Geographic dissemination of endovascular stroke thrombectomy in Catalonia within the 2011–2015 period

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Abstract

Introduction: Endovascular thrombectomy was recently established as a new standard of care in acute ischemic stroke patients with large artery occlusions. Using small area health statistics, we sought to assess dissemination of endovascular thrombectomy in Catalonia throughout the period 2011–2015.

Patients and methods: We used registry data to identify all endovascular thrombectomies for acute ischemic stroke performed in Catalonia within the study period. The SONIA registry is a government-mandated, population-based and externally audited data base that includes all reperfusion therapies for acute ischemic stroke. We linked endovascular thrombectomy cases identified in the registry with the Central Registry of the Catalan Public Health Insurance to obtain the primary care service area of residence for each treated patient, age and sex. We calculated age-sex standardized endovascular thrombectomy rates over time according to different territorial segmentation patterns (metropolitan/provincial rings and primary care service areas).

Results: Region-wide age-sex standardized endovascular thrombectomy rates increased significantly from $3.9 \times 100,000$ (95% confidence interval: 3.4–4.4) in 2011 to $6.8 \times 100,000$ (95% confidence interval: 6.2–7.6) in 2015. Such increase occurred in inner and outer metropolitan rings as well as provinces although highest endovascular thrombectomy rates were persistently seen in the inner metropolitan area. Changes in endovascular thrombectomy access across primary care service areas over time were more subtle, but there was a rather generalized increase of standardized endovascular thrombectomy rates.

Discussion: This study demonstrates temporal and territorial dissemination of access to endovascular thrombectomy in Catalonia over a 5-year period although variation remains at the completion of the study.

Conclusion: Mapping of endovascular thrombectomy is essential to assess equity and propose actions for access dissemination.

Keywords

Ischemic stroke, endovascular therapy, mechanical thrombectomy, accessibility, dissemination

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Introduction

After clear demonstration of the efficacy of endovascular thrombectomy (EVT),^{1–5} countries and regions are now compelled to deliver evidence-based care to all acute ischaemic stroke (AIS) patients including EVT for those with large vessel occlusions (LVO). This is challenging since not all hospitals involved in acute stroke care are sufficiently resourced to deliver such level of care in a timely manner. To adapt systems of acute stroke care for allowing an equitable access to EVT, health and community planners need to geographically analyse health data at the community level. Using small area health statistics, we sought to analyse geographic dissemination of EVT for stroke in Catalonia within a 5-year period (2011–2015).

Patients and methods

The region of Catalonia includes a total population of 7.5 million inhabitants distributed throughout an area of 32,000 km². The Stroke Programme of Catalonia

rolled out a Stroke Code protocol in 2006 based on 14 Primary Stroke Centres (PSC) to cover the entire region. Later on, five Comprehensive Stroke Centres (CSC) were recognised out of the initial 14 PSC to perform EVT in AIS patients. CSC are located in the metropolitan area of Barcelona where 2/3 of the Catalan population live. In 2013, the stroke network of acute hospitals was expanded by adding 12 Telestroke Centres (TSC) with capacity to deliver intravenous rtPA (IVT) in remote areas not directly covered by PSC or CSC (Figure 1). Importantly, our stroke code protocol, designed and implemented in the thrombolysis era, establishes that any patient with suspected acute stroke attended by the Emergency Medical Services must be transferred to the nearest Stroke Centre regardless of hospital type (TSC, PSC or CSC) and patient's characteristics, therefore enhancing early diagnosis and delivery of IVT. Patients with clinically suspected or radiologically confirmed LVO, who are admitted to a PSC/TSC, must be secondarily transferred to a CSC after initiating infusion of IVT to eventually determine need of EVT.

Figure 1. Geographic distribution of acute hospitals involved in the Stroke Code Network of Catalonia.

This observational study is based on data available in the SONIIA registry, a prospective, government-mandated registry of AIS patients treated with reperfusion therapies, either IVT and/or EVT. Further details of the registry have been published elsewhere.⁶ We used data from consecutive patients treated with direct EVT or combined IVT + EVT (January 2011 to December 2015). For this study, we used small-area health statistics. Each small area represents a primary care service area. Population data per age, sex and primary care service area were obtained from the central registry of the Catalan Public Health Insurance. Each patient record was linked to his primary care service area of residence and aggregated into a 17 age-sex groups of 5 years wide. The SONIIA registry satisfies all legal requirements mandated by the local law of protection of personal data.

