Original research

# Stroke thrombectomy volume, rather than stroke center accreditation status of hospitals, is associated with mortality and discharge disposition

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## ABSTRACT

**Background** Few studies have explored the association between stroke thrombectomy (ST) volume and hospital accreditation with clinical outcomes.

**Objective** To assess the association of ST case volume and accreditation status with in-hospital mortality and home discharge disposition using the national Medicare Provider Analysis and Review (MEDPAR) database.

**Methods** Rates of hospital mortality, home discharge disposition, and hospital stay were compared between accredited and non-accredited hospitals using 2017–2018 MEDPAR data. The association of annual ST case volume with mortality and home disposition was determined using Pearson's correlation. Median rate of mortality and number of ST cases at hospitals within the central quartiles were estimated.

**Results** A total of 29 355 cases were performed over 2 years at 847 US centers. Of these, 354 were accredited. There were no significant differences between accredited and non-accredited centers for hospital mortality (14.8% vs 14.5%, p=0.34) and home discharge (12.1% vs 12.0%, p=0.78). A significant positive correlation was observed between thrombectomy volume and home discharge (r=0.88; 95% CI 0.58 to 0.97, p=0.001). A significant negative relationship was found between thrombectomy volume and mortality (r=−0.86; 95% CI −0.97 to −0.49, p=0.002). Within the central quartiles, the median number of ST cases at hospitals with mortality was 24/year, and the median number of ST cases at hospitals with home discharge rate was 23/year.

**Conclusion** A higher volume of ST cases was associated with lower mortality and higher home discharge rate. No significant differences in mortality and discharge disposition were found between accredited and non-accredited hospitals.

## BACKGROUND

The stroke systems of care are continuously evolving. Large vessel occlusion ischemic stroke carries higher morbidity and mortality than small vessel stroke.[1] Provision of endovascular treatment for large vessel occlusion stroke has become central to the organization of stroke systems of care.[1–3] As a principle, access to endovascular care should be timely and universal. Aldstadt *et al* reported that access to endovascular care at thrombectomy-capable centers (TCCs) or comprehensive stroke centers (CSCs) is only available to 49.6% residents by ground and 64.8% via both ground and air.[4] Although a need for more endovascular-capable centers (ECCs) is intuitive, concerns exist about the volume of cases necessary to establish and maintain an ECC while ensuring competency of the interventionists.

The distribution of ECCs in the USA is non-uniform.[5] Several large metropolitan areas are saturated with ECCs, competing for stroke cases within the same catchment areas.[4] By contrast, the operators at some ECCs are responsible for covering vast geographic areas in the states where only a few centers may be available to provide stroke care for a much larger population.[4] Therefore, the annual number of stroke thrombectomy (ST) cases required to maintain competency at individual and institutional levels has been hotly debated.[6 7] Unfortunately, only a few studies have looked at the association of case volume with clinical outcomes and these indicate a positive association between the two variables.[8 9] Available recommendations on the minimum case volume required for accreditation and to maintain individual competency are based on consensus statements issued by several neurointerventional organizations.[3 6 7] The accreditation and certification criteria differ between accreditation agencies, with different requirements for the specific number of cases needed for institutional and individual accreditation.[10] These accreditation standards were derived through consensus between experts in the field. For example, the Joint Commission formulated a technical advisory panel on certification of stroke centers, which consisted of experts from multiple disciplines. The panel held discussions with various stakeholders and recommended an individual volume of 15 cases per year with a hospital volume of 25–30 cases per year.[11] This recommendation was endorsed by the Society of NeuroInterventional Surgery (SNIS), Society of Vascular and Interventional Neurology, American Association of Neurological Surgeons, and the Congress of Neurological Surgeons.[12] There has been criticism of these numbers.[13] Fargen *et al* argued that these numbers are too low to maintain competency, especially because each center is likely to have two to three neurointerventionists, meaning that each operator will have performed only five cases per year or up to 10 in 2 years.[13] Nevertheless, leading experts in the field have repeatedly supported the above numbers.[7,12] In this context, more data on the association of ST volume and clinical outcomes would be critical to help formulate evidence-based recommendations. In the presence of limited data, consensus among field experts on an optimal case volume may be the best approach, yet the data on the association of ST volume and clinical outcomes remains vitally important.

Few studies have explored the impact of accreditation with the current volume requirement on the clinical outcomes at ECCs. In this study, we explored the association of ST volume and accreditation status with mortality, discharge disposition, and in-hospital length of stay using nationwide Medicare Provider Analysis and Review (MEDPAR) data (https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/MedicareFeeforSvcPartsAB/MEDPAR). Further, we estimated the number of annual ST cases associated with optimal clinical outcomes with a rationale to provide data to support decision-making with respect to accreditation standards and policies.

