Seizure Treatment in Children Transported to Tertiary Care: Recommendation Adherence and Outcomes

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abstract

BACKGROUND AND OBJECTIVES: Convulsive seizures account for 15% of pediatric air transports. We evaluated seizure treatment received in community hospital emergency departments among transported patients for adherence to recommended management.

METHODS: This study was a retrospective cohort study of children transported for an acute seizure to a tertiary pediatric hospital from 2010 to 2013. Seizure treatment was evaluated for adherence to recommended management. The primary outcome was intubation.

RESULTS: Among 126 events, 61% did not receive recommended acute treatment. The most common deviation from recommended care was administration of >2 benzodiazepine doses. Lack of adherence to recommended care was associated with a greater than twofold increased risk of intubation (relative risk 2.4; 95% confidence interval, 1.4–4.13) and 1.5-fold increased risk of admission to the ICU (relative risk 1.65; 95% confidence interval, 1.24–2.16). Duration of ventilation was commonly <24 hours (87%) for patients who did or did not receive recommended acute seizure care. Among events treated initially with a benzodiazepine, only 32% received a recommended weight-based dosage, and underdosing was most common.

CONCLUSIONS: Adherence to evidence-based recommended acute seizure treatment during initial care of pediatric patients using medical air transportation was poor. Intubation was more common when patients did not receive recommended acute seizure care. Educational efforts with a sustained quality focus should be directed to increase adherence to appropriate pediatric seizure treatment of children in community emergency departments.

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DOI: 10.1542/peds.2016-1527

Accepted for publication Sep 22, 2016

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

WHAT'S KNOWN ON THIS SUBJECT: Acute seizures are common, and during early childhood they often are initially treated in community hospital emergency departments. Acute seizures are also a common reason for airway management and medical transport to a tertiary children's hospital.

WHAT THIS STUDY ADDS: Low adherence to recommended management was common in community hospital emergency departments among children transported to a pediatric hospital. The most common error was administration of >2 benzodiazepine doses. Risk of intubation was greater when care deviated from recommendations.

To cite: Siefkes HM, Holsti M, Morita D, et al. Seizure Treatment in Children Transported to Tertiary Care: Recommendation Adherence and Outcomes. *Pediatrics.* 2016;138(6):e20161527

Convulsive seizures account for a substantial proportion of health care utilization among pediatric patients. The Healthcare Cost and Utilization Project estimated that convulsive seizures accounted for >250 000 emergency department visits for US children in 2013.[1] Likewise, seizures are a common reason for hospital admission. In 2012, nearly 70 000 children were admitted to the hospital for convulsive seizures.[2] These can be costly admissions, with mean hospital charges >$25 000 per admission.[2] If helicopter transportation is used, it may add an average $18 000 to the cost.[3] Because acute seizures account for up to 15% of pediatric air transports, this is a costly patient group that warrants investigation for opportunities to improve care.[4]

Appropriate seizure treatment may shorten seizure duration, enabling an otherwise well child to be sent home and avoiding transport to a tertiary hospital. Although brief seizures (<5 minutes) do not necessitate treatment, longer seizures should be treated because timely antiepileptic drug (AED) administration affects seizure cessation and outcomes.[5–7] Benzodiazepines (BZDs) are the recommended first-line treatment, but >2 doses are not recommended because of prolonged sedation and potential respiratory compromise.[8–12] Despite clear recommendations, compliance is inconsistent.[13–15] Evaluating transported patients for adherence to recommendations is warranted to determine potential needs for educational and quality interventions in community hospitals regarding acute seizure management.

The objective of this study was to determine whether children transported for seizures received treatment in accordance with recommendations and whether outcomes differed by receipt of recommended care.

METHODS

The University of Utah and Primary Children's Hospital (PCH) institutional review boards approved this study and waived the requirement for consent.

Study Design

This study was a retrospective cohort of patients aged 29 days to 18 years with an acute seizure episode necessitating AED administration, identified from our pediatric medical transport (Life Flight) records during 2010 to 2013, transported to PCH from referring hospitals or from the scene. Children with a tracheostomy were excluded because placement of a secure airway was our primary outcome. Children with acute head trauma, nonepileptic seizures, and seizures that resolved spontaneously were excluded because these children are treated differently from those with convulsive seizures that warrant treatment. Seizure events with incomplete documentation precluding treatment classification were excluded. Eight patients were transported more than once for seizures during the study period. Each episode that met inclusion criteria was counted as an event (N = 20).

