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Association between telemedicine and incidence of status epilepticus during the COVID-19 pandemic

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ABSTRACT

Objective: We aimed to investigate the association between telemedicine and the incidence of status epilepticus (SE) in patients with epilepsy (PWE) during the coronavirus disease 2019 (COVID-19) pandemic using a large population database in the United States.
Methods: We performed a retrospective analysis of a private, cloud-based healthcare platform (Explorys Inc., Cleveland, Ohio, USA). We compared each of the previously reported risk factors for SE, such as child, male, and refractory epilepsy, using the chi-square test or Fisher's exact test in two groups: PWE with SE or without SE. We determined whether telemedicine could be a risk factor for the incidence of SE using multivariate binary logistic regression analysis incorporating statistically significant variables in the chi-square test or Fisher's exact test ($p < 0.05$). Statistical significance was set at $p < 0.05$.
Results: We identified 1600 PWE with SE and 61,700 PWE without SE from May 2020 to May 2021. The proportion of children, males, refractory epilepsy, and telemedicine was higher in PWE with SE than in PWE without SE (children: 21.9% vs. 17.7%, $p < 0.001$; male: 52.5% vs. 48.2%, $p = 0.001$; refractory epilepsy: 20.6% vs. 8.2%, $p < 0.001$; telemedicine: 42.5% vs. 23.6%, $p < 0.001$). The multivariate binary logistic regression model identified four significant variables as follows: child (odds ratio [OR], 1.32; 95% confidence interval [CI], 1.17–1.50), male (OR, 1.19; 95% CI, 1.07–1.31), refractory epilepsy (OR, 2.44; 95% CI, 2.15–2.77), and telemedicine (OR, 2.29; 95% CI, 2.07–2.54).
Conclusion: Telemedicine might be associated with an increased risk of SE in PWE during the COVID-19 pandemic.

1. Introduction

Telemedicine is the delivery of healthcare services to improve patient outcomes using information and communication technologies [1]. Telemedicine has many advantages, such as saving travel time and money and eliminating access restrictions in medically underserved areas [2–4]. Telemedicine has rapidly become available in epilepsy care since 2019 to prevent the spread of coronavirus disease 2019 (COVID-19) due to its advantage of reducing the risk of severe acute respiratory syndrome coronavirus 2 infection during the COVID-19 pandemic [4–7]. Most patients, caregivers, and physicians in epilepsy care were highly satisfied with telemedicine during the COVID-19 pandemic [5,6,8]. However, telemedicine would have difficulty in making an accurate diagnosis, determining the side effects of medications, and performing physical examinations [2].

Status epilepticus (SE) is the most severe type of seizure and epilepsy-related and neurological emergency [9]. SE causes many complications and a poor prognosis [10,11]. It is important for physicians to control seizures in patients with epilepsy (PWE) to prevent them from developing SE. Some risk factors for SE, including younger age, sex, low blood levels of antiepileptic drugs, and refractory epilepsy, have been reported [11-13]. Understanding whether telemedicine during the COVID-19 pandemic impacted the incidence of SE is important for the further promotion of telemedicine.

However, epidemiological data are not available to evaluate the association between telemedicine and the incidence of SE during the COVID-19 pandemic. Therefore, our objective was to investigate the association between telemedicine and the incidence of

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SE in PWE during the COVID-19 pandemic using a large population database in the United States.

2. Methods

2.1. Database and patient selection

We performed a retrospective analysis of a private, cloud-based healthcare platform (Explorys Inc., Cleveland, Ohio, USA) [14]. This database consists of 26 leading healthcare networks containing 360 hospitals, over 920,000 providers, and 64 million unique patient records for both inpatient and outpatient settings. The Explorys dataset covers approximately 15% of the entire population in the United States. Explorys is composed of deidentified patient data extracted from electronic health records, billing, and laboratory systems. This information was obtained from each participating healthcare institution. The data were automatically updated weekly. To normalize and standardize the data, the system uses systemized nomenclature of medicine-clinical terms (SNOMED-CT), medical subject headings, Logical Observation Identifiers Names and Codes, and RxNorm. We extracted previously reported risk factors for SE, including child, sex, and refractory epilepsy, in addition to telemedicine [11–13]. For example, patient characteristics were identified using the following terms: "diagnosis: epilepsy," "diagnosis: status epilepticus," "encounter: telemedicine," "demographic: junior," "demographic: male," "diagnosis: refractory epilepsy," and "diagnosis: status epilepticus," respectively. The data on the number of telemedicine appointments are not available.

In this study, we included the PWE from May 2020 to May 2021, and the extracted cohort was divided into two groups: PWE with the code of "diagnosis: status epilepticus." This study was exempted from Institutional Review Board approval because the extracted dataset from Explorys was already organized as deidentified patient data beforehand. This platform has been validated in many medical fields [15,16].

2.2. Statistical analysis

We report the descriptive characteristics of PWE with and without SE. We compared each variable using the chi-square test or Fisher's exact test in two groups: PWE with SE or without SE. Statistically significant variables in the chi-square test or Fisher's exact test ($p < 0.05$) were analyzed using a multivariate binary logistic regression model to determine factors independently associated with SE. A p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed using the free software environment R version 4.0.5 (R Development Core Team 2021).

