The prevalence of electroencephalographic abnormalities and usefulness of electroencephalography in psychiatry

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Abstract
Clinical electroencephalography (EEG) is a non-invasive, low cost, neurodiagnostic technique widely available in general and psychiatric hospitals in South Africa. Psychiatric patients are regularly referred for EEG's. The major indication for EEG in psychiatric practice is to rule out an organic cause of mental illness. Organic disease can closely mimic functional psychiatric illness. This has major implications in developing countries such as South Africa where the psychiatric effects of physical disease are particularly widespread. Organic brain syndromes often arise from potentially treatable causes.

Keywords: *Electroencephalography, Organic, Epilepsy, Psychiatry*

Clinicians are called upon to differentiate between organic brain syndromes and functional psychiatric disorders, frequently without the aid of advanced neuroimaging. There is a well-established association between EEG abnormalities and organic brain disease. EEG recordings can detect a wide variety of pathological conditions. The validity of EEG in modern psychiatric practice, however, has been strongly criticised as being of limited clinical, diagnostic or prognostic value.

When determining the efficacy of EEG screening of psychiatric patients, the documentation of an abnormality does not necessarily indicate clinical usefulness. Abnormalities may reflect underlying relevant neurological disorders like temporal lobe epilepsy, but may also be the result of many incidental factors including medication, other psychiatric disorders, age and recording conditions. An abnormal EEG result is arguably only useful if it leads to a change in diagnosis or management.

Our aim was to review what is known about the prevalence and usefulness of the EEG recording in psychiatric patients. Medline (1966 - 2003) was searched for relevant published studies in the English literature and added further studies from reference lists of retrieved articles.

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South African studies

There is little South African data examining either prevalence or usefulness of EEG abnormalities among adult psychiatric patients. Some work has been done in adolescents. Szabo[1] reviewed all admissions to the adolescent inpatient unit at Tara Hospital between 1990 and 1995. Of the 36 patients who underwent EEG during this period, 44 % received a definite diagnosis of complex partial seizures, based on both clinical features and EEG findings. In the remainder, 34 % had non-specific abnormal EEG's and 22 % were normal. Therefore, a significant majority of patients referred for EEG had an abnormal result.

The clinical features most predictive of a diagnostic EEG were aggression in 60 %, mood instability in 33 %, hallucinations in 53 %, dissociative states in 33 %, and a premorbid organic insult in 26 %. The clinical features predictive of an EEG abnormality but not a change in diagnosis or management, included aggression in 36 %, hallucinations in 45 % and a premorbid organic insult in 36 %.

In this study, patients were carefully selected for EEG. Of the 360 patients who were admitted to the unit, only 36 patients were referred for EEG. Every patient who was referred had either ictal symptoms as described or a history of a premorbid organic insult. Both would likely have increased the probability of an abnormal EEG. The high prevalence of abnormal EEGs, particularly of EEGs supporting a diagnosis of epilepsy may reflect a high prevalence in the study population, but more likely reflects the careful selection of patients referred for EEG.

The only other published study from South Africa was a retrospective study performed by Stein[2] at Hillbrow Hospital,

Table 1. Major characteristics of the studies of the prevalence and 'usefulness' of the EEG in psychiatry

Region	*Study (First author, year)*	*Reason for inclusion in study / EEG referral*	*Sample size*	*Prevalence of abnormal EEG*	*Number of EEGs leading to a change in diagnosis or management*
South Africa	Szabo, 1999	Careful patient selection	36	16 (44 %) epileptogenic, 78% abnormal	16 (44 %)
	Stein, 1991	Overt psychiatric symptoms and no clinical neurological findings	145	71 (49 %)	Unknown
Rest of world	Lam, 1988	Not clear	150	16 (11 %)	Unknown
	Warner, 1990	Not clear	190	31 %	2 (1,7 %)
	Schwitzer, 1992	Routine screening and pre-ECT	1 065	415 (39 %)	24 (2,3 %)
	Fenton, 1993	Not clear	91	34 (37 %)	83 (92 %)
	Struve, 1976	Routine screening	> 4000	25 – 54 %	Unknown

Johannesburg. All departmental referrals for EEG during a 1-year period (1986/1987) were analysed in an attempt to establish their value and benefit to patient care. The inclusion criteria were direct referral by the Department of Psychiatry, overt psychiatric symptomatology and an absence of clinical neurological findings.

The study group consisted of 145 patients, who met the inclusion criteria. Nearly half the study population were shown to have clearly demonstrable abnormalities on EEG. This subgroup contained 71 patients. Thirty-five (50 %) exhibited definite epileptiform activity on investigation. Forty eight patients (67 %) had localised EEG dysfunction, with twenty-three (47 %) of abnormalities being found in the temporal lobe areas. All patients included in the study had been provisionally diagnosed as suffering from a functional psychiatric illness and referred to the Department of Psychiatry for ongoing treatment after discharge from acute medical care. In addition to a clinical examination, the patients with abnormal recordings had also undergone formal psychiatric assessment before EEG investigation. In only 29 % of cases had a query about possible organic aetiology arisen.

