



<https://doi.org/10.1016/j.jemermed.2019.05.036>

Selected Topics: Prehospital Care

TREATMENT OF SEIZURES IN CHILDREN AND ADULTS IN THE EMERGENCY MEDICAL SYSTEM OF THE CITY OF ZURICH, SWITZERLAND – MIDAZOLAM VS. DIAZEPAM – A RETROSPECTIVE ANALYSIS

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Abstract—Introduction: Seizures count to critical situations emergency medical systems (EMS) are confronted with. **Objectives:** Evaluation of a modified treatment algorithm (MTAS-EMS) using diazepam and midazolam due to a supply bottleneck of iv lorazepam in 2012. **Methods:**

Department to which the work is attributed: Blood Transfusion Service Zürich, SRC, Schlieren, Switzerland and University of Zurich, Zurich, Switzerland.

Oliver M. Theusinger designed the study, conducted the study, analyzed the data and wrote the manuscript. Peter Schenk designed the study, conducted the study and wrote the manuscript. Katharina Dette-Oltmann helped to write the manuscript. Sergio Mariotti designed the study, conducted the study and made significant contributions to the manuscript. Werner Baulig helped to conduct the study, and made significant contribution in the preparation of the manuscript.

Oliver M. Theusinger has received honoraria or travel support for consulting or lecturing from the following companies: CSL Behring Schweiz, Zurich, Switzerland, Vifor SA, Villars-sur-Glâne, Switzerland, Roche Pharma (Schweiz) AG, Reinach, Switzerland, Pentapharm AG, München, Germany, TEM International GmbH, München, Germany, Octapharma AG Lachen, Switzerland, Instrumentation Laboratory, Bedford, MA. The remaining authors have no conflicts of interest.

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Retrospective study where data from patients treated for seizures by the EMS of the city of Zurich were analyzed. Effectiveness of the MTAS-EMS and i.v. diazepam in children and adults was compared with respect of cessation of seizure without recurrence over the period until arrival at the hospital. The chi-square and Fisher's exact test were used to compare categorical data. The Student's *t*-test and Mann Whitney test were used to compare numerical data. *p*-values < 0.05 are considered significant. Results: Of 584 documented missions, 165 treated patients (126 adults and 39 children) were included. 115 patients (80 adults and 35 children) were treated according the MTAS-EMS. Cessation of seizure was achieved in 85% of the adults and in 97% of the children, if all options of the MTAS-EMS were used. The first dose of nasal midazolam was more successful in children compared to adults ($p = 0.012$). In adults, the single dose of i.v. diazepam terminated the seizure in 98% ($p = 0.001$) compared to 57% for the single dose of iv and 64% for nasal midazolam. Conclusions: The treatment success of the MTAS-EMS is high. However, in adults the single dose of i.v. diazepam is as successful as the completely used MTAS-EMS and seems to be superior to the single dose iv and nasal midazolam. © 2019 Elsevier Inc. All rights reserved.

Keywords—seizure; epilepsy; status epilepticus; Emergency Medical Services; midazolam; diazepam; children; adults

