THE METHODOLOGY OF DIAGNOSTIC REASONING IN TMD

ABSTRACT

TMD's, as a cluster of individual diseases and disorders, pose new intellectual challenges to the diagnostic skills of dentists. New technologies enable dentists to avail themselves of paraclinical data such that diagnosis can and should be disease specific or etiology specific. The importance of logic in diagnostic reasoning is discussed. Studies of the reasoning process of doctors with reputations for having good clinical judgement have resulted in protocols of diagnostic reasoning. Three specific strategies are presented and discussed - probabilistic, causal and deterministic. The difference between intellectual and managerial decisions are explained relative to utility of the strategies.

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Introduction

The end point of diagnosis is the naming of a disease. From the time of Hippocrates to the present, the concept of both disease and diagnosis has undergone evolutionary change. In the era of Hippocrates, identification of disease was an act of observation, i.e., fever, consumption, or rash. Etiology was based strictly on conjecture such as angry gods or deranged humors.

During the seventeenth century, Thomas Sydenham originated the discipline of nosology in which he proposed that each disease was specific to a pathogenetic cause. However, in that period each doctor grouped the various clinical manifestations observed into an arbitrary system of nomenclature and created their own unique collection of diseases.

In the nineteenth century, medical science related morbid anatomy to clinical manifestations observed bedside. With the advent of the microscope, the histopathology of the diseased part could be demonstrated. Such methods as percussion, auscultation, thermometry and sphygmomanometry were developed and results were correlated with histopathological information to advance diagnostic capabilities.

Recently development of the fields of immunology, virology, bacteriology, physiology, biochemistry, biophysics and electronics have advanced the quality of clinical evidence so that diagnosis has now become a complex act of inferential logic.

The evolution of dentistry in diagnosis of TMD's mirrors that of medicine. Costen in the 1930's reported successfully treating a group of patients whose symptoms included hearing loss, aural fullness, tinnitus, preauricular pain, dizziness, eustachian tube fullness, headaches, and burning in the throat, with a mandibular overlay appliance, which separated the teeth 2-4 mm. The designation Costen's Syndrome was given to this diverse symptom cluster and the etiology became the subject of immediate controversy.

Syndromes have traditionally been created by nosologists to provide an abbreviated label for a concordance of multiple entities and commemorate the physician who first described it, rather than as explanatory diagnosis.

This symptom complex became identified as temporomandibular joint syndrome in the 1960's and changed to TMD or temporomandibular disorders in the 1980's. The clustering station has been identified as the temporomandibular joint, but the etiology can be trauma, derangement, histopathological lesion, or dysfunction, with origin either in the masticatory system or a remote location.

Dental education emphasizes acquisition of large amounts of factual data and understanding of pathophysiologic mechanisms. Dental schools instruct students in therapeutic alternatives and the various techniques of treatment. The preeminent function of the clinician dealing with temporomandibular disorders is diagnosis. Yet, little formal effort is directed to the logic of dealing with diagnostic reasoning and decision analysis.

Diagnostic Challenge of TMD's

TMD's pose new intellectual challenges to dentists as diagnosticians. There is much evidence that many TMD's are stress related and multiple etiologies in which identification of the pathology may be an effect rather than the diagnosis. Further complicating specific diagnosis of TMD's is that shared neurological circuitry in the head and neck often makes etiology of the pain difficult to diagnose. Further, the location of pain may not be the site of the pathological lesion and the quality and intensity of pain may not relate to the extent and nature of the disease.

Dentistry must move beyond the histopathological plateau where identification of the pathologic entity determines the disease. Having established that the term TMD refers to a group of distinct disorders and not a single disease entity, diagnosis of the specific disorder is of paramount importance to the dental clinician. For dentistry to continue to parallel medicine as a science, diagnosis must evolve into an act of inferential logic. Applying logic to diagnostic reasoning is not an easy task.

Deductive vs. Inductive Logic

There are two types of logic which need to be identified so they are not confused. *Deductive* reasoning is best exemplified by a geometric proof. Given that the shortest distance between two points is a straight line. The path from here to there is a straight line. Therefore, it is irrefutable that said path is the shortest distance. Given that Koplik's Spots are pathognomonic to measles, and a patient is seen with Koplik's Spots; it is a deductive proof that this person has or will shortly have measles.

Inductive reasoning is based on probabilities and inferences, i.e. the sun rose today. The run has risen every day for over one billion years without exception. Therefore it is a safe and reasonable assumption that the sun will rise tomorrow, but not irrefutable proof. If a specific disease always causes a certain clinical finding then that manifestation (a sine qua non) must be present or the diagnosis is disproved. But the presence of the sine qua non does not *prove* the diagnosis. Having been established in the dental literature that Hutchinson's Incisors are a sine qua non of congenital syphilis, if one sees a patient with congenital syphilis, they will have Hutchinson's Incisors. But the presence of Hutchinson's Incisors is not proof that congenital syphilis is present. Proof demands that findings be unique (pathognomonic), not essential. There are in fact few or no TMD's with pathognomonic characteristics.

