Epilepsy Research 131 (2017) 51–57

Contents lists available at www.sciencedirect.com

Epilepsy Research

journal homepage: www.elsevier.com/locate/epilepsyres

Decreased health care utilization and health care costs in the inpatient and emergency department setting following initiation of ketogenic diet in pediatric patients: The experience in Ontario, Canada

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ARTICLE INFO

Article history:
Received 5 November 2016
Received in revised form
20 December 2016
Accepted 21 January 2017
Available online 20 February 2017

Keywords:
Ketogenic diet
Epilepsy
Health care utilization
Health care costs

ABSTRACT

Objective: To assess the change in inpatient and emergency department utilization and health care costs in children on the ketogenic diet for treatment of epilepsy.
Methods: Data on children with epilepsy initiated on the ketogenic diet (KD) Jan 1, 2000 and Dec 31, 2010 at Ontario pediatric hospitals were linked to province wide inpatient, emergency department (ED) data at the Institute for Clinical Evaluative Sciences. ED and inpatient visits and costs for this cohort were compared for a maximum of 2 years (730 days) prior to diet initiation and for a maximum of 2 years (730 days) following diet initiation. KD patient were compared to matched group of children with epilepsy who did not receive the ketogenic diet (no KD).
Results: Children on the KD experienced a mean decrease in ED visits of 2.5 visits per person per year [95% CI (1.5–3.4)], and a mean decrease of 0.8 inpatient visits per person per year [95% CI (0.3–1.3)], following diet initiation. They had a mean decrease in ED costs of $630 [95% CI (249–1012)] per person per year and a median decrease in inpatient costs of $1059 [IQR: 7890; $p < 0.001$] per child per year. Compared with the no KD children, children on the diet experienced a mean reduction of 2.1 ED visits per child per year [95% CI (1.0–3.2)] and a mean decrease of 0.6 [95% CI (0.1–1.1)] inpatient visits per child per year. Patients on the KD experienced a reduction of $442 [95% CI (34.4–850)] per child per year more in ED costs than the matched group. The ketogenic diet group had greater median decrease in inpatient costs per child per year than the matched group [$p < 0.001$].
Significance: Patients initiated on ketogenic diet, experienced decreased ED and inpatient visits as well as costs following diet initiation in Ontario, Canada.

1. Introduction

Epilepsy affects approximately 15,000 children in Ontario (Ng et al., 2015), Canada's most populous province. Of these children, an estimated 30% have drug-resistant epilepsy. The high-fat, low-carbohydrate, ketogenic diet (KD), in use since the 1920s, is an effective treatment for this patient population. (Kossoff et al., 2009; Neal et al., 2008). A large number of studies, (Kossoff and McGrogan, 2005; Kossoff et al., 2009; Sharma et al., 2013) including randomized-controlled trials and a recently published meta-analysis (Li et al., 2013), indicate that the diet is effective at decreasing the number and severity of seizures. Although the diet has been adopted worldwide in the recent years and the number of countries utilizing the diet is growing (Kossoff and McGrogan, 2005), there is a lack of research on the effect of KD on health care utilization patterns and costs to the health care system.

The primary purpose of this study was to describe and compare ED and inpatient health care utilization patterns and associated costs of Ontario children before and after they were initiated on KD and as a secondary objective this study sought to compare utilization and costs of children who received the diet (KD group) to utilization and costs of children with epilepsy who did not receive

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http://dx.doi.org/10.1016/j.eplepsyres.2017.01.013
0920-1211/

KD (noKD group). We chose to focus on ED and inpatient visits as we hypothesized that use of healthcare services would decline through the use of the KD.

2. Methods

2.1. Study population

The period of interest was the decade between the years 2000 and 2010. Three tertiary care pediatric centers, The Children's Hospital of Eastern Ontario (Ottawa), The Hospital for Sick Children (Toronto), and McMaster Children's Hospital (Hamilton), utilized the diet during the study time frame and participated in data collection. Research Ethics Board approval was obtained for the study. A list of all patients who received KD during the study period was generated via medical records search at all three of the study locations. Search terms included epilepsy, seizure disorder, ketogenic diet, and dietician consult. This list was cross-referenced with a list kept by dieticians and a list of patients for whom an EEG had been obtained, to ensure that all patients who received KD were identified. Retrospective medical chart data from this cohort was entered into RedCap, a secure, online, database. Only patients initiated on KD at each of the three respective centers between January 1, 2000 and December 31, 2010 were included. Given that these were the only three major tertiary pediatric centers in Ontario utilizing the KD for drug-resistant epilepsy, this list of patients represents the majority of Ontario children placed on the KD during the study time frame. Specific variables of interest were: date of epilepsy diagnosis, date of diet initiation, indicator of ongoing diet at the time of database creation, and date of diet termination. In the patient charts, the exact date of diet start date was not always available; as a result, this date might have differed by a few days from the true diet start date.