RECEIVED: 11 May 2018; FINAL SUBMISSION RECEIVED: 10 May 2019;
 ACCEPTED: 13 May 2019

INTRODUCTION

Tonic-clonic seizures requiring emergency medical services (EMS) are a common problem in adults and children, with convulsive status epilepticus being associated with significant morbidity and mortality (1). Thus, management by EMS consists of medication, usually with a benzodiazepine, to terminate the seizures promptly and safely. According to the review by Prasad et al., intravenous (i.v.) lorazepam is the most effective drug for cessation of seizures, and also carries the lowest risk of continuation of status epilepticus (2). The 2016 guidelines of the American Epilepsy Society recommend benzodiazepine (lorazepam, midazolam, diazepam) as first-line choice, followed by second-line agents such as levetiracetam, phenytoin, or valproic acid (3,4). Due to a supply bottleneck of i.v. lorazepam in Switzerland in 2012, the EMS of Zurich (Schutz & Rettung Zürich, Zurich, Switzerland) established a modified treatment algorithm for seizures (MTAS-EMS) using midazolam and diazepam as a first-line drug to ensure comparable processing quality (Figure 1). Midazolam and diazepam can be administered rectally, intramuscularly (i.m.), and by i.v. In addition, midazolam is also suitable for buccal and nasal application. Data on prehospital management show that i.v. lorazepam is most commonly used, although more recently, midazolam for i.m., nasal, or buccal injection was found to have similar efficacy and is easier to administer (5). Based on meta-analysis of the American Epilepsy Society, i.m. midazolam, i.v. lorazepam, i.v. diazepam, and i.v. phenobarbital are reported to be established as efficacious in stopping seizures lasting at least 5 min in adults. In children, i.v. lorazepam and i.v. diazepam are reported to be efficacious in stopping seizures lasting at least 5 min, whereas rectal diazepam and i.m., intranasal, and buccal midazolam are estimated to be probably effective (4). The proposed treatment algorithm for status epilepticus of the American Epilepsy Society advises i.m. midazolam, i.v. lorazepam, and i.v. diazepam as first-line drugs. If none of the three drugs are available, i.v. phenobarbital, rectal diazepam, or intranasal or buccal midazolam are recommended. The MTAS-EMS recommends the i.v., nasal, and i.m. administration of midazolam as the initial drug in adult patients, and rectal diazepam, or nasal or i.v. midazolam in children. If no cessation of the cerebral seizure is achieved with single or repeated use of these drugs, the MTAS-EMS advises the use of i.v. diazepam for both adults and children as subsequent treatment (Figure 1).

The aim of this retrospective study was the evaluation of the effect of the initial given drug and the effect of using all of the MTAS-EMS options to stop seizures.

MATERIALS AND METHODS

As data were collected from the anonymized database of EMS Zurich (Schutz und Rettung Zurich), the local ethics committee (Kantonale Ehtikkommission, Zurich, Switzerland) decided that no approval was necessary for this retrospective data collection and analysis.

EMS Zurich is the largest civil service in Switzerland; it covers an overall area of 240 km² and operates an average of 35,000 emergency missions per year. The City of Zurich has a territory of 92 km². Up to 18 teams are on call, depending on the time of day. Two registered paramedics that accomplished a 3-year advanced federal diploma of higher education form a team. A designated emergency physician (EP) is also brought to the prehospital scene by a rapid response car if a life-threatening emergency has been reported. In the case of life-threatening emergency in neonates, infants, and toddlers, a pediatric EP is used. For the EMS, the median (interquartile range) arrival time after emergency call for each location within the urban Zurich area is 11 (9,13) min, which was reported in a recently published investigation of the outcome of out-of-hospital resuscitation in Zurich (6).

This is a retrospective study. Data on emergency operations for cerebral seizures from June 1, 2013 to December 31, 2014 were collected from the database of EMS Zurich. In this database, all operations of the EMS are anonymized and documented with a code for each main emergency indication (e.g., cardiac arrest, acute coronary syndrome, or seizure). Data were reviewed according to recommendations for performing retrospective data collection and interpretation, and transformed in a designated research database using the comma-separated value file format (7).

Inclusion criteria were: seizure on arrival of the EMS at the emergency site, and the use of midazolam or diazepam or its combination as first-line drugs. Exclusion criteria were: the cessation of the seizure on arrival of EMS, the use of any other than the first-line drugs by the EMS staff, primary induction of anesthesia, incomplete or missing documentation in the EMS database, and cases without seizure. In all patients, routine monitoring by EMS, consisting of electrocardiography and noninvasive blood pressure measurement, in most cases intravenous access and capillary blood glucose measurement, was performed. According to national regulations on the protection of minors in Switzerland, children were defined as patients aged < 18 years and adults aged ≥ 18 years. Seizures are defined as an electrical surge to the brain that affects how someone acts for a short period of time. Recently, the International League Against Epilepsy defined status epilepticus (SE) as

