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Comparison of Clinical Diagnoses versus Computerized Test (Expert System) Diagnoses from the Headache Diagnostic Paradigm (Expert System)

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Abstract

A number of researchers have found that 35%-70% of patients told they have migraine headache actually have muscle tension headaches, underscoring the need for more accurate diagnostic methodology. In this study, 34 patients were evaluated and 104 diagnoses made by the clinician, which were related to headache pain. For these 104 headache related diagnoses, the Headache Diagnostic Paradigm made diagnoses which appeared in the medical records 94.23% of the time (96/104).

Introduction

There are over 60 different types of headaches which have been classified. Unfortunately, many of the research articles failed to rigorously adhere to diagnostic criteria for classifying the headaches. Adding to this confusion is the ever-changing nomenclature associated with diagnosing and treating headaches. As with all components of medicine, proper diagnosis is the ultimate predictive analytic tool. It tells you the etiology of the problem, it tells you the appropriate test used to confirm diagnosis of the problem, it tells you the treatment for the problem, and give some predictive component about the outcome of treatment. Also, accurate diagnosis serves as a unifying language, allowing physicians across the world to understand what is meant with a single diagnosis. Therefore, rigorous adherence to the diagnostic criteria of headaches is essential. Without this, appropriate treatment cannot be implemented.

In a review of the incidence of migraine headache in US Armed forces 1998-2010, the report found that 3% of all men, and 6% of all female had migraine. It further states that 3.9% of men and 11.3% female have some sort of headache. [1]. If diagnosed with migraine, then less than 1% had other types of headaches. [1]. However, this begs the question. What is a migraine?

The most common headaches are [2]:

1) Muscle Tension Headache
2)Migraine-common and classic
3)Trigeminal
4)Cluster
5) Chronic daily headache

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However, the prevalence of misdiagnosis of headache disorders abounds. The medical literature reports that 35%-70% of patients called "migraine" don't have it, but rather has muscle tension headaches or other types [3]. One of the best examples of failure to properly diagnose headaches correctly was reported by Donlin Long, MD, PhD, chairman of neurosurgery at Johns Hopkins Hospital and his colleagues [4]. They studied 70 patients with severe headache and neck pain after a head or neck injury (acceleration-deceleration injury). These patients had X-rays, MRIs and CT of their neck and head. All had been told that they had various types of headaches, such as post-traumatic migraine, post concussion syndrome, classic migraine, common migraine, whiplash, etc. and nothing more could be done to treat them except narcotic and other types of medication. When these 70 patients were evaluated by a multi-disciplinary team, the group determined that 67 of the 70 patients were candidates for additional medical testing, which was collectively called the "diagnostic block protocol." The protocol consisted of C2-3 root blocks, C2-C4 zygapophyseal joint blocks, and provocative disco grams C2-C7. Based on the response to the blocks, 44 of the 67 patients were considered candidates for a posterior cervical fusion, C1-C4, in various combinations. Of the patients who received surgery, 79% had complete relief of their headaches and neck pain, while 14% had satisfactory relief. Therefore, from a group of patients who were told that no treatment was available for their headache, 41 of the original 70 patients (58%) were able to obtain relief when accurately diagnosed and correctly treated [4].

Further adding to the misdiagnosis of headache is the totally imprecise nomenclature now used by some clinicians to describe headaches. The most egregious example of this lack of precision is "chronic daily headache, "defined as a headache which occurs more than 15 days a month. This type of headache lasts more than 4 hours a day. If it lasts less than 4 hours a day, it is considered a trigeminal autonomic cephalalgia (TAC). TACs include episodic & chronic cluster headache, episodic & chronic paroxysmal hemicrania, SUNCT, & hypnic headache. If duration is great than 4 hours, then it is possible to chronic daily headache (CDH) but the differential diagnosis is chronic migraine, chronic tension-type headache, new daily persistent headache and hemicrania continua. [5] This term has no diagnostic value. It is merely a description. It tells you nothing of the etiology of the headache, whether the pain is throbbing, or pounding, or muscle tension, or associated with vertebral body movement. This approach to so-called "diagnosis" is as ridiculous as saying the patient complaining of low back pain has the "diagnosis" of low back pain.

A physician should immediately understand why headaches should be classified based on origin. A single symptom may have multiple origins, such a flat tire, which can be caused by a nail in the tread, cut sidewall, leaky valve stem, or bad bead. A physician has to know the cause in order to properly repair the tire. This is the value of a DIAGNOSIS.

A single cause (DIAGNOSIS), like a spirochete, the causative organism of syphilis or Lyme disease, may have multiple clinical manifestations, such as joint pain, vascular disease, dementia, or neurological pain. Defining the origin of any disorder allows a doctor to treat the causes and address multiple symptoms. There were few reliable diagnostic tests for headache. Headaches are one of the most common symptoms and the list of differential diagnoses has over 60 different types and causes.

