How Does a Pathologist Make a Diagnosis?

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• A pathologic diagnosis is the result of a complex series of activities, mastered by the pathologist. The nature of these activities is, however, rarely talked about in depth. The medical literature occasionally discusses aspects of the pathologic diagnosis processes, generally departing from the pathologic practice. The lack of a model makes discussions about the subject a matter of preference or personal style. Educational programs are largely based on the apprenticeship model, and the development of specific abilities rests on the personal aspects of both apprentice and mentor. A model for the pathologic diagnostic process is proposed. The process of diagnosis can be viewed as an action plan, encompassing 4 domains: (1) cognitive, (2) communicative, (3) normative, and (4) medical conduct. The cognitive domain involves processes of perception, attention, memory, search, hypothesis creation, and verification, among others. Communicative skills consist of providing arguments in support of a diagnostic conclusion, with adequate clinical and relevant pathologic information. Pathologic diagnosis is also subject to technical rules (based on empirical experiences), rules of rational choice (strategies aiming at definite goals), and consensual rules among peers. Finally, the pathologic diagnosis has to be evaluated in the sphere of medical conduct, from the perspectives of both the pathologist and the referring clinician. An understanding of the diagnostic process from a theoretic perspective will benefit pathology as a science and a medical specialty because it provides the basis for understanding diagnostic variations and discrepancies. Pathologic difficulties or errors can be mapped, allowing the institution of specific remedies. This model may also enhance training and educational strategies because specific emphasis can be directed toward a particular difficulty.

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Forty-two years ago, in an editorial published in the *Archives of Pathology*, Lester S. King posed the question: How does a pathologist make a diagnosis?[1] He began by describing a widespread feeling about pathologic diagnosis:

> The pathologist observes and classifies what he *sees*, but he ''makes no deductions or inferences'' in this process. . . . In all ''diagnostic'' decisions, the pathologist is alleged to classify what he *observes*.[1(p331)]

In his comments, King analyzed some properties of observation and inference and the part they play in arriving at pathologic diagnoses. Observations result in descriptions, and when describing a lung, it can be said that ''at the base there are patchy firm slightly bulging areas, partly covered with a delicate friable grayish-green membrane, that on section these areas show an irregularly mottled dark red moist surface exuding frothy sanguineous fluid on pressure.''[1(p331)] According to King, it is generally believed, in pathology, that observers who describe objectively will essentially arrive at similar reports. However, the pathologist may get tired of interminable descriptions and may, instead of aiming at so-called objective description, simply make an inferential leap, and say that the lung shows pneumonia. This is not a description, but a gross diagnosis. Gross diagnoses often are found to be erroneous when the tissues are studied under the microscope.

In more recent editorials, the issue of pathologic diagnosis has been debated. Foucar[2] defended the standardization of the surgical pathology report as a measure to minimize diagnostic variability and error. Foucar's editorial was written in response to a brief letter from Medline,[3] stating that pathologists should retain their individuality and freedom to decide what is relevant to report. In this debate, Murphy[4] depicted the changing trend of the pathologist's work from one of medical consultant (maker of anatomical diagnoses) to one of information specialist (describer of anatomic findings). To make sense of this debate, we must be able to answer that simple question posed by King: As practicing pathologists, even though we make pathologic diagnoses everyday, are we able to give an accurate answer as to how we do that?

We can start with lessons taken from King's editorial. He used examples of autopsy pathology, but in surgical pathology, the reasoning is essentially the same. When one says that a pathologist ''sees'' a myocardial infarction, it is a shorthand way of saying that he or she sees a congeries of colors and textures that are interpreted or identified as a myocardial infarction. Myocardial infarction, epithelioid hemangioendothelioma, basal cell carcinoma, for example, ''are not 'entities' that are seen . . . , they represent concepts, intellectual constructions or abstractions.''[1(p332)] Usually, it is possible to make a clear separation between anatomic *findings* and anatomic *diagnoses.*

According to King,[1(p331)] ''The pathologist and the clinician arrive at diagnosis by steps which are formally identical . . . both start from 'data,' 'building blocks,' 'observations,' 'first order inferences,' or whatever terms we

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wish to use; and by series of inferences of varying complexity arrive at conclusions we can call 'diagnosis.' '' King did not provide refined definitions, and the question he asked himself—how does a pathologist make a diagnosis—has not been answered in depth.

As a tentative answer to this question, we postulate a model by which pathologists arrive at a diagnosis. This model reconciles apparently opposing views, such as standardization versus individuality and medical consultant versus information specialist.

