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Review Article

Analysis of Hospital Data on Angioplasty and Infrainguinal Bypass for Critical Lower Limb Ischemia in Brazil in the Last Decade

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ABSTRACT

Critical Limb Ischemia (CLI) is an advanced form of Peripheral Artery Disease associated with high morbidity, mortality, and the need for revascularization for limb salvage. Treatment involves a choice between angioplasty and open surgery, making it essential to understand the profile of these hospitalizations in a continental-sized country like Brazil. Objective: To characterize hospitalizations in the SUS related to angioplasty and infrainguinal bypass procedures for CLI management in Brazil from 2015 to 2024. Methodology: This is an observational, descriptive, time-series study conducted by collecting secondary data from the Department of Informatics of the Unified Health System (DATASUS) and the Hospital Information System (SIH/SUS). Hospitalization coefficients and lethality rates were calculated, and demographic (sex, age, race/color) and operational variables (cost, stay, and type of care) were analyzed. Data were validated and analyzed using the SPSS v23.0 statistical analysis system, applying simple linear regression to evaluate temporal evolution. Results: Between 2015 and 2024, 109,466 hospitalizations were recorded, of which 83.9% occurred via the endovascular route and 16.1% via the open route. The predominant profile was elderly patients (median age 66-67) and males (66.8% in the open route). Proportional lethality was higher in open surgeries (2.7%) compared to endovascular ones (1.0%), as was the average hospital stay, which was 8.8 days versus 4.6 days, respectively. A growth trend in angioplasties was observed in all regions, with a strong temporal correlation in the Northeast (R^2 = 0.858; p < 0.001), while open surgeries showed a significant reduction in the Southeast and South. Conclusion: The present study demonstrated the consolidation of the endovascular strategy in the national scenario, showing lower in-hospital lethality and shorter hospital stays, despite the average cost per procedure being higher than that of the open route.

Keywords: critical limb ischemia; angioplasty; vascular bypass

Objective

To characterize hospitalizations performed in the Brazilian Unified Health System (SUS) related to angioplasty procedures versus infrainguinal bypass for the management of critical lower limb ischemia in Brazil.

Introduction

Chronic Limb Ischemia (CLI), or critical limb ischemia, is an advanced form of Peripheral Artery Disease (PAD), characterized by persistent reduction of blood flow to the limbs. Inadequate tissue perfusion, even at rest, is associated with worsening quality of life, high morbidity, and mortality 1–3

Treatment involves angioplasty or open surgery. Contemporary studies compare these approaches, with angioplasty gaining prominence in the last three decades for reducing morbidity, mortality, and costs. However, some physicians advocate for surgical revascularization, arguing that it presents greater durability and lower cost in cases of extensive ischemia, despite the higher surgical risk 4. CLI is predominantly associated with atherosclerosis. Symptoms range from claudication to limb-threatening critical ischemia, with accelerated progression in patients with risk factors such as smoking, diabetes, or renal failure 3,5 . A PAD affects about 12% of the adult population, with a slight predominance in men over women, impacting over 200 million people globally, varying by age group. In Europe and North America, an estimated 27 million are affected, resulting in about 413,000 annual hospitalizations attributed to the disease. The incidence increases with age, making it a growing clinical problem due to population aging 6–8. CLI has a poor prognosis regarding the need for amputation. A study in Oxfordshire, United Kingdom, showed that 43.4% of patients monitored over five years underwent this procedure 9 . O bypass emerges as a technique to treat and prevent amputation, using vascular grafts and presenting greater effectiveness and durability. However, it involves high perioperative risk and difficulty in obtaining adequate grafts. Endovascular therapy emerged as less invasive alternative, being preferred for high-risk patients, mainly those without an adequate autogenous vein or with unfavorable lesion anatomy for open surgery (Trans-Atlantic Inter-Society Consensus (TASC) A, B, C). The advancement of this technique includes angioplasty transluminal percutaneous 10–12 . To evaluate the best approach, two large clinical trials were conducted: BEST-CLI (Best Endovascular versus Best Surgical Therapy in Patients with CLTI) and 10 BASIL-2 (Bypass versus Angioplasty for Severe Ischemia of the Leg) 13,14 The BEST-CLI demonstrated lower rates of adverse events, such as reintervention and amputation, for patients undergoing bypass with adequate saphenous vein (42.6% vs. 57.4%) 13. O BASIL-2 indicated lower 30-day mortality for patients treated with angioplasty. However, this approach was associated with a higher rate of reintervention and lower amputation-free survival. Thus, the study concludes that revascularization open, when performed with a viable saphenous vein, presents a better long-term prognosis. Otherwise, angioplasty is the preferred option, a result similar to that reported by the American College of Cardiology Foundation/American Heart Association 14,15. Given this scenario, it is fundamental to understand the profile of hospitalizations for those affected by this condition in a country of continental dimensions and great population diversity. This study aims to analyze and compare hospital data from the main treatment techniques for CAD in the Unified Health System (SUS) over the last two decades, considering regional inequalities and the socioeconomic particularities of Brazil.

