



Thrombectomy for Venous Thromboembolic Events According to Brazilian Hospital Records

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Abstract

Introduction: This study addresses the critical need to analyze thrombectomy application and outcomes for venous thromboembolism (VTE) within the Brazilian healthcare system. It aims to investigate the landscape of thrombectomy for VTE using hospital records from the Brazilian Unified Health System (SUS), understanding its utilization characteristics and associated national outcomes.

Materials and Methods: An ecological, descriptive time-series study with a quantitative approach was conducted using secondary data from public information systems. Data on hospital admissions for venous system thrombectomy and heart failure within the SUS, from 2008 to 2024, were obtained from the Hospital Information System (SIH/SUS) via DATASUS and the TABNET tabulator. The analysis unit was Brazilian geographic regions, including the Federal District.

Results: From 2008 to 2024, 36,365 thrombectomy admissions were recorded, with 494 deaths, costing approximately US\$5 million to the SUS. The national mortality rate was 2.9%, showing significant regional disparities, with the Northeast and Midwest at 4.7%. Statistically significant correlations were found between hospital stay length and VTE mortality in the Northeast and Southeast, and between VTE and heart failure incidence in the North and South.

Conclusion: The study highlights the complex implementation of thrombectomy in Brazil, underscoring its clinical benefits alongside persistent regional disparities. It acknowledges that correlations from aggregated data do not imply individual causality and may be subject to ecological fallacy.

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Introduction

Venous thromboembolism (VTE) is a vascular condition characterized by the formation of a blood clot in the venous system, which may present as deep vein thrombosis (DVT) or, when the thrombus migrates to the pulmonary circulation, as pulmonary embolism (PE)—a high-risk condition that can be potentially fatal [1,2]. It is one of the five most common vascular diseases, potentially severe, directly impacting quality of life, and representing an important marker of global vascular health risk.

It is estimated that approximately 8% of adults in the United States are at risk of developing VTE over their lifetime. The epidemiology of this condition indicates higher prevalence among older individuals, which may be attributed to reduced mobility and the presence of chronic comorbidities, such as heart failure and lung disease, which compromise blood circulation. Hospitalization is considered a significant risk factor, mainly due to prolonged immobilization. Moreover, other factors such as history of trauma, surgical interventions, cancer diagnosis, use of oral contraceptives, pregnancy, obesity, and family predisposition are also recognized as conditions that increase susceptibility to VTE [3].

Its pathophysiology classically involves Virchow's triad—venous stasis, endothelial injury, and hypercoagulability—complemented by inflammatory processes and thrombotic mechanisms [4,5]. Understanding these mechanisms is essential for diagnosis, which frequently relies on imaging tests such as duplex ultrasonography, computed tomography angiography, and magnetic resonance angiography, capable of confirming the presence of the thrombus and guiding interventions [5].

VTE treatment includes anticoagulants, mechanical thrombectomy, or a combination of both, with the latter being potentially more effective in some scenarios [6]. Recent studies have compared these approaches, with percutaneous mechanical thrombectomy

(PMT) gaining prominence as an interventional alternative aimed at removing or fragmenting the thrombus to restore venous flow.

PMT has demonstrated high clinical efficacy, surpassing anticoagulation alone in terms of venous recanalization, although cost-effectiveness analyses may sometimes favor anticoagulation [7]. PMT offers potential advantages, such as a lower risk of bleeding compared to other interventional techniques like thrombolysis [8]. Its application has been explored in different scenarios, such as cerebral venous thrombosis—with benefits still uncertain—and in iliofemoral DVT, with potential to reduce post-thrombotic syndrome compared to anticoagulant therapy alone [9-11].

The effectiveness of PMT may vary depending on thrombus chronicity, with promising results even in subacute and chronic thrombi using specific devices [12]. PMT is increasingly recommended as a relevant approach in severe VTE cases, owing to technological advances that have introduced a wide variety of devices, including aspiration catheters, stent retrievers, and balloon-guided catheters [8,13]. Additionally, specific systems such as InThrill have been developed to address smaller vessels and new multimodal devices designed to sequester the thrombus—reducing the risk of embolization and vascular injury—are under development [14,15].

Given the relevance of VTE and the particularities of different therapeutic approaches such as thrombectomy, it is essential to analyze the application and outcomes of these procedures in the specific context of the Brazilian healthcare system (SUS). This study aims to investigate the landscape of thrombectomy for venous thromboembolic events based on hospital records from the SUS, seeking to understand the characteristics of its utilization and the outcomes associated at the national level.

Materials and Methods

This is an ecological, descriptive study, with a time

series design and quantitative approach, based on secondary data from public information systems. The unit of analysis consisted of the geographic regions of Brazil, including the Federal District, from 2008-2024.