The most important element of establishing an accurate diagnosis for headache is a careful history. This is especially important, because there are very few tests which as physician can use to establish the cause of a headache. In one study of 3026 neuroimaging scans in patients with headache and a normal neurological examination, the researchers found the following pathology: brain tumours, 0.8%; arteriovenous malformations, 0.2%; hydrocephalus, 0.3%; aneurysm, 0.1%; subdural hematoma, 0.2%; and strokes, including chronic ischemic processes, 1.2% [6] . In the 1440 scans of patients with migraine: brain tumour, 0.3%; arteriovenous malformation, 0.07%; and scapular aneurysm, 0.07% [7].

Obtaining a comprehensive history often is difficult. Two studies reported that physician time with patients averaged 10.7 to 11 minutes. [8, 9]. One study recorded the amount of time the patient was able to speak during these patient visits, and found that the patient was able to speak only for about 4 minutes of the 11 minutes [8]. The other study reported face-to-face patient time measured was 10.7 minutes, and even when the time spent on "visit-specific "work outside the examination room was combined it with face-to-face time, the average time per patient visit was only 13.3 minutes [9].

In 2018, The International Classification of Headache Disorders- 3rd edition was published [10]. It is impressively comprehensive, and lists virtually any type of headache or facial pain or injury which could lead to a symptom of "headache." A list of the major categories of

the ICHD-3 Classification Code follows:

1. Migraine
   1.1 Migraine without aura
   1.2 Migraine with aura

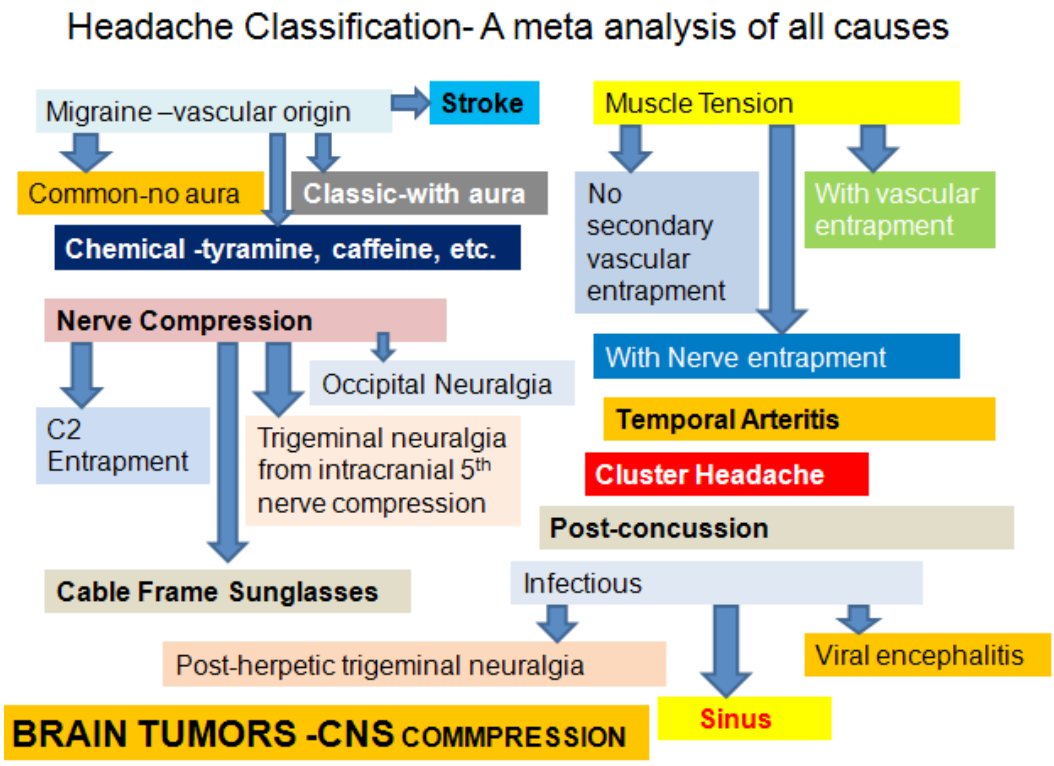
2. Tension-type headache (TTH)
3. Trigeminal autonomic cephalalgias (TACs)
4. Other primary headache disorders
5. Headache attributed to trauma or injury to the head and/or neck
6. Headache attributed to cranial and/or cervical vascular disorder
7. Headache attributed to non-vascular intracranial disorder
8. Headache attributed to a substance or its withdrawal
9. Headache attributed to infection
10. Headache attributed to disorder of homoeostasis
11. Headache or facial pain attributed to disorder of the cranium, neck, eyes, ears, nose, sinuses, teeth, mouth or other facial or cervical structure
12. Headache attributed to psychiatric disorder
13. Painful lesions of the cranial nerves and other facial pain
14. Other headache disorder