3. Results

Table 1 presents the baseline characteristics of the study population. We identified 1600 PWE with SE and 61,700 PWE without SE from May 2020 to May 2021. The proportion of children, males, refractory epilepsy, and telemedicine was higher in PWE with SE than in PWE without SE (children: 21.9% vs. 17.7%, $p < 0.001$; male: 52.5% vs. 48.2%, $p = 0.001$; refractory epilepsy: 20.6% vs. 8.2%, $p < 0.001$; telemedicine: 42.5% vs. 23.6%, $p < 0.001$).

The multivariate binary logistic regression model determined four statistically significant variables as follows (Table 2): child (odds ratio [OR], 1.32; 95% confidence interval [CI], 1.17–1.50), male (OR, 1.19; 95% CI, 1.07–1.31), refractory epilepsy (OR, 2.44; 95% CI, 2.15–2.77), and telemedicine (OR, 2.29; 95% CI, 2.07–2.54).

4. Discussion

In this study, using a large nationwide database, we have shown the association between telemedicine and the incidence of SE during the COVID-19 pandemic. We found that telemedicine might be associated with an increased risk of SE in PWE during the pandemic, independent of other known risk factors.

Our results are not consistent with previous studies that found the safety and efficacy of telemedicine for the treatment of PWE before the pandemic [17,18]. A prospective randomized parallel group study showed that the mean number of breakthrough seizures per patient was similar between 210 in-person visits and 219 telemedicine visits [18]. A retrospective cohort study of 155 patients showed no statistical differences between the in-person/telemedicine clinic and the number of seizures, emergency room visits, and hospitalizations [17]. Meanwhile, similar to previous studies, children and refractory epilepsy were also independent risk factors for the development of SE even during the pandemic [11,13]. The increase in SE in the telemedicine group may be because many hospitals or clinics suddenly shifted to telemedicine during the COVID-19 pandemic without an adequate system and support for telemedicine in place. Patients may also have been forced to use telemedicine without adequate preparation of devices and applications. Alternatively, our results may be because we were not able to adjust for socioeconomic status and other factors related to the COVID-19 pandemic involved in telemedicine.

Our study had several strengths. First, although there are various studies on telemedicine for epilepsy care during the COVID-19 pandemic, most of them are questionnaire surveys or have small samples [4-6]. Our study is a large cohort study in the United States, where COVID-19 was the most prevalent worldwide from May 2020 to May 2021 [19]. Second, no previous study has directly compared seizure control between telemedicine visits and no telemedicine visits during the COVID-19 pandemic [4-7]. This study directly investigated the impact of telemedicine on SE by adjusting for SE risk factors.

Telemedicine will be safe and effective if we improve the system and support for telemedicine during the prolonged COVID-19 pandemic. Previous studies before the COVID-19 pandemic have proven the safety and efficacy of telemedicine in epilepsy care [17,18]. Telemedicine is safe and effective unless there is an emergency situation during the COVID-19 pandemic. It is necessary to investigate the problems of telemedicine in epilepsy care during the COVID-19 pandemic and develop plans for improvement.

Table 1
Characteristics of patients.

	Total $n = 63,300$ (%)	SE $n = 1600$ (%)	No SE $n = 61,700$ (%)	p-value
Children	11,300 (17.9)	350 (21.9)	10,950 (17.7)	<0.001
Male	30,570 (48.5)	840 (52.5)	29,730 (48.2)	0.001
Refractory epilepsy	5390 (8.6)	330 (20.6)	5060 (8.2)	<0.001
Telemedicine	15,270 (24.5)	680 (42.5)	14,590 (23.6)	<0.001

SE, status epilepticus; n, number of patients.

Table 2
Multivariate binary logistic regression analysis.

	OR (95% CI)	*p*-value
Child	1.32 (1.17–1.50)	<0.001
Male	1.19 (1.07–1.31)	<0.001
Refractory epilepsy	2.44 (2.15–2.77)	<0.001
Telemedicine	2.29 (2.07–2.54)	<0.001

CI, confidence interval; OR, odds ratio.

This study had several limitations. First, due to the rapid popularity of telemedicine, some cases may not have been able to be coded. Second, due to the nature of the database, we were unable to include many other factors (such as, race, insurance, etiology, anti-seizure medication, or duration of epilepsy) in the multivariate logistic regression analysis, although we included factors known to be risk factors for SE in previous studies. Third, the data on the number of telemedicine appointments are not available. Although the frequency of telemedicine visits during the study period may change the risk of SE, it has not been evaluated. Fourth, this database is based on data from 26 leading healthcare networks. This indicates that many hospitals that treat patients with more severe or complex conditions are registered in the database. In that case, the database may not necessarily reflect the parent population, which could be a selection bias in this study.

5. Conclusions

In this study, using a large nationwide database, we investigated the association between telemedicine and SE during the COVID-19 pandemic. Telemedicine might be associated with an increased risk of SE in PWE during the COVID-19 pandemic. Although telemedicine has many advantages and is recommended during the COVID-19 pandemic, it might be necessary to investigate the problems of telemedicine in epilepsy care during the COVID-19 pandemic and devise plans for improvement. Further studies are warranted to validate these results.

Funding

Not applicable.

Ethics approval

Waived because of the deidentified patient data beforehand.

Consent for publication

All authors approved the publication of this article. Consent from patients was waived because this article did not include personal details that allow patient identification.

Availability of data and materials

Data will be made available on reasonable request.

Authors' contributions

Takafumi Kubota and Naoto Kuroda contributed to the conception and design of the study. Takafumi Kubota and Naoto Kuroda analyzed the data. Takafumi Kubota drafted the manuscript. Takafumi Kubota and Naoto Kuroda critically reviewed the manuscript and approved the final version of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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