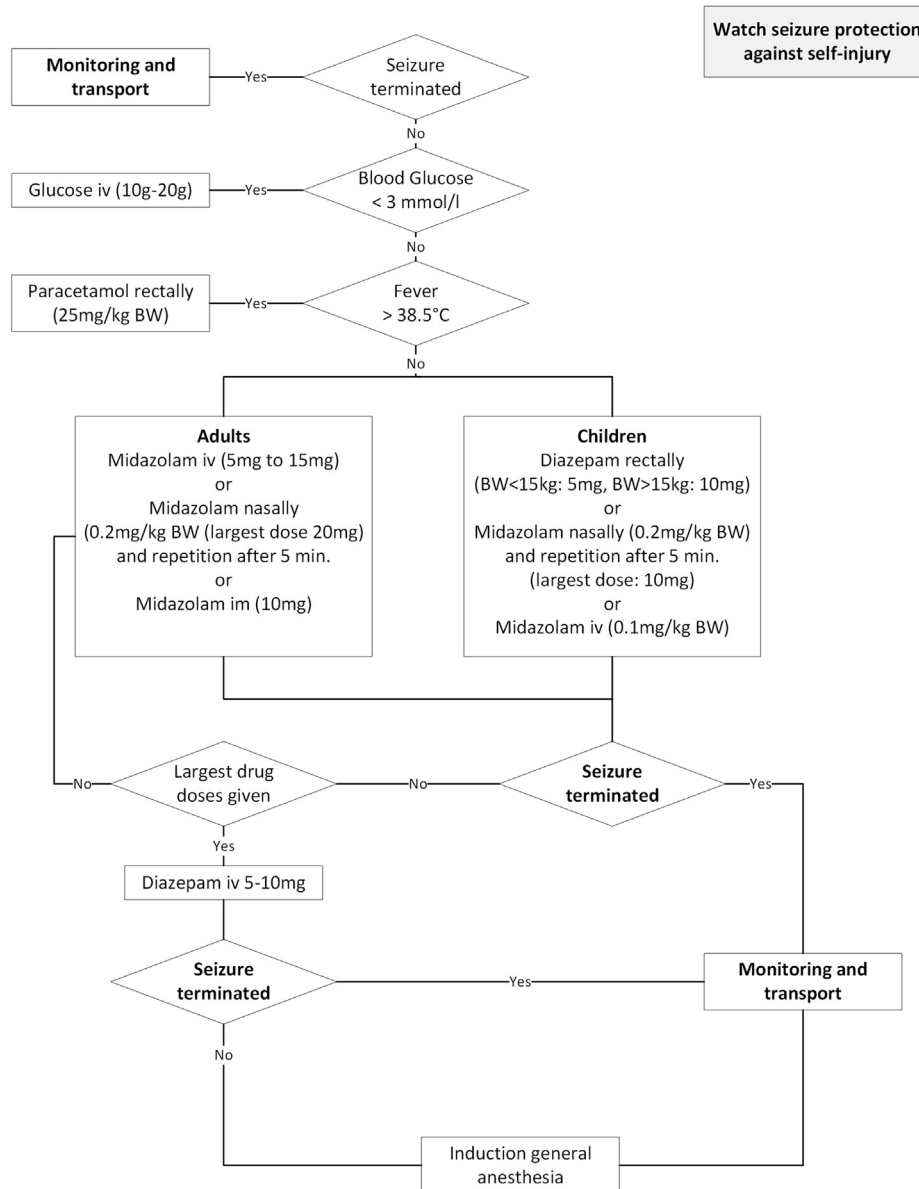


Figure 1. Modified treatment algorithm of the Emergency Medical Services Zurich for cerebral seizures in adults and children (MTAS-EMS). iv = intravenous; BW = body weight.

convulsions persisting for longer than 5 min (time point t_1), with risk of long-term consequences if the duration exceeds 30 min (time point t_2). Therefore, seizures lasting more than 5 min after arrival of the paramedic or EP, restarted after initial cessation, or that needed general anesthesia, were defined as SE (8). The treatment was declared successful when seizure stopped after administration of the first-line drug (single, repeated, or combined doses) with no recurrence prior to arrival in the emergency department (ED). The indication for EP presence on scene for the EMS was cerebral seizures combined with cardiopulmonary instability and cerebral seizures in infants and toddlers.

