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Socioeconomic status influences time to surgery and surgical outcome in pediatric epilepsy surgery

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ABSTRACT

The aims of this study were to evaluate the influence of socioeconomic status (SES) on time-to-surgery (TTS) and surgical outcome in children with treatment-resistant epilepsy in a universal health care system. The cohort consisted of children who had undergone resective epilepsy surgery between 2001 and 2013 in Canada. The patients' postal codes were linked to Statistics Canada National Household Survey data to obtain dissemination area income, which was used to infer SES. Time-to-surgery was defined as the interval from date of epilepsy onset to date of surgery. Seizure outcome was classified using ILAE classification. The associations between SES and TTS, as well as SES and surgical outcome, were assessed. Two hundred eighty-four children who had epilepsy surgery were included. Patients in the lowest income quintile had a significantly higher TTS relative to the highest income quintile ($\beta = 0.121$, $p = 0.044$). There were no significant associations between income quintiles and seizure-free surgical outcome (odds ratio (OR) = 0.746–1.494, all $p > 0.05$). However, patients in the lowest income quintile had a significantly lower odds of an improvement in seizure frequency relative to the highest income quintile (OR = 0.262, $p = 0.046$). The TTS was not uniform across SES in spite of the existence of a universal health care system. This finding highlights the need to address social and economic barriers for epilepsy surgery to improve access to this potentially curative treatment. Those with lower SES had lower likelihood of improvement in seizure control following epilepsy surgery and may require additional support including social and financial support to mitigate the discrepancies in seizure control following surgery between SES levels.

1. Introduction

Treatment-resistant epilepsy in children may be associated with neurodevelopmental, cognitive, academic, behavioral, and social problems [1–3]. In selected patients with treatment-resistant epilepsy, epilepsy surgery offers the potential for seizure cure. Despite the mounting evidence supporting the effectiveness of epilepsy surgery in children [4,5], surgery remains an underutilized treatment [6–8], with less than 2% referral rates for evaluation of epilepsy surgery in children [9]. The problem of underutilization of pediatric epilepsy surgery is compounded by long seizure duration of 4.2 years or greater preceding epilepsy surgery [4,5,10,11]. Timely resective epilepsy surgery may be crucial in mitigating the potential detrimental developmental and cognitive consequences of epilepsy [12–16].

Nonclinical factors including insurance status and socioeconomic factors have been shown to affect time-to-surgery (TTS) in a mixed private and public insurance health system [10,17,18]. It is assumed that in a universal health insurance system which provides a comprehensive coverage for medically necessary hospital and physician services without user fees, with the exception of outpatient prescription medications and home care, there would be no disparity in access to epilepsy surgery care. However, there are some suggestions that socioeconomic status (SES) may affect health resource utilization in patients with epilepsy in a universal health insurance system such as in Canada [19]. To uncover the influence of SES on access to epilepsy surgery and surgical outcomes, we studied a large cohort of children who have undergone resective epilepsy surgery within a universal health insurance system. The aims of this study were to evaluate whether SES influences TTS and epilepsy surgery outcome.

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2. Materials and methods

The study sample was derived from children who had epilepsy surgery from January 1st, 2001 to December 31st, 2013 at the Hospital for Sick Children. Inclusion criteria were children aged 0 to 18 years who have undergone resective epilepsy surgery, with or without invasive monitoring. Exclusion criteria were children who underwent nonresective epilepsy surgeries, such as corpus callosotomy or vagal nerve stimulator insertion, or invasive monitoring without surgical resection.

2.1. Clinical data collection

The demographics, postal code, age at seizure onset, IQ, seizure type, and number of antiseizure medications at the time of presurgical evaluation, as well as seizure frequency before and after surgery, were extracted from the electronic patient charts. Time-to-surgery was defined as the interval from date of epilepsy onset to date of resective surgery. Surgery-related data that were extracted included date of epilepsy surgery, type of surgery (focal/lobar resection, multilobar resection, or hemispherectomy), location of surgery (temporal, extratemporal, or both), whether invasive monitoring was performed, and histology.

2.2. Socioeconomic status and residence location

Socioeconomic status was inferred from dissemination area income levels by linking the patients' postal codes with Statistics Canada National Household Survey (NHS) data, using the 2011 Postal Code Conversion File published by Statistics Canada [20]. Dissemination area is the smallest geographic unit from Census Canada comprising of a population between 400 and 700 people. Dissemination area income levels are based on the median income per single-person equivalent in a dissemination area obtained from the 2011 census [21]. If the survey response rates from the dissemination areas were too low, the median income per single-person equivalent was not published by Statistics Canada. To generate income quintiles, the dissemination area income levels were ranked and assigned to one of five groups (approximately 20% of the population in each group) ranked from lowest (income quintile 1) to highest (income quintile 5).