A system of headache classification was formulated by doing a meta analysis of articles, which examined various types of treatment for different headache disorders [11-46], and is shown in Figure 1 below, which is reproduced, with permission, from Chapter 12 (Headaches-migraine versus muscle tension versus dental versus tumours) from "Why 40%-80% of Chronic Pain Patients Are Misdiagnosed and How To Correct That." [47]. This list is by no means comprehensive. It represents the types of headaches most often seen in clinical practice, and forms the clinical basis for the creation of the questionnaire and scoring algorithm of this article (Figure 1).

Confirmation of diagnosis of certain headaches cannot be done by medical testing. The only real measure of the correct diagnosis was the improvement a patient experiences after accurate diagnosis and the use of the correct medication. This can be a complicated process. As an example of this, one patient, who had a residual acoustic neuroma, underwent a trial of 19 medications before he obtained relief [40]. However, each medication used has a different mechanism of action, which helped to delineate the pathology causing the headache.

The use of the correct medication is also

Figure: 1



problematic. It should not be symptomatic, but specific for the type of tissue damage associated with each type of headache. Matching tissue damage with pharmacological response is described in a recently published article [48].

In order to address the high level of misdiagnosis, often attributable to incomplete history [49], a comprehensive Headache Diagnostic Paradigm was created. Diagnoses generated by results of the Headache Diagnostic Paradigm were compared to diagnoses from physicians from Johns Hopkins Hospital. The results of this comparison are reported in this paper.

Subjects

All subjects were patients at Mensana Clinic, which was an inpatient and outpatient multidisciplinary diagnostic and treatment center for diagnosing and treating chronic pain problems, which operated from 1978 until 2006 in Stevenson. Maryland. Seventy-five percent of the inpatients came from 47 states and 8 foreign countries, and were not from Maryland. There were 34 patients included in this study. The patients included in this study represent new evaluations and returning patients seen between February 2000, through July 2002 by Dr. Hendler and/or Dr. Speed, who functioned as the headache consultant to the clinic. The average age of the patients was 43.4 years. Forty-two percent of the subjects were males, and fifty eight percent were females.

Methods

The Headache Diagnostic Paradigm was compiled based on the set of questions either Dr. Hendler or Dr. Speed would ask a patient. This resulted in a questionnaire with 45 questions, and 758 possible answers. They then selected which answers would lead them to reach a particular diagnosis. Mr. Berne programmed these answers into a computer scored algorithm, using Bayesian logic, which assigned the likelihood of a diagnosis to each of the 758 answers, based on clinical assessment of each answer. The sum of the weighted answers gave a diagnosis and differential diagnosis.

Once the Headache Diagnostic Paradigm was completely programmed, the researchers then retrospectively reviewed 34 patients who had headache as their only chief complaint, or as one of their chief complaints (with or without associated neck pain and facial pain). On the day of their initial medical evaluation, prior to seeing the physician for an evaluation, these patients completed the Pain Validity Test, The Diagnostic Paradigm and Treatment Algorithm, and the Headache Diagnostic Paradigm, The Pain Validity Test and Diagnostic and Treatment Algorithm have been described in earlier publication [50-55]. The information from the answers from the paper –pencil version of the Headache Diagnostic Paradigm was entered into the recently created Internet based electronic format. The Headache Diagnostic Paradigm was scored, by running the computer program, and the computer generated diagnoses and differential diagnoses were recorded, based on the symptoms transferred from each chart to the questionnaire.

The computer generated diagnoses were then compared to the clinical diagnosis recorded in the chart. In some instances, the only chart record was an initial evaluation, while others contained a more complete evaluation, including medical tests, and responses to medicine to help confirm the diagnosis made at the time of the initial evaluation. The diagnosis made at the time of the latest visit recorded in each chart was compared to the diagnoses generated by the Headache Diagnostic Paradigm. The results of this comparison are reported in the next section.

Results

The results of comparing the diagnosis found in the chart and the diagnosis generated by the Headache Diagnostic Paradigm were tabulated. Diagnoses generated by the Headache Diagnostic Paradigm were compared to diagnoses in the chart. The diagnoses by clinicians were assumed to be accurate. The computer generated diagnosis was considered a match if the same diagnosis made by the Headache Diagnostic Paradigm also appeared in the chart. If a diagnosis generated by the Headache Diagnostic Paradigm did not appear in the chart, then this was considered a false positive result. If a diagnosis was not generated by Headache Diagnostic Paradigm, but did appear in the chart, this was considered a false negative result. The Headache Diagnostic Paradigm was designed to be overly inclusive, so that all types of headaches related to a given set of symptoms would be reported. The Headache Diagnostic Paradigm was also designed to consider diagnoses and differential diagnoses. Therefore a patient might have a number of diagnoses made by the Headache Diagnostic Paradigm, but these are rank ordered by the Bayesian analytic technique. Finally, the responses to medication given to help headaches were recorded.