The following data were collected: age, gender, heart rate, noninvasive blood pressure, capillary blood glucose, body temperature, pretreatment drug given by a relative or layperson, route of administration of the drug (i.v., i.m., nasally, rectally) by the EMS staff, drug used (midazolam, diazepam, both, or other) by the EMS staff, the administered drug dose, EP on scene, treatment success with cessation of the seizure until arrival in the ED, number of patients with therapy refractory seizure needing general anesthesia, or recurrence of seizure during transport.

The primary endpoint of this investigation is the frequency, route of administration, and treatment success

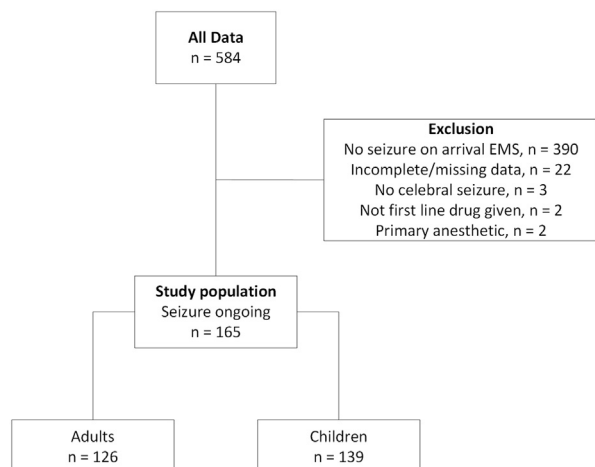


Figure 2. Flowchart: inclusion/exclusion criteria, Proportion of cerebral seizures stopped and ongoing on scene in adults and children. EMS = Emergency Medical Services.

of the initial drug used and after all treatment options of the modified algorithm of the EMS were used in adults compared with children. The second endpoint is the frequency and success of i.v. or i.m. diazepam when administered from the EMS as an initial drug.

Bias: All operations of the EMS were filed in the database of the EMS directly after every mission. After entering the data, these were targeted and could be opened only after entering an assigned password. Any change to the data in a record was thus saved and could be controlled by the system administrator. The data of the initial record were retained. Multiple cross-checks and an additional list for all missions with a National Advisory Committee for Aeronautics score of VI and VII were performed. This limited the recall and selection bias.

Statistical Analyses

To test for normality, the Shapiro-Wilk Test was used. Categorical data were reported as frequency and percentage; numeric data were presented as mean \pm standard deviation if normally distributed, or as median and 25th and 75th percentile (interquartile range) if not normally distributed. The chi-squared and Fisher's exact test were used to compare categorical data. Student's *t*-test and Mann-Whitney *U* test were used to compare numerical data. All statistical analyses were performed by IBM SPSS Statistics 23 (IBM Corp., Armonk, NY). *p*-Values < 0.05 are considered statistically significant.

RESULTS

During the 18-month study period, a total of 584 missions due to seizures were documented in the database of the EMS Zurich. There were 419 patients excluded because the seizure had terminated upon arrival of the EMS, data were incomplete or missing, the patient had an illness other than seizure, patients with ongoing seizures were treated with drugs other than the ones used in the MTAS-EMS, and if patients were immediately given general anesthesia (GA). There were 165 data sets included for analysis (Figure 2). Gender, known epilepsy, and EP on scene were not significantly different between adults and children (Table 1). Pretreatment with various substances of the benzodiazepine group by relatives or laypersons was significantly ($p < 0.001$) more frequent in children (10%) compared with adults (3%). Body temperature was significantly ($p < 0.001$) more often measured in children (95%) compared with adults (36%), and was significantly higher ($p = 0.045$) in children (Table 1). In adults, capillary glucose was significantly more often

Table 1. Comparison of Demographic Data, Medical History, and Measurements on Scene in All (n = 165), Adults (n = 126), and Children (n = 39)