Methods

This is an observational, descriptive, time-series study, using secondary data with a quantitative approach.

The study site was Brazil, a country of continental dimensions, with a total area of approximately 8,510,345 km². According to data from the 2022 Demographic Census, the country has a population of 203,062,512 inhabitants, distributed across 26 states and the Federal District, organized into five major regions: North, Northeast, Center-West, Southeast, and South. The national population density is about 23.8 inhabitants per km².

Brazil has a Human Development Index (HDI) of 0.766, considered high, although there are significant socioeconomic inequalities between the regions. The urbanization rate is approximately 84.8%, reflecting a predominant population concentration in urban areas. The period analyzed in the study covered the years 2015 to 2024.

The data were obtained from the Informatics Department of the Unified Health System (DATASUS), an agency of the Ministry of Health responsible for providing systems of information and technological support to the SUS. DATASUS maintains databases national ones that subsidize health planning and management. Data were used from the SUS Hospital Information System (SIH/SUS), which records hospitalizations in the public network, extracted using the TABWIN tabulator, a tool officially provided by DATASUS itself for statistical organization and analysis of the data. A search was conducted in DataSUS regarding Brazil divided into regions and the federal district during the period from 2015 to 2024.

The research spreadsheet includes data on hospitalizations performed for the treatment of lower limb ischemia (Bypass or angioplasty revascularization), hospitalized by the SUS in Brazil during the studied period, reported by the System 25 of Hospital Information of SUS (SIH/SUS), using the TABWIN tabulator, with data available via the link: https://datasus.saude.gov.br.

- Year (number of hospitalizations)
- Morbidity of hospitalizations
- Race/color (white, black, brown, yellow, indigenous)
- Sex (male, female)
- Age group (1-4, 5-14, 15-24, 25-34, 35-44, 45-54, 55-64, and 65 or older)
- Region of residence
- Procedure cost in Reais (R$)
- Length of stay (days)
- Type of care (emergency or elective)

Microsoft Excel was used for the construction and analysis of the database. Categorical variables were expressed through simple and relative frequency distribution, while quantitative variables with normal distribution were expressed as mean and standard deviation, and non-parametric ones with median and interquartile range. Hospitalization lethality was calculated using a ratio between the number of deaths and the number of hospitalizations. The hospitalization coefficient was calculated considering in the numerator the number of hospitalizations by type of procedure per year and in the denominator the exposed population per year; the result of this ratio was multiplied by 10 5 . For simple linear regression, the SPSS software version 23.0 was used, and B, R^2, and P-value were calculated. For all these analyses, statistical significance was considered when the p-value was <0.05.

The design of this study did not need to be submitted to a Research Ethics Committee, as it used SIH data made available for public access through the DATASUS portal of the Ministry of Health. However, the researchers complied with the provisions of Resolution 466/2012 of the National Health Council.

Results

Between 2015 and 2024, 109,466 hospitalizations were registered for revascularization and angioplasty procedures for the treatment

of critical lower limb ischemia in Brazil. The majority occurred via endovascular (83.9%), while 16.1% were performed via open surgery. Patients undergoing the endovascular approach presented a median age of 67 years (IIQR: 60-74) compared to 66 years for open surgery (IQR: 59–73)), with a predominance ofprocedures in the male sex in both groups, although more pronounced in the open surgery group (66.8% vs. 54.7%).

Wide regional variation was observed in the number of hospitalizations. In open revascularization, the highest percentage was recorded in the Southeast Region (49.9%), followed by the South (33.7%), while the North and Center-West presented reduced proportions., 1.6% and 6.0%, respectively. In angioplasty, there was a redistribution despite the Southeast and South regions maintained the highest number of hospitalizations, 39.3% and 31.3%, respectively. There was a increase considerable in procedures in the Northeast region to 23.4%. The North and Center-West continued with lower representativeness (1.8% and 4.1%). This regional difference indicates that, although the Southeast maintains predominance in both types of treatment, the Northeast has substantially increased its participation in endovascular. procedures. The distribution of procedures by race/color showed a predominance of white patients in both groups, but more expressive in the open approach (53.9%) than in the endovascular approach (45.3%). The proportion of brown and black individuals was higher among endovascularprocedures, 34.7% and 5.9%, respectively. (Table 1)

Table 1 – Demographic profile and regional distribution of hospitalizations for open revascularization and angioplasty endovascular. Brazil, 2015-2024.

