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Healthcare Utilization Following Pediatric Out-of-Hospital Cardiac Arrest

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Abstract

Background: Understanding longterm health care utilization after survival of a pediatric OHCA (out-of-hospital cardiac arrest) may allow more fully integrated and cost-conscious health care.

Objective: To evaluate frequency and type of re-hospitalizations, procedures and hospital charges for pediatric OHCA survivors.

Methods: Retrospective cohort study from 1/1/1976 to 12/31/2007 of persons < 19 years who survived OHCA in King County, WA.

Results: Patients were female (49.4%) and ≤ 5 years (43.2%). 53% were readmitted in 189 readmission events, most commonly respiratory (30%) and cardiac (21%) related. Those with unfavorable Pediatric Cerebral Performance Category (PCPC) scores at initial discharge were at higher risk for ≥ 3 hospital readmissions compared to those with favorable PCPC scores (RR 5.94 (95% CI 1.50, 23.61)). Unwitnessed compared to witnessed events were associated with an increased risk of ≥ 3 hospital readmissions (RR 2.59 [95% CI 1.26, 5.31]). Upon readmission, half of patients required procedures of which acute, unplanned procedures including intubation, central and arterial line placement were most common. Adjusted to 2017 consumer price index, average charges/hospitalization were $67,005. Over long-term follow-up, the median adjusted total hospital charges/survivor were $123,190 ($11,091-$822,677).

Conclusions: This demonstrates that many children who survive OHCA will develop new chronic health conditions requiring hospital readmission and additional procedures. This data should help parents, primary care providers and subspecialists anticipate and address subsequent needs prior to discharge after the arrest. Early coordinated interventions and establishment of effective outpatient services may reduce hospital readmissions and cost.

Introduction

Pediatric Out-of-Hospital Cardiac Arrest (OHCA) victims have poor survival [1-3] and potentially devastating neurologic consequences [1,3-5]. A percentage of these children will survive with complex medical sequelae requiring intense inpatient and outpatient services. The long-term health care needs and costs that can be expected after survival of a pediatric OHCA have never been described; therefore, we sought to evaluate the frequency and type of re-hospitalizations, subspecialty clinic visits, procedures and hospital charges for survivors of pediatric OHCA. Once the medical community and survivors' parents better understand the needs of this special group of patients, more fully integrated and cost-conscious health care plans may be able to follow.

Methods

Study Design, Setting, and Population

We conducted a retrospective cohort study of all persons < 19 years who experienced OHCA, were successfully resuscitated, and discharged alive from a hospital in the Northwest between January 1, 1976 and December 31, 2007. The county is comprised of urban, suburban, and rural areas and is served by two tiered Emergency Medical Service (EMS) systems that generally followed the American Heart Association Guidelines for resuscitation throughout the years of the study [6]. The size of the population increased from 1.1 million in 1970 to 1.9 million in 2010 [7]. The study was approved by hospital, city and county public health and state Institutional Review Boards.

Cohort Identification and Data Collection

Subjects were identified from county and city cardiac arrest surveillance databases. These databases have prospectively collected information about each OHCA patient treated in the large urban city and greater rural/suburban county since 1976 [8,9]. Patients were determined to have suffered OHCA if an EMS provided CPR and/or the patient was shocked with an AED (by a public access defibrillator) prior to EMS arrival. Patients < 19 years of age who experienced an OHCA and survived to hospital discharge were eligible for this investigation. A uniform, study-specific data collection form was used to review EMS and hospital records. Hospital records were reviewed at a tertiary care children's hospital, and at a county hospital and level one trauma center. Information was collected regarding the Utstein characteristics as well as survival and neurological status at the initial hospital discharge and at each subsequent re-hospitalization or sub-specialty clinic visit [10].

We reviewed hospital records to verify survival to hospital discharge, determine preexisting comorbidities, assess neurological status, identify subspecialty and procedural services, and determine chronic health conditions that developed after the OHCA event. New chronic health conditions were identified as conditions that developed as sequelae from the OHCA event. Examples included new onset seizures, feeding intolerance, tracheostomy dependence, anoxic brain injury, etc. To identify specialized, follow up needs, subspecialty clinic visits were reviewed and categorized. Neurological status was assessed at every subsequent re-hospitalization or subspecialty clinic visit using the Pediatric Cerebral Performance Category (PCPC) score. The PCPC score is a reliable and validated score created as an efficient way to quantify a child's cognitive function following a critical illness or injury [11,12]. The score ranges from 1-6 where 1 is normal and 6 is brain death [11,12].