In the 34 patients included in the study, there were 104 diagnoses made by the clinician, which were related

to headache pain, often associated with cervical or jaw pathology. Diagnoses of co-existing lower back pain, and limb pain, with the exception of radial nerve entrapment and thoracic outlet syndrome (which produce headache symptoms), were not included in the tabulation.

In the review of 104 headache related diagnoses made by the clinician, the Headache Diagnostic Paradigm made diagnoses which appeared in the medical records 94.23% of the time (96/104). This represents the accuracy or "match rate." On the other hand, 23% (24/104) of the time the Headache Diagnostic Paradigm made diagnoses which were not in the chart. This is considered a "false positive rate." Finally, 6.73% (7/104) diagnoses which appeared in the medical records were not detected by the Headache Diagnostic Paradigm, representing the "false negative" rate, which essentially is a missed diagnosis.

The rationale for the Report of the Headache Diagnostic Paradigm was to be as inclusive as possible with diagnoses and differential diagnoses, so that no diagnosis would ever be overlooked. This led to generating a large number of false positive results, which then would require refinement using pharmacological trials, since there are very few objective tests which can diagnosis headache. By being overly inclusive in diagnoses, the chance of missing a possible diagnosis is reduced. However, the actual sensitivity of the test cannot be calculated.

In general, sensitivity and specificity requires the prevalence of a disorder in order to be properly calculated. The prevalence of disorders is determined by the number of cases extant in a population at a give point in time. Unfortunately, the prevalence of various types of headaches is hard to determine, since so many types of headaches are over-diagnosed, as in the case of migraine, or under-diagnosed, as in the case of a mixed muscle-tension/vascular headache, or totally undiagnosed, as in the case of the description "chronic daily headache". Moreover, the sample size, at present, it too small to generate any meaningful statistics.

Discussion

After years of work in the area of expert systems, a number of authors feel limited progress has been made [56]. One major hurdle to any developer of an expert system is the quality of knowledge used to create the system, and the availability of accurate patient data [57]. Other authors emphasize the value of the longitudinal clinical data collection, and "data mining" to develop expert systems [58].

The accuracy of any "expert systems" is a core issue. The expert systems which have the best results are those which focus on specialized area of medicine. One questionnaire for rheumatologic disease, evaluated 358 patients. It had 60 questions, and evaluated 32 rheumatologic diseases, [59]. The correlation rate was 74.4%, and an error rate of 25.6%. Forty-four percent of the errors were attributed to "information deficits of the computer using standardized questions," [59]. However in a prospective study of "RHEUMA" on 51 outpatients, there was a 90% correlation with clinical experts [60]. The diagnosis of jaundice has been addressed by other groups. The expert system ICTERUS produced a 70% accuracy rate [61], while 'Jaundice' also had a 70% overall accuracy rate [62]. An expert system for vertigo has an accuracy rate of 65%, [63]. The expert system was named O to Neurological Expert (ONE), and it had same results reported in the earlier article [64]. In the psychiatric realm, an expert system and a clinician had a 76% agreement for diagnosis of depression [65]. There was an 85.7% agreement level with three clinicians using the Computer Assisted Diagnostic Interview (CADI) for a broad range of psychiatric disorders, [66]. However, a group of 18 family practitioners felt the treatment suggested by the computer system Hypercritic was erroneous 16% of the time [67]. Others have developed a check-list to remind treating physicians about tests they should order, based on input into electronic patient records [68]. Only in the narrow area of managing lipid levels was there an agreement of 93% between expert system management advice and a specialist, using the interpretation of laboratory and clinical data [69]. One major stumbling block to the use of expert systems is the low level of accepting comments from expert systems (65%) regarding diagnosis of a patient, and the resistance to recommendations for prescriptions for patients, with only a 35% acceptance level [70].

The Headache Diagnostic Paradigm has achieved the same level of accuracy as the Diagnostic Paradigm and Treatment Algorithm, in the 94%-96% range (54, 55). In large part, this is due to the high percentage of headaches which are of cervical origin, or are post-traumatic in nature. Therefore there were a number of questions which overlapped between the two diagnostic tests. Further testing on a large number of more diverse headache patients is needed to improve the specificity and sensitivity as well as the accuracy of the Headache Diagnostic Paradigm.

Disclosure

Mr. Berne and Dr. Hendler have a financial interest in www.HeadacheAssist.com, the website which offers the Headache Diagnostic Paradigm.

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