Evaluation of the efficiency of inpatient 24-hour VEEG combined with MRI in consecutive patients with newly diagnosed epilepsies

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A B S T R A C T

A total of 128 patients were recruited into this study to evaluate the cost efficiency of 24-hour video electroencephalography (VEEG) combined with magnetic resonance imaging (MRI) in people with newly diagnosed epilepsies. The rate of neuroimaging abnormalities detected was 14.8% higher with MRI than with computed tomography (CT), whereas 25.7% more EEG abnormalities were detected with inpatient 24-hour VEEG than with outpatient EEG. In the partial seizure (PS) group, MRI combined with 24-hour VEEG revealed that 20 of 73 (27.4%) patients had local epileptogenic lesions, whereas CT with outpatient EEG revealed a rate of 10 in 73 (13.7%). With respect to the economic impact, 27.3% of the patients spent more than 17.8% of their annual household income for 24-hour VEEG and MRI. However, 82.7% of the patients spent less than that, and among these patients, only 16.4% spent less than 5.9% of their annual household income. Hence, we conclude that the combination of MRI and 24-hour VEEG as a compulsory tool should be popularized in less developed countries.

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1. Introduction

Epilepsy is one of the most common neurological disorders in the world, with 85% of the 50 million with the disease living in developing countries [1]. Thus, accurate diagnostic classification is essential to establishment of the appropriate treatment plan. Although conventional history taking, clinical semiology analysis, computed tomography (CT), outpatient electroencephalography (EEG), and physical examination are necessary to obtain an accurate diagnosis, such methods cannot detect the underlying causes or predisposition to the disease. With the development of neuroimaging and long-term video EEG (VEEG) techniques, an increasing number of epilepsies are found through abnormalities in the brain structure and in the electrophysiological tests.

To date, evaluations of the efficiency of MRI and VEEG in newly diagnosed epilepsies are scarce in less developed countries. In most areas of China, epilepsies are diagnosed primarily on the basis of the conventional clinical experience of doctors, with most patients being advised to undergo outpatient EEG and brain CT. Consequently, only a few cases of epilepsy have ever been examined with VEEG and brain MRI.

In our epilepsy center, the routine diagnostic procedure involves a package comprising 24-hour VEEG and brain MRI. Thus, this article is an evaluation of our center’s management algorithm based on feedback received over the past 3 years. Our aim was to provide objective data highlighting the benefits of using MRI and inpatient 24-hour VEEG—better diagnostic accuracy and economic efficiency—with special emphasis on popularizing those techniques in less developed countries.

2. Methods

2.1. Settings and work model of our center

Our academic epilepsy center affiliated with West China Hospital is located in the capital city of Sichuan Province, which has a total population of 83,291,000. It is the largest center in southwestern China and is responsible for screening and recruiting patients. We have eight monitoring beds, three EEG technicians, and three epilepsy experts.

Our management algorithm for the epilepsies is different from most of those used in other hospitals. Fig. 1 gives the overall impression of how our center’s method of diagnosis differs from those of other hospitals. In other hospitals (especially lower-level hospitals), most patients with newly diagnosed epilepsies (NDES) are evaluated using EEG and outpatient brain CT, whereas major examinations comprise inpatient 24-hour VEEG and brain MRI. This was the reason we chose these examination results as points of comparison, because these were the key procedures with unique features in each algorithm.

2.2. Study design

This study was prospectively designed and performed among patients with NDES. Results of evaluations, including diagnostic
suggests that the majority of patients with NDEs were directly tested with 24-h-VEEG. In our experience, at least 80% of patients initially present to our center rather than through a referral, and that the examination is conducted if necessary; AEDs: antiepileptic drugs. Note that some additional sphenoidal electrodes. A bandpass filter was set at 0.3–70 Hz, and a notch filter was set at 50 Hz. Data were collected, including interictal samples, using a Stellate Harmonie digital system (Stellate Systems, Canada) or EB Neuro digital system (Galileo NT PMS, Italy). All episodes were visually screened without automatic spike and seizure detection modules.

The EEG results were initially reviewed and analyzed by at least two skilled electroencephalographers and subsequently by two epilepsy experts. If the patients had several outpatient EEGs, we selected the first for comparison.

MRI was superior to CT in obtaining results at our center. The majority of the rural patients underwent CT at local town hospitals before coming to our clinic. Thus, these patients provided their CT results because CT examination was not initially recommended, according to the general policy in our center.

MRI was randomly performed using a 3.0-T image system (EXCITE, General Electric, Milwaukee, WI, USA) or a 1.5-T image system (Philips Achieva, Holland, and Sonata, Siemens, Germany). Contrast-enhanced (CE) MRI was used when the CT/MRI scan showed suspicious/unclear abnormalities. The standardized MR images consist of standard sagittal, axial, and coronal images at 5-mm intervals, whereas the standardized scanning sequences consist of T1 and T1-weighted spin echo, T2 and T2-weighted fast spin echo, and, for most patients, coronal fast fluid-attenuated inversion recovery (FLAIR). The clinical value of MRI is highly dependent on the expertise of our radiologists and epilepsy specialists.