## METHODS

We analyzed the hospital-based Centers for Medicare and Medicaid Services (CMS) MEDPAR data from 2017 and 2018. Permission for analysis was obtained from the CMS. Endovascular mechanical thrombectomy (MT) cases were identified using the International Classification of Disease 10th revision (ICD-10) codes 03CG3Z7, 03CK3Z7, 03CL3Z7, 03CP3Z7, 03CQ3Z7, 03CG3ZZ, 03CK3ZZ, 03CL3ZZ, 03CP3ZZ, and 03CQ3ZZ. National Provider Identifiers (https://www.cms.gov/Regulations-and-Guidance/Administrative-Simplification/NationalProvIdentStand) were used to identify the hospitals where the procedures were performed. Lists of CSCs and TCCs were obtained from the Joint Commission (https://www. jointcommission.org/ accreditation- and- certification/certification/ certifications- by- setting/ hospital- certifications/stroke- certification/ advanced- stroke/ comprehensive- stroke- center/), Det Norske Veritas (DNV) Healthcare (https://www.dnvglhealthcare.com/hospitals? search_ type=and&q=& c=20 806& c=& prSubmit=Search&page=8), Healthcare Facilities Accreditation Program (https://www. hfap.org/search- facilities/), and state health departments. Both CSCs and TCCs were considered endovascular-capable stroke centers. The list of stroke centers that performed endovascular ST was cross-referenced with the list of accredited centers. Clinical outcomes of interest included mortality, discharge to home, and length of hospital stay.

The independent t-test was used to compare the mean rates of mortality, home discharge, and length of stay between accredited and non-accredited centers. Pearson's correlation was determined between institutional volume of ST cases and mortality, discharge disposition, and length of stay for 2017 and 2018 separately and for the combined 2017 and 2018 data. After removing the centers at which fewer than five cases were performed over those 2 years, we determined the IQR for mortality. The median number of cases at hospitals achieving mortality rates within that IQR was then determined.

## RESULTS

A total of 29 355 procedures of ST were performed over 2 years at 847 hospitals across the USA. The number of cases increased from 12 386 in 2017 to 16 969 in 2018, an increment of 37.0%. Of the hospitals, 354 (42%) were accredited. A total of 21 319 (72.6%) procedures were performed at accredited centers (20 128 in CSCs; 1191 in TCCs), and 8036 (27.4%) were performed at non-accredited centers. There was no significant difference between the accredited and non-accredited centers in hospital mortality (14.8% vs 14.5%, $p=0.34$) and home discharge disposition (12.1% vs 12.0%, $p=0.78$). There was also no significant difference between accredited and non=accredited centers in the length of hospital stay ($8.09\pm7.2$ vs $8.1\pm8.1$, $p=0.79$). No significant difference in mortality was seen between CSCs, TCCs, and non-accredited centers (14.8% vs 13.3% vs 14.8%, respectively, $p=0.16$). The percentage of patients discharged home was significantly lower for TCCs than for CSCs and non-accredited centers (10.1% vs 12.3% vs 12.0%, respectively, $p=0.018$). However, it must be noted that procedures performed at TCCs constituted 7.2% of all cases. A significant positive correlation was observed between thrombectomy volume and percentage of patients discharged home. This trend was consistent for both 2017 and 2018 ($r=0.97$, 95% CI 0.86 to 0.99, $p<0.001$; and $r=0.89$, 95% CI 0.58 to 0.97, $p=0.001$, respectively) (figure 1A and B). The positive correlation of thrombectomy volume with home discharge for the overall 2-year (2017 and 2018) cohort was $r=0.66$ (95% CI 0.047 to 0.91, $p=0.039$) (figure 1C).

A significant inverse relationship was found between thrombectomy volume and mortality for both 2017 ($r=-0.75$; 95 CI $-0.94$ to 0.24, $p=0.012$) and 2018 ($r=-0.85$, 95% CI $-0.96$ to $-0.48$, $p=0.002$) (figure 2A and B). The negative correlation for the overall cohort (2017 and 2018) was $-0.86$ ($-0.97$ to $-0.49$, $p=0.002$) (figure 2C). A statistically significant