In this study, neither the sample nor the study population was clearly defined. Any patient who had psychiatric symptoms and a normal neurological examination was included. There were no definite selection criteria for EEG. Although the prevalence of EEG abnormalities was almost 50 %, unfortunately the percentage of abnormal EEG's actually leading to a change in diagnosis or management was not determined.

International literature

Review of international literature revealed few studies examining both prevalence and usefulness of EEG abnormalities in adult psychiatric patients. Lam et al, reviewed the records of 150 psychiatric inpatients referred for EEG to survey the clinical use of the EEG by psychiatrists.[3] Individual psychiatrists referred between 18 % and 31 % of their caseloads and 11 % of the EEG's were abnormal. The only clinical indications significantly associated with an abnormal EEG were a history of epilepsy and suspicion of a recent seizure. In 58 % of patients referred an organic factor was identified in the history, mental status examination or physical examination; and this was significantly associated with an abnormal EEG. All EEGs were considered useful in that they precipitated further investigations. Of the 64 patients with no organic features on history who were referred, only 3 (14 %) had abnormal EEG's. In all 3 cases, the clinicians ignored the abnormal results.

The most striking finding of this study was that no unsuspected organic disorders were detected by abnormal EEG's. This suggests that the EEG was not useful as a screening test. An abnormal EEG was only helpful when it supported the suspicion of an organic disorder as suggested by an organic factor on history or examination. Based on this data, the authors discouraged routine use of the EEG for psychiatric patients, recommending that an EEG be considered only when the clinical history and findings suggest an underlying organic disorder.

In this study, like the previous one, neither the sample nor the study population was clearly defined; and there were no clear selection criteria for EEG referral. Different psychiatrists had different rates of referral. The term "usefulness" was used loosely; and whether or not an abnormal EEG led to a change in diagnosis or management was not clearly specified. The prevalence of abnormal EEG's in the study population was 11 %, but this figure cannot be accurately compared to other figures of prevalence because of the limitations mentioned.

Warner et al's retrospective review investigated the usefulness of screening EEG's in psychiatric patients.[4] Usefulness was defined as leading to a change in diagnosis or treatment, rather than just documentation of an EEG abnormality. He reviewed a total of 190 EEG recordings and records. It is not clear how the recoreds were selected. 102 were normal and eighty-eight abnormal.

The reasons for requesting an EEG in the normal EEG group included screening (78 %), seizure history (20 %), and the suspicion of a specific neurological disorder (2 %). In the abnormal EEG group, the reasons included screening (41 %), a seizure history (32 %), the suspicion of a specific neurological disorder (16 %), and a history of head trauma (10 %). Of the 190 charts that were reviewed, a total of 115 patients (61 %) had routine screening EEG's. While 36 (31 %) of these screens led to an abnormal EEG finding, only 2 (1,7 %) lead to a change in diagnosis that might otherwise have been missed. MRI helped to establish a diagnosis of multi-infarct dementia in these two patients.

In this study, once again, the sample and study population were not defined. Some of the patients referred for EEG had

no clinical features suggestive of organic disease and were performed simply for screening purposes, while others had features on history or examination which were suggestive of possible electrical abnormality on EEG.

Schwitzer et al reviewed 1 065 routine EEG's.[5] They found a total of 415 (39 %) abnormal EEG recordings. A change of diagnosis was established in 24 (2,3 %) of the patients. Fourteen of these patients (1,3 %) were diagnosed as having previously unsuspected dementia following neuroimaging. They detected brain tumours in 4 patients and epileptic discharges in 6 patients who had no previous seizure history. Two hundred and forty three EEG records were obtained in the context of ECT or drug monitoring and in 41 (17 %) of these cases, treatment was modified because of severely abnormal EEG's.

Although the findings of this study were described in a letter in response to an earlier study4, it has a number of positive attributes. All psychiatric patients underwent routine EEG's prior to commencing pharmacotherapy or ECT. Furthermore, both prevalence and usefulness of EEG abnormalities among psychiatric patients were clearly described.

More recently, Fenton and Standage carried out an audit of the use of clinical electroencephalography in a psychiatric service.[6] In each patient who underwent EEG, an attempt was made to determine to what extent the EEG findings influenced management. EEG results were classified into one of three groups; those which had a positive value, those that had a negative value, and those that were of no value. Positive value was defined as EEG findings that provided useful additional evidence to support a clinical diagnosis of organic brain dysfunction or epilepsy, hence increasing the probability of such target diagnoses. In contrast, negative value referred to an EEG finding that significantly reduced the probability of organic brain involvement or epilepsy.