2.5. Diagnostic definitions and categories

Diagnosis and seizure classification were achieved through the consensus of our epilepsy professors and in accordance with the International League Against Epilepsy guidelines [2,3]. EEG abnormalities consisted of ictal epileptic events (IEEs) and interictal EEG abnormalities. Interictal EEG abnormalities consisted of epileptic discharges (IEDs) and slow waves (ISWs). Epileptic discharges refer to a group of epileptiform waves, including spikes, polyspikes, sharpwaves, slow spike-and-wave complexes, and slow sharp-and-wave complexes. Meanwhile, ISW abnormalities comprise mainly persistent/intermittent diffuse or focal slow activity. If IEEs were present, we preferentially defined them as a subgroup of EEG abnormalities and IEDs/ISWs were not considered. On the other hand, if IEEs were absent, IEDs were the superior subgroup in EEG abnormalities, and ISWs were not considered. ISWs were only named as a subgroup if IEEs and IEDs were absent. The normal EEG variants that could be misinterpreted as interictal EEG abnormalities were carefully considered and excluded [4].

Neuroimaging abnormalities included various abnormalities of both the cortex and the white matter, such as encephalomalacia, cavernous angioma, and mass-occupying lesion. A potentially epileptogenic lesion (PEL) on the MR image was defined as a lesion known to be associated with focal epilepsy, especially when the localization of the lesion was supported by EEG findings [5]. With this definition, nonspecific abnormalities such as white matter lesions were not considered potentially epileptogenic.

The correlation between inpatient 24-hour VEEG abnormalities and neuroimaging abnormalities was classified into four degrees: (1) strongly related—IEEs well matched the location of the neuroimaging PEL; (2) slightly related—IEDs well matched the location of the neuroimaging PEL; (3) suspiciously related—ISWs well matched the location of the neuroimaging PEL; (4) not related—(a) neither IEEs, IEDs, nor ISWs matched the location of the neuroimaging PEL, and (b) normal EEG or MRI, which suggested no relationship.

Seizure type was classified as generalized (GS), including tonic, clonic, and tonic–clonic, or partial (PS), including complex/simple partial and secondarily generalized. Uncommon types, such as myoclonic seizures, were excluded from our design. Some patients with both GS and PS were also excluded.
The initial valuation of cost items was in Chinese currency, renminbi (RMB). For reference, the exchange rate was USD 1 = RMB 6.821 in 2008.

### 2.6. Statistical analyses

Statistical analyses were performed using SPSS 16.0. The χ² test was used for statistical comparisons. Results were considered statistically significant at an α value of 0.05.

### 3. Results

A total of 128 patients (74 males and 54 females) were enrolled in our study (Table 1). Among these patients, 55 (43.0%) had GS and 73 (57.0%) had PS, including 25 with secondarily GS (19.5%) (Table 2).

Table 2 shows that 14.8% more neuroimaging abnormalities were detected with MRI than with CT; MRI revealed abnormalities that were completely absent from CT scans. A slight difference of 5.3% was detected with MRI than with CT; MRI revealed abnormalities that were more useful in qualitatively analyzing abnormalities. Table 2 also points out that 25.7% more abnormalities were detected with inpatient 24-hour VEEG than with outpatient EEG. Furthermore, 7.9% more IEEs, 15.7% more IEDs, and 2.3% more ISWs were detected with inpatient 24-hour VEEG than with outpatient EEG. Note that many ISWs were not counted following the priority of diagnostic principle in our design.

We found that 78 of 128 (60.9%) patients had either abnormal MRI or abnormal inpatient 24-hour VEEG results as compared with 43 of 128 (33.6%) patients with abnormal CT or outpatient EEG results.

Twenty of 73 (27.4%) patients in the PS group were found to have local epileptogenic lesions by MRI and 24-hour VEEG (Table 3). The rate was lower (10/73, 13.7%) when the combination of CT and outpatient EEG was used (P = 0.041 to <0.05) (Table 4).

Table 5 shows that 27.3% of the patients spent more than 17.8% of their annual household income for 24-hour VEEG and MRI. However, 82.7% of the patients spent less than that, with only 16.4% of these patients spending less than 5.9% of their annual household income.

### 4. Discussion

Currently, a thorough evaluation of patients presenting with suspected NDEs is strongly recommended. Those assessments, which are based mainly on neuroimaging and VEEG, are common in Western countries. In less developed countries, however, these procedures are rarely carried out because of limited medical resources and low income.

Epilepsy, as one of the chronic diseases, is increasingly gaining public attention. In our study, we sought to establish a practical diagnostic evaluation algorithm for NDEs and provided data to verify its efficiency so that it could replace the old assessment based on brain
CT and outpatient EEG. Although immediate changes in therapeutic plans (i.e., surgery) are made for only a few patients, as most patients receive antiepileptic drugs (AEDs), this algorithm is still potentially significant for long-term prediction of prognosis and future presurgical evaluation.

