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Research Article

Analysis of Hospital Data on Endarterectomy and/or Angioplasty Secondary to Extracranial Carotid Atherosclerotic Disease in Brazil

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Abstract

Introduction: Extracranial carotid atherosclerosis (ECA) is a leading cause of stroke and transient ischemic attack (TIA). It can be treated surgically through carotid endarterectomy and/or angioplasty.

Objective: Analysis of hospital data on these procedures in Brazil.

Methodology: Descriptive, time-series study, secondary data, and public domain, covering all Brazilian regions. Variables related to the number of hospital admission authorizations (AIH), number of deaths, and case fatality rates for each procedure were evaluated, stratified by type of care (elective or emergency), between 2008 and 2024.

Results: Angioplasty predominated over endarterectomy throughout the period, with an increasing trend and a higher concentration of emergency procedures. Endarterectomy, in turn, remained stable, with a predominance of elective procedures and a downward trend in mortality rates. Angioplasty has seen higher absolute numbers of deaths and an increase in mortality in recent years, while endarterectomy has shown a progressive reduction, especially after 2013. A significant reduction in the performance of both procedures was also observed between 2019 and 2021, associated with the impact of the COVID-19 pandemic on elective surgeries.

Conclusion: Angioplasty was performed more frequently despite the higher mortality rate, but further studies are needed to better stratify individual patients, which is one of the limitations of our analysis.

Key words: endarterectomy; angioplasty; carotid

Introduction

Extracranial carotid atherosclerosis (ECA) occurs when plaques composed of dead cells, fats, cholesterol crystals, and other materials build up in the walls of the extracranial carotid artery (and can also occur in the intracranial artery), blocking blood flow.1 The prognosis can be influenced by the severity of atherosclerosis, the effectiveness of treatment, and the presence of risk factors such as advanced age, dyslipidemia, smoking, hypertension, and race. Furthermore, total cholesterol, smoking, and blood pressure appear to be related to the extent of the plaque-affected area. 2 Thus, ECA caused by atheromatous plaques can directly affect the cerebrovascular system, leading to complications such as cerebral embolism, hypoperfusion due to severe stenosis, intracranial extension of a carotid thrombus resulting from an atherosclerotic plaque, or arterial wall dissection. 3

Thus, ECA is one of the main causes, accounting for approximately 15% of transient ischemic attacks (TIAs) and strokes. 4 The clinical presentation of cerebral ischemia secondary to extracranial carotid artery disease can vary depending on the location, extent, and duration of the event. However, in symptomatic cases, patients generally present with focal events, such as amaurosis, hemi- or monoplegia, hemi- or monoparesis, dyslalia, and motor or sensory deficits on the side opposite the lesion. 5 In turn, treatment for ECA can be surgical (through conventional carotid endarterectomy or stent angioplasty) or medical, both with the goal of preventing stroke.6 It is known that controlling risk factors and adopting a healthy lifestyle are essential for effective medical treatment, including hypertension management, smoking cessation, lowering cholesterol levels, and the use of antiplatelet agents.7

Generally, for risk stratification and management purposes, patients are divided according to their clinical presentation: symptomatic or asymptomatic. Asymptomatic patients with stenosis of less than 60% or with occlusion of the internal carotid artery will be referred for medical treatment. Those with stenosis between 60% and 99% but with a life expectancy of less than 5 years, unfavorable anatomy, and/or the absence of clinical or imaging

features that indicate a high risk of stroke should also be treated medically. Symptomatic patients with carotid stenosis below 50% or internal carotid artery occlusion should be managed conservatively.

Conversely, asymptomatic patients with stenosis between 60% and 99%, a life expectancy of more than 5 years, favorable anatomy, and/or the presence of clinical or imaging features that may be associated with a higher risk of stroke may be considered for carotid endarterectomy. For symptomatic patients with stenosis between 70% and 99%, carotid endarterectomy is recommended, while endovascular treatment should be reserved for patients with high risk factors.