	All	Adults	Children	<i>p</i> -Value
All, n (%)	165 (100)	126 (76.4)	39 (23.6)	<0.001
Male, n (%)	90 (54.5)	74 (58.7)	16 (41.0)	n.s.
Age, years (median [IQR 25; 75])	40.8 [19.0; 66.1]	53 [36.9; 72.8]	3.4 [1.9; 5.9]	
Known epilepsy, n (%)	77 (46.7)	61 (48.4)	16 (41.0)	n.s.
EP on scene, n (%)	92 (55.8)	65 (51.6)	27 (69.2)	n.s.
BT measuring, n (%)	82 (49.7)	45 (35.7)	37 (94.9)	<0.001
BT, °C (mean \pm SD)	37.6 \pm 1.6	37.3 \pm 1.7	38.0 \pm 1.5	0.045
Glucose measuring, n (%)	151 (91.5)	121 (96.0)	30 (76.9)	0.010
Glucose, mmol/l (mean \pm SD)	7.3 \pm 2.3	7.5 \pm 2.4	6.8 \pm 1.9	n.s.
Pretreatment with benzodiazepine	8 (4.8)	4 (3.2)	4 (10.3)	<0.001
Treatment according to the EMS algorithm performed	115 (70)	80 (63)	35 (90)	0.04
Treatment initially with the second-choice drug of EMS algorithm (diazepam i.v.)	50 (30)	46 (37)	4 (10)	<0.001

n.s. = not significant; IQR = interquartile range; EP = emergency physician; BT = body temperature; EMS algorithm = modified treatment algorithm of the Emergency Medical Services (EMS) Zürich for seizures; i.v. = intravenous.

Data are presented in absolute (n) and relative (%) values, continuous data are presented as mean \pm SD, or median [interquartile range]. *p*-Value < 0.05 is considered to be significant.

Table 2. Treatment Success of the Route of Administration for All Patients, Adults, and Children if Only the Initial Single Drug of the Modified Treatment Algorithm of the EMS Was Given

Route of Administration of the Drug	All, n = 115	All Treatment Success, n (%)	Adults, n = 80	Adults Treatment Success, n (%)	Children, n = 35	Children Treatment Success, n (%)
Midazolam i.v.	36	20 (55.6)	35	20 (57)	1	0
Midazolam nasally	56	40 (71)	44	28 (64)*	12	12 (100)*
Diazepam rectally	23	20 (87)	1	1 (100)	22	19 (86)
Sum of all drugs	115	80 (70%)	80	49 (61%)	35	31 (89%)

i.v. = intravenous application; nasally = nasal application; i.m. = intramuscular application; EMS = Emergency Medical Services; rectally = rectal application.

Data are presented as absolute value (n) and, if necessary, in percentage (%) of the patients. p -Value < 0.05 is considered to be significant for comparison between adults and children.

* $p < 0.05$.

measured compared to children ($p = 0.01$). No significant difference in the capillary glucose concentration was found between the groups (Table 1).

In total, 115 (70%) of the 165 patients (80 adults [63%] and 35 children [90%]) were treated according to the MTAS-EMS. Significantly more children ($p = 0.04$) were treated according to the MTAS-EMS compared with adults. The i.m. administration of midazolam was not used. In 50 patients (46 adults and 4 children), i.m. or i.v. diazepam was given as the initial drug (Table 1). One hundred sixty-five patients received 202 drugs.

In the patients treated according to the MTAS-EMS, i.v. or nasal administration of midazolam was chosen as the initial drug in 79 (99%) of the 80 adults, and in 12 (34%) of the 35 children ($p < 0.001$). In 22 (63%) of the children and in 1 adult, diazepam was given rectally (Table 2).

In adults, cessation of seizure by administration of a single dose of the initial drug was achieved in 57% with i.v. and 64% with nasal midazolam. In children, the initial single dose of nasal midazolam was more successful in stopping the seizure (100%) than rectal diazepam (86%) (Table 2). Compared with adults, the initial single nasal application of midazolam was significantly ($p = 0.012$) more successful in children. Overall, cessation of seizure by an initial drug dose according to the MTAS-EMS was achieved significantly more frequently ($p = 0.02$) in children (89%) compared with adults (61%).

