

## Rising Stroke Incidence in Young Adults: More Epidemiological Evidence, More Questions to Be Answered

Yannick Béjot, MD, PhD; Benoit Delpont, MD; Maurice Giroud, MD

The burden of stroke is extremely high. Recent estimations indicated that the global prevalence rate was 5 per 1000 person-years, corresponding to 33 million people living after a stroke. In addition, 5.9 million people suffered a stroke-related death in 2010, and stroke resulted in more than 102 million lost disability-adjusted life years (DALYs), corresponding to the sum of premature death and years of healthy life lost attributed to disability.<sup>1,2</sup> Therefore, continuous epidemiological surveillance is of a major importance so as to analyze temporal trends, establish needs with regard to implementation of dedicated services, and guide and evaluate future prevention and therapeutic priorities.

In this issue of the *Journal of the American Heart Association (JAHA)*, two articles point out the epidemiological challenge for stroke in the coming years. The first by Ramirez et al., which was based on data obtained from the US Nationwide Inpatient Sample, showed that although hospitalization rates for acute ischemic stroke decreased by 18.4% between 2000 and 2010, trends were divergent according to age categories.<sup>3</sup> Hence, the decrease observed in individuals ages 65 to 84 years (−28.5%) and 85 years and over (−22.1%) contrasted with a marked rise in individuals ages 25 to 44 years (+43.8%) and a slight increase in those ages 45 to 64 years (+4.7%). In the second article, Tibæk et al. analyzed the Danish National Patient Register to identify all cases of first-ever hospitalized stroke and transient ischemic attack (TIA) in people ages 15 to 30 years in Denmark.<sup>4</sup> They demonstrated that hospitalization rates increased by 40% for

stroke and by 3-fold for TIA between 1994 and 2012. Of note, the increase in hospitalizations for stroke was driven by a rise in hospitalization rates for ischemic stroke, which contrasted with stable rates for intracerebral hemorrhage and subarachnoid hemorrhage. In addition, this rise was particularly pronounced until 2006.

Taken together, these findings are consistent with recently published studies conducted in different areas of high-income countries. For example, in the Greater Cincinnati/Northern Kentucky region, an increase in the incidence of ischemic stroke in individuals ages 20 to 44 years between 1993 and 2005 was reported.<sup>5</sup> The Dijon Stroke Registry, a French population-based study, also found a rise in the incidence of ischemic stroke in individuals age <55 years from 8.1 in 100 000/year in 1985–1993 to 10.7 in 100 000/year in 1994–2002, and to 18.1 in 100 000/year in 2003–2011.<sup>6</sup> Similarly, analyses performed on other large administrative databases reached the same conclusions. Hence, increased hospitalization rates for stroke and TIA were observed between 2000 and 2007 in people age <65 years at a nation-wide level in France.<sup>7</sup> Moreover, a rise in the incidence of hospitalization for stroke in individuals ages 30 to 65 years old was noted in Sweden between 1989 and 1991 and 1998 and 2000.<sup>8</sup> Finally, the Nationwide Inpatient Sample also noted a rise in hospitalizations for ischemic stroke in people <45 years old between 1995 and 2008 in the United States.<sup>9</sup> It is interesting to note that when analyses were stratified by sex, consistent results between studies were found and similar trends in men and women were observed.

There is now a large amount of evidence that ischemic stroke incidence is on the rise in young adults, and the reasons for this trend are probably multiple.

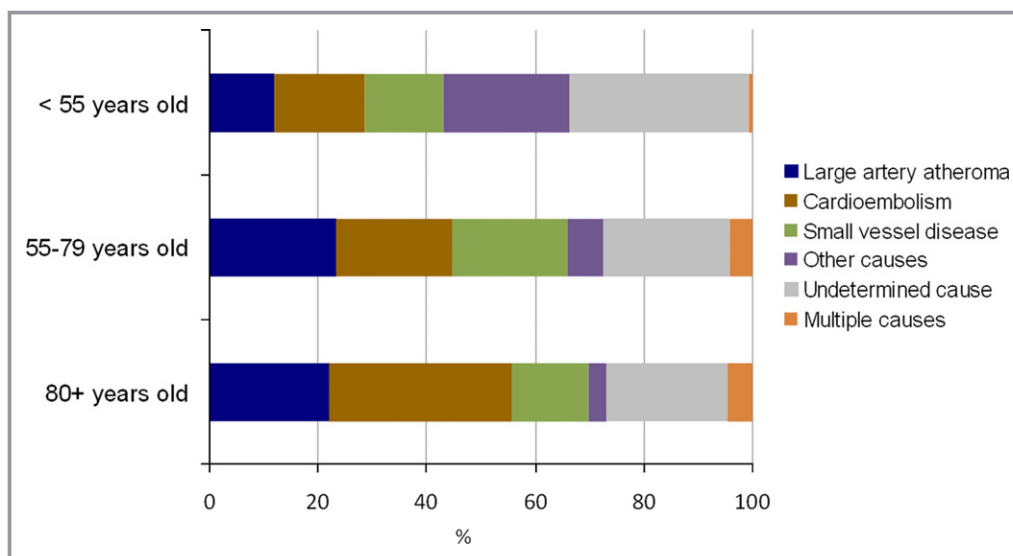
First, it cannot be excluded that the identification of stroke cases improved over time for several reasons. Attitudes of patients toward seeking medical attention or of practitioners toward referring their patients with suspected stroke to specialists may have changed. The increasing use of brain magnetic resonance imaging could have led to better stroke diagnosis, especially in patients presenting with minor or rapidly regressive symptoms. However, if the observed change was exclusively related to better capture and

