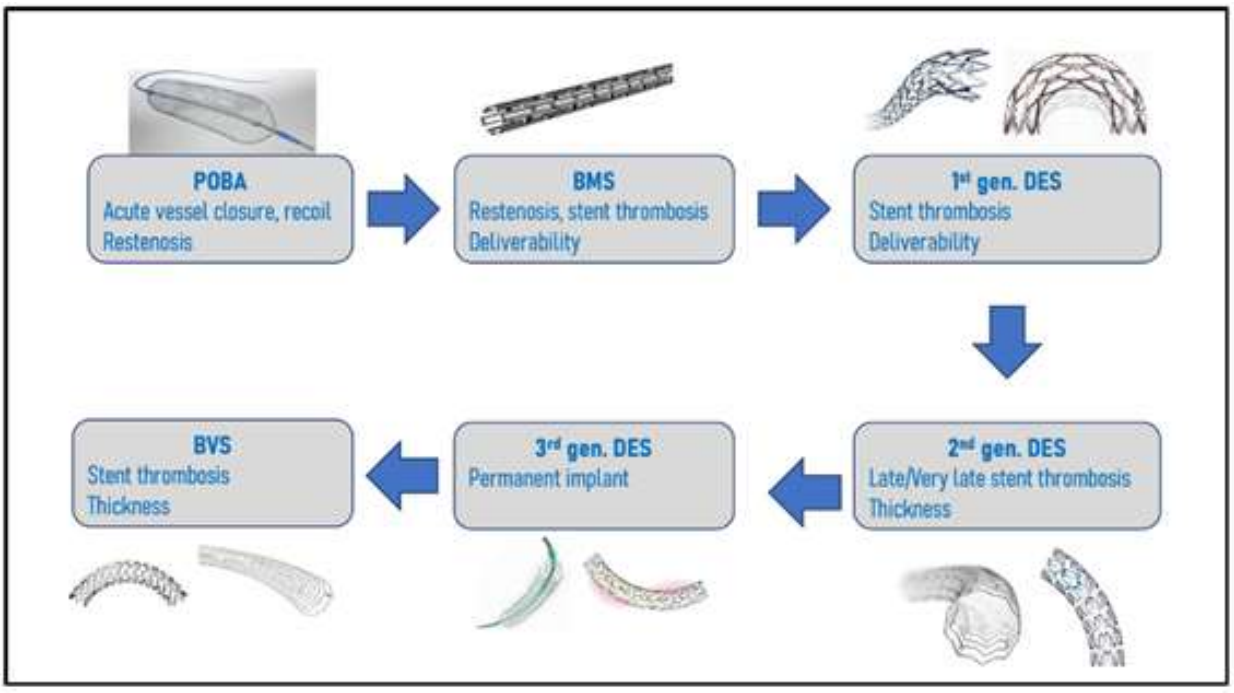

Figure 1. Evolution of the stent platform to overcome challenges. Source: (Brami, P et.al, 2023).

For calcified lesions, intravascular lithotripsy has emerged as a promising technique. The Shockwave device, for example, emits acoustic shock waves that fragment calcium deposits, facilitating proper stent expansion and improving clinical outcomes (Unimed Catanduva, 2021).

Robotic angioplasty is another innovation that is gaining prominence. Procedures performed with robotic assistance offer greater precision in the handling of catheters and stents, as well as reducing the exposure of professionals to radiation. Hospital Israelita Albert Einstein, for example, performed the first robotic angioplasty in the Southern Hemisphere, demonstrating the viability and benefits of this technology (Einstein, 2018).

In the field of devices, bioabsorbable stents represent a significant development. Made from materials that are gradually reabsorbed by the body, these stents offer temporary support to the artery and, once absorbed, allow the vessel to recover its natural function, reducing potential long-term complications (Medicalway, 2015).

Dedicated stent technology for bifurcations is also worth mentioning. These stents are specifically designed to treat lesions at arterial bifurcations, providing better coverage of the lesion and reducing the rate of restenosis compared to conventional techniques (Apollo Hospitals, n.d.).

The three-dimensional fusion of fluoroscopic angiography images with SPECT myocardial perfusion images (FIGURE 2) has been explored to guide percutaneous coronary interventions. This multimodal approach provides a comprehensive view of coronary anatomy and tissue perfusion, aiding therapeutic decision-making (Tang et al., 2020).