Data collection was via chart review of emergency medical service (EMS), referring hospital, Life Flight, and PCH records. Life Flight records were used in lieu of missing EMS and referring hospital records, because the transport staff documents care received at the referring facility.

Exposure Classification and Outcomes

Seizure events were classified as either treated in accordance with recommended care or not. Before 2012, the last American guideline for treatment of status epilepticus was published in 1993.[9] The Neurocritical Care Society and American Epilepsy Society published guideline updates in 2012 and 2016, respectively.[16,17] However, changes in care evolved between the 1993 and 2012 guidelines. Because our study period was from 2010 to 2013, the exposure classification was based on our hospital care pathway, authored by physician staff in pediatric neurology, emergency medicine, and critical care, which reflected contemporary medical evidence for management for prolonged seizures and other international guidelines.[8–11] The recommended treatment includes 4 steps and progresses to the next step if the seizure persists (Fig 1). The first 2 steps are BZD administration. Steps 3 and 4 are administration of second- and third-line AEDs. Intubation is considered during the fourth and final step. Events were classified as treated not in accordance with recommendations if intubation occurred before step 4 while seizure activity was still present, if >2 BZD doses were administered, or if a non-BZD AED was administered first. The recommendations also include time intervals between each step of 5 to 10 minutes depending on the source.[8–11] Time intervals were not considered in the classification for this study because many were missing or estimated. However, 2 seizure events had delays in treatment initiation or between additional treatments of >30 minutes, while the patient was in the care of medical providers, and thus were classified as delayed treatment not in accordance with recommendations. Administration of second-line AED before a second BZD dose was considered an appropriate deviation and classified as treated in accordance with recommendations.[18] Medication dosing was not considered in classifying treatment adherence to recommendations. For an additional analysis the initial BZD dosage was evaluated separately and considered appropriate if it was within 20% of recommended weight-based dosing (Table 1).

TABLE 1 Appropriate and Inappropriate BZD Dosing Definitions

Appropriate Dosing
Within 20% of the following:
Midazolam 0.1 mg/kg IV or IM, maximum 10 mg
Midazolam 0.2 mg/kg IN, maximum 10 mg
Lorazepam 0.1 mg/kg IV or IM, maximum 4 mg
Diazepam 0.1 mg/kg IV, maximum 10 mg
Diazepam rectal form adapted from Diastat AcuDial package insert[19]
2–5 y 0.5 mg/kg
5 mg for 6–10 kg
7.5 mg for 11–15 kg
10 mg for 16–20 kg
12.5 mg for 21–25 kg
15 mg for 26–30 kg
17.5 mg for 31–35 kg
20 mg for 36–44 kg
6–11 y 0.3 mg/kg
5 mg for 10–16 kg
7.5 mg for 17–25 kg
10 mg for 26–33 kg
12.5 mg for 34–41 kg
15 mg for 42–50 kg
17.5 mg for 51–58 kg
20 mg for 59–74 kg
≥12 y 0.2 mg/kg
5 mg for 14–25 kg
7.5 mg for 26–37 kg
10 mg for 38–50 kg
12.5 mg for 63–75 kg
17.5 mg for 76–87 kg
20 mg for 88–111 kg
Inappropriate dosing
>20% or <20% difference from defined recommended dosing above
Or dose over maximum doses listed above

