Screening EEG in Aircrew Selection: Clinical Aerospace Neurology Perspective

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As clinical aerospace neurologists we do not favor using screening EEG in pilot selection on unselected and otherwise asymptomatic individuals. The role of EEG in aviation screening should be as an adjunct to diagnosis, and the decision to disqualify a pilot should never be based solely on the EEG. Although a policy of using a screening EEG in an unselected population might detect an individual with a potentially increased relative risk, it would needlessly exclude many applicants who would probably never have a seizure. A diagnostic test performed on an asymptomatic individual without clinical indications, in a population with a low prevalence of disease (seizure) may be of limited or possibly detrimental value. We feel that rather than do EEGs on all candidates, a better approach would be to perform an EEG for a specific indication, such as family history of seizure, single convulsion (seizure), history of unexplained loss of consciousness or head injury.

Routine screening EEGs in unselected aviation applications are not done without clinical indication in the U.S. Air Force, Navy, or NASA. The USAF discontinued routine screening EEGs for selection in 1978, the U.S. Navy discontinued it in 1981, and NASA discontinued it in 1995. EEG as an aeromedical screening tool in the US Navy dates back to 1939. The US Navy routinely used EEGs to screen all aeromedical personnel from 1961 to 1981. The incidence of epileptiform activity on EEG in asymptomatic flight candidates ranges from 0.11 to 2.5%. In 3 studies of asymptomatic flight candidates with epileptiform activity on EEG followed for 2 to 15 years, 1 of 31 (3.2%), 1 of 30 (3.3%), and 0 of 14 (0%) developed a seizure, for a cumulative risk of an individual with an epileptiform EEG developing a seizure of 2.67% (2 in 75). Of 28,658 student naval aviation personnel screened 31 had spikes and/or slow waves on EEG, and only 1 later developed a seizure. Of the 28,627 who had a normal EEG, 4 later developed seizures, or .0139% (4/28627). After review of the value of the EEG as a screening tool, the US Navy now uses EEG only for certain clinical indications (head injury, unexplained loss of consciousness, family history of epilepsy, and abnormal neurological exam). Currently the US Navy does not use EEG for screening for any flight applicant without a neurologic indication. In the US Navy, an electroencephalographic pattern is determined to be epileptiform by a neurologist.

The use of screening tests has received renewed scrutiny in the field of preventive medicine, as exemplified by controversy in mammography, fecal occult blood test and prostate specific antigen test. The use of a lab test as a condition of employment or fitness for duty is even more problematic. A strategy for employing a screening test should be well established. Factors to be considered in a screening program include statistical measures (sensitivity, specificity, positive and negative predictive value, false positive and negative value, test efficiency, and predictive accuracy), target population, disease prevalence. Also important are considerations for the risk of adverse physical effects from the test as well as consequences of false positive and negative tests. The goal should be defined and test procedures (administration and interpretation) should be validated. The issue of what is a normal or abnormal EEG is a major consideration. A variety of EEG abnormalities carry a variable clinical significance. Minor EEG abnormalities and normal variants, such as small sharp positive spikes, 14 and 6 Hz rhythms, and 6 Hz theta rhythms (psychomotor variant), should not be considered disqualifying. The EEG classification scheme should be accepted and normative data should be drawn from age matched controls to establish the baseline of epileptiform patterns in non-epileptic subjects. Cost effectiveness analysis should be considered in any screening program. The cost effectiveness analysis by Everett and Jenkins did not

establish EEG as a cost-effective aeromedical screening tool. Everett et al used a 6 year period for assessing cost effectiveness of EEG in military pilots. The authors use of a 35 year duration will increase the prevalence and hence the risk. Although a commercial pilot may fly 35 years, a military pilot's career is significantly shorter, hence time should be a factor considered by the aeromedical certification authority. A sensitivity analysis to evaluate effect of different time frames (10, 20, 30 years) would be a useful way to address this factor.

