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Adding Video Recording Increases the Diagnostic Yield of Routine Electroencephalograms in Children with Frequent Paroxysmal Events

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Summary: *Purpose:* To report on the usefulness of adding video recording to routine EEG studies of infants and children with frequent paroxysmal events.

Methods: We analyzed the efficacy of this diagnostic means during a 4-year period. The decision whether to add video recording was made by the pediatric EEG interpreter at the time of the study. Studies were planned to last between 20 and 30 min, and, if needed, were extended by the EEG interpreter. For most studies, video recording was added from the beginning of EEG recording. In a minority of cases, the addition of video was implemented during the first part of the EEG test, as clinical events became obvious. In these cases, a new study (file) was begun. The success rate was analyzed according to the indications for the EEG study: paroxysmal eye movements, tremor, suspected seizures, myoclonus, staring episodes, suspected stereotypias and tics, absence epilepsy follow-up, cyanotic episodes, and suspected psychogenic nonepileptic events.

Results: Video recording was added to 137 of 666 routine studies. Mean patient age was 4.8 years. The nature of the event was determined in 61 (45%) of the EEG studies. Twenty-eight percent were hospitalized patients. The average study duration was 26 min. This diagnostic means was particularly useful for paroxysmal eye movements, staring spells, myoclonic jerks, stereotypias, and psychogenic nonepileptic events. About 46% of 116 patients for whom cognitive data were available were mentally retarded. EEG with added video recording was successfully performed in all 116 cases and provided useful information in 29 (55%) of these 53 patients.

Conclusions: Adding video recording to routine EEG was helpful in 45% of cases referred for frequent paroxysmal events. This technique proved useful for hospitalized children as well as for outpatients. Moreover, it was successfully applied in cognitively impaired patients. Infants and children with paroxysmal eye movements, staring spells, myoclonic jerks, stereotypias, and pseudoseizures especially benefited from this diagnostic means. Because of its low cost and the little discomfort imposed on the patient and his or her family, this technique should be considered as a first diagnostic step in children with frequent paroxysmal events. **Key Words:** Video recording—Routine—Electro encephalogram—Children.

Prolonged video-EEG has long been used in the evaluation of paroxysmal events in children (1,2). With this diagnostic means, a correlation between clinical events suggestive of being epileptic seizures and EEG activity can be established in many cases, thus confirming or ruling out the epileptic nature of these events.

Main indications for this procedure include the diagnosis of epilepsy and seizure classification, the differentiation between epileptic and nonepileptic events, the characterization of seizure frequency, and presurgical evaluation (2,3). Despite its advantages, the procedure has significant limitations, which include the high cost associated with hospital admission, the discomfort to the child and his family, and the need for highly trained staff to handle the equipment during the long procedure (4,5).

Short-duration video EEG (SDVEEG), lasting usually a few hours, does not require hospitalization, is more convenient for the child and the family, and is less time consuming for the medical staff. The procedure has become available in many centers, and its value in the diagnosis of paroxysmal events in children has been established (5–8). Although its contribution is undeniable, SDVEEG is still a relatively long procedure, lasting 2 to12 h in most cases (5,7–9), and has been reported mostly as an outpatient diagnostic procedure.

Little has been published on the diagnostic yield of adding video recording to routine EEG examinations (lasting 20–40 min) of children with paroxysmal events. We

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report on our experience with adding video recording to routine EEG studies in such patients. This study involves a large series of pediatric patients and includes both in- and outpatients.

METHODS

Video recording was added to routine EEG studies of infants and children with very frequent clinical paroxysms. The period evaluated extends from February 2000 to February 2004. We retrospectively reviewed the clinical and electrographic data of all studies performed in this fashion. All studies were performed at the EEG laboratory at Wolfson Medical Center and included both hospitalized children and outpatients. Recordings were performed by using the mobile Ceegraph IV BioLogic system (Bio-Logic Systems Corporation, Mundelein, IL, USA). Scalp electrodes were positioned according to the international 10/20 system or the 10/10 system when necessary. The decision whether to add video recording to the routine examination was made at the pediatric EEG interpreter's discretion, based on the frequency and nature of the events. As a rule, events had to occur multiple times during the day to warrant the addition of video recording. Patients were positioned to allow a better view of the spells. Most studies where recorded with the child in the supine position or sitting in a reclinable coach. If needed, patients with attacks occurring while standing would have part of their video-EEG recording in a standing position. For the majority of studies, video recording was added from the beginning of EEG recording. In a minority of cases, the addition of video was done during the first part of the EEG test, as clinical events became obvious. In these cases, a new study (file) was begun. Studies with added video recording were intended to last between 20 and 30 min. However, when deemed appropriate, the physician extended the EEG study to try to capture clinical events.

All studies were analyzed by the same interpreter, who was aware of the patient's clinical history and took active part in the care of most of these patients. The majority of outpatients in this series were referred by the hospital's child neurology clinic. All inpatient EEG tests were requested in agreement with or at the request of a child neurology consultant.