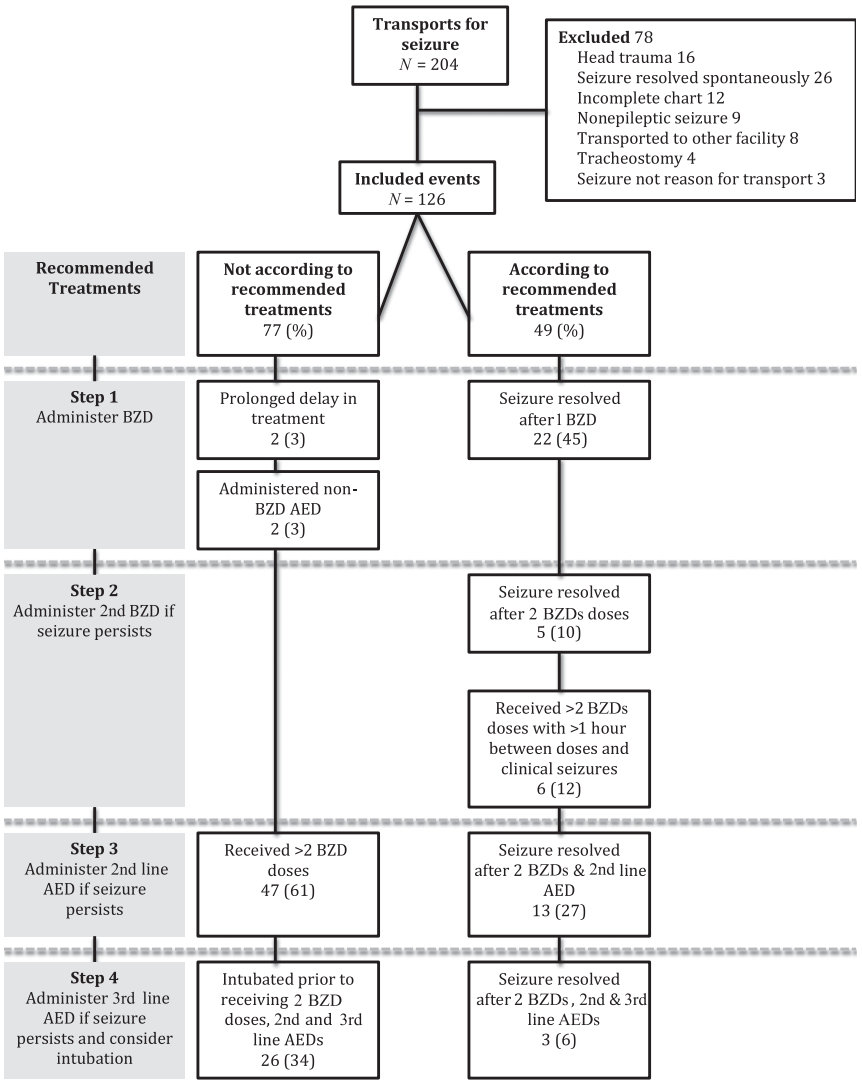

FIGURE 1
Consort diagram of patients transported for seizures and treatment received for seizure event relative to recommended treatment.

The primary outcome was respiratory failure, defined as placement of an endotracheal tube or laryngeal mask airway. Secondary outcomes included intubation duration and complications, length of ICU stay, and hospital length of stay. Coinvestigators reviewed 10% of charts to generate a κ statistic for agreement in treatment classification and inclusion.

Statistical Analysis

Summary statistics for the comparison groups were presented as medians or frequencies with interquartile ranges (IQRs) or percentages, respectively. The medians were compared for continuous data. The χ^2 or Fisher exact test was used to compare categorical data. A P value ≤.05 was considered statistically significant. Relative risks (RRs) were calculated with 95% confidence intervals (CIs). The data were analyzed with Stata Statistical Software, release 13.1 (Stata Corp, College Station, TX).

RESULTS

A total of 204 seizure events were identified from transport records. Seventy-eight were excluded (reasons listed in Fig 1). Of the remaining 126 included events, 77 (61%) were not treated according to recommendations (Fig 1). The κ statistic for agreement of inclusion was 0.88 and for treatment classification was 1.0.

Demographics and Seizure Characteristics

Events not treated according to recommendations occurred in younger patients compared with events treated according to recommendations (median 25 vs 41 months, P = .04). Other demographic data were similar between the 2 groups (Table 2). Total estimated median seizure duration was longer

TABLE 2 Select Demographic and Clinical Characteristics of Seizure Events: Comparing Acute Seizure Management