The diagnostic process can be viewed as a problem-solving strategy. In resolving the problems presented by the case, the pathologist must elaborate an action plan, contemplating 4 different domains: cognitive, communicative, normative, and medical conduct.[5]

Rather than simply accommodating apparently opposing concepts, such as individuality and standardization or medical consultant and information specialist, the purpose of this article is to provide a broader view of the pathologic diagnosis. The literature on this theme has strongly emphasized the cognitive skills involved in the task. Few articles on clinical decision making have dealt with the communicative aspects of the diagnosis, particularly in the framework of argumentation. Questions derived from the normative and the medical conduct domains have not received due attention. These fragmentary discussions in the literature have failed to address the diagnostic issue as a whole and have not proposed actions specifically designed to improve our diagnostic abilities. In this article, we envision the pathologic diagnosis as a human task, involving people—the pathologist, the patient, and the referring clinician (hereafter, a *clinician*)—and as such, the processes involved in the diagnosis should integrate cognitive, communicative, normative, and medical conduct domains. These domains function in conjunction, in an integrated manner, comprising a model of an action plan for resolving a problematic situation. They are presented in a logical sequence, providing a guide with the essential elements of diagnosis organized within appropriate domains. We begin by discussing specific aspects of each domain; then, we proceed to integrate the domains into an action plan; and lastly, we briefly evaluate some implications of this model for pathology practice, investigation, and education.

COGNITIVE DOMAIN

As a first step, in the cognitive domain, pathologists use cognitive processes, such as perception, attention, memory, and search, to collect data from the case, including macroscopic and microscopic findings and clinical or radiologic information. Based on these data, hypotheses are elaborated, and then these hypotheses are checked against the data. Importantly, conscious control is exerted on these cognitive processes, performing a metaconscious or a metacognitive function.[6] Metacognition is an active control over one's thought process. The process of thinking is consciously guided in the direction of solving a problem. Metacognitive skills include planning the way to approach a task, being aware of internal or external distracting stimuli, evaluating progress toward task completion, and maintaining motivation until the task has been completed.

The strategies pathologists use to arrive at a diagnosis are not qualitatively different from those used by clinicians, such as the following ones, adapted from Sackett et al.[7]

Pattern Recognition

When looking at a histologic slide, the pathologist can make a diagnosis, based on a strategy called *pattern recognition.* When asked to explain why he or she is sure of the diagnosis of basal cell carcinoma, the answer can be simply stated: ''Because that's what basal cell carcinoma looks like!'' or ''What else could it be?'' Pattern recognition is the realization that the histologic picture conforms to a previously learned picture of the disease.

Multiple Branching or Arborization (Algorithms)

Another strategy can be called *multiple branching* or *arborization*. This is the progression of the diagnostic process down one of a large number of potential, preset paths, by a method in which the response to each diagnostic inquiry automatically determines the next inquiry to be carried out and which, ultimately, leads to the correct diagnosis. The algorithm must be spelled out in its entirety, before the case arrives, and must include all relevant findings or clues, linking them by pathways that represent the idealized diagnostic process of the expert pathologist.

Exhaustive Strategy

Another strategy is to collect all possible data (scrutinize all sections, review all clinical data and x-rays, and evaluate special stains and immunohistochemistry slides) and to proceed to the second stage of searching for the diagnosis. This is the *exhaustive strategy* and may be a method of the novice. With experience, it is expected that the pathologist will use some shortcuts. However, now and then, the exhaustive strategy can reappear, to rule out remote diagnostic possibilities, to justify a delay in sign-out while the pathologist thinks about something else, or to establish rapport with the patient, the clinician, or a referring pathologist in a consulting case.

Hypothetical and Deductive Strategy

The *hypothetical and deductive strategy* consists of formulating, from the earliest clues in the pathologic picture, a short list of potential diagnoses, followed by the performance of pathologic (searching for additional histologic evidence, ordering special stains or immunohistochemistry) and parapathologic (eg, searching clinical, laboratory, radiologic data) strategies that will best reduce the length of the list. This strategy contains 2 elements: hypothesis creation and hypothesis verification. Hypothesis creation is a highly individualistic process and depends on mastery of the dynamic models of structure, function, and response to stimuli that comprise the knowledge from basic science disciplines, such as anatomy, biochemistry, physiology, genetics, basic pathology, and microbiology, as well as clinical medicine, surgery, and dermatology, among others. The second element, hypothesis verification, is a mastery of selection, acquisition, and interpretation of pathologic and parapathologic data that will best shorten the list of hypotheses. Values can be assigned to these data, and the strength of hypothesis testing can be standardized.

Valuable reviews of diagnostic decision-making in surgical pathology were presented by Foucar.[8,9] In his reflections on the theme, he struggles to present some concepts of diagnostic epistemology to a community of pathologists who react negatively to these discussions. He understands that decision making is an immature scientific field, and he slips into poorly defined, almost transcendental factors,