To identify subsequent hospitalizations, procedures and diagnoses, we utilized 2 different search methods. For the years 1976-1986 we performed chart review at the above described hospitals. For the years 1987-2007, we linked our dataset to a state hospital reporting system/database. This database contains coded hospital inpatient discharge information (derived from billing systems) available from 1987 to 2013. It is used to collect information such as the age, sex, zip code and billed charges of patients, as well as the codes for their diagnoses and procedures [13]. Patients with 0-2 readmissions to hospital were classified as "Low frequency readmissions" and patients with 3 or more readmissions were classified as "high frequency readmissions."

Procedures were defined as any inpatient procedural service recorded in the hospital database that the child underwent at subsequent hospitalizations. These services ranged from unplanned emergent procedures such as intubation and central line placement to planned procedures such as device implantation and tendon release. Procedures were grouped into the following categories with typical examples provided as follows: Digestive (Nissen fundoplication, feeding tubes), Respiratory (intubation, bronchoscopy, tracheostomy tubes), Cardiac (implanted devices, cardiac catheterization), Musculoskeletal (tendon release, fracture care), and Other/Unknown (genitourinary procedures, neurosurgical procedures, central line placement, etc.).

To identify subsequent deaths, we linked patients to the National Death Index and the state death database using identifiers such as name, date of birth, father's name and/or mother's maiden name. Patients identified in the National Death Index or the state death database were deemed non-survivors. Survival time was calculated from the date of hospital discharge until the date of death or until December 31, 2009 when the database was last searched.

Statistical Analysis

We used descriptive statistics to characterize demographic, clinical, and long-term care features. All charges were adjusted to the 2017 consumer price index [7].

Results

For the period 1976 - 2007, there were 1,683 cases of EMS-treated pediatric OHCA in the county. Of those, 91 patients survived to hospital discharge for an overall survival of 5.4%. Of the 91 patients who survived to hospital discharge, 20 (22%) subsequently died during 1449 person-years of follow-up. Ten patients were lost to long-term follow up. The subset analysis of hospital readmission, subspecialty clinic visits, procedures and cost represents the 81 patients whose follow up was known. Table 1 compares patients with low frequency readmissions to those with high frequency readmissions.

In this cohort, approximately half of patients were female (49.4%) and ≤ 5 years (43.2%). Patients' year of arrest was evenly distributed throughout the years of the study period: 1977 - 1986

(29%), 1987 - 1996 (34%) and 1997 - 2008 (37%). The most common cause of arrest was cardiac (16/81, 19.7%) followed by drowning (15/8, 18.5%) and respiratory (12/81, 14.8%) (Table 1). Prior to the arrest, 67% of patients either had no premorbid conditions or had missing data (19.7%). Following arrest, 89% of surviving patients were diagnosed with a new chronic condition requiring readmission or subspecialty clinic follow up (Table 1).

	Overall	Low-frequency readmissions (0-2 readmissions)	High-frequency readmissions (3+ readmissions)
	N=81	N= 59	N = 22
Female gender	40 (49.4)	32 (54.2)	8 (36.4)
Age > 5	35 (43.2)	25 (42.4)	10 (45.5)
Witnessed event	52 (75.4)	43 (82.7)	9 (52.9)
Duration of CPR (minutes)			
< 10	21 (31.8)	18 (37.5)	3 (16.7)
30-Oct	40 (60.6)	27 (56.3)	13 (66.7)
>30	5 (7.6)	3 (6.3)	2 (11.1)
Doses of epinephrine			
0 doses	31 (42.5)	25 (48.1)	6 (28.6)
1-2 doses	29 (39.7)	19 (36.5)	10 (47.6)
≥3 doses	13 (17.8)	8 (15.4)	5 (23.8)
Shockable rhythm	22 (28.2)	17 (30.4)	5 (22.7)
Pre-existing comorbidities			
None/unknown	50 (66.9)	35 (76.1)	15 (78.9)
Cardiac	7 (10.8)	5 (10.9)	2 (10.5)
Neurologic	5 (7.7)	3 (6.5)	2 (10.5)
Other	3 (4.6)	3 (6.5)	0 (0)
Cardiac arrest diagnosis			
Cardiac	16 (24.2)	12 (25.5)	4 (21.1)
Drowning	15 (22.7)	9 (19.2)	6 (31.6)
Respiratory	12 (18.2)	10 (21.3)	2 (10.5)
Trauma	8 (12.1)	6 (12.8)	2 (10.5)
Other	15 (22.7)	10 (21.3)	5 (26.3)
Year of cardiac arrest			
1977-1986	23 (28.4)	17 (28.8)	6 (27.3)
1987-1996	29 (35.8)	20 (33.9)	9 (40.9)
1997-2008	29 (35.8)	22 (37.3)	7 (31.8)
Initial PCPC score at hospital discharge			
Favorable (1-2)	26 (42.6)	24 (55.8)	2 (11.1)
Unfavorable (3-5)	35 (57.4)	19 (44.2)	16 (88.9)

