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Original Article

Changes in ischemic stroke occurrence following daylight saving time transitions

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ABSTRACT

Background: Circadian rhythm disruption has been associated with increased risk of ischemic stroke (IS). Daylight saving time (DST) transitions disrupt circadian rhythms and shifts the pattern of diurnal variation in stroke onset, but effects on the incidence of IS are unknown.
Methods: Effects of 2004–2013 DST transitions on IS hospitalizations and in-hospital mortality were studied nationwide in Finland. Hospitalizations during the week following DST transition (study group, n = 3033) were compared to expected hospitalizations (control group, n = 11,801), calculated as the mean occurrence during two weeks prior to and two weeks after the index week.
Results: Hospitalizations for IS increased during the first two days (Relative Risk 1.08; CI 1.01–1.15, P = 0.020) after transition, but difference was diluted when observing the whole week (RR 1.03; 0.99–1.06; P = 0.069). Weekday-specific increase was observed on the second day (Monday; RR 1.09; CI 1.00–1.90; P = 0.023) and fifth day (Thursday; RR 1.11; CI 1.01–1.21; P = 0.016) after transition. Women were more susceptible than men to temporal changes during the week after DST transitions. Advanced age (>65 years) (RR 1.20; CI 1.04–1.38; P = 0.020) was associated with increased risk during the first two days, and malignancy (RR 1.25; CI 1.00–1.56; P = 0.047) during the week after DST transition.
Conclusions: DST transitions appear to be associated with an increase in IS hospitalizations during the first two days after transitions but not during the entire following week. Susceptibility to effects of DST transitions on occurrence of ischemic stroke may be modulated by gender, age and malignant comorbidities.

1. Introduction

Ischemic stroke (IS) is the second leading cause of death worldwide and a significant source of disability. Despite advances in primary prevention and treatment of IS, as reflected by decreases in age-standardized incidence and case-fatality during recent decades [1,2], the absolute number of IS victims continues to increase because of population growth and aging [3]. Traditional vascular risk factors have become better controlled in high-income countries but further efforts are still needed [4,5]. New ways of preventing cerebrovascular disease and IS should also be sought.

Similar to myocardial infarction (MI), IS shows a clear circadian rhythmicity with peaking incidence in the morning hours [6,7], and even the safety and efficacy of thrombolytic therapy for non-lacunar IS has been reported as being associated with circadian factors [8]. Occurrence of MI has been affected by transitions to and from daylight saving time (DST) [9–14], which disrupt circadian rhythms and beget sleep deprivation [15]. Circadian disruption associated with rotating night shift work [16] as well as aberrant sleep duration [17,18] have been associated with increased risk of IS. DST transitions shift the pattern of diurnal variation in stroke onset [7]. Effects of DST transitions to stroke incidence and severity are however unknown. Therefore, we studied the effects of DST

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transitions on stroke hospitalizations and in-hospital mortality in a multihospital, nationwide setting.

2. Methods

2.1. Study patients

We studied all patients aged ≥15 years admitted to participating hospitals with IS as the primary discharge diagnosis (ICD-10 code I63) during 2004–2013. Patients admitted two weeks prior and three weeks after DST transition were included in the current study (see exceptions caused by Easter below). Data were collected from the 20 hospitals that provide care for patients with acute IS in Finland by using the Finnish Care Register for Health Care (CRHC), an obligatory, nationwide, and automatically collected database. This database covers virtually all acute stroke hospitalizations in Finland, whose population grew from 5.2 to 5.4 million during the study period. The manuscript does not contain clinical studies and involved no contact with patients. Therefore no approval of an ethics committee was needed. Anonymous patient data were collected retrospectively from patient records with the approval of the National Institute of Health and Welfare (permission THL/143/5.05.00/2015).

2.2. Analysis

Association between IS and DST transitions was measured by calculating relative risks (RR) of observed hospitalizations following DST transition (study group) to expected hospitalization (control group) calculated as the mean occurrence during control weeks prior to DST and two weeks after DST transition. Hospitalizations following DST transition were analyzed during first two and seven days after transition as well as by weekdays. In Finland, DST starts on the last Sunday of March and ends on the last Sunday of October. Since the Monday following Easter Sunday is a national holiday in Finland, years with DST spring transition on Easter Sunday were excluded from the analysis (2005 and 2013) to avoid confounding. In addition, occurrence of Easter Sunday within two weeks prior or after DST transition was adjusted by not including the week following Easter as control, but selecting the prior or following week. Shortening of Sunday after transition into DST was adjusted with multiplying the number of IS hospitalizations by 24/23, and lengthening of Sunday after transition out of DST with multiplying by 24/25 [9,10]. Confidence intervals (95%) (CI) were calculated by using SAS CINV function and tested as previously described [19] with Bonferroni corrections applied as appropriate.