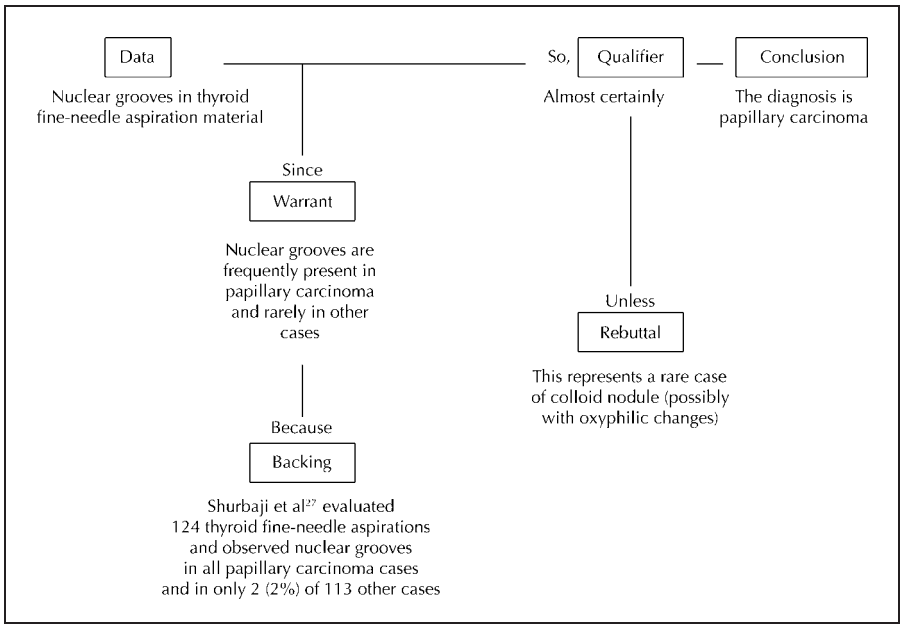

Figure 1. *The Toulmin model of the structure of argumentation. Words in rectangles are the constituents of an argument. Data are facts from which conclusions are drawn. Warrants represent other data that allow the step from data to conclusion. The warrants are supported by backings. The qualifier describes the degree of certainty about a conclusion based on the nature of the warrant. The rebuttal provides an alert for situations in which a conclusion may not be valid. Adapted from Toulmin.[11] Reprinted with permission from Cambridge University Press. Data example was taken from Shurbaji et al.[27]*

such as intuition, flair, luck, gut impression, and others, which might be related to an implicit or tacit knowledge that pathologists use in making diagnoses, but which are not formally expressed. A better comprehension of Foucar's arguments is possible when these relevant topics are discussed from communicative and normative perspectives, when pathologists are urged to verbally explain, justify, argue for, or interpret a diagnosis. In the reasoning process, Foucar[8,9] also stresses the necessity of a scientific base that results in acceptably low levels of diagnostic variation. According to him, the pathway to this scientific approach is to progress toward evidence-based medicine. His proposal must be analyzed carefully, as many of the best standards in the study of diagnostic tests have not been fulfilled for pathologic diagnoses. These standards include[10]

- interpretation from a blind comparison with a gold standard diagnosis
- evaluation of an adequate sample with a spectrum of mild to severe disease, with the addition of samples from individuals with different, but commonly confused, disorders
- delineation of settings and patient filters, adequately described
- determination of the precision (reproducibility) and observer variability of the test
- explanation of a normal finding, sensibly defined
- validation of the contribution of individual tests if the test is part of a sequence of tests, for example, molecular tests after morphologic evaluation
- description of tactics sufficiently detailed to allow exact replication
- determination of test utility

Although not conforming to these standards, the pathologic diagnosis, more often than not, is considered a gold standard to which other tests are compared. The role of the evidence data in the diagnosis is best understood when it is analyzed in the communicative domain, in the context of argumentation.

COMMUNICATIVE DOMAIN

The diagnostic process is not limited to cognitive functions. Communicative and language functions are equally important. After the initial cognitive approach, the pathologist describes and interprets the findings and makes assertions about the case in a written report. Relevant communicative activities also include receiving adequate clinical or surgical information, talking to the clinician or the patient, preparing a case for presentation or publication, and image documenting. On occasion, a final diagnosis can be satisfactorily achieved only if the pathologist is able to search for relevant information on that case.

The Uses of Argument

It is in communicative discourse that the pathologist argues that his or her conclusion is a valid construction derived from the data. The Toulmin[11] structure of argument is relevant in this setting (Figure 1). The passage from data to conclusion can be challenged, and the pathologist must be able to provide warrants for the validity of this step. The warrants must be supported with backings. In the King[1] example, macroscopic changes of the lung are diagnosed as pneumonia. That conclusion, however, may be challenged: ''How did you get there?'' The pathologist must, therefore, provide warrants, such as ''lung macroscopic changes in pneumonia are described as such'' and when backings are requested (''What do you have to go on?''), provide the justification, such as citing, for example, autopsy studies of pneumonia cases. The nature of warrants and backings will determine the acceptability and certainty of the pathologic conclusions. The reasoning might thus be structured: The lung was macroscopically changed (data), as described, so this is possibly pneumonia (conclusion), because the macroscopic findings in pneumonia cases are frequently described as such (warrant), based on autopsy studies of pneumonia cases (backing).