Because we had anticipated that it would be rather difficult to visualise changes in EVT rates over time, considering a 5-year study period only, we grouped primary care service areas to produce larger geographic areas according to distance to the nearest CSC (Figure 2).⁷

The inner metropolitan ring (M0) corresponds to the area primarily covered by CSCs, reachable within <30 min (2.9 million inhabitants). The outer metropolitan rings (M1: 2.1 million inhabitants; M2: 0.7 million inhabitants) are surrounding the M0 area and are served by PSCs or TSCs. Transfer times from any M1/M2 hospital to the nearest CSC are around 60 min. The provinces (1.9 million inhabitants) are the most external layer and are served by PSCs and TSCs. Transfer times from provinces to nearest CSC are >80 min.

Crude and age-sex standardized rates by 100,000 persons were calculated in the overall population per primary care service and geographic areas (M0, M1, M2 and P) and year. To display the spread out and use of EVT within Catalonia in the 2011–2015 period, standardized rates were mapped out per year.

A Poisson loglinear model (1) was estimated to compare the EVT rate by year. Number of performed therapies added by year, age-sex group and primary care service area was used as dependent variable and number of inhabitants by year, age-sex group and

Figure 2. Segmentation of Catalonia according to geographic areas (metropolitan rings and provinces).

primary care service area was used as offset. Year was introduced in the model as a dummy variable using 2011 as reference category. Age and sex groups were used as adjusting factors.

$$\log(\mu/t) = \alpha + \beta_1 \text{sex} + \beta_2 \text{age} + \sum_{j=1}^4 (\beta_3 \text{year})_j \quad (1)$$

A second Poisson loglinear model (2) was estimated to compare the EVT rate by geographic areas. The number of therapies performed by year, age-sex group, zone and primary care service area was used as dependent variable and the number of inhabitants by year, age-sex group, zone and primary care service area was used as offset. Zone was introduced in the model as a dummy variable using M0 as reference category. Age and sex groups were used as adjusting factors.

$$\log(\mu/t) = \alpha + \beta_1 \text{sex} + \beta_2 \text{age} + \sum_{j=1}^4 (\beta_3 \text{zone})_j \quad (2)$$

In both models, the term $\log(t)$ is the offset. Parameter estimates can be interpreted as the expected increase in log count for a one-unit increase in factor. For simplicity, $\log(\mu) = \alpha + \beta X$ is equivalent to $\mu = \exp(\alpha + \beta X)$. So if $\beta = 0$, then $\exp(\beta X) = 1$, and the expected count, $\mu = E(Y) = \exp(\alpha + 0X) = \exp(\alpha)$, and Y and X are not related. Moreover, if $\beta > 0$, then $\exp(\beta) > 1$, and the expected count $\mu = E(Y)$ is $\exp(\beta)$ times larger than when $X = 0$. And if $\beta < 0$, then $\exp(\beta) < 1$, and the expected count $\mu = E(Y)$ is $\exp(\beta)$ times shorter than when $X = 0$.

The level of statistical significance was established at a two-tailed value of $p < 0.05$. All analyses were performed using R version 3.1.1 and maps using STATA version 13.

Results

Between 2011 and 2015, age-sex standardized EVT rates increased by 77% in Catalonia (Table 1). As shown by Figure 3, the highest EVT rate was seen in men of 75–80 years of age ($25 \times 100,000$) and in women aged 80–85 ($22.5 \times 100,000$). When 2011–2015 EVT rates are disaggregated by geographic areas, the M2 ring and the provinces show significantly reduced EVT rates (M2 hazard ratio (HR): 0.74, 95% confidence interval (CI): 0.59–0.93; Provinces hazard ratio (HR): 0.38, 95% CI: 0.32–0.45) pointing at an effect of distance to nearest CSCs on the likelihood to eventually get treated. Figure 4 shows the annual evolution of EVT rates by geographic areas. Among all the geographic areas, the M0, where all CSCs are located,

Table 1. Dissemination of endovascular stroke thrombectomy in Catalonia and adjusted comparison across years (2011–2015).

	Crude EVT rate $\times 100,000$ inhabitants	Standardized EVT rate $\times 100,000$ inhabitants (95% CI)	Hazard ratio	p-value
2011	3.9	3.9 (3.4–4.4)	1	–
2012	4.6	4.6 (4.1–5.1)	1.17 (0.97–1.41)	0.096
2013	3.8	3.7 (3.3–4.2)	0.95 (0.79–1.13)	0.552
2014	3.8	4.0 (3.5–4.5)	1.02 (0.84–1.25)	0.808
2015	6.7	6.8 (6.2–7.6)	1.77 (1.10–1.47)	<0.001

achieved the highest EVT rates by year with the exception of 2014. In 2013 and 2014, a clear drop of EVT rates was seen in M0, which may have been related to active recruitment of cases for the REVASCAT trial that compared EVT against best medical treatment (including IVT) in a 1:1 ratio. Mapping of EVT rates by primary care service areas from 2011 to 2015 (Figure 5) illustrates the geographic dissemination of EVT across the region.