Of the 91 EEG's studied, 40 (44 %) were normal, 17 (19 %) were anomalous and 34 (37 %) were abnormal. It was felt that 7 of the investigations (8 %) had been of little or no value. Of the other 84 recordings, 48 (53 % of the total) were of positive value and 36 (39 %) of negative value. Ninety two percent of EEG's were judged to be of clinical value.

In this study, the sample and study populations were not clear. The definition of usefulness was much broader than the definition cited in Warner and Schwitzer study; leading to a vastly greater percentage of EEG's considered useful.[4,5]

Several earlier studies did not examine the 'usefulness' of the EEG in psychiatric patients, but did investigate the prevalence of abnormal EEGs when the EEG was used as a routine screening tool in consecutive patients.

Struve[7] examined the results of routine EEG's of over 4 000 hospitalised psychiatric patients over a 9 year period, and found the prevalence of EEG abnormalities to range from 25 to 54 %. The number of abnormal EEG's which led to a change in diagnosis or management was not described.

For a five-month period during 1974, Struve kept records on a series of 90 consecutive patients displaying EEG abnormalities.[7] These 90 patients were divided into two groups. Included in the first group were cases where the EEG request form indicated either a clear indication of known or suspected organic dysfunction, or at least some remote mention of a physical symptom (i.e. headache, blackout). The second group comprised patients with EEG requests marked "routine" and no clinical features suggesting organicity.

Sixty four (71 %) of the 90 abnormal EEG's occurred in the second group – those patients in which there was no pre-existing suspicion of brain dysfunction. He indicates that these patients were identified only because a screening program existed, and if they had relied on a "referral when indicated" system, over 70 % of these patients would not have been identified and the results would not have been made available to the treating clinical team. These figures indicate that in one out of every six patients admitted to the hospital, screening electroencephalography detected presumptive evidence of some degree of organic involvement, which was not previously suspected by the treating staff. This contrasts markedly with Lam's results.

In relation to this study, Struve suggested that some EEG findings are more serious than others and one would expect that patients with the most serious abnormalities would be most readily suspected of having some features suggesting organicity by the treating clinical team. Serious EEG abnormalities were those considered to be epileptogenic or encephalopathic, and comprised 59 of the 90 cases. Of the 59 serious EEG abnormalities, 33 (56 %) had no pre-existing suspicion of brain dysfunction and would not ordinarily have been referred for EEG. Twenty-six cases (44 %) had clinical features suggestive of organicity.

Of the 21 clearly epileptogenic EEG's, showing diffuse or focal spiking, 6 (28 %) were unsuspected clinically; and of the 38 EEG's showing focal, generalised or proximal slowing, 27 (71 %) were unsuspected. This study indicates that a significant number of unselected psychiatric patients display "serious" EEG abnormalities. On the basis of this the author advocated routine screening of all psychiatric patients.

Struve published a further study in 1977.[8] Over a seven month period a consecutive series of 547 admitted patients received initial routine screenings electroencephalograms. The results were very similar to those found previously by the same author. Of those patients with EEG abnormalities, 70,5% were not suspected of having any organic problem and would not have been referred for EEG. They were detected only because of the existence of a routine EEG screening program. Struve published another paper in 1980[9], and a fourth study in 1984.[10] At the time of publishing the last study, 15 000 consecutively admitted psychiatric patients had been referred for EEG evaluation, with a prevalence of EEG abnormalities of between 16,2 and 30,8 %. Reports suggested that 65 % to 71 % of patients with EEG abnormalities are detected only through routine screening – that is they would have been missed with selective referrals.

It is Struve's opinion that until good evidence is presented to the contrary, the assumption that psychiatric patients likely to have positive EEG findings can be appropriately selected and referred by treating personal, remains untenable. He has added that careful medical follow-up is essential to a successful EEG screening program; without good follow-up efforts, detection of even serious findings diminish in value.

Both the data compiled over 9 years, as well as the 1977 study by Struve[8], were extremely useful as all psychiatric patients had routine EEG's; hence avoiding the problem of selective referral bias which contaminated a number of the other studies described above. The issue of usefulness of EEG abnormalities in terms of leading to a change in diagnosis of management was not explored in any of Struve's papers, however.

Gibbs[11] examined EEG reports and patient data on 1 000 consecutive adult psychiatric inpatients and found comparable results to Struve. The prevalence of EEG abnormalities was 39,6 %. Twenty five percent had abnormalities that are generally accepted as indicative of organic disease. An additional 15 % had abnormalities that are considered controversial, but which are found in only 4 % of adult control subjects, that is 14 and 6 per second positive spikes, 6 per second spike and wave discharges; and psychomotor variant discharges.