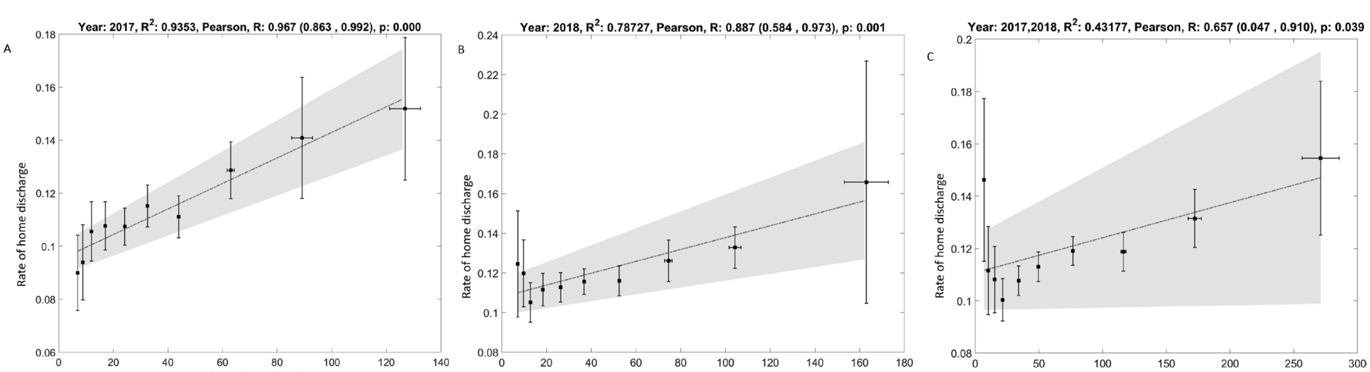


**Figure 1** Graph shows a positive and significant statistical correlation between rate of home discharge (y axis) and thrombectomy volume (x axis) for the year 2017 (A). Similar relationships are shown for 2018 (B) and a combination of years 2017 and 2018 (C).

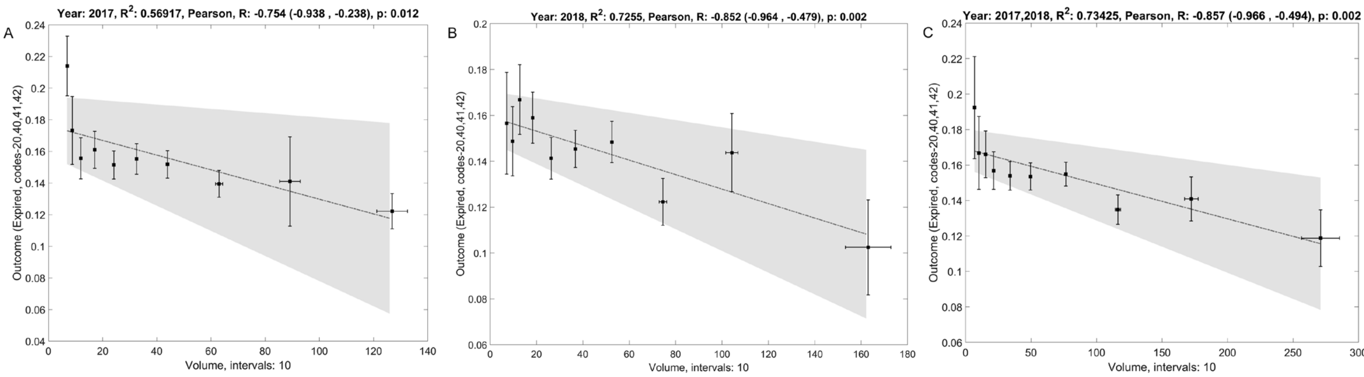


**Figure 2** Graph shows a negative and significant statistical correlation between in-hospital mortality (y axis) and thrombectomy volume (x axis) for the year 2017 (A). Similar relationships are shown for year 2018 (B) and a combination of years 2017 and 2018 (C).

negative correlation was seen between volume and length of stay (r=−0.10, p=0.043).

The median mortality was 7.8% (IQR 15.9–21.4). The median number of cases performed at hospitals with mortality rate between the first and third quartiles was 48 per 2 years (IQR 20–69) or 24 per year (IQR 10–34.5). The median rate of home discharge was 5.36% (IQR 11.1–17.6). The median number of ST cases in hospitals within the first and third quartiles was 46 per 2 years (IQR 26.24–77) or 23 per year (IQR 13.12–38.5).

## DISCUSSION

We present several key statistics to guide accreditation standards for stroke systems of care in the USA. ST was performed at 847 centers, of which fewer than 50% were accredited or designated as comprehensive or thrombectomy-capable stroke centers. Interestingly however, the accredited centers were responsible for 72.4% of all MT cases in the USA.