Residence location was categorized as rural area, small population center (1000 to 29,999 people), medium population center (30,000 to 99,999 people), and large urban population center (over 100,000 people) defined using the patient's postal code and Statistics Canada Census data from 2011.

2.3. Epilepsy surgery outcome

Seizure outcome was classified using ILAE classification [22]: ILAE I is defined as completely seizure-free with no auras; ILAE II is auras only with no seizures; ILAE III is one to three seizure days per year ± auras; ILAE IV is four seizure days per year to 50% reduction of baseline seizure days ± auras; ILAE V is less than 50% reduction of baseline seizure days to 100% increase of baseline seizure days ± auras; and ILAE VI is more than 100% increase of baseline seizure days ± auras. Seizure outcome at one year after surgery was categorized in two ways: as seizure-free (ILAE I) versus persistent seizures (ILAE II-VI), and as improvement (ILAE I–IV) versus no improvement (ILAE V–VI) in seizure control.

2.4. Statistical analyses

Analyses were done using IBM SPSS Statistics version 20.0 (IBM Corp. Armonk, NY, U.S.A.). The baseline characteristics were compared across the income quintiles using analysis of variance (ANOVA) for continuous variables and χ^2 test for categorical variables. Linear regression was done to assess the relation between income quintiles and TTS, first using univariate regression, followed by multivariate regression, adjusting for age at surgery, sex, residence location, seizure frequency, and number of antiseizure medications. We have not adjusted for race as this variable was not available in the patients' charts. Logistic regression was done to evaluate the relation between SES and seizure-free surgical outcome, first using univariate regression, followed by multivariate regression, adjusting for age at seizure onset, type of surgery, location of surgery, invasive monitoring, and histology, as these factors have been shown to affect seizure outcome [4,5,23–25]. We have not adjusted for infantile spasm, as patients with infantile spasm present in infancy, and we have adjusted for age at seizure onset. Logistic regression was also done to evaluate the relation between SES and improvement in seizure control following surgery, first using univariate, followed by multivariate regression, adjusting for age at seizure onset, type of surgery, location of surgery, invasive monitoring, and histology. This study had the approval of the institutional research ethics board.

3. Results

There were 327 children who had undergone resective epilepsy surgery from January 1st, 2001 to December 31st, 2013. In 23 patients, the data on median income per single-person equivalent were not available from Statistics Canada because of poor survey response rates from the dissemination areas. Two patients had international residences, and therefore, their SES could not be assessed. Sixteen patients were lost to follow-up. There were two deaths; one patient died a day after surgery from cerebral edema, and the other patient had sudden unexplained death six months after surgery.

The final cohort consisted of 284 Canadian patients, with 8 residing outside the province of Ontario. The baseline characteristics and surgical variables of this cohort are shown in Table 1. The mean age at surgery was 10.57 ± 5.29 years, and there were 123 (43%) females. One hundred ninety-nine (70.1%) patients were on two or more antiseizure medications, 84 (29.6%) patients were on one antiseizure medication, and one (0.3%) patient was on one antiseizure medication but had ceased taking the medication a few weeks before surgery. There were no significant differences in age at surgery, sex, baseline IQ, number of antiseizure medications, seizure frequency, and types of seizure across the income quintiles (all $p > 0.05$). Age at seizure onset varied across income quintiles ($p = 0.022$), being lowest for the lowest income quintile (quintile 1) (4.10 ± 4.12 years) and greatest for income quintile 4 (6.99 ± 4.77 years).

There were also no significant differences in the side of surgery, operative location, operation type, surgical complications, and histology across the income quintiles (all $p > 0.05$). Invasive monitoring was done in 111 (39.1%) patients and varied across income quintiles ($p = 0.019$), highest in income quintile 3 and lowest in income quintile 2.

3.1. Relation between income quintiles and time to surgery

Time-to-surgery varied from 0.01 to 18.84 years across the study sample, with a mean TTS of 5.60 ± 4.66 years. Patients in the lowest income quintile had the highest mean TTS (6.52 ± 4.92 year), and those with the highest income quintile had the lowest mean TTS (4.65 ± 4.16 years) (Fig. 1).

The relation between income quintile and TTS is shown in Table 2. Patients in the lowest income quintile had a significantly higher TTS relative to the highest income quintile ($\beta = 0.160$, $p = 0.033$) in the unadjusted model, and this association remained significant ($\beta = 0.121$, $p = 0.044$) after adjusting for age at surgery, sex, number of antiseizure medications, residence location, and preoperative seizure frequency. Patients in the middle income quintile also had a significantly higher TTS relative to the highest income quintile ($\beta = 0.149$, $p = 0.047$) in the unadjusted model; however, the association was not significant ($\beta = 0.035$, $p = 0.568$) in the multivariate model.