If all options of the MTAS-EMS were used, the cessation of seizure occurred in 89% ($n = 102$) of all patients. The treatment success was higher in children (95%) compared with adults (85%), but not significantly different (Table 3). In adults, the application of nasal midazolam and its completion by other routes of midazolam i.v. diazepam was significantly ($p = 0.049$) more successful (93%) than the i.v. midazolam and its completion by i.v. diazepam (74%). Completion of rectally administered diazepam by i.v. or nasal midazolam in children increased the success of treatment to 100% (Table 3).

In 50 (30%) of the 165 included patients (46 adults and 4 children), diazepam i.v. and diazepam i.m. with subse-

quent i.v. completion was used as the initial drug (Table 4). The initially applied single dose of i.v. diazepam resulted in cessation of the seizure in 98% of the adults and in 100% of the children. In adults, the initial i.v. administration of diazepam was significantly ($p = 0.001$) more successful than a single dose of i.v. or nasal midazolam.

In total, 151 (92%) of the 165 patients were treated successfully on scene. Eight patients developed SE. In 2 adults, convulsive seizures repeatedly occurred during transportation. In 12 patients, GA was performed on scene. GA was necessary in 6 patients after unsuccessful use of the MTAS-EMS (2 adults with nasal midazolam and subsequent i.v. midazolam, and 4 adults with i.v. midazolam followed by i.v. diazepam). In the 6 other patients, GA was performed due to respiratory complications of the treatment (one child with a single dose of midazolam, one adult with a single dose of i.v. diazepam, 4 adults with a single dose of i.v. midazolam).

DISCUSSION

The main findings of this study are: 1) 63% of the adults and 90% of the children were treated according to the MTAS-EMS; 2) cessation of seizure was achieved significantly more frequently in children compared with adults with application of an initial drug of the MTAS-EMS; 3) if all options of the MTAS-EMS were used, the effectiveness in stopping the seizure was high; 4) in adults, the single dose of i.v. diazepam is as successful as the completely used MTAS-EMS.

Seizures are the most common serious brain disorder worldwide, and the prevalence in Europe is 8.2 per 1000 people, with an estimated number of children and adults of 0.9 million (9). The bimodal distribution of both the incidence and the mortality of seizures and SE, with high incidence and mortality in the first decade of life and after 60 years, has also been found in epidemiologic studies in Americans and Asian subjects (10). The premature termination of seizure at the scene is thus the ultimate goal of each initial treatment concept.

Table 3. Treatment Success if the MTAS-EMS Was Completely Used; in All Patients (n = 115), Adults (n = 80), and Children (n = 35)

Drugs Used	All, n = 115	All Treatment Success, n (%)	Adults, n = 80	Adults Treatment Success, n (%)	Children, n = 35	Children Treatment Success, n (%)
Midazolam i.v.	26	20	25	20	1	0
Midazolam i.v. + diazepam i.v.	10	6	10	6	0	0
Sum midazolam i.v. + all combinations	36	26 (72)	35	26 (74)	1	0
Midazolam nasally	40	40	28	28	12	12
Midazolam nasally + i.v.	6	4	6	4	0	0
Midazolam nasally + diazepam i.v.	7	7	7	7	0	0
Midazolam nasally + i.v. + diazepam i.v.	3	2	3	2	0	0
Sum midazolam nasally + all combinations	56	53 (95)	44	41 (93)	12	12 (100)
Sum midazolam all routes and all combinations	92	79 (86)	79	67 (85)	13	12 (92)
Diazepam rectally	20	20	1	1	19	19
Diazepam rectally + midazolam i.v.	2	2	0	0	2	2
Diazepam rectally + midazolam nasally	1	1	0	0	1	1
Sum diazepam all routes and all combinations according to algorithm	23	23 (100)	1	1	22	22 (100)
Total	115	102 (89)	80	68 (85)	35	34 (97)
Seizure started again		2		2		
GA		11		10		1

MTAS-EMS = modified treatment algorithm of the EMS Zurich for cerebral seizures; i.v. = intravenous application; nasally = nasal application; i.m. = intramuscular application; rectally = rectal application; + = combination of different drugs and their route of application; GA = general anesthesia.