Primary diagnoses at readmission			
Respiratory	56 (29.6)	3 (10.3)	53 (33.1)
Cardiac	40 (21.2)	6 (20.7)	34 (21.3)
Other	27 (14.3)	3 (10.3)	24 (15.0)
Rehab	17 (9.0)	6 (20.7)	11 (6.9)
Musculoskeletal	16 (8.5)	2 (6.9)	14 (8.8)
Gastrointestinal	13 (6.8)	2 (6.9)	11 (6.9)
Neurology	11 (5.8)	3 (10.3)	8 (5.0)
Drowning/Injury/Poison	5 (2.7)	1 (3.5)	4 (2.5)
Unknown	4 (2.1)	3 (10.3)	1 (0.6)
New chronic condition following OHCA Event			
None	7 (11.1)	7 (15.9)	0 (0)
Any	56 (88.9)	37 (84.1)	19 (100)
Types of chronic condition following OHCA event			
Neurologic	50 (79.4)	31 (70.5)	19 (100.0)
Pulmonary	26 (41.3)	12 (27.3)	14 (73.7)
Cardiac	19 (30.7)	11 (25.0)	8 (44.4)
GI	15 (23.8)	9 (20.5)	6 (31.6)
Orthopedic	10 (15.9)	5 (11.4)	5 (26.3)
None	7 (11.1)	7 (15.9)	0 (0)
Genitourinary	6 (9.7)	4 (9.1)	2 (11.1)
Psych/Behavioral	5 (8.1)	3 (6.8)	2 (11.1)
Renal	2 (3.3)	2 (4.6)	0 (0)
Types of specialty care follow-up			
Neurology	32 (54.2)	21 (50.0)	11 (64.7)
Rehabilitation	23 (40.4)	12 (30.0)	11 (64.7)
Cardiac	14 (24.1)	10 (23.8)	4 (25.0)
None	9 (15.3)	7 (16.7)	2 (11.8)
Pulmonary	7 (12.1)	3 (7.1)	4 (25.0)
Gastrointestinal	6 (10.3)	4 (9.5)	2 (12.5)
Psychosocial	6 (10.3)	4 (9.5)	2 (12.5)
Surgical	2 (3.4)	2 (4.8)	0 (0)
Genitourinary	1 (1.7	1 (2.4)	0 (0)

Patients with procedures after index admission			
None	58 (71.6)	51 (86.4)	7 (31.8)
Any	23 (28.4)	8 (13.6)	15 (68.2)
Total number of procedures at read-mission			
None	140 (74.1)	20 (65.5)	121 (75.6)
Other/Unknown	36 (19.1)	8 (27.6)	28 (17.5)
Digestive	29 (15.3)	4 (13.8)	25 (15.6)
Respiratory	27 (14.3)	2 (6.9)	25 (15.6)
Cardiac	20 (10.6)	6 (20.7)	14 (8.8)
Musculoskeletal	14 (7.4)	1 (3.5)	13 (8.1)
Missing data patient characteristics: Gender: 0; Age: 0; Witnessed event: 12 (7 low readmission group/5 high readmission group); CPR duration: 15 (11/4); Epinephrine doses: 8 (7/1); Shockable rhythm: 3 (3/0); Pre-existing comorbidities: 16 (13/3); Cardiac arrest diagnosis: 15 (12/3); Year of cardiac arrest: 0; Initial PCPC score: 20 (16/4); New chronic condition: 18 (15/3); Types of specialty care: 22 (17/5) Missing data, admission characteristics: none Number of patients with any readmission: 43 Number of patients with no readmissions: 38			

Table 1: Patient Characteristics by Readmission Frequency.

