Stroke is the leading cause of disability and the second most frequent cause of death worldwide. In France, both stroke and transient ischemic attack result in over 125,000 hospitalizations annually, and standardized mortality rates for stroke are estimated at approximately 25 to 30/100,000/year [1].

Diabetes mellitus (DM) is one of the major risk factors for stroke, as it contributes to the progression of atherothrombotic cerebrovascular lesions.

In this article, we review epidemiological data about stroke in diabetic patients by discussing: 1) the risk of stroke in individuals with diabetes, the influence of this risk and ways to reduce it; 2) the frequency of DM in stroke patients and their outcomes; 3) the role of diabetes in the occurrence of stroke subtypes; and 4) the impact of diabetes on functional outcomes and long-term outcomes in stroke patients.

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the clinical characteristics of diabetic stroke patients; and 3) the prognosis of stroke patients with DM in terms of the risk of recurrence, mortality, disability, handicap, and cognitive impairment.

2. Risk of stroke in diabetic patients

Epidemiological studies have suggested that the overall relative risk of stroke is 1.5 to 3 times greater in patients with DM than in healthy controls [2-4]. This increase in risk is particularly pronounced in younger subjects as well as in women. Hence, compared with healthy controls, the risk of developing a stroke is 2 to 3 times higher in men with DM, and 3 to 6.5 greater in women with DM [2,5,6]. In a large cohort study in the UK, which included 41,799 type 2 diabetic subjects and 202,733 controls, the absolute rate of stroke was 11.9 per 1,000 person-years in people with DM, and 5.5 per 1,000 person-years in the control group. The maximum likelihood estimate of the hazard ratio for stroke was observed in the 35-54 year age group (4.66 in men, and 8.18 in women), and the risk decreased with age [7].

The risk of stroke is also influenced by other factors such as the severity of the diabetes. The Atherosclerosis Risk in Communities (ARIC) study, which included 15,792 people aged 45-64 years at baseline, with a mean follow-up of 8-10 years, showed a robust association between diabetes-specific HbA1c tertiles and incident stroke risk, both in diabetic and non-diabetic subjects [8]. In diabetic patients, the adjusted relative risk of stroke was 2.33 (95% CI: 1.29-4.21) in the highest tertile of HbA1c (HbA1c > 6.8%) compared with the lowest one (HbA1c < 4.7%). A high level of proteinuria, defined as over 300 mg/d, is also considered an independent and strong risk factor for stroke in type 2 diabetic patients, even though no correlation between proteinuria and stroke mortality has been established yet [9].

The other classical vascular risk factors, including hypertension, dyslipidaemia, smoking and atrial fibrillation, also contribute to the increase in the stroke risk in patients with DM. Hypertension is twice as prevalent in diabetic as in non-diabetic individuals and in patients with diabetes; it is associated with accelerated progression of both microvascular and macrovascular complications, leading to a greater risk of stroke. Several randomized clinical trials have demonstrated that antihypertensive treatment dramatically reduces this risk in diabetic patients [10,11]. Therefore, in the UK Prospective Diabetes Study (UKPDS), a 10 mmHg reduction in mean systolic blood pressure was associated with a 44% reduction in stroke incidence [10]. In the secondary prevention setting, the Perindopril Protection Against Recurrent Stroke Study (PROGRESS) showed a 38% risk reduction in diabetic patients treated with the combination therapy perindopril plus indapamide [11]. A meta-analysis of 14 randomised trials on statin therapy conducted in over 18,000 diabetic patients reported a highly significant reduction in stroke risk in diabetic patients (21%; 95% CI: 7-33%); this reduction was more marked than in the non-diabetic group (16%; 95% CI: 7-24%) [12]. Finally, the cumulative effect of lifestyle risk factors, such as cigarette smoking, alcohol abuse, obesity, physical inactivity, poor diet and stress, could be greater in individuals with diabetes than in those without.

Contrasting with these data, which clearly demonstrate that the control of vascular risk factors in diabetic patients is associated with a reduction in the incidence of stroke, there is longstanding controversy about the efficacy of improving glycaemic control in the risk reduction of macrovascular complications, including stroke, in patients with DM. A recent systematic review and meta-analysis of all randomized controlled trials comparing interventions to improve glycaemic control with conventional treatment included 1800 patients with type 1 DM and 4472 patients with type 2 DM [13]. The author found clear evidence that glycaemic control is associated with a substantial decrease in macrovascular risk in diabetic patients. Interestingly, in type 1 DM, improved glycaemic control significantly reduced the risk of cardiac events and peripheral vascular disease, whereas it did not reduce the risk of stroke. In contrast, for type 2 DM, a significant 42% reduction in the risk of stroke was noted with active treatment and a similar reduction was observed for peripheral vascular disease, but not for cardiac events [13].