Nuclear cardiology is linked to the approach to cardiovascular physiology, currently covering metabolism, innervation, myocardial perfusion, ventricular function and synchronization. It is possible to detect cardiovascular pathophysiological alterations early on, enabling interventions that can interrupt or reverse the disease condition before structural alterations become established in a definitive, evolving and irreversible way (Tang et al., 2020).

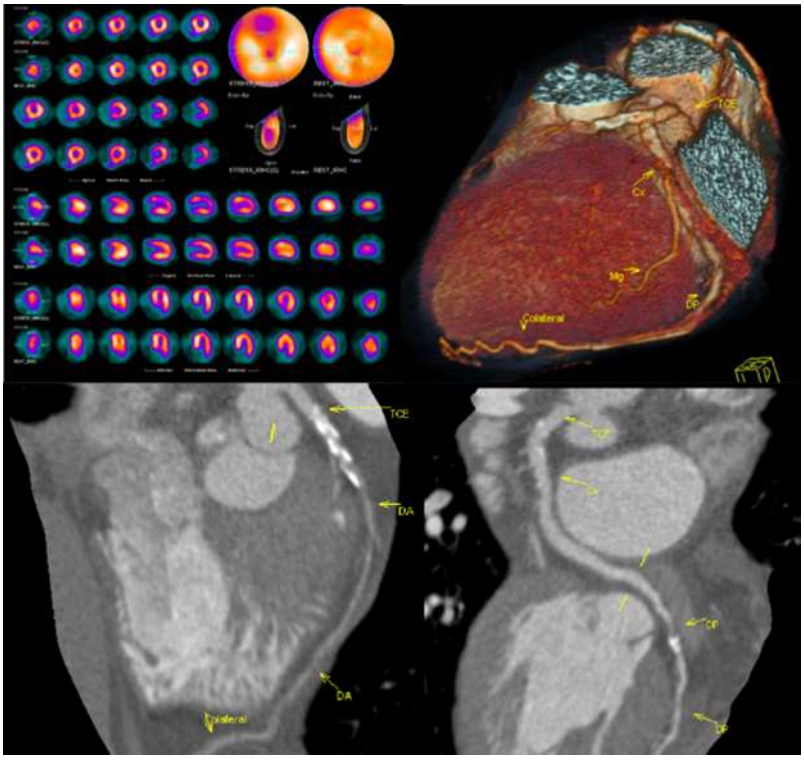

Figure 2. Myocardial perfusion scintigraphy with anterior ischemia and coronary CT angiography. Source: Richet.com.br/medicos/blog/cintilografia-de-perfusao-miocardica-com 2025.

The use of balloon catheters with improved designs also contributes to the success of the procedures. These catheters allow for the effective dilation of narrowed arteries, facilitating the implantation of stents and improving coronary blood flow (Medicover Hospitals, 2023).

The evolution of the materials used in stents, such as the introduction of bioabsorbable polymers, has significantly reduced the rates of restenosis and thrombosis, improving the clinical outcomes of patients undergoing angioplasty (Momy, 2023).

The incorporation of minimally invasive techniques, such as percutaneous transluminal angioplasty, has replaced more invasive surgical procedures, offering patients therapeutic options with shorter recovery times and lower associated risks (Tribuna do Norte, 2023).

Brain protection devices during heart valve implantation procedures also represent an important advance. These filters capture fragments that could be released into the bloodstream during the procedure, preventing cerebral embolic events and increasing the safety of interventions (Nunes, n.d.).

The combination of different imaging modalities, such as the fusion of fluoroscopic angiograms with myocardial perfusion images, has improved the guidance of coronary interventions, allowing for a more precise and personalized approach for each patient (Tang et al., 2020).

Ongoing research and development into stent technologies and angioplasty techniques aims not only to effectively treat arterial obstructions, but also to restore the natural function of vessels and minimize long-term complications, reflecting a significant advance in interventional cardiology (Momy, 2023).

Technological innovations in angioplasty procedures, including new techniques, devices and therapeutic approaches, have transformed the treatment of coronary heart disease. These advances provide safer, more effective and personalized interventions, significantly improving clinical outcomes and patients' quality of life (Momy, 2023).

In interventional radiology, AI has been applied to optimize critical stages in the planning and execution of procedures. Predictive algorithms are used to select the best vascular accesses for embolizations and calculate the ideal size of stents for endovascular interventions. In addition, automatic segmentation software helps to precisely define tumor margins prior to image-guided ablative procedures, improving therapeutic efficacy (Jovem Pan, 2023).