Surgical treatment involves two interventions: endarterectomy and carotid angioplasty. Endarterectomy, an open surgery, is a procedure that involves a longitudinal incision along the anterior border of the sternocleidomastoid muscle with dissection of the different planes of the region to access and expose the carotid arteries, allowing the removal of atherosclerotic plaques present in the carotid bifurcation.8 The second surgical intervention that is sometimes preferred in the treatment of extracranial atherosclerotic carotid artery disease is angioplasty, a minimally invasive intravascular procedure. As defined by Medical Subject Headings (MeSH), this is a procedure used to repair or restore blood vessels by expanding a narrowing in an artery or vein, removing atheromatous plaques and/or the inner lining, or using a balloon to compress the atheroma.

Multicenter randomized controlled trials conducted in the 1980s and 1990s on carotid stenoses, both symptomatic and asymptomatic, in the United States (The North American Symptomatic Carotid Endarterectomy Trial for symptomatic cases and The Asymptomatic Carotid Atherosclerosis Study for asymptomatic cases) and in Europe (European Carotid Surgery Trial for symptomatic cases and Asymptomatic Carotid Surgery Trial for asymptomatic cases) established guidelines for the management of severe internal carotid artery stenoses. These studies generally showed agreement, showing that endarterectomy was more effective than medical treatment in preventing ischemic cerebral events over a 5-year period, in both symptomatic and asymptomatic cases. 09–14

With the advancement of endovascular surgery in the carotid artery, an important question arose in clinical practice: whether the use of angioplasty and stenting (a procedure recognized as less invasive than endarterectomy) would yield comparable, or at least non-inferior, results to those of endarterectomy.

To answer this question and provide new insights for determining the indications for each technique, multicenter studies were conducted in the 2000s and 2010s, both in the United States (notably The Carotid Revascularization Endarterectomy vs. Stenting Trial (CREST)) and in Europe (including The International Carotid Stenting Study (ICSS), among others). Unlike the studies of the 1980s and 1990s, the results of the main studies from that era proved conflicting.

The results of the North American CREST study showed that the rate of combined events (stroke, myocardial infarction, or death) was similar between the groups undergoing stent angioplasty (11.8%) and endarterectomy (9.9%) (p=0.51). However, stent angioplasty was associated with a higher risk of periprocedural stroke (4.1% vs. 2.3%; p=0.01), while endarterectomy had a higher incidence of myocardial infarction (2.3% vs. 1.1%; p=0.03).15 On the other hand, several European studies have pointed to the inferiority of stent angioplasty in relation to endarterectomy. For example, in the ICCS, after 4 months, the rate of death, stroke, or myocardial infarction in the stent group was 8.5%, compared to 5.2% in the endarterectomy group.15,16

In asymptomatic patients, the ACT I study demonstrated non-inferiority of stent angioplasty compared to endarterectomy, with similar combined outcome rates at 30 days (3.8% and 3.4%, respectively), suggesting that this first procedure may be a viable alternative in well-selected populations.17 Furthermore, a meta-analysis conducted by Howard et al. with data from over 6,000 patients demonstrated that the risk of periprocedural stroke increases with age in the stent angioplasty group, which was not observed in the endarterectomy group.18 This observation is crucial, given that most patients eligible for carotid revascularization are over 65 years of age, often with comorbidities that also influence perioperative mortality.