Frequency of association of a particular manifestation with a disease has affirmative value. Manifestations which closely reflect the basic disease process are known as diagnostic criteria. Diagnostic criteria are important both as aids in clinical diagnosis and to insure that statistical studies are based on genuine instances of the disease.

Presence of compatible diagnostic criteria however do not *prove* a diagnosis; they establish that it is possible. One can affirm *(but not prove)* a hypothetical diagnosis if it is found that the disease accounts for the symptoms. The validity of this reasoning is imperfect, however, to the extent that the manifestations of the illness could have been produced by other diseases. Asserting that a diagnosis is *"proven"* by establishing that it explains all the findings is the logical fallacy of "affirming the consequent."

The clinician does not have to summarily reject a hypothetical diagnosis when one encounters an incongruous feature of the case. The odd symptom or sign may be caused by the presence of an additional disease to the one under hypothetical consideration. Invoking multiple diseases, however, damages logical simplicity. According to Occam's Principle[22] the more complicated the hypothesis, the less likely it is.

Diagnostic Problem Solving

Logic alone might seem to impart a maze of pitfalls to clinical problem solving. In fact no *comprehensive* description of diagnostic problem solving exists. There are doctors with reputations for having excellent clinical judgement. Often they make virtual instantaneous diagnoses that prove correct. And this judgement has been regarded as an art or mystique. But art and mystique rarely conform to rules and in many cases cannot be taught. Studies, in which these experts are required to watch themselves perform and then verbalize their thought processes, have been undertaken and resulted in a better understanding of their protocol, principles and strategies.

Diagnostic reasoning is the process of assembling evidence to support identification of the diseases. The input or evidence is the information obtained from the patient history, examination and paraclinical data. Its purpose is to provide explanations for the observed evidence.

Controversy and misunderstanding becomes rampant when clinical examination only utilizes subjective criteria in diagnosis and treatment of temporomandibular disorders. With criteria missing, undeveloped or excluded for thought processes which convert clinical observation into anatomic inference, each clinician develops his own mystique of diagnostic reasoning. There is no inherent immunity of TMD's to spare them critical examination on the same scientific basis as other aspects of medicine.

The Predicament of Dentistry

Accurate reproducible identification of the disease is necessary for dentists to incorporate scientific attributes to the treatment of temporomandibular disorders. Treating dentists must have suitable diagnostic criteria to allow for identification of each TMD.

One such problem dentists have had in clinical reasoning is advancing from first order observations of TMD to subsequent inferential classifications. With the exceptions of Weldon Bell and the exponents of neuromuscular instrumentation[14,] there are inadequate clinical criteria for reasoning necessary to arrive at second or third order inferential classifications which lead from clinical observation to anatomic diagnosis.

Interpretation is severely impaired without precise standardized objective information and adequate diagnostic criteria. Dentists not utilizing such neuromuscular instrumentation as computerized jaw scanning, electromyography and sonography fail to acquire data critical to the diseased people they are treating.

Technological advances such as these should be availed to aid the clinician in applying a rational methodology to diagnostic reasoning. If the study of TMD's is to advance to a higher level of diagnostic specificity the etiological component and not merely the pain symptoms must be treated.

Unfortunately, the relations between signs, symptoms and disease are not the same in every patient. Even if one could accurately and unambiguously determine the clinical signs and symptoms, uncertainty in TMD about the presence or absence of disease remains. Can a patient have an asymptomatic

TMD? If a click is abnormal, when does one treat? Often the signs and symptoms do not fall into well defined categories. Regardless of the complexity, diagnostic decisions must be made which will affect treatment. Also the effect of treatment has a degree of uncertainty in any given TMD patient, given individual variance.

Decision Matrices

Diagnostic decision analysis is not meant to describe the intuitive process. By learning decision matrices the clinician becomes more likely to make appropriate decisions in the face of multiple symptomatology and etiology and, thus, master the *science* of medicine.

Most diagnostic strategies require the clinician to disaggregate the problem into component parts so they can be individually studied and organized in logical ways that lead to a sound decision. Diagnostic decisions should be consistent with the underlying structural assessment of the problem.

In diagnostic reasoning, a clinician makes a series of inferences about the nature of the patient's problems. The basis for these inferences or input is history, examination, and data from clinical testing. Reasoning proceeds by a protocol consisting of hypothesis generation, hypothesis evaluation, information gathering and causal reasoning.