Most patients 43/81 (53%) who survived to hospital discharge required hospital readmission resulting in 189 readmission events. Readmissions were most commonly for respiratory (30%) and cardiac (21%) conditions (Table1). The total number of readmissions per year decreased sharply within the first two years following initial hospital discharge (Figure 1).

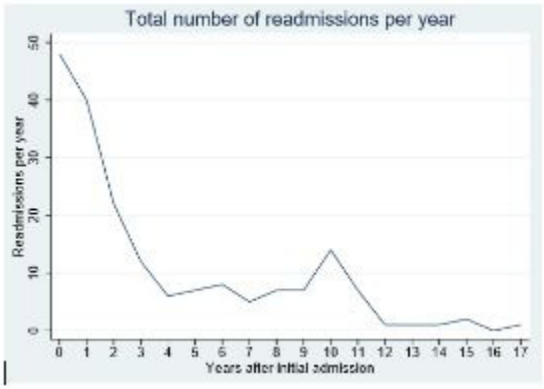

Figure 1: Total number of patient readmissions per year following initial hospital discharge after OHCA.

(Table 1) Of the patients requiring readmission, 22/43 (51.1%) required at least 3 readmissions. The patients with an unfavorable PCPC score at initial hospital discharge were at significantly higher risk to experience high frequency hospital readmissions as compared to those with favorable PCPC scores (RR 5.94 [95% CI 1.50, 23.61]). An unwitnessed compared to a witnessed cardiac arrest was the only other variable associated with an increased likelihood of having high frequency hospital readmissions (RR 2.59 [95% CI 1.26, 5.31]).

Half of patients required additional procedures upon readmission to the hospital. The majority of procedures were acute, unplanned procedures including intubation (grouped under "Respiratory"), central line and arterial line placement (grouped under "Other"). Gastrointestinal procedures such as feeding tube placement, respiratory procedures such as tracheostomy and cardiac procedures such as device implantation were also well-represented (Table 1).

The majority 61/81 (75%) of surviving patients required subspecialty clinic follow-up, most commonly neurology (54%) followed by rehabilitation services (physical therapy, occupational therapy and speech therapy; 40%) (Table1). Adjusted to 2017 CPI (consumer price index), average hospital charges per hospitalization were $67,005. Over long-term follow-up, the median adjusted total hospital charges per survivor were $123,190 ($11,091-$822,677). For this cohort, 87% of the total hospital charges

($7,463,493) were accumulated in the first 2 years after hospital discharge. The rate of rise of the patient's cumulative charges for their hospitalizations also decreased as time went on (Figure 2). Once a patient survived beyond the first 2 years after their initial discharge, the average adjusted hospital charges were less than $56,167 per year.

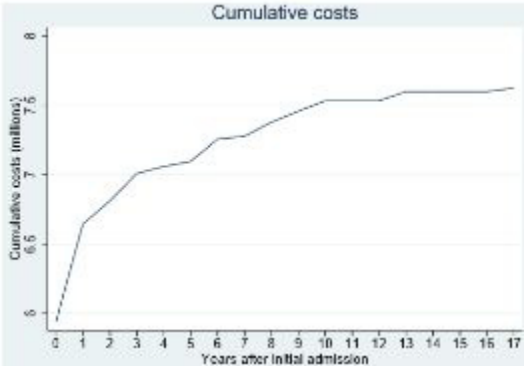

Figure 2: Cumulative health care related costs for this cohort following initial hospital discharge. Cost of care for the initial event is not included.