Comparatively, angioplasty offers advantages such as the absence of the need for general anesthesia, allowing the patient's neurological status to be monitored during the procedure. Furthermore, it provides greater patient comfort and generates significant cost savings due to the short recovery time. The fact that it does not require a cervical incision drastically reduces the risk of cranial nerve injury and paralysis, surgical wound infections, or neck hematomas. This procedure can also reduce morbidity and mortality in patients considered high-risk for surgery, such as those with severe comorbidities, contralateral carotid occlusion, post-endarterectomy restenosis, stenosis caused by radiation, or anterior neck dissection. It is also an excellent alternative for patients with lesions that cannot be reached by conventional surgery.19

Regarding the disadvantages and complications of angioplasty, the incidence rate of myocardial infarction, stroke, and death varies among the different types of angioplasty, being low (<1%) in cardiac and femoral artery procedures, but higher in interventions on the carotid and abdominal aorta. Local vascular complications are present in approximately 6% of all procedures, and arterial perforation can occur, although rare. Furthermore, there is a risk of bleeding, and failure to control bleeding can lead to hematomas, pseudoaneurysms, and retroperitoneal bleeding. Bleeding complications are more common in women than in men and are more common when the approach is via the femoral artery compared to the radial approach. Systematically, atheroembolism may occur, caused by trauma to the arterial walls that leads to the rupture of atherosclerotic plaques in larger arteries, such as the femoral or aorta, resulting in the displacement of small cholesterol emboli into the systemic circulation. Acute kidney injury may also occur, caused by factors such as contrast exposure, atheroembolism, or reduced blood perfusion. To prevent this condition, intravenous hydration before the procedure and aggressive modification of risk factors for atheroembolic events are recommended.20,21

Regarding endarterectomy, its advantages include superior protection against ipsilateral stroke, in both symptomatic and asymptomatic patients.8 Patients over 80 years of age are four times less likely to suffer a stroke when compared to those undergoing angioplasty.

Regarding endarterectomy, its advantages include superior protection against ipsilateral stroke, both in symptomatic and asymptomatic patients.8 Patients over 80 years of age are four times less likely to suffer a stroke compared to those undergoing angioplasty, indicating that age is not a risk factor for complications. Furthermore, the risk of death is reduced compared to angioplasty.2 On the other hand, among the disadvantages is that patients with mild stenosis may still maintain a risk of ipsilateral stroke. There are also higher rates of myocardial infarction, and, in cases of evolving symptoms, there is an increased risk of death compared to patients with stable symptoms.8 Local complications can include perioperative stroke, cranial nerve injuries, and hematomas, while systemic complications can include hemodynamic instability, hypotension, hypertension, and the risk of restenosis due to technical failures. Regarding prognosis, carotid endarterectomy has the potential to dramatically reduce neurological symptoms and the incidence of late cerebrovascular events in elderly patients undergoing this procedure, thus reducing potential postoperative sequelae and mortality secondary to these events. On the other hand, research indicates that stent treatment increases the risk of stroke, as does any procedure using the femoral artery approach, and the increased risk of sequelae and mortality associated with this procedure is also understood. In addition to surgical interventions, controlling risk factors and adopting a healthy lifestyle are essential for effective clinical treatment, since hypertension management, smoking cessation, lowering cholesterol levels, and the use of antiplatelet agents are responsible for a favorable prognosis and increased patient survival.7

The study "Association between Hospital Carotid Endarterectomy Procedure Volumes and In-Hospital Mortality in São Paulo State," conducted in 2023 in the state of São Paulo, Brazil, retrospectively analyzed SIH-SUS data on in-hospital mortality after carotid endarterectomy and stenting angioplasty in

Brazil. The results showed that in-hospital mortality was significantly higher in patients undergoing stenting angioplasty compared with carotid endarterectomy. The analysis identified that elderly patients, especially those over 70, had a higher risk of death, as did those with underlying comorbidities such as diabetes mellitus, uncontrolled hypertension, and chronic kidney disease.

Given the above, this study aims to analyze ACE procedures in Brazil over a 16-year period.

Materials And Methods

A descriptive time series using secondary and public domain data, analyzing the entire national territory, using the five major regions of Brazil (North, Northeast, Central-West, South, and Southeast), encompassing 5,565 municipalities with a total of 190,755,799 inhabitants, according to the 2010 Census conducted by the Brazilian Institute of Geography and Statistics (IBGE). It is worth noting that, during the study, Brazilian population estimates from 2008 to 2024 were used, which are available on the IBGE website. The target population of the study included all individuals who underwent carotid artery bypass grafting and intraluminal angioplasty of neck vessels or supra-aortic trunks (with or without covering or uncovered) as documented in the hospital admission authorization (AIH).