Information was obtained from the Hospital Information System/SUS (SIH/SUS), accessed through the Department of Informatics of SUS (DATASUS), under the Ministry of Health.

Data extraction was performed using the TABNET tabulator, the official tool provided by DATASUS, through the following electronic address: <https://datasus.saude.gov.br/>. Data collection included hospital admission records related to venous system thrombectomy and heart failure, specifically within the SUS.

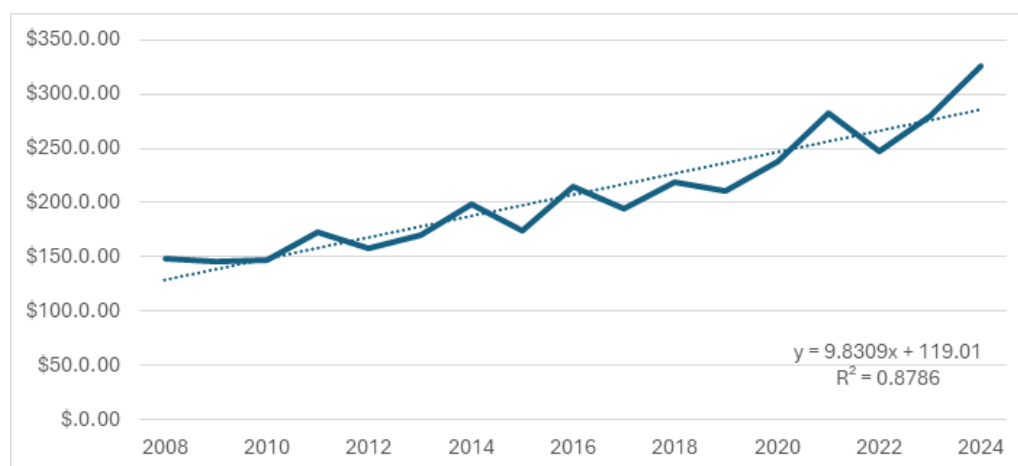
The constructed dataset included variables such as year of admission, geographic region, number of admissions, number of deaths, average hospital stays (in days), and procedure cost in Brazilian (converted to US dollars). Hospital mortality was calculated as the ratio between the number of deaths and hospital admissions.

For statistical analysis, Microsoft Excel and Jamovi software were used. Categorical variables were described by absolute and relative frequencies. The distribution of quantitative variables was assessed using the Shapiro-Wilk normality test, with $p < 0.05$ indicating non-normal distribution. For normally distributed variables, Pearson's correlation coefficient was applied, while for asymmetrically distributed variables, Spearman's correlation coefficient was used. Quantitative variables with normal distribution were represented by mean and standard deviation, and those with non-parametric distribution by median and interquartile range.

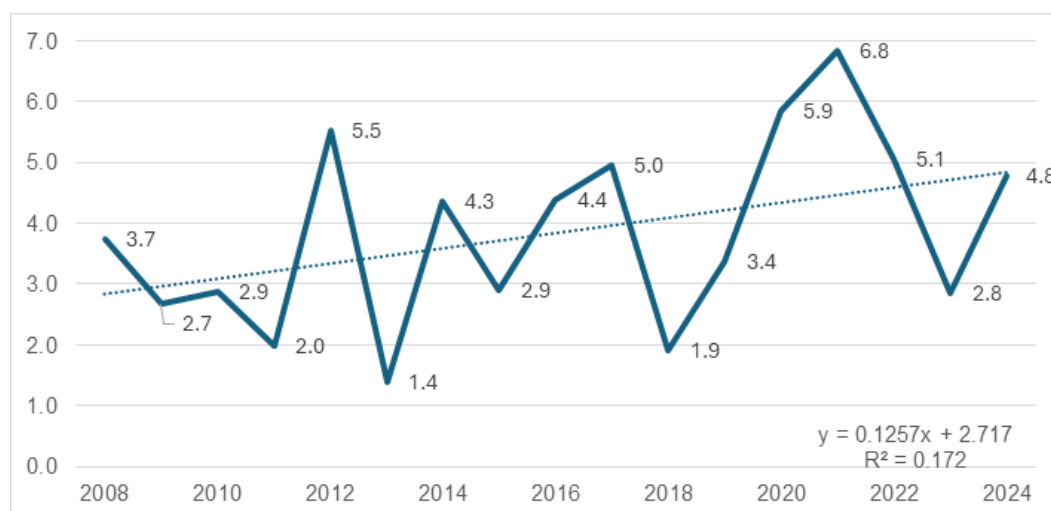
Regarding ethical considerations, this study was exempted from submission to a Research Ethics Committee, as it exclusively used publicly accessible data, in accordance with current legislation. Nevertheless, the researchers followed the ethical principles established by Resolution No. 466/2012 of the Brazilian National Health Council, ensuring confidentiality and responsible use of the analyzed information.