Discussion

In this cohort of pediatric OHCA victims who were successfully resuscitated and discharged alive from the hospital, readmissions to the hospital were common for complications following arrest. The re-hospitalization rate was 28.5% which is six times higher than the general pediatric population and closely mimics what has been described for other groups of medically complex children [14]. While the majority of survivors were re-hospitalized, patients with a favorable PCPC score at hospital discharge were unlikely to experience frequent readmissions to the hospital. Concomitantly, patients with an unfavorable PCPC score at initial hospital discharge were most likely to experience frequent readmission events, especially in the first two years after the initial hospitalization. A previous study showed that unfavorable neurologic status at initial hospital discharge was also associated with greater likelihood of death [17]. This study re-demonstrates that a small minority of medically complex pediatric patients account for a relatively large portion of healthcare utilization and that some of these patient outcomes can be predicted [14-16, 20].

While the hospital readmission rate for this cohort was similar to other groups of medically complex children, the causes of readmission were unique. Patients surviving OHCA were primarily readmitted for respiratory and cardiac causes while the general medically complex pediatric population was most often readmitted for neuromuscular causes (39%) and malignancy (22%) [14]. This highlights the opportunity for a coordinated medical home for OHCA patients discharged from the hospital. Any patient with an unfavorable neurologic status at the time of discharge will likely experience re-hospitalizations, multiple procedures and intense home care needs in addition to a substantial risk for subsequent death [17].

Cohen et al. stated the small population of pediatric high utilizers should be targeted for care coordination intervention [18]. Improving aspects of care delivery by improved care coordination, more integrated community and hospital based teams as well as the use of pediatric medical homes may improve care and decrease costs for this unique population of children [16,18-20]. Kuo, et al. suggested that important outcome measures for this kind of care coordination should include: decreasing unplanned hospital admissions, decreasing emergency department use, ensuring access to health services, limiting out-of-pocket expenses for families, and improving patient and family experiences, quality of life, and satisfaction with care [20]. Although not all pediatric OHCA survivors will become medically complex children, an understanding of their use of the healthcare system is the first step in offering more complete and efficient health care following discharge.

There were several limitations to this study. The number of survivors of OHCA is modest so there was limited ability to evaluate healthcare utilization patterns. Of the ten patients lost to follow up, a review of the index admission charts suggested that they had very good outcomes resulting in no need for re-hospitalization or subspecialty care. Our follow up data were limited to state hospital data and from the years 1977-1986, the follow up data represents only two hospitals; therefore, the data does not account for patients' hospital utilization if they moved out of state and likely underestimates total utilization and cost. Physician charges for hospital care and procedures were not included in hospital charges. These missing data make it likely these results underestimate utilization and cost.

The cohort was from one county where the large majority of specialty based pediatric care was centered at a single hospital so their hospitalizations and care may not be generalizable. Lastly, the cost data of this study were limited to hospitalization data and did not include out of hospital care visits and charges these children and their families experienced.

This study required linking data systems which can introduce the chance of error. Additionally, survivors may have changed their names - especially if female - so there was potential bias to underestimate long term deaths. As children rarely have recorded social security numbers, we were unable to use this as a search method. To address this limitation, we used alternate search strategies that relied on birth date and parent name. Moreover, we did not see a difference in long-term survival between males and females suggesting that name change did not produce bias in follow up.

Conclusion

This study demonstrates that a significant number of children who survive OHCA will go onto develop new chronic health conditions requiring readmission to the hospital, additional procedures and significant healthcare charges - especially in the first 2 years of survival. We also show that the children most likely to experience significant healthcare utilization are predictable; those with unwitnessed OHCA events and those discharged with unfavorable PCPC scores are more likely to experience frequent hospital readmission and procedures. This data should help parents, pediatric primary care providers and subspecialists begin to anticipate and address the child's subsequent care needs prior to discharge after the cardiac arrest. Families need to be aware of and assisted in preparation for the possibility of serious medical complications and their impact on the family and finances. This also suggests that targeted early coordinated interventions and establishment of more effective outpatient services after discharge should be explored to reduce hospital readmissions and the long-term financial cost to the healthcare system. Moreover, long-term outcome measures following devastating events like cardiac arrest should include utilization and cost data.

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Contributor Statements

- Erica Michiels: Conceptualized and designed the study. Reviewed data. Wrote and edited the manuscript.
- Linda Quan: Assisted in conceptualizing and designing the study. Reviewed data. Edited the manuscript.
- Randall Leja: Reviewed data. Designed tables and figures. Assisted in concept of and writing of manuscript.
- Thomas Rea: Assisted in conceptualizing and designing the study. Review and edit of data. Edited manuscript.

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