Hypothesis generation serves the function of forming a context within which information gathering takes place. Hypothesis evaluation consists of assessing coherency relative to findings. Reasoning consists of elimination of hypotheses that can be disproven or become unlikely. Information gathering and reasoning via questioning, ordering of clinical tests and examination proceeds in a sequential search for immediate causes until a diagnosis is determined.

This sequence may occasionally be interrupted by the administration of therapy. The therapy is usually conservative and may sometimes serve as a diagnostic test. If successful, the diagnostic process may be terminated without accomplishment of precise diagnosis provided the patient symptoms disappear completely. The etiologic end point of diagnostic reasoning may vary with each clinical situation.

Logic applies not only to finding a satisfactory answer to a clinical problem, but to organized structuring of problems in general as a sequential and systematic method of evaluation. No single method or strategy can be acceptable to all people who engage in diagnostic reasoning, nor can any methodology solve every nuance of each unique situation.

Reasoning Techniques - Probabilistic

Three principle reasoning techniques seem to predominate from the recent medical literature. These are probabilistic reasoning, causal reasoning and deterministic reasoning. *Probabilistic* reasoning (also called statistical reasoning) is based on the statistical relationships between clinical variables. Derived from a concept of probability called Bayes Theorem, it is frequently used in calculating disease likelihood, evoking diagnostic hypotheses and assessing the data from clinical tests. A probability represents a belief in the state of a patient or in the meaning of a test result. The strategy is to quantitatively combine clinical data and likelihood ratios. Use of this strategy requires a rigorous definition of diseases, a "gold standard" based on histology, radiology and clinical criteria. Each disease must be mutually exclusive of all other diseases.[29]

The first task in applying a statistical strategy is estimating the probability of all possible diseases from the patient's demographic and clinical data. It is critical that this reflect as closely as possible the population from which the patient is derived. If one disease is left out, it will never emerge as a potential cause. Each disease must be mutually exclusive of all other diseases or a repeat count of the same information will result.[29]

The purpose of probability analysis is to decide on an appropriate action and/or forecast the subsequent course of the disease. Threshold is the point at which either of two alternative choices has equal probability; thus the consequence of treating or not treating are equal. At disease probabilities greater or less than threshold, choice of action becomes easier

The statistical strategy offers the scientific advantage of expressing a rational process in mathematical symbols. A decision is approached immediately without dissection into components as with other strategies. The pertinent substantiating data are assembled directly and the diagnosis made on the basis of mathematical computation.[30]

Causal Reasoning

Causal reasoning builds a pathophysiologic model against which the patient's findings are evaluated for coherence and completeness. A causal model describes the healthy workings of the body versus its pathophysiologic behavior in disease. Traditional principles of science require that natural phenomena be explained not merely labelled. Claude Bernard has stated that "science consists in finding the relations which connect any phenomenon with its immediate cause."[31]

The causal protocol consists of testing, validating and verifying or excluding cause mechanisms. It supports clinicians' performance by simulating possible courses of disease. It provides a consistency check of the related finding and its coherency with the diagnostic hypothesis.

A framework and sequential stations for the causal strategy of diagnostic reasoning have been delineated by Feinstein.[29] (fig. 1)

Clinical Domains

A *clinical domain* is the structural or functional source of a manifestation. A single domain can be composed of more than one structure or function. A convenience is that the domain of many TMD's can now be easily identified as "TMJ." If the domain contains many structures or functions a focus within the domain must be selected as the structure or function responsible for the manifestation.[29] In diagnosis of temporomandibular disorders a list of the foci might include nerves, muscles, tendons, blood vessels, bones, ligament, disc, teeth, joint capsule and synovial fluid.

A *disorder* is a gross abnormality in the structure or function of a domain. A disorder of structure is a *lesion* and a disorder of function is referred to as a *dysfunction*. Disorders can occur in the quality, quantity or orientation of either structure or function.[32]

Lesions can be disorders of size, composition or location. The functions are expressed as transportational movements such as contraction of muscles, circulation of blood, nerve transmission, joint movement and classified according to amount, operation, and direction.[29]

Disorders can be both structural and functional, and one disorder can be associated with another. Causes of disorders can be identified with several degrees of pathologic specificity. A derangement is a pathologic process responsible for a disorder. Inflammation, neoplasia, disc displacement, trauma, congenital and biochemical abnormalities are derangements associated with the TMJ. A derangement differs from a disorder in three main ways: 1) derangement must be examined microscopically or chemically, 2) with the exception of disc displacement, derangements are seldom expressed in functional terms because they are identified as either morphologic or biological entities, and 3) a single disorder can be caused by several different derangements.[29]

A pathoanatomic entity is defined as a specific topographic and morphologic abnormality that may lead to derangements and disorders.[29] An example of a pathoanatomic entity might be a torn right posterior disc attachment.