Information regarding carotid artery bypass grafting and intraluminal angioplasty of neck vessels or supra-aortic trunks was obtained from the consolidated hospital production data (SIH/SUS) AIH (RD) by hospitalization location from the Tabnet system, Brazil by region and state, developed by the Department of Information Technology of the Unified Health System (DATASUS) to facilitate and democratize access to data in the healthcare field. Access is available at: https://datasus.saude.gov.br/acesso-a-informacao/producao-hospitalar-sih-sus/. Variables: Hospital admission authorization (AIH); Year of care; Type of care; Number of deaths by type of care; Total number of deaths per year of care; Case fatality rate per year of care.

Case fatality rates for both procedures were calculated by dividing the total number of deaths per procedure by the total number of approved AIHs per procedure, multiplying the final value by 100, and presenting this variable as a percentage.

To process and analyze the collected variables, a database was created in Microsoft Office Excel® for Windows version 11. The results were presented in tables, charts, and pie charts, parallel bars, and juxtaposed bars created in Microsoft Office Excel® for Windows version 11.

Trend lines for the number of approved AIHs per procedure and case fatality rates per procedure were also calculated in Microsoft Office Excel® for Windows version 11 using simple linear regression. The nature of the care consisted of elective or emergency and the sum of these two values, per year, results in the total value of AIH approved each year. To obtain data on the number of deaths by type – elective or emergency – and year of care, the DATASUS data platform was accessed using the TabNet application, accessed at https://datasus.saude.gov.br/informacoes-de-saude-tabnet/, and the "Health Care" tab was selected. Then, we selected "Hospital Production (SIH/SUS)" and the option "Consolidated AIH Data (RD), by place of hospitalization – from 2008 onwards," considering the geographic scope: "Brazil by Region and Federation Unit." When accessing the system page for data tabulation, we selected "Type of care" for the Row space; "Year of care" for the Column space; and "Deaths" for the Content space. As for the available periods, we selected January 2018 to December 2024. In Available Selections, on the "Procedure": We selected the desired procedure (carotid bypass-thromboendarterectomy or intraluminal angioplasty of neck vessels or supra-aortic trunks – with or without a covered or uncovered stent).

To obtain the data necessary to calculate the fatality rate per year of care, we accessed the DATASUS data platform. Using the "TabNet" application, available at https://datasus.saude.gov.br/informacoes-de-saude-tabnet/, we selected the "Health Care" tab. Then, we selected "Hospital Production (SIH/SUS)" and selected the option "Consolidated AIH Data (RD), by location of admission – from 2008 onwards," considering the geographic scope: "Brazil by Region and Federation Unit." When accessing the system page for data tabulation, we selected "Procedure" for the Row space; and "Column" for the Column space. “Year of service”; for the Content space: “Approved AIH”. As for the available periods, we chose from January 2018 to December 2024. In Available Selections, in the “Procedure” tab, we chose the desired procedure (carotid bypass-thromboendarterectomy or intraluminal angioplasty of neck vessels or supra-aortic trunks – with or without covered or uncovered stent). Thus, we can calculate the fatality rate for each year based on the ratio between the total number of deaths (the sum of the number of deaths by type for each year) and the total number of approved AIHs for each procedure.

Because this is a project that uses secondary data available to any citizen on government digital platforms, it is not necessary to submit the work to the Research Ethics Committee (REC). There are no conflicts of interest. The information will be used solely for academic purposes, ensuring confidentiality.