Data are presented as absolute value (n) and, if necessary, in percentage (%). Eighty (63%) adults and 35 (90%) of the children received the drugs according to the modified treatment algorithm; 46 (37%) adults and 4 (10%) children were initially treated with the second subsequent drug of this algorithm. In total, in 102 (89%) patients, the treatment with both drugs in single or combined use was successful.

After a 1-year introduction period of the MTAS-EMS, this retrospective investigation shows that this algorithm has not been implemented in all patients. Interestingly, it was used in 90% of the children but in only 63% of the adults. A probable explanation for high frequency use in children may be found in the recommendation for the route of administration of the initial drug in children. Mahmoudian and Zadeh compared nasal midazolam with i.v. diazepam in pediatrics and reported a faster time to drug administration with nasal midazolam, but the time period between medication and seizure cessation was shorter for i.v. diazepam (11). For the EMS, rectal or nasal application is easier and, above all, faster to perform compared with i.v. administration of the drug in children. In this patient population, i.v. access is usually rather difficult to establish on scene. Given the significantly lower frequency of

MTAS-EMS use in adults, the routine use of i.v. diazepam or i.v. lorazepam prior to introduction of the algorithm may be responsible. Although i.m. administration of midazolam was one of the first-choice options for adults in the MTAS-EMS and its superiority was reported, it has not been used in any patients (12). This retrospective data analysis shows that the i.v. and nasal administration of midazolam was performed as the initial treatment of the MTAS-EMS in adults. Nasal midazolam and rectal diazepam were mainly used in children. Intravenous midazolam was administered in only one child.

Single doses of i.v. and nasal midazolam of the MTAS-EMS have led to cessation of seizure in 57% and 64% of the adults, respectively. These results are largely consistent with the results of the only few other investigations in adult patients (13,14). Contrary to the treatment

Table 4. Treatment Success of Initially i.m. or i.v. Applied Diazepam in All Patients, Adults, and Children

Drugs used	All, n = 50	All Treatment Success, n (%)	Adults, n = 46	Adults Treatment Success, n (%)	Children, n = 4	Children Treatment Success, n (%)
Diazepam i.v.	49	48	46	45	3	3
Diazepam i.m. + i.v.	1	1	0	0	1	1
Sum diazepam all routes and all combinations	50	49 (98)	46	45 (98)	4	4 (100)
Seizure started again		0		0		0
GA		1		1		0

i.v. = intravenous application; i.m. = intramuscular application; + = combination of different drugs and their route of application; GA = general anesthesia.

Data are presented as absolute value (n) and, if necessary, in percentage (%) of the patients who received the drug via the respective route of administration; 46 (37%) adults and 4 (10%) children were initially treated with diazepam (i.v. and i.m.). In total, in 49 (98%) patients, the treatment was successful.

success in adults, in children the single dose of nasal midazolam has stopped seizures in 100%, whereas cessation of seizure was achieved by single rectal dosing of diazepam in 86%. In a study of 46 children, Bhattacharyya et al. reported cessation of seizures within 10 min after drug administration in 97% of patients in the nasal midazolam group and 89% of patients in the rectal diazepam group (15). Fisgin et al. also reported intranasal midazolam to be more likely to stop seizure activity within the first 10 min (87%) compared with 58% for rectal diazepam in 45 children (16). Additionally, more children in the rectal diazepam group required a second anticonvulsant to stop the seizure. In the 3 children in this study in which rectal administration of diazepam did not terminate the seizure, additional nasal or i.v. midazolam stopped the seizure. All in all, the cessation of seizure was achieved significantly more frequently in children compared with adults with administration of a single drug according to the MTAS-EMS.