	Not According to Recommended Treatments, $N = 77$	According to Recommended Treatments, $N = 49$	P
Age, mo, median (IQR)	25 (16–59)	41 (21–78)	.04
Male, No. (%)	49 (64)	26 (53)	.24
Previous history of seizures, No. (%)	36 (47)	25 (51)	.64
Epilepsy	24	20	—
Febrile	9	3	—
Possible seizure event	0	1	—
Other	3	1	—
Other history of neurologic abnormality (eg, developmental impairment, cerebral palsy, stroke), No. (%)	34 (44)	20 (41)	.71
Seizure onset before arrival at referring hospital, No. (%)[a]	61 (82)	42 (88)	.45
Time to EMS arrival after seizure onset, min, median (IQR)[b]	14 (9–21)	21 (15–26)	.28
Time to referring hospital arrival after seizure onset, min, median (IQR)[c]	25 (2.5–36)	27 (4–55)	.62
Seizure etiology, No. (%)			
Epilepsy	39 (51)	25 (51)	.09
Febrile seizure	22 (29)	10 (20)	—
Meningitis	3 (4)	1 (2)	—
Toxin	0	2 (4)	—
Electrolyte abnormality	3 (4)	0	—
Hypoglycemia	0	0	—
Tumor	0	3 (6)	—
Other	10 (13)	8 (16)	—
Total estimated seizure duration, min, median (IQR)[d]	52.5 (35–85)	37 (20–60)	.05
Duration of transport to PCH, min, median (IQR)	29 (21–75)	32 (21–80)	.85

Includes 20 events from 8 patients who had repeat seizure events prompting transport. —, Statistical analysis applies to overall distribution of main heading, anaylsis of sub-headings was not performed.

[a] Variable available for 122 of 126 events.

[b] Variable available for 33 events of 126 events. Not all 126 events used EMS.

[c] Variable available for 95 of 126 events. Events that started in the hospital were counted as 0 min.

[d] Variable available for 119 of 126 events.

in events not treated according to recommendations (52.5 vs 37 minutes, $P = .05$), whereas other seizure characteristics were similar between the 2 groups (Table 2).

Benzodiazepine Administration

The most common deviation from recommended management was administration of >2 BZD doses ($N = 47$). This deviation accounted for 61% of events not treated according to recommendations and 37% of the entire cohort. Of events treated initially with a BZD, only 32% (37 of 117) received appropriate weight-based dosing as defined in Table 1. This deviation did not differ between the 2 groups (Table 3). Among all events, the median first BZD intravenous or intramuscular (IV or IM) dosage was below the 0.1 mg/kg recommended dosage (0.07 mg/kg, IQR 0.04–0.1), and the median intranasal (IN) dosage was below the recommended 0.2 mg/kg dosage (0.13 mg/kg, IQR 0.1–0.2).

Of events treated with inappropriate IV, IM, or IN dosages, 80% (51 of 64) received an initial dosage more than 20% below recommended dosing. Of underdosed seizure events, the median IV or IM dosage was 0.04 mg/kg (IQR 0.03–0.05), and the median IN dosage was 0.1 mg/kg (IQR 0.07–0.13). The median dosages did not differ between events in which treatment adhered to recommendations and those that were not in compliance. The other 20% of seizure events treated with inappropriate IV, IM, or IN dosages were >20% over the recommended dosing; however, no dosages were over the maximum recommended BZD dosage for an adult. Of the seizure episodes treated initially with rectal BZD, 30% (6 of 20) received appropriate weight-based dosing. The median initial IV or IM BZD weight-based dosages did not differ statistically between intubated patients and others (median initial dosage 0.08 vs 0.06 mg/kg, $P = .58$). Additionally, we did not observe a correlation between initial BZD weight-based dosage and seizure duration. The median estimated seizure duration did not differ between events treated with inappropriately low compared with appropriate initial BZD dosage (45 vs 50 minutes, $P = .15$).

Other Medication Administration

The most common second-line AED administered was fosphenytoin/phenytoin (73%, 67 of 92). Four seizure events involved rapid-sequence intubation before BZD or other AED administration. Another 15 events were treated with propofol before administration of other recommended AED. The median ages for the 3 most commonly initially administered non-BZD AEDs, fosphenytoin/phenytoin,