This structural model of the argument provides us with different uses of data. Besides the data from the case, we use data as the foundation of a conclusion (warrant-using

data) and as the backing, the justification for a warrant (warrant-establishing data). In a sense, diagnostic criteria are applied as warrant-using data, authorizing a conclusion, and their utility is more apparent after a diagnosis is made. Evidence from the literature has a role as warrant-establishing data. A major difficulty in pathology arises because most studies and textbooks generally focus on diagnostic entities, not on findings. The pathologist must combine information from different studies on lung pathology (pneumonia, interstitial pneumonitis, and pulmonary embolism) to provide the warrants that allow the conclusion that pneumonia is the most appropriate diagnosis. In an ideal scenario, the pathologist would have available the frequencies of diagnoses within a series of findings, making possible a probabilistic, Bayesian inference. Simplistically, Bayes theorem allows the calculation of the probability that a patient belongs in a given diagnostic category, given the presence of a certain finding or test result.[9] However, even if sensitivity and specificity statistics (as well as likelihood ratios and predictive positive and negative values) were available for every possible pathologic finding in relation to a diagnosis, such external evidence could never replace individual, pathologic expertise. It is this expertise that determines whether the external evidence applies to the particular case and how the data should be integrated in the pathologic decision. Put into the context of the dispute between individuality and standardization, the pathologist, individually, has to choose which standards must be applied in a given case.

The available evidence does not always necessitate a particular conclusion; in most cases, the evidence provides some degree of confidence, not absolute certainty. Accordingly, the structure of the argument has a *qualifier* element, which expresses the cogency or force attached to the conclusion. The conclusion may be qualified with terms like *probably, probably not, possibly, possibly not, certainly*, and *almost certainly*, among many others. Qualifiers are frequently stated in a pathology report because the pathologist may be hesitant to commit to a particular conclusion. As Burger and colleagues[12] have stated, qualifiers are not to be used as exculpatory reservations if the diagnosis turns out to be wrong. Both the pathologist and the clinician should understand these qualifiers as expressions of the level of certainty in a diagnostic conclusion.

The level of diagnostic certainty has been presented as a function of the diagnostic value of case data for establishing a diagnosis and the robustness of a diagnostic category.[9] However, the robustness of a diagnostic category may itself be a function of the diagnostic value of the data because diagnostic categories are constructions in which diagnostic data play a major role.

To resolve this apparent tautology, a distinction should be made between the diagnostic value of data from cases studied to date and the diagnostic value of data from the current case requiring a diagnosis. In both cases, arguments are necessary to ensure the strength of the data, but the arguments are of a different nature in each situation. In the latter situation (the case requiring diagnosis), we make use of warrant-using arguments: We rely on a datum to establish a conclusion, by appeal to some warrant that is accepted beyond doubt. In the first group (cases studied to date), by contrast, we make use of warrant-establishing arguments. These will be the arguments found in scientific articles, in which novel warrants are proposed, by means of studying a number of cases in which both the data and the conclusion are independently verified. Warrant-using arguments are deductive, applying established warrants to new data to derive a conclusion. Warrant-establishing arguments are communicated to render a proposition general by induction. In other words, observations of regularities are used as the backing for a novel warrant. The interface between warrant-using and warrant-establishing arguments can be understood as the building edge of a railway. As long as warrants have already been established, the steps from data to conclusion are like a journey along a railway already built. The production of novel warrants is to build the railway itself.[11]

Pathology can be viewed as both a medical specialty and an investigative scientific discipline. The same methods we use to make diagnoses, we also commonly use to establish novel warrants. Our published literature is largely observational, and reports of case series are the principal source of the warrants we rely on in making a diagnostic conclusion.[13] On the other hand, the practicing pathologist is not really engaged in expanding the universe of available warrants but, instead, attempts to collect data that are likely to be relevant, according to established warrants, in placing a patient within a known disease category.[9]

The practicing pathologist and the investigative pathologist should both be aware of the importance of argumentation, in establishing a diagnosis in an individual case and in establishing new warrants or proposing new diagnostic categories. Both the certainty of the scientific knowledge in pathology and the firm conviction of a beyond-a-doubt diagnosis rest on the reasons the pathologist can adduce in refuting objections against them. These certainties are based on argumentation, not in previous experience. Previous experience serves as a warrant in an argument. If these certainties were based in experience, not on argumentation, scientific progress in pathology would depend on the production of new experiences and not on new interpretations of the same experiences. In a particular case, the idea of the objectivity of the histologic perception does not ensure the truth of the corresponding diagnosis; instead, it represents only one instance of an experience in the diversity of its possible interpretations.

A diagnosis beyond a reasonable doubt is thus a function neither of the diagnostic value of the data nor the nature of a conclusion. Instead, it rests in the warrants that allow one to proceed from data to conclusion. The classic example of argumentation[11] makes this point clear:

Socrates is human;
All humans are mortal;
So, Socrates is mortal.

The first premise (Socrates is a human) is the data from which the conclusion (Socrates is mortal) is derived. The certainty of the conclusion is not a function of the nature of the data or of the conclusion; instead, the certainty is derived from the nature of the warrant (in this example, the universal premise: all humans are mortal). Interestingly, when a backing is requested for this warrant, we have to acknowledge that the warrant was inductively construed from the factual observation that all humans who have existed so far have ultimately died.