Results

A temporal analysis of the frequency of carotid endarterectomy and angioplasty procedures performed in Brazil between 2008 and 2024 reveals a predominance of angioplasty over endarterectomy throughout the analyzed period. Angioplasty showed an increasing trend in the number of procedures, with a more pronounced increase starting in 2012, when 1,794 procedures were performed. Thus, 2023 was the year with the most carotid angioplasties, with a total of 2,590 procedures, while 2008 was the year with the fewest, with only 1,390 procedures. The linear trendline equation ($y = 59.603x + 1,495.6$) and the coefficient of determination ($R^2 = 0.7006$) indicate a moderate positive correlation, suggesting that the number of angioplasties performed has increased consistently over time.

On the other hand, endarterectomy remained relatively stable, with small annual variations and no clear upward or downward trend. The year with the highest number of endarterectomies performed (1,409 procedures) was 2023, while 2020 was the year with the lowest number (843 procedures). The trend equation ($y = -0.7843x + 1,223.8$) and the very low R^2 value (0.0007) indicate an absence of significant correlation, which reinforces the stability of this procedure over the years. In 2020, there was a sharp decline in the number of both procedures; however, in the following years, the numbers increased again, especially for angioplasty, which reached its highest values in 2023 and 2024.

Even so, when analyzing the time series of angioplasty procedures by type of care, it is possible to see that throughout the period between 2008 and 2024, emergency procedures outnumbered elective procedures. The year with the lowest number (814) of procedures performed was 2008, which then showed progressive growth until 2019, when it peaked at 1,597 procedures. Starting in 2020, there was a slight decrease in the numbers, with fluctuations between the following years. The second highest value (1,584) was recorded in 2023, followed by a further decline in 2024, when 1,350 procedures were performed.

Elective procedures showed more gradual growth until 2014, with 906 procedures performed, followed by a slight fluctuation between 2015 and 2019. In 2020, there was a sharp drop, reaching the lowest value (514 procedures) in the time series, with recovery from 2021 onwards. The largest increase occurred between 2022 and 2024, when 1,220 procedures were performed, the highest value in the historical series for this type of care.

Furthermore, the analysis of the time series of approved AIHs for endarterectomy by type of care between 2008 and 2024 shows that, unlike angioplasty, the number of elective endarterectomy procedures performed exceeded emergency procedures in most years, with this trend only reversing in 2010, 2020, and 2021. Elective procedures showed progressive growth between 2008 and 2016, with fluctuations between 2017 and 2019. In 2020, there was a sharp decline, with the lowest number (357) of elective procedures performed in this series. Subsequently, there was a continuous increase from 2021 onward, reaching the highest number (850) of elective procedures performed in the analyzed period in 2024.

Emergency procedures showed an increase between 2008 and 2010, with the latter being the year in this series with the highest number (677) of such

procedures performed. These remained relatively stable until 2015, when 589 were performed. From then on, a downward trend was observed, with the lowest number (413) recorded in 2019. In the following years, there was a slight recovery until 2023, with a further decline in 2024, when 441 procedures were performed, the second lowest number in the historical series analyzed.

An analysis of the evolution of in-hospital deaths associated with endarterectomy and angioplasty between 2008 and 2024 reveals significant differences in the safety of the two procedures. Throughout the study period, angioplasty had a higher number of deaths in most years compared to endarterectomy, except in a few specific periods, such as between 2011 and 2012, when both procedures reached an equivalent number of deaths. It should be noted that both methods exhibited annual fluctuations, with no clear downward or sustained upward trend.

Angioplasty reached its highest in-hospital death rates at the end of the analyzed series, in 2023 and 2024, causing 58 and 49 deaths, respectively. The lowest number of deaths related to this procedure was recorded in 2009 and 2012, with 24 deaths recorded each year. Regarding endarterectomy, it is possible to observe relative stability in the last decade, with discreet occasional increases, with a lower number of deaths (2) at the beginning of this series, in 2008, and its highest value (32) in 2011, followed by a relative decrease in this number. When analyzing the number of perioperative deaths secondary to angioplasty by type of care, it is possible to observe that, compared to elective procedures, emergency procedures account for the highest percentage of total deaths throughout the analyzed series, with the highest number of deaths (approximately 86%) in 2023 and the lowest (75%) in 2008. In elective procedures, the highest percentage of deaths (approximately 41%) occurred in 2008 and the lowest percentage (2.5%) in 2020.