This study also eliminated selective referral bias, in that all psychiatric inpatients were referred for EEG providing useful prevalence figures. The issue of usefulness was not however addressed.

Discussion

From a summary of the available literature examining prevalence and usefulness of EEG abnormalities in adult psychiatric patients, it is clear that discordance exists. Comparable prevalence figures are affected by varying referral practices. Among those studies in which consecutive psychiatric inpatients underwent routine screening EEG's, the prevalence of EEG abnormalities ranged from 20 to 39 %. Estimates of prevalence in Stein, Lam and Warner's studies are not comparable, as they used different selection criteria for patients referred for EEG. Regarding usefulness, only Warner and Schwitzer examined the percentage of abnormal EEG's leading to a change in diagnosis or management, and these figures were remarkably similar. Unfortunately, few of the studies provide detail on exactly how patients were selected (case-mix) for EEG referral. The would influence both the prevalence of abnormal EEGs and 'usefulness' of the EEG.

Of course the question arises whether one should not simply follow Struve's approach and refer all patients utilitising a psychiatric service for an EEG. While that may be considered by some to be the ideal, the EEG result may reveal confusing 'false-positive' or unrelated abnormal results complicating the clinical picture rather than clarifying it. Furthermore, in a region with limited resources such as our own this approach is not appropriate in our opinion.

So ideally we need a South African study that is prospective in design and includes consecutive adult psychiatric inpatients. It would be useful to determine whether specific features on history or examination are predictive of an EEG abnormality that may lead to a change in patient diagnosis or management. Each patient should be carefully assessed for any clinical evidence of organic disease prior to being referred for EEG, preferably by more than one psychiatrist. EEG interpretation should be performed by more than one neurologist, blinded to the patient's clinical state. In each case, it would be useful to determine to what extent an EEG abnormality contributed to a change in the patient diagnosis or management following predetermined definitions. From this we may be able to better develop guidelines for referral of adult psychiatric patients for EEG. This information is currently lacking and represents an important gap in the available literature.

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The EEG in psychiatry

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The value of EEG in the practice of psychiatry has been a debated issue since the advent of these neurophysiological studies in the 1930's. Surprisingly, there are few credible studies in this area, and much of the earlier work is bedevilled by poor research design and hence unwarranted conclusions. A brief review in this issue highlights some of the conflicting reports and ventures the opinion that routine referral of all patients attending a psychiatric service is not appropriate in view of the likely low yield of results which will change the patient's management, and the attendant risk of over-interpretation of minor non-specific findings which may lead to false-positive diagnoses.

I would agree with the view expressed that we do not at present have a sufficient base of evidence from which to form firm guidelines, and that this information is sorely needed. Nevertheless, we need to proceed with what we have, and, in my opinion, there is a clear contribution that EEG may at times make in attempting to diagnose the symptoms encountered in psychiatry. In everyday clinical work, the EEG remains the only practical functional test of brain function, and, as such, complements the fine anatomical and pathological detail given by modern imaging. The value of an EEG depends heavily upon the diagnosis. It is especially of great value in assisting with the identification of epilepsy and of organic mental disorders. Epilepsy is primarily a clinical diagnosis, but the EEG may provide strong support by the finding of inter-ictal epileptogenic discharges and also be used to define the site of seizure onset and the epilepsy syndrome. However, a normal inter-ictal EEG can never refute or exclude a clinical diagnosis of epilepsy. Organic mental disorders is increasingly an unsatisfactory term, as many of the so-called functional psychiatric disorders have a neurobiological basis. Nevertheless, the typically marked focal or generalised slowing found in the EEG in patients with acute or chronic encephalopathies due to metabolic changes, infections, toxins, trauma and tumours is useful to the clinician in the differentiation of these disorders from psychiatric disorders. However, a normal EEG does not exclude all forms of structural disease, and in particular extra-parenchymal intra-cranial lesions such as meningiomata or subdural haematomas typically result in no EEG abnormalities.

Turning to psychiatric disorders, it is clear that it is not uncommon to find typically minor EEG abnormalities in some syndromes and this is not surprising. Perhaps the best recognised is the non-specific EEG slowing often found in the temporal and central areas in aggressive psychopaths.

It becomes clear then that the frequency and clinical value of EEG abnormalities found in psychiatric patients depends very much upon the case-mix, and the differential diagnosis being considered. And it is not sufficient to regard merely the EEG abnormalities as being of potential use, as it may be just as worthwhile to know that the study is normal. As always the clinical value of a test depends upon the question being asked, and the likelihood of finding an answer.

As suggested a rigorous study under local conditions would indeed be of interest.

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