With cessation of the seizure in 85% of the adults and in 97% of children, the completely used MTAS-EMS was a successful treatment algorithm. In all adult patients in this investigation, the i.v. or nasal application mode was usually chosen. Among adult patients, seizures were stopped in 68 of 80 (85%). These results are at least as successful as those reported by others. In a double-blinded study of 70 adult patients with SE, i.v. lorazepam was successful for 78% of subjects after one dose and 89% after two doses, and i.v. diazepam was successful for 58% of subjects after one and 76% after two doses, which was not significantly different and shows the comparable effectiveness of both drugs (17). The high success of the MTAS-EMS to terminate seizures in 97.5% of the children with application of one drug alone or the combination of diazepam and midazolam confirms the results of others (15,16).

However, this retrospective study shows that i.v. administration of a single dose of diazepam resulted in cessation of seizure in 98% of the adults, which was as successful as the completely used MTAS-EMS. Additionally, i.v. diazepam was significantly more successful in stopping seizures, compared with the effect of a single dose of i.v. and nasal midazolam in adults. This treatment success seems to be considerably higher than has been reported in the few previous studies in adults. Leppik et al. compared the effectiveness of i.v. lorazepam and i.v. diazepam to stop seizures in 70 adults with convulsive status epilepticus (17). They found no significant difference between i.v. lorazepam (success of 78% after one and 89% after two doses) and diazepam (success of 58% after one and 76% after two doses) in seizure cessation. In out-of-hospital adult patients, Alldredge et al. reported the cessation of seizures by i.v.

diazepam administration in only 42.6% (18). Recently, Clemency et al. reported cessation of seizures in 58% of adults with i.v. diazepam, compared with 62% with i.v. midazolam (13). The high treatment success of i.v. diazepam in adults in this study is rather unusual. This result cannot be explained with a possible overdose of i.v. diazepam, because with the exception of 3 patients, the recommended dosage of i.v. diazepam was applied (data not shown).

Limitations

There are some essential limitations. First, the retrospective design of this investigation, which allowed access only to the data collected by the EMS. Although EMS's data collection is structured and standardized, the quality of the data collection was different and certainly depended on the presence or absence of an EP. Additionally, considerable data are not collected in the city of Zurich's EMS, such as time of administration of the drug, timing of the onset of seizure, indication of which drug was given at which time, and when several medications were necessarily. In only 8 of 165 patients, pretreatment by relatives or laypersons was documented. In all other cases the information about potential pretreatment was missing, and therefore, possible interaction with the performed first-line treatment was not calculable. However, this unknown variable could have a significant impact on treatment success reported in this retrospective investigation. Second, the missing sample size calculation in this retrospective cohort study is a potential limitation. Even if the sample size and the number of patients having received midazolam or diazepam in this retrospective study are within the size of other studies, such as that by McIntyre et al., who included 177 patients, the number of included patients is not sufficient enough to make certain statements (19). Third, there are no sufficient data on the period between the first emergency call and the arrival of EMS on scene, so the duration of the epileptic convulsions cannot be assessed in either the patients with SE or those with spontaneous termination of the epileptic seizure. Fourth, there is no follow-up once patients have been admitted to the ED, as data were provided anonymously.

CONCLUSION

The MTAS of the EMS Zurich is a reliable tool for early termination of seizures in children and adults. However, in adults, the single dose of i.v. diazepam is as successful as the completely used MTAS-EMS, and seems to be superior to single-dose i.v. and nasal midazolam.

Acknowledgment—We thank S.M. Müller, MD and Mr. M. Schumann for providing us the needed data from Schutz und Rettung Zürich, Switzerland.

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ARTICLE SUMMARY

1. Why is this topic important?

Different benzodiazepines have been used over time to treat seizures. Various studies on different drugs and populations exist.

2. What does this study attempt to show?

To compare midazolam and diazepam in children and adults in the preclinical setting of seizures in the emergency medical system.

3. What are the key findings?

Both midazolam and diazepam can be safely and successfully used as first line medication in patients with status epilepticus. While the application of diazepam rectally and midazolam nasally is preferred in children, the main route of administration in adults is intravenous or nasally.

4. How is patient care impacted?

Seizure treatment based on the modified treatment algorithm of the EMS using both midazolam and diazepam is at least as successful as the recommended first line therapy with lorazepam.