This same analysis of perioperative deaths, but now secondary to endarterectomy, by type of care, reveals a relative balance between the percentages of elective and emergency procedures. However, emergency procedures still account for a higher percentage of deaths than emergency procedures throughout the series analyzed, with a higher number of deaths (approximately 66%) in 2011, following a downward trend with small variations, which can be observed with the lowest number (approximately 43%) in 2018. There is a small inversion of this situation in the years 2012, 2016, 2017 and 2018, when the percentages of perioperative deaths in elective endarterectomies (approximately 54%, 58%, 58% and 57%, respectively) exceed those in emergency procedures. Regarding elective procedures, the highest number of deaths (approximately 58%) was observed in 2017, while the lowest percentage (20%) occurred in 2020.

Comparing the fatality rate of the two procedures, it is noted that the fatality rate of endarterectomy was higher than that of angioplasty for much of the historical series, especially between 2008 and 2013. In 2016, the fatality rates for these two procedures were equal (both 1.4%), and, starting in 2020, a reversal was observed, with angioplasty presenting higher fatality rates than endarterectomy in several subsequent years. The analysis of the evolution of lethality rates associated with angioplasty and endarterectomy procedures in Brazil, between 2008 and 2024, shows that endarterectomy showed a downward trend over the period (represented by the regression line equation $y = -0.0679x + 2.3934$, with coefficient of determination $R^2 = 0.5276$). This indicates that approximately 52.8% of the variation in the fatality rate can be explained by temporal progression, suggesting a progressive improvement in the outcomes of this procedure. The highest fatality rate for endarterectomy was recorded in 2009, reaching 2.8%, while the lowest value occurred in 2020, at 1.2%.

In contrast, angioplasty showed a slight upward trend in fatality over the years (according to the equation $y = 0.024x + 1.4544$, with $R^2 = 0.1574$). The low coefficient of determination indicates that only 15.7% of the variation can be explained by the time variable, reflecting greater instability in annual results. The highest fatality rate for angioplasty occurred in 2023, at around 2.2%, followed by a drop in 2024, reaching 1.9% at the end of this historical series, while the lowest rate (1.1%) was observed in 2018.

Discussion

Angioplasty was the most frequently performed procedure throughout the period, showing an increasing trend, while endarterectomy remained relatively stable. This finding is possibly related to the less invasive nature of angioplasty, which eliminates the need for general anesthesia, offers greater comfort, and a faster recovery for the patient—aspects highlighted by Tumelero et al.19 as important advantages of this method compared to open surgery.

However, when analyzing mortality and case-fatality outcomes, the results suggest a complex relationship between procedure frequency and safety. In this context, angioplasty presented higher absolute numbers of in-hospital deaths, especially in the final years of the historical series, while endarterectomy, despite presenting higher fatality rates in the early years (2008–2013), showed a progressive downward trend, reaching 1.2% in 2020. This behavior corroborates findings from international studies, such as CREST 15, which showed a higher risk of peri-procedural stroke for angioplasty – a more lethal condition – when compared to a higher incidence of myocardial infarction among patients undergoing endarterectomy, an adverse effect with a better clinical outcome.

Similarly, ACT I 17 demonstrated that angioplasty is not inferior to endarterectomy in well-selected asymptomatic patients, but the relative safety of the procedure appears to depend heavily on the patient's clinical profile. This observation reinforces the need for caution when interpreting the higher number of deaths found in angioplasty in the present study, since this technique was most frequently performed in emergencies, a scenario in which patients are clinically unstable and at high risk.