A further element that requires definition is the *rebuttal*, which refers to factors that limit the validity of the conclusion. Whenever a conclusion cannot be taken as com-

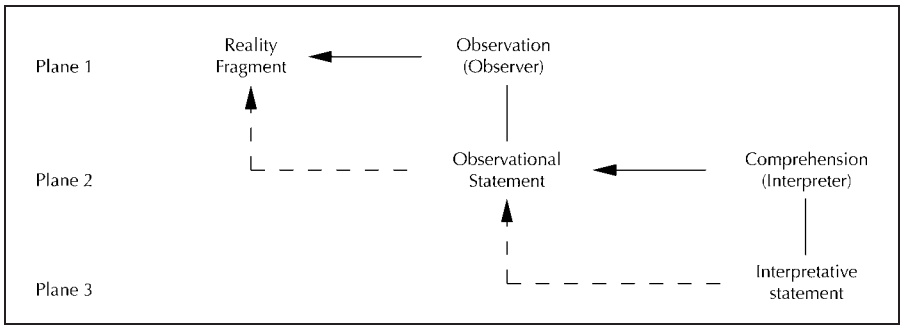

Figure 2. *Sensorial versus communicative experiences. The comprehension act refers to the symbolic expression (the observational statement), as the observational act refers to reality (arrows). The interpretative statement reproduces the semantic content of an observational statement, as the observational statement reproduces a piece of reality (arrows with dashed lines). The comprehension (of an observational statement) is expressed in an interpretative sentence, as the observation (of a reality fragment) is expressed in an observational (descriptive) sentence (lines). Adapted from Habermas.[19] Reprinted with permission from Suhrkamp Verlag, Frankfurt, Germany.*

pletely certain, the situations in which it may not be valid are expressed in the rebuttal. In the pathology report, the rebuttal is customarily expressed in a note.

The Toulmin structural model of argumentation[11] emphasizes that warrants are required by pathologic conclusions, even in the absence of research data to establish them. In the absence of (and sometimes despite of) good quality research data, pathologic reasoning may be guided by medical heuristics. This is the case of a diagnosis sustained in pattern recognition. In the context of argumentation, heuristics can be understood as warrants, and backings for those warrants would be individual, pathologic expertise. Of course, medical heuristics may be passed from pathologist to pathologist, in training activities, consultations, books, and meetings, and they form part of the background knowledge that pathologists use to make diagnoses, but they are not usually reflected on or made explicit. In any time period, firmly established heuristics and diagnostic patterns may include new information and techniques. Advances in diagnosis are made by the substitution of tests with high sensitivity and specificity for previous, marginally reliable heuristics that directed patient workup.[9] Heuristics will ever be useful in activating hypotheses, but as anatomic pathology advances as a science, their use as warrants is expected to decrease as morphologic findings and molecular techniques are established as more reliable warrants authorizing the diagnostic conclusions.

The Toulmin structural model of argumentation[11] has been sporadically addressed in the literature on clinical decision-making. According to Dickinson,[14] the argument helps to make a clear distinction between the different uses of data. Data serve as a foundation for a conclusion (warrant-using) and as the backing for a warrant (warrant-establishing), allowing the integration of individual clinical expertise and the best available evidence. Sackett and collegues[15] comment, ''Good doctors use both individual clinical expertise and the best available evidence, and neither alone is enough.'' Horton[16] found that, among both scientists and clinicians, it was difficult to discern the connection between science and practice, and that the ability to reason was a skill that was generally lacking in physicians, so that learning the structure of argumentation was necessary for them to think effectively. Argument is useful because it helps to make explicit medical reasoning.[17] Because there are gray zones in medical practice, uncertainty should be clearly acknowledged. This might be a source of considerable epistemologic and ethical tension.[18] These questions anticipate the importance of a normative domain in the diagnostic process.

Sensorial Versus Communicative Experiences

The step from cognitive to communicative domains can be also understood when we contrast sensorial and communicative experiences (Figure 2).[19] From review (an observational act) of a histologic section (fragment of the reality), the pathologist (observer) produces a histologic description (observational statement). Departing from this observational statement (the symbolic expression of the reality), the pathologist (as an interpreter) produces an interpretative statement, through an act of comprehension.

King[1] has intuitively approached these concepts, as he contrasted the actions of observing, describing, and inferring, and made distinctions between pathology findings (observational statements) and pathology diagnosis (interpretative statement). As the pathologist departs from the plane of reality, general and specific hypothetic considerations of causality are necessary, to explain the meaning of the observational statements. Anticipating an aspect of the normative domain, the rules guiding the analytic steps from a pathology finding to a diagnostic interpretation are the *know-how* in pathology because they comprise the implicit, tacit knowledge by which the practicing pathologist demonstrates mastery. As the pathologist reconstructs explicitly and objectively these rules, that know-how ultimately transforms into a *know that*.[19] This reconstruction is better understood using a parallel with grammar theory. This theory has the purpose of articulating a rule, which is intuitively known by competent speakers. The purpose of such reconstruction is to represent the system of rules that allows a potential speaker to acquire the competency to produce and understand grammatically correct sentences in a particular language.

