

Artificial intelligence in the clinical laboratory

We are impressed with Galen's statement that about 10% of America's gross national product is spent on health care and 10% of that is spent on laboratory tests. The wise use of the laboratory is no small concern. The ever-expanding number of possible tests confronts the physician with many possible combinations. There is both the risk of overutilization of the laboratory resulting in costly and useless data or underutilization resulting in misunderstanding and delay of appropriate treatment.

See the paper by Van Lente et al (pp 171-175).

Tests can be ordered in sequence or in parallel. For a specific type of patient, one test result can routinely lead to follow-up testing. The first test is ordered, the results are returned the next day, and the follow-up test and report take another day. An alternative to this time-consuming sequential testing would be to order first and follow-up tests together in parallel, even if many of these tests turn out to be unnecessary. Van Lente et al¹ propose a way to address this problem through the use of an artificial intelligence (AI) computer program to develop automatic decision rules for follow-up analysis of tests depending on prior information, thus avoiding the delays of traditional sequential testing and the costs of unnecessary parallel testing. For Van Lente et al to accomplish this, they combined two computerized parts. The first is a data base on more than 3,000 outpatients developed over several years. The second is PALI (or Programmed Accelerated Laboratory Investigation²)—a system de-

signed to carry out automated test analysis as new tests are received. PALI is implemented in this case by an AI program called EXPERT, which uses programmer-defined decision rules to analyze the tests.

First, some words about EXPERT. Weiss and Kulikowski designed EXPERT as a consultation program to act like a human expert; in this case, like a physician consult within the limited domain of aspartate transaminase elevations. This is one of several AI programs at work in medicine. Others include INTERNIST,³ developed by Meyers at Pittsburgh, and MYCIN, by Shortliffe at Stanford. MYCIN is used to "provide consultative advice on diagnosis of and therapy for infectious disease—in particular, bacterial infections of the blood."⁴ MYCIN is written in a high-level AI language called LISP. EXPERT is more accessible because it is written in FORTRAN and makes building focused expert systems relatively easy. At the Cleveland Clinic, EXPERT has been used to create systems designed to classify lipoprotein disorders and design theophylline dosing regimens. It is the program used for accelerated laboratory investigation to screen liver enzymes, as reported here. EXPERT systems store knowledge in a rule-based form and have several advantages. They are easy to create from the programmer's point of view, so the main effort involved in creating such a system is in formulating the knowledge base. They store patient information in such a way that it is easy to access and use for research purposes, and they are easy to modify as new information becomes available. This last point is very important, for, as Chou has pointed out, "the ultimate goal of any computer operation must center on the continued

refinement of the computer programs to match laboratory needs."⁵

While Altshuler, who with his colleagues at The Medical College of Wisconsin developed PALI, described how such a system can be used in the care of specific patients with specific indications, Van Lente et al describe how a similar system can be used in a screening program for healthy people. Their study group included 3,096 patients "seen for routine periodic health examinations as part of an extensive health program." The program was designed to investigate AST elevations. For each patient, a clinical history questionnaire, as well as enough blood to obtain "a biochemical profile, a complete blood count (CBC), and possible secondary testing," was sent to the lab. Of the 3,096 initial tests, additional tests were ordered for 79 patients whose AST values were elevated. Of these, 74 were confirmed by additional testing to have abnormalities in liver functioning. The program's ordering of a second round of tests is important because physicians have a tendency to ignore abnormal laboratory results in patients who do not have clinically significant symptoms of disease.⁶ Part of the beauty of the EXPERT-directed laboratory investigation is that it can be used to assess its own usefulness. Follow-up study of the patients who were found to have abnormalities will show whether the information obtained will be useful, and the data on all the patients are stored by EXPERT in a convenient and easily accessible form. It is easy to see how this kind of EXPERT-based PALI method can be used to evaluate other proposed screening

programs. The decision rules can be institution-specific because they are based on the population cared for by the hospital. The paper by Van Lente et al also shows the value of a close working relationship between clinician and pathologist. Thus their study has wide implications beyond the treatment of liver dysfunction.

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