In the national context, the study conducted in São Paulo in 2023 demonstrated similar results, with significantly higher in-hospital mortality associated with angioplasty compared to endarterectomy, in addition to marked regional differences, especially in the North and Northeast regions.9 These findings help interpret the high mortality found in angioplasties during the analyzed period, possibly reinforcing the influence of structural factors and access to healthcare on clinical outcomes.

Another relevant aspect was the analysis of the nature of the care. Angioplasty was mostly performed urgently, while endarterectomy predominated in elective procedures. This difference may partly explain the higher mortality rates observed in angioplasty, since emergency care is associated with patients with more severe conditions and greater clinical instability. Furthermore, international data reinforce that patient profile significantly influences outcomes: Howard et al. 18, in a meta-analysis of more than 6,000 patients, identified an increased risk of peri-procedural stroke with advancing age in patients undergoing angioplasty, an effect not observed with endarterectomy. Therefore, considering that the majority of patients undergoing carotid revascularization in Brazil are over 65 years of age, this factor may have contributed to the higher mortality observed in angioplasty. However, these subgroups are not identifiable in the DATASUS database, which could explain part of the progressive increase in the adoption of this procedure in Brazil, observed with the increase in approved AIH, even in the face of relatively higher mortality rates. Furthermore, the progressively decreasing mortality rate of endarterectomy may reflect technical improvements and increased safety of this open procedure over the years, possibly associated with improved surgical protocols and increased experience at referral centers. 56 In contrast, the mortality rate of angioplasty has shown instability, with higher values in recent years, which may reflect both infrastructure limitations and the use of this method in more severe clinical situations.

These findings reinforce that, despite the increase in angioplasty performance in Brazil, its relative safety in terms of in-hospital mortality is still lower than that of endarterectomy, especially in emergency care. These data converge with international literature, which indicates more consistent results with endarterectomy, especially in elderly patients and those with a higher burden.

It is of great importance to highlight that during the COVID-19 pandemic there was a sharp reduction in the performance of surgical procedures, especially elective ones, due to the organizational measures adopted to free up beds, protect teams and prioritize COVID-19 care. This may explain the

decline in the number of procedures performed between 2019 and 2021, both for endarterectomy and angioplasty. This fact is also elucidated in a study analyzing national databases, entitled "What happened to the most frequent surgeries performed in the Brazilian Unified Health System during and after the COVID-19 pandemic. An analysis of 2 million procedures," which also documented significant reductions in the total number of surgical procedures between 2019 and 2020, demonstrating the systemic impact of the pandemic on the supply of surgical care. 21-23

Beyond the national context, global estimates indicate that during peak weeks, up to 72% of elective surgeries were postponed or canceled, generating a large backlog of pending procedures.

This may explain, after the decline (2019-2021), the greater increase compared to previous years in the performance of both procedures in 2022 and 2023, when pandemic restrictive measures were more severe.

Regarding the vascular specialty, multicenter studies and reviews have also reported substantial declines in the volume of elective procedures, with readjustments in procedures to prioritize urgent cases and changes in the demand profile, which potentially increased the risk of disease progression and the need for emergency interventions. 23 This may explain the sharp decline observed in elective endarterectomies between 2019 and 2020, associated with a slight increase in emergency procedures. These changes have clinical and public health implications, including delayed treatment of chronic diseases, future system overload, and the need for strategies to recover the backlog of surgeries.

This study contributes by providing a national and updated overview of clinical practice, covering 16 years of data across Brazil. Nevertheless, its limitations, inherent to the use of secondary databases, must be recognized. Therefore, the absence of individual clinical information (for example: associated comorbidities, severity of stenosis, previous symptoms and age range of patients) must be considered when interpreting the results, as it makes it impossible to stratify patients.

Conclusion

Our results are consistent with Brazilian data that associate hospital volume with better outcomes, prioritizing endarterectomy when eligible and angioplasty for specific scenarios. Further studies are needed to better stratify individual patients, which is one of the limitations of our analysis.

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