Validity Claims

The validity of a pathologic report, as a speech act (ie, the truth that we claim propositions to have by asserting them), depends on 2 conditions: (1) it must be grounded in experience, meaning that it is not dissonant with experience; and (2) the statement must hold up against all counterarguments,[20] that is, it must be discursively recoverable (redeemable). This means the communication is implicitly tied to argumentation and discursive procedures for the recovery (redemption) of validity claims. A pathologic report, to reach consensus, must be intelligible, must have normative rightness, must not raise doubt about the pathologist's sincerity, and its propositional content must be validated as truth. Whenever one of these claims becomes problematic, questions are raised.

If there is a problem with the intelligibility (comprehen-

sibility) of the proposition, people will ask: What do you mean by that? How am I to understand that? What does that mean? Answers to such questions are *interpretations.* The intelligibility of the pathologic report requires that the symbolic expressions made by the pathologist be understood by the clinician within the same system of rules. The surgeon's misinterpretation of a pathologic diagnosis of dermal cylindroma as adenoid cystic carcinoma results from deviations in the formal semantic rules. *Consistent with* may be interpreted by surgeons as *diagnostic of.*[21]

If the truth of the propositional content is problematic, people will ask: Are things really as you say? Why are they that way and not some other way? Answers to such questions are *assertions* and *explanations.*

If the normative rightness of a report or its normative context is problematic, people will ask: Why did you do that? Why didn't you behave differently? Answers to these questions are *justifications.*

If a pathologist's sincerity is questioned, people will ask: Am I being deceived? Is the pathologist deceiving him or herself? These questions are addressed to third parties. How a pathologist might exhibit insincerity may require an example: Consider the case of a pathologist who ''. . . is a willing accomplice to the surgeon who is liberal in the clinical diagnosis of chronic appendicitis. These pathologists never call an appendix normal.'' [22(p760)]

NORMATIVE DOMAIN

The medical practice of pathology also has a normative domain. As with every human action that has meaning, pathology is driven by rules and norms. Three different kinds of rules must be followed, with different consequences if they are disrespected.[23] The instrumental action is governed by technical rules, which are based on empirical knowledge and which can be proved to be correct or incorrect. An example of a technical rule is that a primary antibody has to be applied before a secondary antibody. The purposive, rational action is governed by strategies (rules of rational choice), which are based on analytical knowledge and which are derived from preference rules and decision-making procedures. The purposive, rational action is aimed at definite goals under given conditions. For example, in taking sections for histologic study, analysis of the margins may be accorded a higher value than the study of the lesion. One histologic finding may be disregarded, whereas another may be valorized in the process of making a diagnosis. The assignment of value to data must follow appropriate strategies, guided by rules of rational choice. The communicative action is governed by social norms that define reciprocal expectations and that must be accepted by at least 2 acting subjects. Whereas the effectiveness of technical rules and strategies depends on the validity of empirically true or analytically correct propositions, the validity of social norms is ensured by an intersubjective recognition that is based on consensus or mutual understanding. Rules to grade or stage tumors, report standardization, and ethical issues, for example, are entirely founded on formulated consensus among peers. Violating a rule has different consequences in each case. Failure to follow proven technical rules or correct strategies may result in lack of success. Learned rules of purposive, rational action provide us with a menu of skills, and all actors must make this choice by themselves. Violating prevailing social norms may trigger sanctions only externally connected to the rules, in other words, by convention. Learning the rules of instrumental and purposive, rational actions strengthens the pathologist's skills and enables him or her to make diagnoses or, in the Murphy[4] view, to become the medical consultant. Acting in conformity to the norms of communicative action depends on motivations. The Medline[3] defense of individuality can be localized to purposive, rational actions, whereas the Foucar[2] defense of standardization has to deal with intersubjective consensual norms. Neither of them, however, would violate technical rules, under the penalty of failing. Such rules guide actions that are not opposed to each other; instead, they are complementary and relevant to pathologic practice.

A brief commentary on classification rules will be made here. Classification schemes should be, as much as possible, based on strategic rules, and the decision to choose which classification is most appropriate for a given case relies on the objectives we have in mind when classifying. A thyroid neoplasm, for example, may be classified by architectural (follicular vs papillary), cytoplasmic (oxyphilic vs nonoxyphilic), or nuclear (papillary characteristics vs nonpapillary characteristics) findings. The best classification rule is the one that allows us to best comprehend how the neoplasm is expected to behave. Therefore, we classify a neoplasm of the thyroid follicular epithelium on the basis of nuclear characteristics, and a particular case may be diagnosed as papillary carcinoma, even if it is entirely follicular and/or oxyphilic.[24]

MEDICAL CONDUCT DOMAIN

The last domain in the process of pathologic diagnosis is the domain of medical conduct. The actions that should be, or are expected to be, carried out by the pathologist and by the clinician have to be evaluated before the final diagnosis is signed out. The pathologist must clearly know the consequences of a diagnosis in the management of a case, and the report should make clear both the diagnosis and the expected conduct derived from it. Also, the pathologist must consider the necessity or appropriateness of ordering or suggesting a new sample, additional sections, special stains, immunohistochemical studies, further clinical or laboratory investigation, or a consultation to another pathologist. The pathologist is technically responsible for the diagnostic interpretation he or she makes. This responsibility is linked to the medical conduct consequent on the diagnosis. As a practicing medical specialist, the pathologist is assumed to be acquainted with the practical implications of his or her diagnoses, thereby admitting responsibility for the actions resulting from them.