Results

Between 2008 and 2024, a total of 36,365 hospital admissions for thrombectomy were recorded, with 494 deaths. The procedure generated an approximate cost of 5 million US dollars to the SUS during the period, with an average cost per hospitalization of 200 dollars. The highest mean cost was observed in the Northeast region (273 dollars) and the lowest in the North region (177 dollars), with a significant increase in average values over the analyzed years.



The national mortality rate was 2.9 ± 1.5 , with the highest averages recorded in the Midwest (4.7 ± 3.7) and Northeast (4.7 ± 2.5), followed by the North (4.26 ; IQR: 7.1), Southeast (3.2 ± 1.0), and South (2.3 ± 1.2). A gradual upward trend in national mortality was observed over the years, despite regional variations.



The average length of hospital stay showed a slight downward trend over the analyzed period. The highest averages were observed in the North (5.7; IQR: 2.2), Midwest (5.5±1.4), and Northeast (5.2±2.7), followed by the Southeast (3.41±0.7) and South (3.3±0.6), with a national median of 3.5 days (IQR: 0.8). The correlation between mortality rate and length of hospital stay is presented in Table Y.

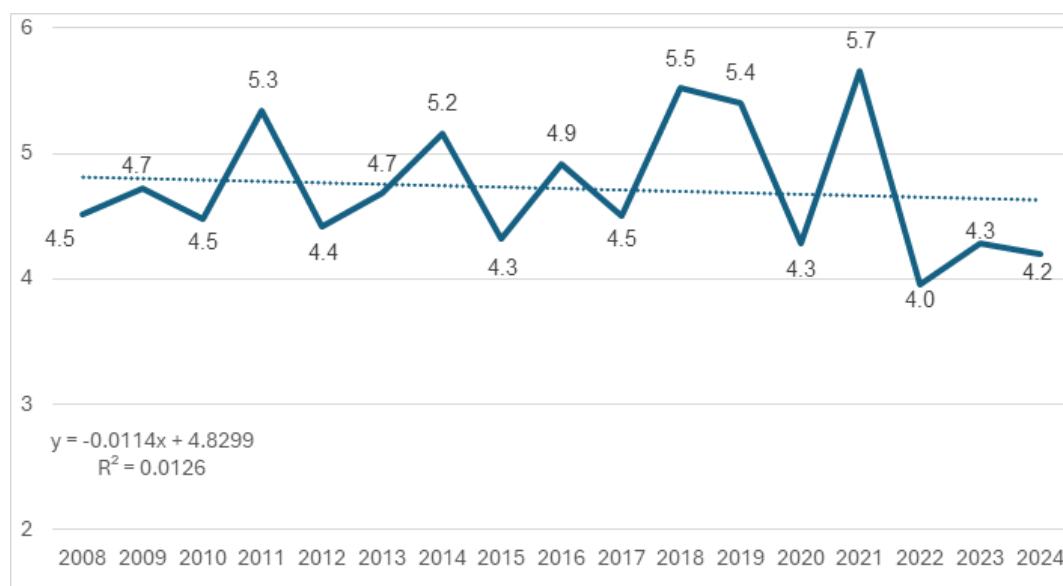


Table 1: Correlation Between VT Hospital Mortality and ALOS Across Brazilian Regions

Regions	Correlation Type	Coefficient (r or ρ)	p-value
North	Spearman	0.017	0.947
Northeast	Pearson	0.765	<0.001
Southeast	Pearson	0.518	0.033
South	Spearman	0.202	0.438
Center-west	Pearson	-0.228	0.378
Total*	Spearman	0.77	<0.001

*The Northern region was not included in the total due to a reporting error in the DATASUS system.

Regarding the incidence of thrombectomy per million inhabitants, the regional averages were: Northeast 2.3 ± 0.7 , Southeast 6.4 ± 2.1 , South 5.8 ± 2.8 , and Midwest 3.1 ± 1.3 . The North region presented a median of 1.7 (IQR: 1.6) and a significant increase between 2022 and 2023, with a variation of 14,720%, indicating a possible inconsistency in the data extracted from the DataSUS platform. Table X presents the correlation between the incidence of venous system thrombectomy and the incidence of hospitalizations due to heart failure, stratified by macro-regions.

Table 2: Comparison of VT and HF Incidence Across Brazilian Regions

Regions	Correlation Type	Coefficient (r or ρ)	p-value
North	Spearman	0.662	0.004
Northeast	Spearman	-0.500	0.041
Southeast	Spearman	0.407	0.105
South	Pearson	0.941	<0.001
Center-west	Spearman	-0.154	0.554
Total*	Spearman	0.581	0.014

*The Northern region was not included in the total due to a reporting error in the DATASUS system.