The implementation of AI-assisted image reading systems has demonstrated improvements in diagnostic accuracy. The Doctor Balmis Hospital in Alicante, for example, has adopted an AI tool for analyzing chest and bone X-rays, achieving 90% accuracy in detecting pathologies. This technology not only increases the accuracy of diagnoses, but also speeds up the process, allowing for faster and more effective interventions (Cadena SER, 2025).

In breast cancer screening programs, AI has been used to improve the interpretation of mammograms. The Murciano Health Service has implemented a pilot project that uses AI to analyze mammograms, helping radiologists to identify anomalies with greater precision and speed. This approach potentially reduces the workload of professionals and reduces waiting times for patients (Cadena SER, 2024).

Automated image analysis using AI has also shown potential in differentiating between cancerous and normal cells. Researchers have developed systems capable of identifying alterations at the nanometric level, allowing for the early detection of viral infections and malignant transformations. Although still in the research phase, these tools promise to significantly improve medical diagnoses and treatments in the future (Huffington Post, 2024).

The integration of AI into modern CT scanners has improved the quality of images and reduced the time needed to obtain results. The Vithas Xanit International Hospital has incorporated a CT scanner that uses AI to offer intelligent workflows, resulting in faster and more accurate diagnoses, as well as reducing patients' exposure to radiation (Cadena SER, 2024).

AI has been applied to the analysis of large volumes of radiological data, helping in the early identification of diseases and the personalization of treatments. Advanced algorithms can detect subtle patterns in images, contributing to more accurate diagnoses and safer interventions (Higia, 2022).

The use of AI in echocardiography has also proved effective. AI-based tools help evaluate cardiac images, providing more accurate diagnoses and contributing to more informed clinical decision-making (ABC Imaging, 2023).

Telemedicine, driven by AI, has expanded access to specialized care, allowing remote consultations and monitoring with high diagnostic accuracy. This approach is especially beneficial for patients in remote areas or with reduced mobility, ensuring timely and safe interventions (Portal Telemedicina, 2023).

However, the implementation of these technologies faces challenges, including the need for adequate infrastructure, training of professionals and ethical considerations related to the use of AI in medicine. It is crucial that there is collaboration between technology developers, healthcare professionals and regulatory bodies to ensure the safe and effective integration of these innovations into clinical environments (Recima21, 2020).

Artificial intelligence and new imaging technologies have a significant impact on diagnostic accuracy and the safety of interventional procedures.

As these tools continue to evolve, they are expected to provide faster and more accurate diagnoses, personalized treatments and an overall improvement in the quality of healthcare.

The evolution of coronary stents has been fundamental in the treatment of coronary artery disease. Among the innovations are conventional drug-eluting stents (DES) and bioresorbable stents (BLS), each with specific characteristics, advantages and challenges.

DES were developed to release antiproliferative drugs, reducing neointimal hyperplasia and, consequently, restenosis. Studies have shown that DES significantly reduce the need for reinterventions compared to conventional metal stents (Silva et al., 2018).

However, the permanent presence of the metallic stent may be associated with risks such as late thrombosis and chronic inflammation.

In contrast, SBs are designed to provide temporary support to the vessel and then be reabsorbed by the body. This feature aims to restore the anatomy and natural function of the vessel, eliminating the presence of a permanent foreign body. In addition, the resorption of the stent can facilitate future interventions in the same arterial segment, if necessary (Viana et al., 2024).

Despite the theoretical advantages of SB, clinical studies have shown mixed results. Some studies have indicated higher rates of adverse events, such as thrombosis and restenosis, compared to DES. These findings suggest the need for improvements in SB technology and the appropriate selection of patients for their use (Silva et al., 2018).

One of the challenges of BMS is to guarantee controlled resorption that coincides with proper vessel healing. The composition of the material and the thickness of the stent struts directly influence this process. Thicker materials can slow down resorption and increase the risk of adverse events, while thinner materials can compromise the structural integrity of the stent (Viana et al., 2024).

The SB implantation technique requires precision and experience on the part of the interventionist. Inadequate expansion or poor stent apposition can increase the risk of thrombosis. Therefore, the learning curve and the standardization of procedures are crucial aspects for therapeutic success (Silva et al., 2018).

From an economic point of view, SB tend to be more expensive than DES. The high cost can limit their availability, especially in health systems with restricted resources. Thus, the cost-benefit ratio of BS should be carefully evaluated, considering the clinical benefits and available resources (Silva et al., 2018).

Future prospects for SB involve advances in materials engineering, with the aim of developing polymers with better biocompatibility and optimized resorption rates. In addition, the combination of antiproliferative and anti-inflammatory drugs could enhance the therapeutic benefits of these devices (Viana et al., 2024).