All recordings were analyzed by using a split-screen video, thus allowing optimal visualization of the patient and the EEG tracing simultaneously. Most studies were analyzed separately after the actual test was completed. However, if clinical events were captured and the EEG interpreter was present during the test, the segment with added video recording could be ended as soon as enough clinical and electrographic data were obtained.

Patients were classified into nine subgroups according to the indications for the EEG study: paroxysmal eye movements, tremor, suspected seizures, myoclonus, staring episodes, suspected stereotypias and tics, absence epilepsy follow-up, cyanotic episodes, and suspected psychogenic nonepileptic events.

TABLE 1. *Percentage of contributory studies according to age groups*

Age group	Number of cases	Contributory studies	%
0–2 mo	7	0	0
2–12 mo	19	6	32
1–3 yr	33	20	61
4–10 yr	48	23	42
>10 yr	30	8	27

RESULTS

A total of 666 children underwent routine EEG recordings during the 4-year period. Video recording was added to 137 studies. Their ages ranged from 2 days to 18 years (mean, 4.8 years). The age distribution was as follows: Seven neonates, 19 infants (2 months to 1 year old), 33 toddlers (1–3 years), 48 preschool- and school-age (4–10 years) children, and 30 patients older than 10 years. We could determine the nature of the paroxysmal event in 61 (44.5%) of 137 studies. The percentage of contributory studies varied according to the different age groups. The highest proportion of helpful studies occurred in the 1- to 3-year-old group, whereas all EEGs in the neonatal group were noncontributory (see Table 1). Twenty-eight percent of studies involved hospitalized infants and children.

Mean duration of the EEG studies was 26 ± 12.7 min. This includes 20 cases in which the EEG study lasted <20 min, as the clinical question could be solved within a few minutes, such as in suspected stereotypias and in some of the paroxysmal eye movement cases. Of note, the mean duration of EEG recordings was within the same range for the subgroup whose study's indication was to confirm or rule out seizures: 21.7 ± 6.4 min for those records that helped confirm or discard seizures, and 26.6 ± 5.7 min for those studies that did not provide this information. Moreover, the percentage of records depicting interictal epileptiform activity was close to 50% in both groups. Three studies among those aimed at confirming or ruling out seizures extended beyond 1 h, lasting ≤ 75 min.

In all, adding video recording helped establishing the diagnosis or ruled out epilepsy in 18 of 78 studies with the indication of "rule out seizures." Nine were performed on known epilepsy patients with new, different spells that necessitated clinical characterization to avoid diagnosing nonepileptic events as seizures; in all nine cases, the attacks were proven to be epileptic in nature. Among the remaining nine cases, three children were diagnosed with epilepsy in view of the video-EEG findings, whereas in six studies, the events were not epileptic. Conversely, of the 60 cases for which video recording addition was not

TABLE 2. *Percentage of effective studies according to the indications for EEG*

	Number of recordings	Video recording informative	%
Tics and stereotypias	5	5	100
Suspected psychogenic nonepileptic events	4	4	100
Paroxysmal eye movements	15	13	87
Staring spells	9	7	78
Myoclonus	13	10	77
Absence seizures f/u	10	4	40
Rule out seizures	78	18	23
Cyanotic episodes	3	0	0
Total	137	61	45

helpful, none experienced clinical events during the EEG study. Of these EEGs, 20 were performed on children with known epilepsy children, and three patients were later confirmed as such. The case of a 3-month-old girl is worth mentioning, inasmuch as the first study, although depicting epileptiform activity, did not capture any clinical events. Six days later, a repeated EEG with added video recording captured a seizure and allowed a semiologic characterization of the attack.

Adding video recording also assisted in establishing the nature of paroxysmal eye movements in 13 of 15 children. Ten patients were mentally retarded, three had normal cognition, and two infants were too young to determine their cognitive potential. Among the remaining 101 patients for whom information on their cognitive status was available, 43 had various degrees of mental retardation. Hence, the proportion of cognitively impaired infants and children was higher in the subgroup of patients with paroxysmal eye movements as the indication for the EEG study.

The yield in establishing the true nature of the clinical events varied according to the indications for performing an EEG study. In cases of paroxysmal eye movements, staring episodes, tics and stereotypias, myoclonus, and those being treated for absence seizures, addition of video recording was most beneficial. Moreover, video recording helped establish a diagnosis of psychogenic nonepileptic events in all four patients with this clinical suspicion. Three young infants underwent the study for apparent life-threatening event; in these cases, the diagnostic technique was not useful. The effectiveness of adding video recording to routine EEG varied according to the different subgroups and is shown on Table 2.

DISCUSSION

Outpatient short-duration video-EEG has been increasingly used in recent years as a means to enhance the diagnostic yield of EEG, particularly to confirm or rule out an epileptic origin of paroxysmal events. This technique also allows better characterization and recognition of subtle seizures in known epilepsy patients (4–10). Although several studies on outpatient short-duration video EEG have been reported in recent years, the duration of the EEG recordings has ranged from 2 h (5,10) to an average of 8 h (4). In one study on adult patients, investigators performed short-duration video-EEG that lasted between 40 and 50 min and showed that shorter recording time also may be effective in establishing the nature of the attacks; it was useful in 58% of cases (6).