3. Prevalence of diabetes mellitus in stroke patients

DM is a frequent condition in stroke patients. Population-based registries of stroke have reported a global prevalence of DM ranging from 9.5% to 20% [14-16]. In France, based on the national database called “Hospital Discharge Diagnosis Records” (Programme de Médicalisation des Systèmes d’Information, PMSI), the prevalence of diabetes among all hospitalized patients from 2005 through 2008 with a diagnosis of stroke has been estimated at 15% (unpublished data). In addition, in a recent study 16% to 24% of patients with undiagnosed DM at admission for acute stroke were found to have DM according to an oral glucose tolerance test performed 12 weeks after the stroke [17]. The prevalence varied greatly according to the subtype of stroke considered. Hence, the prevalence of DM is lower in patients suffering from spontaneous intracerebral haemorrhage than in those with ischemic stroke. In the latter group, the prevalence is around 25% [18-22]. However, some variations have been noted according to the etiological subtype of ischemic stroke (lacunar, cardioembolic, or large vessel ischemic stroke). Several studies, most of which were hospital-based, have suggested that lacunar stroke is associated with a particular risk factor profile characterized by a higher frequency of hypertension and DM, both of which contribute to the development of lipohyalinosis involved in small vessel brain disease [23,24]. Contrasting with these results, in a previous study conducted on the population-based stroke registry of Dijon, France, we reported a DM prevalence of 19.1% in lacunar strokes, 21.9% in large vessel strokes, and 13.6% in cardioembolic
strokes [25]. After multivariate regression analysis, this study, like other population-based studies, did not find an association between DM and a particular ischemic stroke subtype, including lacunar stroke [24-26]. In a systematic review of 28 studies comparing the risk factor profiles of lacunar and non-lacunar infarcts, the authors found that the apparent excess of diabetes in lacunar versus non-lacunar stroke was encountered only in studies that applied a classification of stroke subtypes in which diabetes and other risk factors were used to classify patients [24]. Conversely, among studies with a risk-factor-free classification, there was no difference in the prevalence of diabetes in lacunar versus non-lacunar infarction (pooled RR 0.95; 95% CI: 0.83-1.09). Therefore, the authors concluded that the controversial assertion that diabetes, as well as hypertension, are particularly associated with lacunar stroke may arise almost entirely from classification bias [24]. Finally, clinically silent infarcts, infratentorial infarcts, as well as cerebellar infarcts have been reported to be more common in diabetic patients [27].

Few data about temporal trends in the prevalence of prior-to-stroke DM are available. Whereas a stable prevalence of approximately 10% was observed in Oxford, UK between the study periods 1981-1984 and 2002-2004, a significant increase was noted in Auckland, NZ between 1981-1982 and 2002-2003 (from 10% to 17.4%, p < 0.001) [15, 16]. In Dijon, where the assessment of stroke has been continuous since 1985, the prevalence of prior-to-stroke DM rose from 10.4% to 17.5%, with an odds-ratio adjusted for age and sex of 1.04 (95% CI: 1.03-1.06, p < 0.01) [18]. Similarly, in the Framingham Heart Study the proportion of cardiovascular disease, including stroke, attributable to DM increased from 5.4% to 8.7% between 1952 and 1998 [28]. These results are probably related to a rising prevalence of DM in the general population, probably in response to increasing rates of overweight and obesity, and other factors such as a sedentary lifestyle [29].

4. Prognosis of diabetic stroke patients

Several studies have suggested that diabetic patients suffering from stroke have a poorer prognosis than non-diabetic patients. In the FINSTROKE study that recorded 4390 patients with ischemic stroke, 25.1% of whom were diabetic, the four-week case fatality was significantly higher in patients with DM than in those without (20.0% versus 16.9%, p = 0.020) [30]. In this period after stroke onset, diabetic patients were also more likely to be disabled (43.3% versus 33.5%, p < 0.001). In addition, in this study, as in others, after adjustment for other cardiovascular risk factors, diabetes was positively and independently associated with both disability and a fatal outcome after the stroke event [30, 31]. In the UKPDS trial, the level of HbA1C in patients with type 2 DM was shown to correlate with stroke fatality, as were several other factors such as sex, systolic blood pressure, recurrent stroke or white cell count [32]. Hence, each 1% increase in HbA1C was associated with a 37% rise in stroke case fatality. In the Malmö Stroke Registry, DM was associated with both mortality and recurrence rates of stroke after 3 years of follow-up [33]. Nevertheless, other authors found no differences between patients with and without diabetes in terms of mortality one year after ischemic stroke [3].

Similarly, some studies have demonstrated that DM influences the long-term functional outcome after stroke. Hence, the European BIOMED Stroke Project reported in a sample of 4537 patients from 7 European countries that handicap (OR = 1.47; 95% CI: 1.13-1.91; p = 0.005) and disability (OR = 1.39; 95% CI: 1.05-1.83; p = 0.016) were significantly higher in diabetic than in non-diabetic patients at 3 months from onset, whereas no significant difference was noted for mortality [34]. However, other studies found no influence of DM on motor and functional outcomes in the acute and post-acute phases after stroke [35,36].

Finally, the cognitive status of stroke patients also appears to be influenced by DM. In a recent meta-analysis, Pendlebury and Rothwell showed that diabetes was a strong predictor of post-stroke dementia with an odds-ratio of 1.4 (95% CI: 1.2-1.7, p < 0.0001) [37].

5. Conclusion

Patients with DM are at a higher risk of stroke than those without, but glycaemic control and the treatment of comorbid conditions such as hypertension and hypercholesterolemia can markedly decrease this risk. Although diabetes is frequent in ischemic stroke patients, it does not predict the etiological subtype of the ischemic stroke. Finally, diabetic stroke patients are characterized by poorer functional outcomes and a greater risk of death. These data, associated with the rising prevalence and incidence of DM in western countries, underline the need for particular attention to be paid to this vascular risk factor.

6. Conflicts of interest

None related to the content of this article.

References