Personalizing treatment, taking into account the individual characteristics of each patient, is another promising aspect. Specific biomarkers can help to identify patients who would benefit more from the use of SB over DES, promoting more precise and effective medicine (Silva et al., 2018).

Interventional cardiology in Brazil has seen significant advances with the incorporation of new technologies aimed at improving the diagnosis and treatment of cardiovascular diseases. Minimally invasive procedures, such as Transcatheter Aortic Valve Implantation (TAVI), MitraClip and the use of bioabsorbable stents, have been progressively introduced into clinical practice, offering less invasive alternatives and faster recovery for patients (HCor, 2023).

However, the implementation of these innovations faces considerable challenges. One of the main obstacles is regulatory approval. The National Health Surveillance Agency (ANVISA) plays a crucial role in the evaluation and release of new medical devices. Historically, the approval process in Brazil has taken longer than in other countries, which can delay the availability of emerging technologies for Brazilian patients (De Carvalho et.al, 2025).

In addition to regulatory issues, cost-effectiveness analysis is fundamental for the incorporation of new technologies into the Unified Health System (SUS). Detailed studies are needed to assess whether the clinical benefits of new interventions justify the associated costs, especially in a health system with limited resources (De Carvalho et.al, 2025).

Hospital infrastructure also represents a significant barrier. Many health institutions in Brazil lack modern equipment and trained professionals to operate new technologies. Acquiring advanced equipment requires substantial investment, which can be unfeasible for hospitals with restricted budgets (Oliveira, 2024).

Professional training is another critical aspect. The introduction of new technologies requires health professionals to be up-to-date and properly trained. Continuing education programs and specific training are essential to ensure the effectiveness and safety of interventional procedures (CFM, 2023).

Regional inequality in Brazil exacerbates these challenges. While large urban centers may have easier access to technological innovations, peripheral and rural regions often face difficulties in implementing these innovations, resulting in disparities in cardiovascular health care (Munhoz Junior, 2020).

Collaboration between public and private institutions can speed up the adoption of new technologies. Public-private partnerships can enable investment in infrastructure and training, as well as facilitating the clinical studies needed to approve and implement new interventions (CFM, 2023).

Brazil's active participation in international clinical research is also beneficial. Being involved in multicenter studies allows the country to have early access to innovations and contribute to the generation of scientific evidence relevant to the local population (Munhoz Junior, 2020).

Continuous evaluation of the efficacy and safety of new technologies is imperative. Even after implementation, it is necessary to monitor clinical results and adjust practices as necessary to ensure the best possible care for patients (Pristilo, 2024).

In terms of cost-effectiveness, although new technologies may have high initial costs, they have the potential to reduce expenses in the long term by reducing the need for prolonged hospitalizations and reinterventions. Comprehensive economic analyses are essential to determine the real financial impact of these innovations on the Brazilian health system (Candido, 2024).

Patient awareness and education also play a vital role. Informed patients are more likely to adhere to treatments and recognize possible complications early on, which can improve clinical outcomes and optimize healthcare resources (Munhoz Junior, 2020).

The integration of information technologies, such as electronic medical records and clinical decision support systems, can improve the efficiency and quality of care. These tools facilitate access to up-to-date information and aid evidence-based decision-making (Pristilo, 2024).

TABLE 1 presents the summaries of interventional cardiology in topics.

Although knowledge has advanced significantly with the introduction of new technologies, the full implementation of these innovations faces challenges related to regulation, cost-effectiveness, infrastructure and professional training. Overcoming these barriers requires coordinated efforts between the government, health institutions, professionals and society, with the aim of providing excellent cardiovascular care to the entire Brazilian population.

Table 1. Technological Innovations in Angioplasty Procedures (Systematic Review)

Category	Innovation	Description	Reference
New Techniques	**Intravascular lithotripsy**	Use of shock waves to fragment calcium and facilitate stent expansion.	Unimed Catanduva, 2021
	Robotic angioplasty	Provides greater precision and reduces exposure to radiation.	Einstein, 2018
	Three-dimensional image fusion	It combines fluoroscopic angiography and SPECT myocardial perfusion to guide interventions.	Tang et al., 2020
	Percutaneous transluminal angioplasty	Minimally invasive alternative to conventional surgical procedures.	Tribuna do Norte, 2023
	Use of improved balloon catheters	Improves arterial dilation before stent implantation.	Medicover Hospitals, 2023
Advanced Devices	**State-of-the-art drug-eluting stents**	They include zotarolimus eluters, which have expandable diameters for better adaptation.	Solaci, 2023