Previous studies have shown that care in designated stroke centers results in a reduction in mortality.[14 15] There are few data that directly compare mortality between accredited and non-accredited centers after the institution of the thrombectomy guidelines. In our study, no significant difference in mortality or discharge disposition was seen between the accredited and non-accredited centers. Hospital ST volume alone was seen to strongly correlate with mortality and discharge disposition. We saw a 37% increase in the case volume from 2017 to 2018. This is in line with previously reported estimates and could be a result of the increasing number of ST-capable sites, better organized stroke triage mechanisms, and the expansion of clinical indications in 2018 after the publication of the Defusion-weighted imaging or CT perfusion Assessment with clinical mismatch in the triage of Wake-up and late-presenting strokes undergoing Neurointervention with Trevo (DAWN) and Endovascular Therapy Following Imaging Evaluation for Ischemic Stroke (DEFUSE) three trials.[13 16 17] In a recent analysis of Medicare data from 2016 and 2017, thrombectomy volume was found to be the most important determinant of mortality and favorable outcomes.[9] The authors of that study found that for every 10 additional procedures, patients had 4% lower adjusted odds of inpatient mortality (adjusted OR (aOR)=0.96 (95% CI 0.95 to 0.98); p<0.0001) and 3% greater adjusted odds of favorable outcome (aOR=1.03 (95% CI 1.02 to 1.04); p<0.0001).[9] Similarly, for every 10 additional hospital cases (combined cases of all the proceduralists at the hospitals), patients had 2% lower odds of inpatient mortality (aOR=0.98 (95% CI 0.98 to 0.99); p=0.0003) and 2% greater odds of favorable outcome (aOR=1.02 (95% CI 1.01 to 1.02); p<0.0001).[9] With increasing volumes, there were higher odds of favorable outcomes.[9]

A possible reason for the lack of association between accreditation and clinical outcomes is the relatively small volume of cases required to obtain accreditation. For example, the Joint Commission requires a stroke center to have performed endovascular MT on 15 patients in 1 year or 30 cases in the preceding 2 years (https://www.jointcommission.org/-/media/tjc/documents/accred-and-cert/certification/certification-by-setting/stroke/dsc-stroke-grid-comparison-chart.pdf). Additionally, the Joint Commission requires an individual neurointerventionist to have performed 15 cases per year, which may be carried out at more than one hospital or health facility. Similarly, DNV requires CSCs to have performed 25 ST procedures over 2 years. A volume of 15 thrombectomies over the initial year is regarded as adequate by DNV. There has been criticism of these numbers.[13] Fargen *et al* argued that this number is too low to maintain competency, especially as each center is likely to have two or three neurointerventionists, meaning that each operator will have performed only five cases a year or up to 10 in 2 years.[13]

In our study, the median number of cases performed at hospitals with mortality rates within the two central quartiles of the nationwide mortality rates was 24 cases per year (IQR 10 to 34.5). Similarly, the median number of MT cases performed at hospitals with home discharge rates within two central quartiles of the nationwide home discharge rate was 23 per year (IQR 13.12 to 38.5). Because this number is derived solely from CMS data, it is almost certainly an underestimation of the actual or true volume of cases being performed at those hospitals. This suggests that the actual annual case volume required to achieve median mortality rates is higher than 24 per year. The results of the study suggest that previous consensus-based recommendations of 15 cases per year for a given center may be too low.[7] Unfortunately, the optimal individual operator volume cannot be estimated from the CMS data because those data provide only aggregate case volume information. Nevertheless, it is possible to speculate that the hospital target of 24 cases and an individual volume of 15 cases per year is achievable for a center with two operators.

This is the first study that compares hospital volumes with accreditation status and identifies clear volume-related thresholds that affect discharge disposition to home and mortality. Given the limitations of these data, it may be difficult to present definitive recommendations; however, the data do suggest that the number of cases required to achieve optimal outcomes may be higher than consensus-based numbers used by the agencies to accredit stroke centers. Additional studies will be needed to better identify volume standards for individual interventionists.

## Limitations

The study has limitations. The database does not include private payer-only insurance data, which may be different with respect[5] to demographics and clinical outcomes. Also, the CMS data are excellent for assessing the outcomes for institutions but individual operator-specific information is not available. This precludes an assessment of the effect of the annual case volume of individual operators on clinical outcomes. In addition, the data were not adjusted for baseline stroke severity because the MEDPAR database does not contain information about disease severity. Therefore, it is likely that differences in stroke severity might have influenced the outcomes at individual centers. Superior outcomes at certain centers may partly be due to patient selection rather than differences in clinical expertise and system efficiency because more procedures might have been performed on patients with higher National Institutes of Health Stroke Scale scores and more comorbidities at accredited CSCs. Unfortunately, the database does not provide the stroke severity for individual patients. Additionally, there may be transport bias with more complex cases being transferred to accredited ECCs.

## CONCLUSION

This study provides critical information for policymakers, accreditation agencies, and care-giver organizations responsible for developing and approving recommendations for stroke systems of care. Nationwide registries may help to validate the findings of the current study and determine the association of individual operator ST volume with clinical outcomes.

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