Discussion

In Catalonia, semi-urban and rural areas are primarily covered by acute hospitals that can provide intravenous rtPA based on telestroke technology or PSCs that have a full stroke unit but not the full range of services for complex ischaemic and hemorrhagic stroke patients. CSCs are located within the city of Barcelona and the inner metropolitan ring, which are densely populated areas that account for 40% of the Catalan population. Our stroke care system was developed within the thrombolysis era as a highly decentralised model to cover the entire region of Catalonia with hospitals that offer early expert assessments and IVT. In that respect, and using small area health statistics, we could demonstrate a significant geographic dissemination of access to IVT between 2005 and 2012.⁸ The setting though changed dramatically after publication of five randomised trials in a row^{1–5} that demonstrated the benefits of EVT over medical therapy. Evidence is now pushing systems of stroke care worldwide to make organisational changes to ease access to EVT and, for that matter, mapping the real EVT activity is useful to detect geographic areas not covered by the current system of care. Therefore, in this study, we sought to analyse the degree of territorial dissemination of a new intervention for AIS (i.e. EVT) using small area health statistics and considering a 5-year span. The data show a significant increase of EVT activity between 2011 and 2015 overall and by geographic areas. Differences across geographic areas though are significant and reveal a hampered access to EVT for residents of

Figure 3. Population-based EVT rates by age groups and sex.

Figure 4. Standardized EVT rates by geographic areas and year.

Figure 5. Age-sex standardized EVT rates per 100,000 by primary care service area: 2011 to 2015 (Panels A to E).

distant areas. Remarkably, maps of EVT dissemination show a dim but obvious spreading of neurointerventionism over time that has gone beyond the limits of CSCs primary catchment areas to reach secondary and even tertiary areas.

This study is part of the “Atlas of Variations and Quality of the Catalan Healthcare System” (website: <http://aquas.gencat.cat/ca/projectes/atles-de-variacions-i-de-qualitat-del-siscat/> (accessed 2 December 2016)), a project led by the Agency for Health Quality and

Assessment of Catalonia that focuses on the evaluation of quality of healthcare services and on the study of variations in clinical practice. In 2014, the Atlas targeted the dissemination and variability of IVT in ischemic stroke between 2005 and 2012. Maps showed a significant spread of IVT to virtually cover the entire country, even though variability of standardized rates persisted.⁸ Actions and recommendations focused on strengthening education activities on stroke both at the general population level and non-expert

healthcare professionals. A more recent analysis considering the 2013–2015 period has shown a dramatic drop of IVT rates variability within the whole metropolitan area with some degree of remaining variability in the furthest provincial area (Supplemental Figure).

The main limitation of this study is the short period considered (2011–2015), which limits the likelihood of detecting significant changes. However, this period comprises both the time immediately before and after publication of trials that demonstrated efficacy of EVT and, thus, offers the possibility of analysing the impact of recent scientific evidence on geographical spread of EVT for stroke. This study has strengths too. First, it is based on prospective data of consecutive AIS patients treated with EVT. Since inclusion of cases is compulsory, the registry is regularly monitored to ensure consecutive inclusion. Undeclared cases are retrospectively included at the end of each year. Altogether, along with the fact that all hospitals with capacity to treat AIS patients in Catalonia are onboard, makes this study a population-based one and provides real-world information of current (and past) EVT rates.

Conclusion

The analysis of the territorial dissemination of an evidence-based therapy over time is mandatory for a decision-making process in health planning. To overcome the barriers imposed by the thrombolysis era, new systems of stroke care are needed that allow a much more generalized access to EVT while ensuring effectiveness. It is likely that new systems of care will reinforce the role of Emergency Medical Systems by including some kind of prehospital assessment of stroke severity as a necessary tool to triage potential EVT candidates. The RACECAT study (NCT02795962) is to determine whether potential EVT candidates, as defined by a prehospital RACE score >4 ,⁹ will benefit from bypassing the nearest TSC or PSC to be directly transferred to an EVT-capable hospital. In this scenario, access to EVT would be maximised due to direct and quicker transfers to CSC but at the expense of a reduced and/or delayed access to IVT. Be that as it may, scientific evidence will guide us to redefine future roles of TSC and PSC to offer a better care to the whole constellation of acute stroke patients.

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Declaration of Conflicting Interests

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Ethical approval and informed consent

The SONIIA registry satisfies all legal requirements mandated by the local law of protection of personal data. Inclusion of cases in the registry is mandatory since the SONIIA registry is part of a quality assessment/monitoring initiative launched by the Stroke Programme/Health Department of Catalonia.

Guarantor

SA.

Contributorship

SA and MG conceived the study. SA and CT developed the statistical plan and CT performed the data analysis. SA wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Appendix I. The Catalan Stroke Code and Reperfusion Consortium members

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