Modified Poisson regression with robust error variances was used to analyze associations of patient features and IS occurring during the week after DST transition. Models were adjusted for study year and spring/autumn period [20,21]. In-hospital mortality was analyzed using Cox's proportional hazards regression stratified for study year. Variable selection to Cox's regression model was performed by using augmented backwards elimination procedure with significance threshold $\alpha = 0.2$ and change-in-estimate threshold $\tau = 0.05$ [22]. Age, gender and occurrence of IS during seven days after DST transition were forced into the Cox's model. Results of regression analyses are given as RR or hazard ratio (HR) as appropriate. Statistical significance was inferred at $P < 0.05$. SAS for windows v. 9.4. was used for analyses (SAS Institute, Cary, NC, USA).

3. Results

Total study population included 14,834 patients with IS (age 71.3; SD 12.7; 54.2% men) of whom 3033 (20.5%) were admitted during seven days following DST transition and 11,801 (79.6%) during control weeks. DST transition was followed by an increase in IS hospitalizations during the first two days (RR 1.08; CI 1.01–1.15, P = 0.020) after transition. When observing the whole week after transition, trend for increase persisted but was not statistically significant (RR 1.03; 0.99–1.06; P = 0.069). A weekday-specific increase in hospitalizations was observed on the second day (Monday; RR 1.09; CI 1.00–1.90; P = 0.023) and fifth day (Thursday; RR 1.11; CI 1.01–1.21; P = 0.016) after transition (Fig. 1). Of all study patients, 6464 (43.6%) were admitted in spring and 8370 (56.4%) in autumn. There were no weekday-specific differences in relative risk of IS after DST transitions between spring and autumn periods, nor were the differences during the first two (RR 1.07; CI 0.95–1.21; P = 0.552) or seven days (RR 0.99; CI 0.95–1.06; P = 0.757) after transition (Fig. 2).

Women were more susceptible to temporal changes after DST transitions compared to men (Fig. 3); relative risk of IS was higher among women on the second day after DST (RR 1.18; CI 1.02–1.38; P = 0.031), but lower on the sixth day after transition (RR 0.83; CI 0.69–1.00; P = 0.045). Relative risk for IS between genders did not differ during the whole week after transition (RR 1.02; CI 0.95–1.08; P = 0.625).

Variation in risk of IS was detected also with regard to age. Older patients (>65 years of age) had higher risk of IS than younger patients on the second day (RR 1.23; CI 1.03–1.47; P = 0.021) as well as on the first two days (RR 1.20; CI 1.04–1.38; P = 0.020) after DST transition (Fig. 4), but risk during the whole week after transition was similar to that in younger patients (RR 1.02; CI 0.95–1.10; P = 0.580).

Co-morbidity distribution of IS patients did not differ between patients admitted during the week after DST transition or the control weeks, with the exception of malignancy that was more common in IS patients during the week after DST transition (Table 1). Use of thrombolysis or duration of hospital admissions were not altered by DST transition. In-hospital mortality was 3.1% in the total study population. Daylight saving time transition did not affect in-hospital mortality in univariate (HR 1.02; CI 0.82–1.28; P = 0.848) or multivariate model (HR 1.02; CI 0.81–1.28; P = 0.870).

Increasing age, spring period, malignancy, atrial fibrillation and heart failure/cardiomyopathy were associated with increased mortality (Table 2).

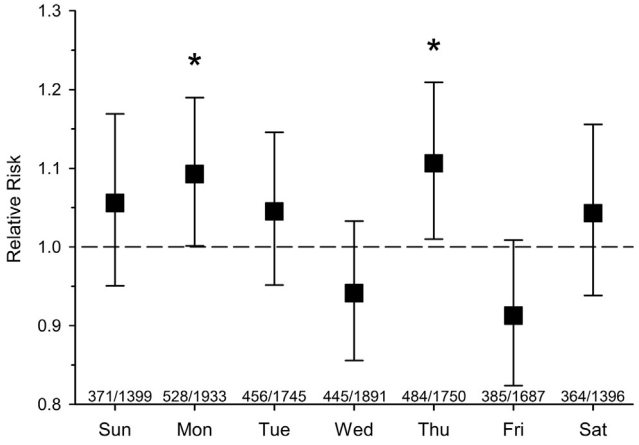

Fig. 1. Overall occurrence of ischemic stroke hospitalizations after DST transitions. Relative risk of ischemic stroke hospitalizations in the week following daylight savings time transition compared to control weeks. Both spring and autumn transitions are included. The total number of hospitalizations for each day during the study weeks and the control weeks is presented above the horizontal axis. Error bars represent 95% confidence interval. * = P < 0.05.