Category	Innovation	Description	Reference
	Bioabsorbable stents	Made of materials that are gradually reabsorbed by the body, allowing the vessel to recover its natural function.	Medicalway, 2015
	Dedicated stents for bifurcations	Designed to treat complex arterial lesions, reducing restenosis rates.	Apollo Hospitals, n.d.
	Brain protection devices	Filters that capture fragments during interventions, preventing embolic events.	Nunes, n.d.
	Evolution of stent materials	Development of advanced pharmacological coatings and bioabsorbable polymers to reduce thrombosis.	Momy, 2023
Innovative Therapeutic Approaches	**Artificial Intelligence (AI) in angioplasty**	AI-assisted imaging systems for identifying arterial obstructions and algorithms for optimizing therapeutic strategies.	InCor, 2024
	Personalizing treatment with biomarkers	Use of genetic biomarkers to optimize stent selection and therapeutic strategies.	Silva et al., 2018
	Use of image multimodalities	Integration of different imaging techniques for greater diagnostic and therapeutic precision.	Tang et al., 2020
Challenges and prospects	**Efficacy and safety of drug-eluting stents**	Reduced rates of restenosis and in-stent thrombosis.	Sastry & Morice, 2008
	Development of new generations of bioabsorbable stents	It aims to improve safety and efficacy.	Silva et al., 2018
	Cost-effectiveness and implementation barriers	Regulation and approval of new devices by ANVISA; limitation of hospital infrastructure and specialized training.	Raul I, 2025
	Inequality of access	Difference in the implementation of technologies between urban centers and peripheral regions.	Raul I, 2025
	Telemedicine and AI in interventional cardiology	Expanded access to specialists and remote monitoring, reducing diagnosis time and optimizing personalized treatments.	Telemedicine Portal, 2023
	Research and development	Encouraging participation in international clinical studies and investment in new therapeutic approaches.	Pristilo, 2024

SOURCE: AUTHORS

Technological innovations in angioplasty procedures have revolutionized interventional cardiology, providing greater safety, efficiency and personalization in the treatment of coronary artery disease. Despite the challenges of implementation, the continued advancement of these technologies promises to further improve clinical outcomes and patients' quality of life.

CONCLUSIONS

Technological developments in interventional cardiology have played a fundamental role in optimizing the treatment of cardiovascular diseases, providing safer, more effective and personalized approaches for patients. The development of new techniques, advanced devices and the incorporation of artificial intelligence and imaging technologies have increased the diagnostic accuracy and safety of procedures, resulting in increasingly favorable clinical outcomes.

Advances in drug-eluting stents, from the first generations to bioresorbable models, demonstrate the ongoing effort to reduce rates of restenosis and in-stent thrombosis. Despite improvements in the safety and efficacy of these devices, challenges such as choosing the ideal stent for each patient and the need for strict adherence to antiplatelet therapy still remain. Future studies should continue to investigate the personalization of treatment through the integration of biomarkers and artificial intelligence, ensuring more precise and effective interventions.

Artificial intelligence and new imaging technologies have been essential for interventional cardiology, enabling earlier diagnoses and safer interventions.

The application of predictive algorithms, automated image analysis systems and robotic devices has improved the accuracy of procedures, reducing risks and optimizing patient recovery times. However, the implementation of these innovations faces barriers such as the need for adequate hospital infrastructure, professional training and specific regulations.

In Brazil, the incorporation of these technologies faces additional challenges, such as regional disparities in access to cutting-edge treatments and rigorous cost-effectiveness analysis, which is essential for adoption in the Unified Health System (SUS). The time it takes for new technologies to be approved in the country can delay patients' access to more advanced interventions. In addition, the lack of specialized training can limit the efficient adoption of these innovations.

Interventional cardiology in Brazil has progressively advanced with the introduction of new technologies and minimally invasive techniques. Expanding the use of telemedicine and collaboration between public and private institutions are factors that can facilitate the dissemination of these innovations and reduce inequalities in access to highly complex treatments. In addition, multicenter clinical research in the country can speed up the process of validating and adopting these technologies.

Finally, the constant evolution of interventional cardiology demonstrates the importance of research and development of new materials, devices and techniques to improve the quality of care for patients with cardiovascular diseases.

The balance between innovation, cost-effectiveness and accessibility must be one of the main focuses to ensure that new technologies benefit a greater number of patients, reducing complications and improving survival and quality of life for the population.

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