TABLE 3 Features of AEDs Administered by Treatment Group

	Not According to Recommended Treatments, *N* = 77	According to Recommended Treatments, *N* = 49	*P*
Deviation from recommended treatments, No. (%)			
> 2 BZD doses	47 (61)	N/A	N/A
Delay in treatment (>30 min)	2 (3)	N/A	N/A
Administered non-BZD first	2 (3)	N/A	N/A
Intubated before receiving 2 BZD doses, second- and third-line AEDs during ongoing seizure activity	26 (34)	N/A	N/A
1st BZD dose, No. (%)			
Appropriate dose, within ±20% of recommended dosing	24/68 (35)	13/49 (27)	.32
First administered second-line AED, No. (%)[a]			
Levetiracetam	9 (16)	6 (17)	.73
Fosphenytoin/phenytoin	41 (72)	26 (74)	—
Phenobarbital	6 (11)	2 (6)	—
Valproic acid	0	1 (3)	—
Other	1 (2)	0	—

N/A, not applicable; —, Statistical analysis applies to overall distribution of main heading, anaylsis of sub-headings was not performed.
[a] Sum of numbers is less in this category because 19 did not receive a second-line AED. Also excluded the 15 who received propofol, all of which were part of rapid sequence intubation, as first non-BZD administered medication.

TABLE 4 Intubation Status and Initially Administered Second-Line AED

First Administered Second-Line AED[a]	Not Intubated	Intubated	*P*
Keppra, No. (%)[b]	8 (53)	7 (47)	.88
Fosphenytoin/phenytoin, No. (%)[b]	34 (51)	33 (49)	—
Phenobarbital, No. (%)[b]	3 (38)	5 (62)	—

—, Statistical analysis applies to overall distribution of first adminstered second-line AED, anaylsis comparing each second-line AED was not performed.
[a] Excluded the 15 who received propofol, all of which were part of rapid sequence intubation, as first non-BZD administered medication. Also excluded 2 patients who received AEDs other than the 3 listed.
[b] Displayed percentages are row percentages.

levetiracetam, and phenobarbital, were not significantly different (34, 48, and 22.5 months, respectively, *P* = .2). Frequency of intubation did not differ between patients based on the initially administered non-BZD AED (Table 4).

Outcomes

Seizure treatment not adherent to recommendations was more likely to involve intubation (RR 3.0; 95% CI, 1.78–4.95). The increased risk persisted when the events including intubation before step 4 of the algorithm were excluded (*N* = 26) (RR 2.4; 95% CI, 1.4–4.13). The median total duration of intubation did not differ between the 2 groups (7.8 vs 8.1 hours, *P* = .86). Of all events involving intubation, the total duration of intubation was <8 hours in 50% and <24 hours in 87%. Complications such as multiple intubation attempts, postextubation stridor necessitating treatment, and unintended extubation occurred only among events not treated according to recommendations (Table 5).

Seizure events not treated according to recommended management were more likely to result in ICU admission compared with those treated according to the recommendations (RR 1.64; 95% CI, 1.24–2.16). For both groups the median length of ICU stay was <1 day and 75% of events not treated with recommended care stayed <33 hours compared with <28 hours in events treated with recommended care, but these differences were not statistically significant (Table 5). Events not treated according to recommendations were nearly twice as likely to have spinal fluid testing (RR 1.96; 95% CI, 1.14–3.38); however, meningitis as an etiology for the seizure was similar between the 2 groups (Table 2). The risks of other diagnostic testing occurred at similar rates between the 2 groups (Table 5).

DISCUSSION

More than half (61%) of the seizure events resulting in transportation to a tertiary pediatric hospital were not treated with recommended medication type, number of doses, or timing of airway management. Events where treatment deviated from recommended care were 3 times more likely to involve intubation. The most common deviation from this recommended care was administration of >2 BZD doses. Another important area of noncompliance was intubation before completing the stepwise AED administration during ongoing seizure activity. Additionally, inappropriate initial BZD dosing was common. Only one-third of seizures were treated with an initial dosage within 20% of recommended weight-based dosing, and underdosing was more common than overdosing.