An encoded version of the patients' Ontario Health Insurance Plan (OHIP) number was used to deterministically link patients to health administrative data from several Ontario-wide databases available at the Institute for Clinical Evaluative Sciences (ICES), capturing Ontario residents' contact with the province's universal healthcare system across time. The following databases were used: Ontario Registered Persons Database (RPDB) for demographic variable, OHIP physician claims data to identify matched controls for the children receiving the diet, Discharge Abstract Database (DAD) to obtain inpatient visits, and costs related to these visits, ERCLAIM for health care utilization in the ED setting and National Ambulatory Care Reporting System (NACRS; available starting fiscal year 2003) for the ED cost analysis. Two ED databases were used because, unlike NACRS, ERCLAIM does not contain health system costing variables but does cover the entire study period. ERCLAIM is derived from physician billing data for services covered under the OHIP that are rendered at the ED. NACRS data are captured through a reporting system that records patient visits at hospital and community based ambulatory care centers, including the ED. Costs for ED and inpatient visits were obtained using costing methods developed for health administrative data (Wodchis et al., 2013). These methods capture direct healthcare costs paid out by the Ontario healthcare system. In the context of inpatient and ED visits, these methods capture the cost of a case by multiplying the case's Resource Intensity Weight (RIW) by the average provincial cost per weighted case (CPWC). Generally speaking, the RIW is a measure of a case's resource usage relative to the resource usage of an average case; CPWC is a measure of the expenditures generated in treating the average case. RIW's and CPWC's are year and sector specific; the appropriate values were used for inpatient and ED visits.

Patients in the KD database who initiated the diet between January 1, 2000 and December 31, 2010 were excluded from the study if they had an invalid OHIP number (i.e. out of province patient). Patients were also excluded if their diet status at the time of data abstraction or if date of epilepsy diagnosis were missing. Patients who died during the observation period or who were not eligible to receive OHIP coverage in the defined observation window were also excluded. If patients started the diet on multiple occasions, only the first diet initiation was used. We did not expect patients to die for reasons related to the diet and did not want to capture the healthcare use and costs related to end of life. Henceforth, the patients remaining after exclusions are referred to as the KD group.

2.2. Design

The index date for the KD group was defined as the date that the ketogenic diet was initiated. A look-back window and look-ahead window was defined in reference to the index date. For each patient in the KD group, the look-ahead window was defined as the minimum of two dates: date of KD termination, and two years (730 days) post index date. The length of the look-back window was mirrored, unless it extended past a patient's date of birth. In this case, the beginning of the look-back window, the patient's study start date, was equated to the date of birth.

We compared health services utilization and cost of the KD group to the utilization and cost generated by a matched group of children with epilepsy not on the KD (noKD group). The noKD children were selected based on a 1:1 match of KD group patients. To make the two groups more comparable, matching was performed based on epilepsy diagnosis during the study period, sex, rural/non-rural status of the child's residence at index event date (Kralj 2009), date of birth within one year, and fiscal year of study start. Additionally, each match was followed for the same amount of time that the corresponding KD group patient was followed for. Following each match for an equivalent amount of time as the corresponding case is important because the average rate at which healthcare visits are generated should not be assumed to be independent of follow-up time. Matching was performed sequentially based on the randomly ordered patients in the KD group. Since the noKD group did not have a naturally defined index date, their index date was defined relative to the date of epilepsy diagnosis to ensure the matched pairs had epilepsy for the same amount of time in the observation window, as depicted in Fig. 1. Note that amount of time between epilepsy diagnosis and Study start was not a matching factor due to limitations on the time spanned by the administrative data. Additionally, the KD group had a small number of patients who, in the data, received an epilepsy diagnosis some days after the diet start; this was likely because of the slight variation of diet start date abstracted from the charts. To identify patients diagnosed with epilepsy from the health administrative data, we used an algorithm requiring three physician claims (OHIP diagnostic code 345) at least 30 days apart in a two-year period (Tu et al., 2014). This algorithm has been validated in the Ontario adult population with sensitivity 73.7 (64.8–82.5), specificity 99.8 (99.6–99.9), PPV 79.5 (71.1–88.0) and NPV 99.7 (99.5–99.8). As in the validation paper, the third physician billing was taken to be the epilepsy diagnosis date. Although both the KD and the noKD group were identified as having epilepsy, we could not match based on drug resistant epilepsy.

2.3. Analysis

The number and cost of ED and inpatient visits was obtained for the look-back window and for the look-ahead window for patients in both the KD and noKD groups. Inpatient visits corresponding to a birth record were eliminated in order to maintain a fair comparison. Additionally, given that the KD is often started in an inpatient setting, inpatient admissions corresponding to the KD start were also