Variable	Open approach	Endo vascular
Total hospitalizations	17.668 (16.1%)	91.798 (83.9%)
Sex (%)	Male: 66,8% Female: 33.2%	Male: 54,7% Female: 45.3%
Median Age (years)	66 (IQR: 59–73)	67 (IQR: 60-74)
Race/Color (%)	• White: 53.9% • Brown: 28.6% • Black: 5.1% • Yellow: 1.4% Indigenous: 0.01% o information: 11,	• White: 45.3% • Brown: 34.7% • Black: 5.9% • Yellow: 1.3% • Indigenous: 0.02% • No information: 12.8%
Hospitalization by region (%)	• North: 1.6% • Northeast: 8.9% Center-West: 6.0% • Southeast: 49.9% • South: 33.7%	• North: 1.8% • Northeast: 23.4% • Center-West: 4.1% • Southeast: 39.3% • South: 31.3%

Source: Elaborated by the author (2026), with data from SIH/DATASUS/MS.

Regarding the nature of the care, most hospitalizations occurred on an emergency basis, representing about 70% of procedures in both groups. The average hospital stay was substantially longer in open surgeries (8.8 ± 0.5 days) compared to endovascular ones (4.6 ± 0.2 days). The average cost of hospitalizations was also higher in the endovascular approach (R$ 3,756 ± 92) compared to the open one (R$ 3,335 ± 271). The total expenditure for all hospitalizations was R$ 404,314,239.55, with 14.5% of this amount corresponding to open surgeries. A total of 1,455 deaths were registered in the period, with 471 after open revascularization and 984 after angioplasty. Despite the higher absolute number of deaths in the endovascular, the proportional lethality was higher in open surgeries (2.7 ± 0.4%) compared to endovascular (1 ± 0.1%). (Table 2)

Table 2 – Characteristics of hospitalization and hospital outcomes for open revascularization and angioplasty endovascular. Brazil 2015-2024.

Variable	Open approach	Approach endovascular
Nature of care (%)	• Elective: 28.7% • Urgency: 71.2% • Others: 0.06%	•Elective: 31.4% • Urgency: 68.6% • Others: 0.02%
Average Value (Reais)	3335 ± 271	3756 ± 92
Average length of stay (days)	8.8 ± 0.5	4.6 ± 0.2
Deaths	471 (32.4%)	984 (67.6%)
Lethality of hospitalizations (%)	2,7%	1%

Source: Prepared by the author (2026), with data from SIH/DATASUS/MS.

The analysis of annual trends showed distinct behaviors between approaches and regions. In open surgical procedures (CIR), a progressive reduction in hospitalization coefficients was observed over the years in the Southeast ($R^2 = 0.810$; $p < 0.001$) and South

(R^2 = 0.627; p = 0.006) regions, while in the Northeast, despite showing a reduction trend, this variation did not reach statistical significance (R^2 = 0.335; p = 0.079). In contrast, the North (R^2 = 0.609; p = 0.008) and Center-West (R^2 = 0.415; p = 0.044) regions showed an increasing trend. (Graph 1)

Graph 1. Temporal evolution of the hospitalization coefficient for open revascularization by region of Brazil, 2015–2024

Source: Prepared by the author (2026), with data from SIH/DATASUS/MS.

Region	Coefficient (B)	R^2	p-value
North	+0,013	0,609	0,008
Northeast	–0.010	0,335	0.079*
Southeast	–0.030	0,810	0,000
South	–0.075	0,627	0,006
Center-West	+0,016	0,415	0,044

Source: Prepared by the author (2026), with data from SIH/DATASUS/MS processed in SPSS software.

For endovascular procedures (CIA), the general trend was growth in all regions, with a strong temporal correlation in the Northeast (R^2 = 0.858; p < 0.001), Southeast (R^2 = 0.859; p < 0.001), and Center-West (R^2 = 0.911; p < 0.001). The North (R^2 = 0.228; p = 0.163) and South (R^2 = 0.269; p = 0.124) regions showed a more discrete growth trend and without statistical significance. (Graph 2)

Graph 2. Temporal evolution of the hospitalization coefficient for endovascular revascularization by region of Brazil, 2015–2024

Source: Prepared by the author (2026), with data from SIH/DATASUS/MS.