ACTION PLANNING

In the interval between receiving a specimen and signing out a report, the pathologist executes a series of actions and operations. Such actions and operations should be planned before they are undertaken. Because we see the diagnosis as an instance of problem solving, our model provides a guide to elaborating an action plan to resolve a problematic case. The definition of a problematic case should be as broad as possible. To the novice, every single diagnosis might be problematic, and he or she may have to go through a complete sequence of operational steps. In contrast, the expert pathologist might operate through shortcuts, in a continuous interplay between multiple domains, and arrive at a definitive diagnosis, apparently not going through a sequence of operational steps. As these

abilities are gained with practice, they are generally not reflected upon and not made explicit. However, even the expert may face a problematic case and arrive at an inconclusive diagnosis (a situation in which his or her diagnostic process would still be open to analysis), but these are not cases generally presented in meetings or seminars.

Before proceeding to the actions related to diagnosis, the pathologist should elaborate a plan of action for the problematic case. This plan should include consideration of the 4 domains described earlier in this article.[5] Questions raised by the case should be answered, and if new questions arise from these answers, a new cycle of planning and action is iteratively undertaken until no doubts remain or no answer can be found to the raised questions. The implicit knowledge in pathology, comprising many of the tasks involved in diagnosis, involves an interaction among different domains. This know-how in pathology aids in the solution of the case, even if a diagnostic label cannot be applied. When such a situation occurs, the pathologist is expected to present a communication stating the facts that precluded a final diagnosis, to follow adequate rules, and also, to propose a managerial approach to the case. The present model has the purpose of making explicit these multiple facets of pathologic diagnosis. As they are explicated, the diagnostic process can be discussed and analyzed by the persons involved. A generic diagnostic action plan is presented below.

Cognitive Domain

- Plan diagnostic strategies for the case (macroscopy, microscopy, immunohistochemical, or special stains).
- Select a most appropriate diagnostic approach to the case (pattern recognition, algorithms, hypothetic deductive).
- Use cognitive skills to collect data for the case (perception, attention, memory); exert permanent, conscious control upon these cognitive functions (metacognition).
- Elaborate and test diagnostic hypotheses.
- Search for specific diagnostic findings.

Communicative Domain

- Ask: Is there enough clinical information?
- Formally express the warrants and backings for your conclusion.
- Attend to the intelligibility, normative rightness, truth, and sincerity of the pathologic report.
- Ask: Besides the written information in the report, should we talk to the clinician?
- Document the case; prepare it to be presented in a meeting or a publication.
- Search the literature.
- Record any useful event for quality control measures.

Normative Domain

- Specify and justify rules guiding your diagnosis (empirical rules, rules of rational choice, and social norms)—rules to classify, report, and grade and stage tumors, for example.
- Respect the patient, the clinician, and the referring pathologist.
- Conduct yourself according to the ethical code (in relation to the patient, to other doctors, to the earning of fees, and the like).

Medical Conduct Domain

- Consider: What is the consequence of your diagnosis to the management of the case?
- Consider: Does your communication make clear the diagnosis and the expected conduct?
- Consider: Is this a case for which you can assume all the responsibility for the diagnosis, or should you share it with another pathologist?
- Consider: Should you seek a consultation with another pathologist, request a new sample, order special stains or immunohistochemical studies, or some other clinical investigation to confirm the findings?

Evaluation of the Diagnostic Action Plan

Feedback on the outcome of the patient is of paramount importance in evaluating the diagnostic plan of action. As Foucar[9] has stated, ''The diagnostic improvement fails if it lacks truthful feedback about the success or failure of a specific course of action.'' Frequently, pathologists have no notice of the outcome, performed treatments, or results of outside consultations or immunostains performed on a case.

The resident in pathology, as an apprentice, has his or her diagnosis checked by the mentor, and the process leading to the diagnostic conclusion, more than the diagnostic conclusion itself, should be evaluated with the preceptor, to detect specific difficulties, pertaining to different domains of the diagnostic task.

The purpose of this model is to reconstruct the practice of pathology within a structured framework. We categorized actions and operations involved in the diagnostic task within appropriate domains and provided some brief theoretic insight in support of them. In dealing with more difficult diagnoses, the pathologist uses these actions and operations. As an example, the introductory chapter in the Armed Forces Institute of Pathology's *Atlas of Tumor Pathology: Tumors of the Soft Tissues*[25] presents some of these basic elements. In this chapter, the authors discuss cognitive aspects of diagnosis (referring to pattern recognition, histologic findings, and immunohistochemical markers); communicative aspects (clinical information needed to diagnose soft tissue tumors, the content of the surgical pathology report); and normative aspects (rules to classification—with an interesting discussion on the basis of scientific and managerial classifications—and grade, rules to handle the resection specimen). Finally, the authors present a plan of action, as a capsulized approach to the diagnosis.