Clinical decision makers are approaching outcome measures using evidence based medicine and consensus panels to develop clinical practice parameters and technology assessments which are based on level of evidence which then supports the strength of the recommendation. Practice parameters are strategies for patient management that assist physicians in clinical decision making and are specific recommendations based on analysis of evidence of a specific clinical problem. The development of an evidenced based guideline follows a well-established process, which is designed to rigorously evaluate the strength of the literature and formulate explicit recommendations to improve patient outcomes. Technology assessments are statements that assess the safety, utility, and effectiveness of new, emerging, or established therapies and technologies in the field of neurology. Class I evidence is provided by one or more well designed randomized controlled clinical trials, including overviews (meta-analyses) of such trials. Class II evidence is provided by well designed observational studies with concurrent controls (e.g., case control and cohort studies). Class III evidence provided by expert opinion, case series, case reports, and studies with historical controls. The recommendations are rated as a Standard, Guideline or Option. A Standard is a principle for patient management that reflects a high degree of clinical certainty (usually this requires class I evidence that directly addresses the clinical question, or overwhelming class II evidence when circumstances preclude randomized clinical trials). A Guideline recommendation for patient management reflects moderate clinical certainty (usually this requires class II evidence or a strong consensus of class III evidence). A Practice option is a strategy for patient management for which the clinical utility is uncertain (inconclusive or conflicting evidence or opinion). Strength of recommendations are classified as:

Type A: Strong positive recommendations, based on Class I evidence, or overwhelming Class II evidence when circumstances preclude randomized clinical trials.

Type B: Positive recommendation, based on Class II evidence.

Type C: Positive recommendation, based on strong consensus of Class III evidence.

Type D: Negative recommendation, based on inconclusive or conflicting Class II evidence.

Type E: Negative recommendation, based on evidence of ineffectiveness or lack of efficacy, based on Class II or Class I evidence.

Based on this classification at best EEG as a screening tool in an unselected aviation population would be considered a practice option based on Class III evidence with a Type C strength of recommendation.

Given the relatively low incidence of epileptiform EEGs in the aviation population, the low incidence of seizures associated with an epileptiform EEG in the aviation population, low positive predictive value of the EEG, and the high false positive value, we feel that the EEG is not be a good screening tool in a medically screened aviation applicant population. Ultimately the medical decision to evaluate applicants with a screening EEG is up to individual aeromedical certification agencies.

Statistical Analysis of the EEG as an Aeromedical Screening Tool

From Hedriksen and Elderson's data

	Seizure (S+)	No Seizure (S-)	Subtotals
Positive EEG (E+)	2.6 (a)	29.9 (b)	32.5 (a+b)
Negative EEG (E-)	2.4 (c)	965.1 (d)	967.5 (c+d)
Subtotals	5 (a+c)	995 (b+d)	1000 (n)

Post Hoc Analysis: Given the presence or absence of disease, what is the likelihood the test will be positive or not.

Sensitivity (Sn) = a/(a+c) = 2.6/5 = .52 = 52%

Specificity (Sp) = d/(b+d) = 965.1/995 = .9699 = 96.99%

Positive predictive value = a/a+b = 2.6/32.5 = .08 = 8.00%

Negative predictive value = d/(c+d) = 965.1/967.5 = .9975= 99.75%

False positive value = b/(a+b) = 29.9/32.5 = .92 = 92.00%

False negative value = c/(c+d) = 2.4/967.5 = .0025 = 0.25%

Test Efficiency (portion of test results that are correct)
Eff = (a+d)/(n) = 967.7/1000 = 0.9677 = 96.77%

Predictive Accuracy
Equation 1
Predictive Accuracy = (Sn)(Pr)/ [(Sn)(Pr) + (1-(Sp)(1 - (Pr)] = (a/(a+c)) (Pr)/ [(a/(a+c)) (Pr) + (1-(d/(b+d))(1-Pr)]
Sensitivity = Sn, Specificity = Sp, Prevalence = Pr

Assumption 1: If you assume the Lifetime Prevalence of a Single Seizure (Pr) using Shorvon literature, using Pr estimated at 20/1000 = .02, in the Predictive Accuracy equation (Eq 1) then Predictive Accuracy is (.52) (.02)/ [(.52) (.02) + (1- .9699)(1 - .02)] = .0.2606 or 26.06%

Assumption 2: If you calculate Prevalence based on the formula:

Equation 2
Where Prevalence = Pr = [(Ir)(t)] / [1 +(Ir)(t)]

And using t = duration (years) = 15 and Incidence rate = Ir = .000316 based on 31.6 USAF medical boards for seizure/ 100,000 USAF personnel   (Note: Ir ranges from 11-134/100,000 (Shorvon))

Then Prevalence = Pr =(.000316)(15)/[1 + ((.000316)(15))] = .004717
And in the Predictive Accuracy equation (Eq 1) the calculated Predictive Accuracy is
(.52) (.0047)/ [(.52) (.0047) + (1- .9699)(1 - .0047)] = 0.0754 = 7.54%

If the incidence or duration increases, then prevalence increases, and predictive accuracy of the test increases.

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