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

From the Dijon Stroke Registry, EA4184 University Hospital and Medical School of Dijon, University of Burgundy, Dijon, France.

**Correspondence to:** Yannick Béjot, MD, PhD, Dijon Stroke Registry, Department of Neurology, University Hospital, Bocage Central, 14 rue Gaffarel, BP 77908, 21079 Dijon Cedex, France. E-mail: ybejot@yahoo.fr  
*J Am Heart Assoc.* 2016;5:e003661 doi: 10.1161/JAHA.116.003661.

© 2016 The Authors. Published on behalf of the American Heart Association, Inc., by Wiley Blackwell. This is an open access article under the terms of the Creative Commons Attribution-NonCommercial License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited and is not used for commercial purposes.



**Figure.** Distribution of etiological subtypes of ischemic stroke according to the TOAST classification by age group. Data from the Dijon Stroke Registry. TOAST indicates Trial of ORG 10172 in Acute Stroke Treatment.

diagnosis of stroke, there is no reason to think that the increasing incidence or hospitalization rates of stroke would only be observed in young people.

Second, trends could reflect changes in the burden of classical vascular risk factors in the young.<sup>10</sup> Indeed, a rise in the prevalence of type 2 diabetes mellitus, hypercholesterolemia, and obesity has been observed in high-income countries.<sup>11,12</sup> In addition, cigarette smoking and alcohol abuse are frequent in young people and have tended to increase over time.<sup>13–16</sup>

Last, emergent vascular risk factors may also have contributed, in part, to the increase in ischemic stroke. For example, the Greater Cincinnati/Northern Kentucky study reported a rise in the use of illicit drugs among young stroke patients between 1993 and 1994 and 2005.<sup>15</sup> Other contributing factors, such as air pollution, or modifications in life style and habits attributed to the evolution of the society, may also play a role in the rising stroke incidence in young adults and need to be explored further. Finally, despite comprehensive evaluations, the cause of ischemic stroke remains undetermined in approximately one third of young patients (Figure). This proportion is even greater in very young people: Cryptogenic strokes account for at least half of overall stroke in patients less than 30 years old.<sup>17</sup> Further studies are required to better characterize these patients so as to identify specific features and the underlying pathophysiology of these undetermined strokes.

Stroke incidence increases by a factor of 100 between the age of 40 and 80, thus explaining why only 10% of strokes occur in young people. The aging population is therefore the major contributor of the increase in the absolute number of stroke

cases in high-income countries, despite decreasing incidence in the elderly.<sup>1</sup> Any change in the incidence of ischemic stroke in young adults would have only a limited impact on the global incidence of stroke and would be masked by the heavy burden of stroke in the elderly. Nonetheless, given its major socioeconomic impact and the fact that consequences in terms of lost DALYS in young stroke victims is of a major importance, there is an urgent need to improve primary vascular prevention of ischemic stroke in young adults, based on improved and earlier information as well as education of the population. In addition, further research is needed to better understand young-onset stroke.

## Disclosures

Béjot received honoraria for participation to scientific committees or as a symposium speaker for AstraZeneca France, Daiichi-Sankyo, and MSD France. Giroud received honoraria for participation to a scientific committee for Daiichi-Sankyo. Delpont reports no conflict of interest.

## References

1. Feigin VL, Forouzanfar MH, Krishnamurthi R, Mensah GA, Connor M, Bennett DA, Moran AE, Sacco RL, Anderson L, Truelsen T, O'Donnell M, Venketasubramanian N, Barker-Collo S, Lawes CM, Wang W, Shinohara Y, Witt E, Ezzati M, Naghavi M, Murray C; Global Burden of Diseases, Injuries, and Risk Factors Study 2010 (GBD 2010) and the GBD Stroke Experts Group. Global and regional burden of stroke during 1990–2010: findings from the Global Burden of Disease Study 2010. *Lancet*. 2014;383:245–254.
2. Johnston SC, Mendis S, Mathers CD. Global variation in stroke burden and mortality: estimates from monitoring, surveillance, and modelling. *Lancet Neurol*. 2009;8:345–354.
3. Ramirez L, Kim-Tenser MA, Sanossian N, Cen S, Wen G, He S, Mack WJ, Towfighi A. Trends in acute ischemic stroke hospitalizations in the United States. *J Am Heart Assoc*. 2016;5:e003233 doi: 10.1161/JAHA.116.003233.