Pediatric acute seizure treatment recommendations universally endorse limiting initial BZD administration to 2 doses, followed by a second-line AED if the seizure activity persists.[8–11] We found that more than a third of seizure events were not treated in compliance with this recommendation. Treatments for seizure episodes in our cohort

TABLE 5 Additional Interventions, Tests, and Disposition by Treatment Group

	Not According to Recommended Treatments, *N* = 77 (61%)	According to Recommended Treatments, *N* = 49 (39%)	RR (95% CI)
Secure airway placed, No. (%)	56 (73)	12 (25)	3.0 (1.78–4.95)
Adjusted secure airway, No. (%) (excluding the 26 that were deviations due to early intubation)	30 (59)	12 (25)	2.4 (1.4–4.13)
Respiratory complications, No. (%)			
None	61 (79)	47 (96)	*P* = .04
Aspiration	4 (5)	2 (4)	—
Multiple intubation attempts	4 (5)	0	—
Postextubation stridor	7 (9)	0	—
Unintended extubation	1 (1)	0	—
Duration of intubation			
Total, h, median (IQR)	7.8 (4.6–15.9)	8.1 (4.7–11.7)	*P* = .86
After arrival to PCH, h, median (IQR)[a]	6.3 (2.7–15.0)	7.0 (3–8.8)	*P* > .9
Extubation delayed for procedure or test, No. (%)	15 (27)	3 (25)	1.07 (0.37–3.13)
Admitted to ICU, No. (%)	67 (87)	26 (53)	1.64 (1.24–2.16)
ICU length of stay, h, median (IQR)	22.0 (14.1–32.3)	17.1 (12.3–27.3)	*P* = .39
Hospital length of stay, d, median (IQR)	2 (1–3)	1 (1–2)	*P* = .11
Head computed tomography performed, No. (%)	53 (69)	28 (57)	1.2 (0.91–1.6)
Brain MRI performed, No. (%)	19 (25)	10 (20)	1.21 (0.61–2.38)
LP performed, No. (%)	37 (48)	12 (24)	1.96 (1.14–3.38)
EEG performed, No. (%)	37 (48)	20 (41)	1.18 (0.78–1.77)

—, Statistical analysis applies to overall distribution for main heading, respiratory complications. Anaylsis of sub-headings, types of respiratory complications, was not performed.
[a] Variable available for 61 events. Intubation occurred after arrival to the tertiary hospital in the other 7 events.

included prehospital, referring nonpediatric hospital, interfacility transport, and tertiary pediatric hospital care. Most events were treated with >2 BZD doses before arriving at PCH. Previous studies evaluating children presenting initially to pediatric hospitals found similar frequencies, with 40% to 58% of children receiving >2 BZD doses.[6,14,20] Therefore, compliance with this recommendation appears to be poor in multiple care settings.

In addition to excessive BZD dosages, we found that most initial BZD dosages were inappropriately low (>20% lower than recommended weight-based dosing). Accurate dosing is important because inadequate dosing may play a role in seizure persistence, although we were unable to show this effect in our study. Chin et al[12] reported that subtherapeutic dosing was associated with failure to terminate seizures within 10 minutes of administration. We were unable to evaluate seizure termination relative to BZD administration time because seizure onset was often estimated. Furthermore, early intubation during many of the events would alter apparent seizure duration estimations because of the effect of neuromuscular blockade. Estimated seizure duration did not differ between children treated with inadequate BZD dosages versus children treated with adequate dosages. Additionally, we did not find a correlation between initial weight-based BZD dosage and seizure duration. However, we did find that seizure events treated with the appropriate number of BZD doses, regardless of weight-based dosage, had significantly shorter estimated seizure duration.

More than half of our seizure events involved intubation (54%); this rate is similar to that in previous reports.[6,13,14] Among our cohort, 4 events included intubation before any AED administration. Additionally, 26 events (38% of intubated patients) involved intubation before completion of recommended AED therapy while seizure activity persisted. We found events treated with >2 BZD doses were nearly 2.5 times more likely to involve intubation. Similarly, Chin et al[14] reported just under 1.5-fold greater risk of intubation with >2 BZD doses; however, their finding was not statistically significant. The lower rate reported by Chin might reflect differences in their study population, which was restricted to ICU admissions, whereas we included all transported seizure episodes. In a follow-up study with a broader patient group, Chin et al[12] reported a similar statistically significant risk to ours, with 3 times the odds of intubation with >2 BZD doses. These data suggest that seizure treatment limiting administration to 2 BZD doses is associated with a lower risk of intubation and thus the automatic need for transport to a tertiary hospital. Among our cohort, this would be more than one-third of seizure events resulting in transfer to a tertiary hospital that were not treated with ≤2 BZD doses.