Etiologic entity refers to circumstances or agents that can provoke or predispose to the development of disorders, derangements or pathoanatomic entities. Such etiologic agents include microbial, immunologic, biochemical abnormalities as well as such behavioral or psychic stressors as improper nutrition, hyperactivity, and emotional tension.[29]

One of the hallmarks of a wise diagnostician is the broad scope reviewed before choosing a domain. One must pay close attention not only to the gross structural, functional and physiologic problems which can account for the observed manifestation, but to the possibility that a manifestation in one domain is caused by a referral mechanism at a site remote from the obvious choice.[29]

Deterministic Reasoning

Deterministic reasoning consists of sets of compiled rules generated from routine well- defined practices. If-then rules are an example. Such assertions state, "If (certain conditions are met) then (a certain action is appropriate)". Algorithms or flow charts are constructed. An algorithm is a set of instructions for carrying out a specific task through a structuring of simple steps. They simulate the clinicians perception of the diagnostic process to create a definite roadmap for solution of a particular problem. (fig. 2)

They are decision trees which contain all possible choices and outcomes. The primary aim of the tree is to help the clinician separate the problem into manageable parts and think clearly about the actions available and their timing. The advantages of the tree are that the clinician can concentrate on one part of the problem at a time without losing the total picture.[30]

Advanced algorithms involve prognostic and therapeutic reasoning, as well as diagnostic. They also allow for interruption by treatment, which acts as a diagnostic test that by succeeding, eliminates the need for further diagnosis. Processes for analyzing decision trees by assigning subjective probabilities at choice sites enable the clinician to compare alternative courses of action in quantitative terms.[30]

Decision Goals

Each strategy has its advantages and disadvantages. The goals of clinical reasoning at which decisions are aimed, are intellectual and managerial. In an *intellectual* decision, the final result is an identification or evaluation of an observed entity. The choice of a diagnostic name is an intellectual decision. In a *managerial* decision, the final result is a plan of action. Choice of diagnostic test and mode of treatment are managerial decisions.[32] Evaluation of therapy is a very important diagnostic tool. Measurement of clinical variables such as electromyographic activity create indexes of the effects that occur as responses to therapy. Changes in index variables are the basis of the objective criteria by which effects are evaluated.

Discussion

Causal models are dependent exclusively on fundamental knowledge of physiologic function and dysfunction and the cause and effect relations of clinical events. They are specific to disease entities and independent of the patient population. When scientific precision is obtainable from a paraclinical test, a clinician will heed the result of that test more than any statistical probability.[32]

Probabilistic models are dependent on the population from which the patient is drawn. It is never possible for everyone in a population to be examined so statistics can be skewed. Certain TMD's cannot appropriately be considered simply as either present or absent. There are no diagnostic gold standards for each TMD and each TMD is not mutually exclusive of all other TMD's. Therefore statistical analysis would be inappropriate.

Thus it would seem that in the intellectual choice of a diagnostic name, with the clinician less likely to rely on statistical data, that the causal strategy might be a more judicious choice. The total rejection of statistics in diagnosis, however, would deprive clinicians of the opportunity to utilize mathematical computation to elevate clinical reasoning.[33]

A clinician is more likely to rely on previous statistics to select a mode of *management* for a patient. The optimal way to justify treatment decisions is a careful analysis of the result obtained in previous patients. If a diagnosis cannot be conclusively established, the clinician's next move should be an action decision. Either one seeks additional diagnostic testing, plans a mode of trial therapy to conservatively deal with the uncertainty, or seeks generation of additional hypotheses. Diagnostic hypotheses are dependent on disease prevalence. Causal reasoning does not generate hypotheses as readily as probabilistic strategies.[23] For these situations, a management decision is warranted and the statistical approach desirable.

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A doctor must ascribe to certain general rules, however, an important characteristic of good clinicians is their recognition of the way exceptions modify a general principle. One cannot practice effectively if they regard each patient as so unique that no rules can be established. The statistician is concerned with the average characteristics. The clinician is concerned with the nuances of patients and would be practicing poorly if all decisions were made on the basis of the average patient.

Algorithms offer a method of depicting pathways of thought which are justified at each step, which can be flexible enough to allow branching for individual variations and can still be expressed as probabilities.

Thus understanding all three strategies is important. No single strategy can be acceptable to all people who engage in diagnostic activity. No single mode of reasoning can capture all the nuances of clinical situations. Knowledge and command of all three modes is necessary however before amalgamation of strategies can be more than a random act of intuition.