4. Tibæk M, Dehlendorff C, Jørgensen HS, Forchhammer HB, Johnsen SP, Kammergaard LP. Increasing incidence of hospitalization for stroke and transient ischemic attack in young adults: a registry-based study. *J Am Heart Assoc*. 2016;4:e003158 doi: 10.1161/JAHA.115.003158.
5. Kissela BM, Khoury JC, Alwell K, Moomaw CJ, Woo D, Adeoye O, Flaherty ML, Khatri P, Ferioli S, De Los Rios La Rosa F, Broderick JP, Kleindorfer DO. Age at stroke: temporal trends in stroke incidence in a large, biracial population. *Neurology*. 2012;79:1781–1787.
6. Béjot Y, Daubail B, Jacquin A, Durier J, Osseby GV, Rouaud O, Giroud M. Trends in the incidence of ischaemic stroke in young adults between 1985 and 2011: the Dijon Stroke Registry. *J Neural Neurosurg Psychiatry*. 2014;85:509–513.
7. Béjot Y, Aouba A, de Peretti C, Grimaud O, Aboa-Eboulé C, Chin F, Woimant F, Jouglu E, Giroud M. Time trends in hospital-referred stroke and transient ischaemic attack: results of a 7-year nationwide survey in France. *Cerebrovasc Dis*. 2010;30:346–354.
8. Medin J, Nordlund A, Ekberg K. Increasing stroke incidence in Sweden between 1989 and 2000 among persons aged 30 to 65 years: evidence from the Swedish Hospital Discharge Register. *Stroke*. 2004;35:1047–1051.
9. George MG, Tong X, Kuklina EV, Labarthe DR. Trends in stroke hospitalizations and associated risk factors among children and young adults, 1995–2008. *Ann Neurol*. 2011;70:713–721.
10. von Sarnowski B, Putaala J, Gröttner U, Gaertner B, Schminke U, Curtze S, Huber R, Tanislav C, Lichy C, Demarin V, Basic-Kes V, Ringelstein EB, Neumann-Haefelin T, Enzinger C, Fazekas F, Rothwell PM, Dichgans M, Jungehulsing GJ, Heuschmann PU, Kaps M, Norrving B, Rolfs A, Kessler C, Tatlisumak T; sifap1 Investigators. Lifestyle risk factors for ischemic stroke and transient ischemic attack in young adults in the Stroke in Young Fabry Patients study. *Stroke*. 2013;44:119–125.
11. Berghöfer A, Pischon T, Reinhold T, Apovian CM, Sharma AM, Willich SN. Obesity prevalence from a European perspective: a systematic review. *BMC Public Health*. 2008;8:200.
12. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care*. 2004;27:1047–1053.
13. Dube SR, McClave A, James C, Caraballo R, Kaufmann R, Pechacek T. Vital signs: current cigarette smoking among adults aged ≥18 years—United States, 2009. *MMWR Morb Mortal Wkly Rep*. 2010;59:1135–1140.
14. Kanny D, Liu Y, Brewer RD. Vital signs: binge drinking among high school students and adults—United States, 2009. *MMWR Morb Mortal Wkly Rep*. 2010;59:1–6.
15. de los Ríos F, Kleindorfer DO, Khoury J, Broderick JP, Moomaw CJ, Adeoye O, Flaherty ML, Khatri P, Woo D, Alwell K, Eilerman J, Ferioli S, Kissela BM. Trends in substance abuse preceding stroke among young adults: a population-based study. *Stroke*. 2012;43:3179–3183.
16. Kusnik-Joinville O, Weill A, Salanave B, Ricordeau P, Allemand H. Prevalence and treatment of diabetes in France: trends between 2000 and 2005. *Diabetes Metab*. 2008;34:266–272.
17. Yesilot Barlas N, Putaala J, Waje-Andreassen U, Vassilopoulou S, Nardi K, Odier C, Hofgart G, Engelter S, Burow A, Mihalka L, Kloss M, Ferrari J, Lemmens R, Coban O, Haapaniemi E, Maaijwee N, Rutten-Jacobs L, Bersano A, Cereda C, Baron P, Borellini L, Valcarengi C, Thomassen L, Grau AJ, Palm F, Urbanek C, Tuncay R, Durukan Tolvanen A, van Dijk EJ, de Leeuw FE, Thijs V, Greisenegger S, Vemmos K, Lichy C, Bereczki D, Csiba L, Michel P, Leys D, Spengos K, Naess H, Tatlisumak T, Bahar SZ. Etiology of first-ever ischaemic stroke in European young adults: the 15 cities young stroke study. *Eur J Neurol*. 2013;20:1431–1439.

---

**Key Words:** Editorials • epidemiology • incidence • stroke • young