Other potential risk factors for intubation during or after a seizure include AED administration delays and BZD overdosing.[13,19] In our cohort, among seizure episodes treated initially with BZD only, 15% were treated with an inappropriately high dosage (>20% more than recommended weight-based dosing), and none received more

than the maximum recommended adult dosage; therefore, we did not evaluate for a risk of intubation with high dosing. Our study was also limited in assessing for other risk factors for intubation, because we were unable to accurately evaluate AED administration timing relative to seizure onset because of estimated seizure onset times.

Although 26% of extubations were delayed for sedated procedures, we found that the duration of intubation was short, with 50% extubated within 8 hours. This finding is similar to those of previous studies.[14,21] Although most emergency departments will transfer an intubated child to a tertiary hospital, given this brief duration of intubation, there may be select cases that could be managed without transport if subspecialty consultation is available.

Children not treated according to the recommendations were nearly 2 times more likely to undergo lumbar puncture (LP). However, meningitis as an etiology for the events was similar between the 2 groups. We suspect children not treated according to recommendations underwent LP more frequently because they were intubated more frequently, which requires sedation and reduces the reliability of the neurologic examination. Therefore, children may be perceived as more ill because of intubation. Furthermore, the ease of sedating a child with a secure airway in place may affect decisions to perform LPs.

Deviations from the recommended care for acute seizures may occur because of delays in BZD and other AED administration. Refrigeration and dilution requirements of second-line AEDs make the medications less readily available, and administration delays have been noted in both prehospital and hospital settings.[22,23] This delay may prompt administration of additional BZD doses beyond the recommended 2 doses. Therefore, improving timely accessibility of second-line AEDs may improve recommendation adherence. Furthermore, BZD administration delays have also been noted, which may prolong seizure duration and make a seizure less likely to resolve once BZDs or other AEDs are administered.[12,23] It is unclear why the delays in BZD administration occur, and additional studies are needed to evaluate this delay.

Additionally, deviations from recommended care occurred more frequently in younger children. This difference may reflect characteristics of seizures in younger children that could increase both provider and parental anxiety and prompt administration of extra BZD doses or earlier airway management. For example, younger children are more likely to present with a seizure provoked by an acute illness, a first-time seizure, or a seizure without history of neurologic abnormality.[24] Furthermore, in a controlled study younger children needed progression onto non-BZD administration for convulsive status epilepticus more often; however, this difference was not statistically compared.[25] The greater need for non-BZD medications compounded with the limited access to these medications described earlier may prompt administration of >2 BZD doses in younger children.

This study is limited by its retrospective design, which limited access to clinical information such as accurate timing of seizure duration and events surrounding the clinical outcome in question, intubation. We also did not evaluate other aspects of prolonged seizure management, such as timing interval between medications, which may play a role in outcomes. Furthermore, our hospital is a large tertiary hospital with a referral base expanding into 5 states, so transport can be over long distances; however, our transported seizure events appear to have similar outcomes to those in other reports. The majority of the referring hospitals are urban, but we did not evaluate referring emergency department pediatric volume or the specialty of the medical providers. Evaluating only seizure events involving transportation to a tertiary hospital probably introduced a selection bias because some events treated with appropriate seizure treatment probably did not necessitate transport. This bias would decrease our estimate for the relative risk of intubation, and therefore the true risk of intubation may actually be higher than our estimate.

CONCLUSIONS

Compliance with recommended pediatric acute seizure management in our 5-state referral base was poor despite our generous definition that included only the number and order of adminstered medications, and timing of secure airway placement. Administration of >2 BZD doses was associated with a greater than two fold risk of intubation. The majority of pediatric seizure events resulting in transfer to a tertiary hospital were not treated initially with recommended care. Prospective analysis of acute seizure treatment in community hospitals and qualitative studies evaluating barriers to recommendation adherence are warranted to evaluate need and develop educational interventions or system-based practice adjustments aimed at improving delivery of acute seizure management.

ABBREVIATIONS

AED: antiepileptic drug
BZD: benzodiazepine
CI: confidence interval
EMS: emergency medical service
IM: intramuscular
IN: intranasal
IQR: interquartile range
IV: intravenous
LP: lumbar puncture
PCH: Primary Children's Hospital
RR: relative risk

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

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