FINAL REMARKS

Our model is an attempt to present the diagnostic task as an action plan, which can be logically operated, going through cognitive, communicative, normative, and medical conduct domains. This is, in fact, what we do when we make a diagnosis. However, we are generally not aware that we need warrants for our conclusions, although we seek for warrants in textbooks all the time. We do not feel as if we are following rules, although we classify or stage cases according to published and accepted norms or guidelines. We might not be conscious of a medical conduct domain, but we do thoroughly check the risk of being in error when an amputation or other radical surgery or treatment is expected in consequence of our diagnosis. The previous discussions of this topic have emphasized

cognitive aspects, and because it might be difficult to appropriately intervene in someone's cognitive functions, they have not received adequate attention. As other domains are added to the diagnostic task, pathologists may enhance their diagnostic capabilities, acquiring specific abilities related to other domains by means of expressing relevant warrants and backings to their conclusions, deducing and expressing intrinsic rules that guide the different actions related to the diagnostic task, or knowing the implications his or her diagnosis will have for the patient and clinician. Such a reconstruction of the pathologist's practice may prove useful because it provides the basis for the comprehension of diagnostic variability and discrepancies. A problem in the diagnostic process might, therefore, be located within cognitive, communicative, normative, or medical conduct domains.

In a diagnostic task, the (1) cognitive capability to recognize a histologic finding and to establish a conclusion must be integrated with (2) the communicative ability to appropriately describe and interpret findings and to provide adequate warrants to a conclusion, with (3) obedience to appropriate normative guidelines, and to (4) evaluate the whole task with respect to the conduct that may be instituted as a consequence to the diagnosis.

As long as we deal with the complexity and dynamicity of biologic organisms, we may never be able to extinguish the uncertainty inherent in our tasks. This uncertainty, however, is not to be taken as an excuse for the possibility of failing. In every single diagnosis we make, we are expected to be able to locate where, to explain why, and to estimate how much we are uncertain about the facts. As this model provides sequential steps for the diagnostic exercise, it may be possible to better evaluate these uncertainties.

A model of how pathologists make diagnosis may also provide specific investigative questions and stimulate research to narrow such uncertainties. In the investigation of diagnostic variability, for example, one may find explanations for the lack of agreement among pathologists in the cognitive domain, in the attribution of value to diagnostic data, in the perception of subtle alterations, and in the process of hypothesis elaboration and verification. Diagnostic variability may also reside in the communicative domain because there may be divergences in the nomenclature and in the warrants sustaining particular conclusions. Failure to achieve agreement may be due to normative questions, as in the case of staging a colon carcinoma in one of the modified Duke classifications. Divergent rules are also found in the diagnosis of breast carcinoma in situ, including ones that require a minimum extent of lesion or number of compromised ducts. Medical conduct questions may guide diagnosis and may also contribute to variation, as in the case of a pathologist who feels more comfortable—and therefore more liberal—in diagnosing an atypical hyperplasia or even an adenocarcinoma in an endometrial curettage specimen from a woman in her 50s or older.

Diagnostic difficulties may be mapped into specific domains, allowing for specific education interventions. As a task based in multiple domains, it is possible to create mechanisms that compensate for a particular weakness in one of the domains or to enhance an ability felt to be deficient, by providing contributions from other domains.[5] A weakness in memory (a cognitive function), for example, might be compensated or ameliorated by repeatedly accessing the literature and actively documenting images and texts of more and more cases (communicative domain), by applying specific rules to diagnoses (normative domain) and by conducting a logical-oriented plan of action or asking for help (medical conduct domain).

In training activities, whenever possible, the mentor and the apprentice should establish joint-action formats, meaning that they should share the responsibility of solving the case, with the mentor assuming part of the task. Thus, the resident receives help in elaborating the diagnosis of a more complex case (cognitive domain) but assumes responsibility for writing the report (communicative domain). In other cases, the resident is encouraged to establish the diagnosis but may receive some help in writing the report. The same joint-action format can be applied to other tasks: talking to the clinician, attending the patient or the patient's family and friends, preparing the case for a meeting, presenting the case, always keeping in mind the domains involved in the diagnostic activity. As the resident develops autonomy in the tasks, he or she should gradually perform them autonomously.[6]

A major implication of this model may be the rescue of the practice of pathology as a medical and, above all, a human practice, involving not only cognition but feeling. The pathologist cannot be reduced to a cognitive instrument for assessing diagnoses. In the Bussolati[26] dissection of the pathologists' brain, he found that the eye, the experience, and the school would be the pillars that make up good pathologists. But he was then forced to conclude that, by dissecting a pathologist's brain, ultimately, what is found was a dedicated heart, commenting, ''Memory is stimulated, motivated by interest, by affection, by love. What is the eye, if not a total dedication to morphology, faith in morphology. Finally, the school, in its ultimate essence, is nothing but the transfer of an interest, the transfer of a passion, the transfer through generations of a small flame, the tantalizing but vital flame of curiosity.''[26] All of these feelings originate in the interest and respect for the patient, and the clinician, as well as other pathologists.

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