Region	Coefficient (B)	R^2	p-value
North	+0,062	0,228	0,163
Northeast	+0,295	0,858	0,000
Southeast	+0,209	0,859	0,000
South	+0,173	0,269	0,124
Center-West	+0,204	0,911	0,000

Source: Prepared by the author (2026), with data from SIH/DATASUS/MS processed in the SPSS.

Discussion

Thsand the study analyzed hospitalizations for critical lower limb ischemia (CLI) in Brazil, comparing open surgical and endovascular. In total, 109,466 hospitalizations were recorded between 2015 and 2024, revealing a hegemony of the endovascular approach (83.9%) compared to the open approach (16.1%). This expressive volume of data reflects a consolidated technological transition in the SUS, surpassing previous Brazilian series in absolute numbers, such as that of Magalhães et al., which analyzed 83,218 hospitalizations in the previous decade (2010-2020).[40] This change in technique to the percutaneous approach is due to a global trend driven by lower perioperative risk, greater accessibility, and the advent of more sophisticated materials, such as stents and drug-coated balloons, which expanded indications to cases previously restricted to open surgery.[40]

The demographic profile identified among hospitalizations by open and endovascular technique was a median age between 66 and 67 years, respectively, and a predominance of the male sex, especially in the open approach, when 66,8% of the patients were men. This result is consistent with the findings of Wolosker et al. in a study conducted in São Paulo, which reported 55.4% men and a similar average age.[41] The higher prevalence of procedures in men may be explained by biological and epidemiological factors, given that, in intermediate age groups (50-59 years), the risk of developing Peripheral Artery Disease (PAD) is double that of women.[23] Furthermore, male patients tend to present more extensive and multilevel disease patterns, affecting multiple sites of the arterial tree, which requires more frequent hospital interventions for limb salvage.[6,7,8,23] A relevant finding is that women had a higher proportional participation in the endovascular group (45.3%) than in the open group (33.2%), a pattern also observed by Agarwal et al. in the USA, suggesting that the percutaneous approach may be preferred in this subgroup due to differences in arterial anatomy..[42]

Regarding race/color, a higher proportion of brown (34.7%) and black (5.9%) individuals undergoing angioplasty was observed. While international literature, particularly in the United States, indicates that racial minorities face less access to revascularization and higher amputation rates, the Brazilian reality reveals a medical and structural strategy.[42] The greater use of angioplasty in the brown group may be attributed to the interiorization of healthcare and the expansion of hemodynamic infrastructure in regions with high density of this population, such as the Northeast, which registered the highest proportion of endovascular surgeries in the country (82%) and has 59.6% of its population self-declared as brown according to the 2022 Demographic Census of IBGE..[43] However, socioeconomic barriers persist, resulting in late diagnoses. Brown and black patients frequently arrive at the system in more advanced stages and on an emergency basis; in these scenarios of high surgical risk and debilitated organisms, the endovascular approach becomes the preferred medical option due to being safer in the short term.[44]

Proportional lethality was significantly higher in open surgery (2.7%) compared to the endovascular approach (1%). This finding is consistent with the literature, including the meta-analysis by Fu et al., which demonstrated higher perioperative mortality associated with bypass, and the national data of Wolosker et al., who showed a mortality of 7.32% in open surgery versus 1.67% in endovascular.[41,45] From a pathophysiological and technical point of view, this difference can be partially explained by the greater systemic aggression inherent in open surgical procedures, which involve longer operative time, the need for general anesthesia, and a greater inflammatory response, factors associated with higher perioperative risk, as discussed by Farber et al. in the BEST-CLI study.[12] However, it is essential to consider the presence of selection bias, as open surgery is often reserved for patients with more advanced and complex disease, such as extensive lesions, multilevel occlusions, or anatomies unfavorable to the endovascular approach.[46] In these contexts, the bypass remains a strategy capable of providing more robust and durable flow, albeit at the cost of higher immediate risk. Furthermore, while the BEST-CLI study demonstrated the superiority of bypass with great saphenous vein in reducing adverse events in certain subgroups, the BASIL-2 study suggests that, in infrapoplitealdiseases, the endovascular strategy may be associated with better amputation-free survival, possibly due to lower perioperative mortality, which aligns, in part, with the findings observed in the present study.[12,14]

Approximately 70% of hospitalizations occurred on an emergency basis in both approaches, a rate that aligns with the findings of