The addition of video recording to routine EEG studies helped in solving the clinical issue in 45% of our patients. As shown in Table 1, the proportion of studies that helped answer the clinical issue was highest among toddlers, preschoolers, and school-age children. This is not surprising, because these age groups included most of the EEG indications with the highest diagnostic yield, such as paroxysmal eye movements, staring spells, myoclonus, and tics and stereotypic movements. Adding video recording was not contributory among neonates. This group included seven patients whose EEG indications were rule out seizures in five and cyanotic events in two.

In comparison, the reported yield of short-duration video-EEG in studies lasting 2 to 8 h ranged from 62% to 95% (4,5,7–10) (see Table 3). Longer recording duration enhances the chances of capturing clinical events. One study found that, although the efficacy of 2-h short-duration video-EEG was 62%, longer, overnight studies

TABLE 3. *Reported efficacy of short term video-EEG in establishing the nature of paroxysmal events: comparison with current study*

Reference	Population studied	Number of cases	Video-EEG duration (h)	Outpatient study	Success rate (%)
Valente et al.	Pediatric	39	8 (mean)	+	95
Connolly et al.	Pediatric	43	2–3	+	83
McGonigal et al.	Adult	143	40–50 min[a]	+	58
Foley et al.	Pediatric	100	4 (median)	+	83
Al-Qudah et al.	Pediatric	37	1–4	+	68
Srikumar et al.	Pediatric	45	≤6	+	78
Del Giudice et al.	Pediatric	100	2	+	73
Watemberg et al.	Pediatric	137	26 min (mean)	Mixed[b]	45

[a]Reference included because of the very short duration of video-EEG studies.
[b]In- and outpatients.

were useful in 82% of cases. Short-duration video-EEG was particularly effective for children with frequent clinical events (3). The overall success rate in our patient series, the lower cost, and the reduced time consumption associated with the addition of video recording to routine EEG probably justify this technique as the initial approach in children with very frequent clinical events. Although we did not specifically analyze their input during the EEG study, we concur with other authors in that brief, outpatient video-EEG recording allows direct, real-time parental and caregiver identification of the events, thus increasing the diagnostic yield of the study, particularly for children with subtle clinical spells that may be missed by the EEG technologist (3,5).

Twenty-eight percent of our studies were performed on inpatients, such as neonates, infants with apparent life-threatening events, and a few patients with known history of seizures admitted for reevaluation of their clinical events. The application of short-duration video-EEG in children has not been reported for inpatients (4–10). This may be in part due to the prospective method of the studies. Our findings suggest that the addition of video recording to routine EEG also may be useful for epilepsy patients admitted for an increase in the frequency of seizures.

In our study, the indications for obtaining an EEG study had a direct impact on the efficacy of adding video recording. In patients with very frequent episodes, such as stereotypias, tics, and paroxysmal eye movements, the yield of the study increased, thus allowing briefer studies in some cases. Conversely, longer studies may be warranted for patients with less frequent events, such as treated epilepsy patients referred for characterization or quantification of seizure activity.

In all, ~46% of 116 patients for whom data on cognitive status were available were mentally retarded. EEG with added video recording was successfully performed in all cases, seldom necessitating sedation for the procedure. This is important, because cognitively impaired children often pose a challenge to the EEG technologist. Moreover, the test provided useful information in 29 (55%) of these 53 cases. In comparison, by using 2-h short-term video-EEG, Thrirumalai et al. (3) successfully determined the nature of the events in 70% of 49 mentally retarded patients. Thus, before performing several-hour short-term video-EEG or prolonged video-EEG studies, our rate of success probably warrants the addition of video recording to routine EEG studies in mentally retarded patients with frequent clinical events.

In summary, the addition of video recording to routine EEG studies was effective in almost half of the patients with very frequent clinical events. This technique was particularly useful in cases of paroxysmal eye movements, staring spells, and myoclonus. Although the number of patients with psychogenic nonepileptic events and stereotypias was small, this diagnostic approach was effective in 100% of these patients. In cases with less frequent paroxysmal events, such as partial or generalized seizures, short-term video-EEG lasting several hours is likely to be more effective in establishing the nature of the attacks. Our approach also was effective in mentally impaired patients. This is a retrospective study pertaining to EEG studies that had video recording added according to the EEG interpreter's judgment at the time of the examination. Hence, a referral bias exists in the population studied. Moreover, a direct correlation exists between the percentage of positive (contributory) tests and the type and frequency of the clinical events.

The addition of video recording to routine EEG studies is effective, cheaper, less time consuming, and more comfortable to the patient and his or her family. Hence, this technique should be considered in cases with frequent clinical events before performing longer studies lasting several hours. Therefore this diagnostic approach should be used in the particular setting in which our study was performed.

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