Discussion

When analyzing mortality rate data, it is observed that thrombectomy presents a relatively low lethality rate, with a national average of 2.88%. This result may be attributed to the fact that, despite being a surgical procedure, thrombectomy is minimally invasive. In addition, there has been a shift in the patient profile, as the procedure has increasingly been indicated for more severe cases, such as VTE [8]. Another relevant factor is the capacity of the method to reduce bleeding risk and eliminate the need for admission to intensive care units, elements that contribute to reduced mortality.

However, when focusing more closely on regional variations in Brazil, the Northeast showed the highest mortality rate, reaching 4.71%, which was 2.07 times higher than that recorded in the South region (2.27%). This regional disparity can be explained by several factors, including less experience among teams performing the technique, reflecting the learning curve required for proper execution of the procedure. Furthermore, the limited availability of specialized equipment, restricted access to referral centers, and deficiencies in structural resources may also negatively influence clinical outcomes.

By further analyzing the outcomes, the present study identified statistically significant correlations that warrant in-depth theoretical discussion. In the analysis of the relationship between mean length of hospital stay and VTE mortality, a positive and statistically significant correlation was observed in the Northeast ($r = 0.765$; $p < 0.05$) and Southeast ($r = 0.518$; $p < 0.05$). This finding corroborates the literature, which consistently identifies prolonged hospital stay as a risk factor for adverse outcomes [5,9]. Longer hospitalizations may indicate greater severity of the initial clinical condition, the occurrence of complications such as infections, or slower therapeutic response, factors that, individually or together, contribute to increased mortality [11,13]. The particularly strong correlation in the Northeast may highlight region-specific structural challenges, such as limited access to high-complexity centers or differences in the management protocols of severe cases, leading to longer hospitalizations and, consequently, higher lethality.

Similarly, the analysis of the correlation between the incidence of VTE and heart failure (HF) revealed strong and statistically significant associations in the North ($r = 0.662$; $p = 0.004$) and South ($r = 0.941$; $p < 0.001$). Epidemiological literature already establishes HF as an important risk factor for VTE, particularly in elderly individuals with comorbidities such as chronic lung disease, which impair circulation. The pathophysiology of this association is explained by Virchow's triad, in which ventricular dysfunction in HF promotes venous

stasis, combined with a hypercoagulable state and possible endothelial injury [16]. The strong correlation found, especially in the South, may reflect a higher prevalence of cardiovascular risk factors in the local population or greater diagnostic accuracy, allowing simultaneous identification of both conditions. In contrast, the moderate and inverse correlation observed in the Northeast ($r = -0.500$; $p = 0.041$) represents an atypical and counterintuitive finding. This inversion may be a statistical artifact resulting from uncontrolled confounding factors, such as underreporting of one of the conditions, or may be related to demographic characteristics and healthcare access in the region, warranting further investigation for clarification.

Caution must, however, be exercised when interpreting these results, considering the possibility of ecological fallacy, that is, inferring individual causality from correlations obtained in aggregated population data. Given Brazil's large population, it is possible that some statistically significant correlations (even with $p < 0.05$) may have arisen by mere chance. Therefore, it is important to emphasize that the analyses presented in the tables refer exclusively to correlations and not causal relationships.

This study sought to investigate the landscape of thrombectomy for venous thromboembolic events within SUS, analyzing hospital records to understand the characteristics of its use and the associated outcomes at the national level. The findings reveal the complexity of implementing thrombectomy in Brazil, highlighting both its clinical benefits and the persistent challenges and regional disparities that impact equity and quality of care.

The implications of these findings are multifaceted. The stability in the number of procedures, despite the proven effectiveness of thrombectomy and its potential cost-effectiveness in the medium and long term (considering the reduction of complications such as post-thrombotic syndrome), suggests the need for public policies that encourage broader dissemination and standardization of the technique across the national territory. A review of therapeutic choices, prioritizing thrombectomy in scenarios where its benefits outweigh initial costs, is fundamental to optimize resources and improve patient outcomes [17-29].

Conclusion

This study, although comprehensive, has limitations inherent to the use of secondary data from DATASUS, which do not allow for in-depth analysis of specific patient clinical characteristics or long-term outcomes. Data inconsistencies in some regions, such as the atypical peak observed in the North region in 2023, underscore the need to improve health information recording systems to ensure data reliability and, consequently, the robustness of epidemiological analyses.

For future research, prospective multicenter studies integrating detailed clinical data are recommended, allowing for analyses adjusted by comorbidities and disease severity. Evaluating patients' quality of life and the recurrence of thromboembolic events in the long term would be valuable to complement the available information and guide evidence-based public health policies. Furthermore, investigations into the socioeconomic and geographic factors contributing to the observed regional disparities could provide additional insights for the development of more equitable health strategies.

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