Twenty-four-hour VEEG was our first consideration for the following reasons:

1. Early EEG (within 48 hours) and high-resolution MRI are necessary to accurately diagnose epilepsy and assess the risk of occurrence, which indicates the type of treatment to be planned [6]. However, many patients with NDEs fail to undergo EEG promptly for various reasons, such as the need to travel long distances to hospitals, inconvenient traffic, and queuing for medical services, which make the interval between the onset of seizures and arrival at the hospital exceed 48 hours.

2. Long-term VEEG monitoring is efficient but costly in diagnosing epilepsy and seizure mimics. Likewise, it is the only way to identify candidates for surgery. In China and in many low-income countries, however, the majority of patients with epilepsy cannot afford it.

MRI, the other obligatory examination, is better than CT for most patients with epilepsy (except for demonstrating calcification). Our center recommends MRI together with inpatient 24-hour VEEG in a packaged examination procedure for evaluating epilepsy.

In one report with an EEG study time of 1.14 days, Mohan et al. showed that VEEG monitoring can capture an ictal epileptic event in 14% of patients, an interictal epileptic abnormality in 19.8%, and a normal EEG in 24.3% [7]. In another report by Benbadis et al. [8], VEEG monitoring (mean number of monitoring days = 2.8) revealed that 15% of the 251 patients had seizures, 7.6% had interictal epileptiform discharges, and 15% had no interictal epileptiform abnormalities. Meanwhile, another group reported that during the mean monitoring period of 5.6 days, 45% of patients had ictal epileptic events, and 43% had diagnostic epileptiform interictal EEG findings [9]. Alving and Beniczky noted that long-term monitoring was diagnostically useful in 44% of cases in his study [10].

In our study, 24-hour VEEG showed that 10.2% of patients had IEEs, 31.3% had IEDs, and 43% had normal EEGs. On the basis of previous studies, the number of ictal episodes as well as interictal epileptic abnormalities increases with increasing monitoring time. This is why our diagnostic abnormal EEG findings revealed a lower yield than other research in which the monitoring times were longer. Another significant reason is that our design was aimed at a special population of patients with NDEs. In the control group, outpatient EEG detected abnormalities in 31.3%, including IEEs in 2.3% and IEDs in 15.6%, much lower than the percentages detected with 24-hour VEEG. Compared with other studies, the outpatient EEG abnormality positive rate was 40% [11] and the ictal epileptic event rate was 2.5–7% [12]. We conclude that although 24-hour VEEG is relatively inferior to long-term VEEG, it is more useful than outpatient EEG in diagnosis.

Idiopathic epilepsies have been estimated to represent up to 47% of all cases of epilepsy [13], and a large-scale population study suggested that nearly half of epilepsies were idiopathic [14]. These data indirectly inform us that many cases of epilepsy are potentially symptomatic or cryptogenic. In one report, 32.6% of patients with epilepsy had abnormal MRI results (mean age at onset = 9.4 ± 2.5 years) [15]. Another retrospective chart review found that 17% of young patients (<18 years) had abnormal MRI results [16]. Yet another study reported that 53% of 59 cases of epilepsy had abnormal results with MRI, whereas only 44% had abnormal results with CT [17]. In that study, most patients had chronic, medically intractable seizures.

Meanwhile, in our study, the rate of abnormal results was 32.8%, or 14.8% higher than the rate with CT. Lefkopoulos et al. reported that 65% of their 120 patients with intractable partial seizures had a pathological scan [18]. In our study, 45.2% of the patients with PS had abnormal MRI findings, higher than the rate for patients with GS (16.4%). It is reasonable to assume that because our subjects had NDEs, their rate of abnormal findings would be lower than that in the study of Lefkopoulos et al.

Combined VEEG and neuroimaging is used in the detection of epileptogenic foci in patients with seizures and, further, in presurgical evaluation. In our study, 20 of 128 (15.6%) patients had suspected epileptogenic lesions, indicating a possible change in therapeutic plan. As far as we know, no comparison has been made between the efficiency of 24-hour VEEG/MRI and that of outpatient EEG/CT in detecting epileptogenic foci. Our study suggests that epileptogenic foci were twice as likely to be detected with 24-hour VEEG/MRI as with outpatient EEG/CT.

The average household income in China is only 2.9% of the average household income in Sweden and 2.3% of that in the United States. With respect to economic impact, our colleagues [19] stated that the annual average cost per newly diagnosed case of epilepsy is USD 821. The direct medical cost is about USD 451, including USD 264 for inpatient investigation. Our present study indicates that the majority of patients with NDEs accept the cost of those examinations as the cost constitutes a relatively small portion of their annual household income. However, our sample may have limitations: the people with NDEs in our study may have not included low-income patients who cannot even afford to see a doctor. Nevertheless, the increasing demand for better medical services is a vital issue that needs to be addressed.

This is our first attempt to analyze the efficiency of inpatient combination 24-hour VEEG and MRI in people with NDEs in China. Our study is significant in popularizing these two valuable examinations as accessible and feasible tools in developing countries. The utility and cost effectiveness of long-term VEEG in developing countries still need to be studied. Thus, our next step would be to define the duration of monitoring that would achieve the most efficient cost-utility outcomes in developing countries.

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References