Agarwal et al., who demonstrated an increasing proportion of emergency admissions, reaching 75.4% in the United States.42 This pattern reinforces the hypothesis of late diagnosis and failures in secondary prevention, as discussed by Portela et al., in a scenario associated with the increase in major amputations in Brazil.44 Regionally, the concentration of 81.2% of revascularizations in the Southeast and South regions corroborates the data of Magalhães et al., who identified 83% of the procedures in these regions, in contrast to only 1% in the North region, highlighting significant inequality in the distribution of vascular care.47 Although a reduction in hospitalization rates for open surgery was observed in the Southeast (R^2=0.810) and South (R^2=0.627), the Northeast showed the greatest temporal growth in angioplasty (B = +0.295). Unlike necessarily reflecting greater regional technological development, this finding may be related to structural limitations in the provision of open surgery, which requires greater care complexity, including equipped surgical centers, intensive support, and specialized teams. In this context, the endovascular approach, due to its lower invasiveness and lower immediate structural demand, tends to be more widely used in regions with less installed capacity, possibly reflecting inequalities in access to highly complex vascular care, rather than a process of technological decentralization per se.40

Economically, angioplasty presented a higher average cost of R$ 3,756.00 (cost per day of R$ 817.00) compared to open angioplasty, R$ 3,335.00 (cost per day of R$ 379.00), contributing to a total expenditure of R$ 404,314,239.55. However, the cost-per-day analysis reveals a striking disparity: R$ 817.00 for the endovascular approach versus R$ 379.00 for the open approach. This pattern of high unit cost in the percutaneous technique is corroborated by Nascimento et al., who recorded a 92% increase in the overall costs of angioplasty in Brazil, and by Magalhães et al., who estimate that the cost of endovascular hospitalizations is up to 2.5 times higher than that of open angioplasty due to the high cost of Orthoses, Prostheses and Special Materials (OPME), which are frequently imported.40,41 Although the unit cost is high, the efficiency of care lies in bed turnover: the average length of stay was 4.6 days in the endovascular approach versus 8.8 days in the open approach, numbers that converge with the findings of Nascimento et al. (4.8 vs. 9.2 days) and Magalhães et al. (5.3 vs. 10.2 days). 47,49 Wolosker et al. Studies reinforce this logistical superiority of the percutaneous technique by demonstrating that 29.5% of endovascular patients are discharged in just one day, while in open surgery, 59.1% of hospital stays exceed one week. 50 However, this financial analysis should be interpreted with caution, as the endovascular technique is associated with higher long-term reintervention rates, which can increase the actual accumulated cost, as highlighted by Hussain et al. and Magalhães et al.47,48

This study has limitations inherent to the use of administrative information systems such as SIH, which are susceptible to problems in filling out information about variables, leading to incomplete databases. Since the data refers to hospitalizations and not individual patients, the same individual may have been counted multiple times during the analyzed period, which could overestimate the number of procedures performed. Furthermore, DATASUS does not specify whether the hospitalization corresponds to a first visit or a readmission, which can mask therapeutic failures, especially in cases undergoing endovascular treatment, which have a higher propensity for reinterventions. Added to this is the fact that the revascularization procedure may have been recorded during a hospitalization motivated by another clinical condition, not necessarily being the primary diagnosis of admission, which limits the accuracy of the etiological analysis. Additionally, the database does not allow longitudinal follow-up, making it impossible to evaluate medium- and long-term outcomes, such as reintervention rates, survival, and limb salvage. In this context, it is also not possible to apply contemporary prognostic stratification systems, such as the WIfI classification, widely used to estimate amputation risk and guide therapeutic decisions, which restricts the analysis of the clinical severity of the included cases. Despite this, the knowledge produced provides a reliable overview of the reality of the Brazilian Unified Health System (SUS), serving as an essential subsidy for the planning of public policies focused on optimizing outpatient management.

Conclusion

An analysis of hospitalizations in the Brazilian Unified Health System (SUS) between 2015 and 2024 demonstrated a predominance of endovascular therapy in the treatment of critical lower limb ischemia in Brazil. The patient profile was characterized by elderly men, with the majority of cases occurring in emergency settings. The endovascular approach presented lower in-hospital mortality and shorter hospital stays compared to open surgery. A reduction in open surgeries was observed in more developed regions, and an increase in endovascular interventions in the Northeast. These findings highlight the consolidation of the endovascular strategy in the national context and contribute to the literature by describing, on a national scale, the temporal and regional trends of infrainguinal revascularization in the SUS.

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