Proposed Electronic Medical Record with Emphasis on Hepatitis Diagnosis

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Abstract

Introduction Medical domain is characterized, like many other domains, by an exponential evolution of the knowledge. There are a lot of tools which try to reduce the risk of error apparition in medical life. Medical decision becomes a very hard activity because the human experts, who have to make decisions, can hardly process the huge amounts of data. Diagnosis has a very important role here. It is the first step from a set of therapeutic actions, an error at this level can have dramatic consequences.

The aim of this paper is to present a new electronic medical system for using it on patients with hepatitis virus infection.

Results: Hepatitis is a very complicated disease with numerous different types many of them can lead to serious diseases like cirrhosis and liver cancer. An early correct diagnosis and an adequate treatment could reduce the risks of liver cancer apparition or other severe diseases. The main goal of the system is to use artificial intelligence in order to offer predictions about patients infected with hepatitis virus and also to follow the health condition of the patient reevaluating at every time the initial diagnosis and suggesting tests and treatment. Our effort is to present a new electronic medical record that will "borrow" data from the standard health record of the patient and other resources where information is saved and will process it and give suggestions for the diagnosis and treatment of the patient and at the same time will use a simple operating environment, such as the internet, thus making it easy to use.

Conclusions The medical record is a big step in improving health services in public hospitals. The proposed EMR with the use of artificial intelligence is the next logical step that will help in the diagnosis and early treatment of disease.

Keywords: Artificial intelligence, Neural networks, Fuzzy logic, hepatitis, HAV, HBV, HCV.

Introduction

The health-care community could be doing much more with the networking environment that we have in place today, but we should recognize:
(a) the forces that are preventing optimal cooperation among our organizations given an inherently distributed, competitive environment, (b) the logistical barriers to systems integration, largely in the area of standards development for both data exchange and terminology and
(c) the difficulty in justifying institutional investment by demonstrating cost effectiveness in an environment where intuition is not enough but formal experiments are often flawed or impossible to perform. (Shortliffe, 1998).

With the widespread use of electronic data capture and automation of medical records, medical diagnostic decision support systems (MDSS) have become a valuable aid in improving the accuracy of medical diagnosis. Their purpose is to enhance, not replace, a physician's ability in the complex and highly intuitive process of medical diagnosis. The uses of MDSS in medical diagnosis are predicted to increase 10-fold within the current decade. (Mangiameli, West, Rampal, 2004).

Artificial Intelligence (AI) is the studies of ideas, which enable computers to do the things that make people seem intelligent. AI in Medicine (AIM) is AI specialized to medical applications. The potential of AI in medicine has been expressed by a number of researchers and summarized the potential of AI techniques in medicine as follows:

• Provides a laboratory for the examination, organization, representation and cataloguing of medical knowledge.

Produces new tools to support medical decision making, training and research.

• Offers a content-rich discipline for future scientific medical specialty.

The system we propose here is based on two main branches of artificial intelligence:

— the traditional one, represented by expert systems;

— the connexionist one, where the most common forms used are artificial neural networks. The goal of the system is to offer predictions about patients infected with hepatitis virus.

Hepatitis is one of the principal causes for liver cancer. A correct diagnosis and an adequate treatment could reduce the risks of liver cancer apparition. Such an expert system could be successfully used if it is developed for mutual exclusive diseases and independent symptoms. (Dakshata, Seema, 2011).

There are two main possibilities of implementing expert systems: by logical inference and by statistical inference. Both of them can be used in this system, in order to make some predictions regarding the hepatitis diagnosis and the evolution of an infected patient.

The logical inference could be used in medicine to build expert systems that will produce a diagnosis starting from a set of premises. An expert system implements human reasoning and it needs some rules to make it possible. This type of system is also called rules based expert system and it is the most used system for implementing medical diagnosis. It has a graph structure and a chain logical evaluation is applied on this structure. Such an expert system could be easy to implement and also very easy to use for a non-engineer because its rules are similarly with the natural medical language. For hepatitis diagnosis it is necessary to specify which are the factors that define different types of hepatitis. After that, the rules for the expert system can be drawn. (Drăgulescu, Albu, 2007).

Decision trees have been a good data mining method to diagnose the liver disease as they have very good property and the structure is easy to understand, unless the size of the trees is not so large. This property of decision tree is important in case that human should understand the knowledge structures fully. This is one of the main reasons why decision trees are widely accepted in medical domain.

Another good point of decision trees is that it is very straightforward to transform decision trees into rules so that the rules can be used, for example, to build expert systems. But the training algorithms of decision trees have their weakness of disdaining minor classes. Decision tree generation algorithms divide the training data set based on their own branching criteria. So, due to the dividing as each subtree is being built, each branch in the decision tree becomes to have less training instances. So, the reliability of lower branches becomes worse than upper branches due to the smaller size of training examples. (Hyondai, 2012).

Artificial neural networks are a branch of the artificial intelligence and they have been developed to reproduce human reason and intelligence. The initial idea was that, in order to reproduce intelligence, it would be necessary to build systems with architecture similar to the brain one. Therefore, artificial neural networks are built by the interconnection of certain primary elements, whose structure is similar to the biological neuron.

Like the human brain, these artificial neural networks are able to recognize patterns, manage data and, most important, they have the ability of learning. (Drăgulescu et al., 2006).

Artificial neural networks could be used in every situation in which exists a relationship between

some variables that can be considered inputs and other variables that can be predicted (outputs). The most important an advantage using artificial neural networks is that this kind of system solves problems that are too complex for conventional technologies, do not have an algorithmic solution or the solution is too complex to be used. These characteristics have often appeared in medicine. Artificial neural networks have been successfully applied on various areas of medicine, such as: diagnostic systems, biomedical analysis, image analysis, drug development. (Dakshata, Seema, 2012).

Fuzzy logic is the science of reasoning, thinking and inference that recognizes and uses the real world phenomenon – that everything is a matter of degree. Instead of assuming everything is black and white (conventional logic), fuzzy logic recognizes that in reality most things would fall somewhere in between, that is varying shades of grey. Fuzzy logic is a data handling methodology that permits ambiguity and hence is particularly suited to medical applications. It captures and uses the concept of fuzziness in a computationally effective manner.

Fuzzy expert systems have the structure of a series of 'if – then' rules for modeling. The application of fuzzy logic has been explored in the diagnosis of acute leukemia, breast and pancreatic cancer. (Ramesh et al., 2004).

Fuzzy logic provides an inference morphology that enables appropriate human reasoning capabilities to be applied to knowledge-based systems. The theory of fuzzy logic provides a mathematical strength to capture the uncertainties associated with human cognitive processes, such as thinking and reasoning. (Imianvan, Obi, 2011).

This work proposes diagnostic system using fuzzy logic control system and its design and simulation. Predefined patterns and the behavior of a process are mostly controlled by diagnostic systems.

The problems controlled by such systems involve suggestions for a certain treatment after identification.

Diagnostic systems are in the form of an expert system based on rules. Sure patterns are explained by set of rules which is called as rule based expert system. Evaluation of rules is done after the collection of observed data. Identification of pattern and suggestion of problem linked with that pattern is given when

the rules are logically satisfied. Implication of certain treatment is performed by each one of specific problem. Normally computation of human expert is performed by diagnostic system instead of its replacement. So the conclusive decision is finally made by human diagnostic expert to search the reason and give the prescription. (Baig et al., 2011).

Case Study

The hepatology center receives patients in the context of the regular outpatients' healthcare service of the hospital. Patients visiting for the first time are addressed to the medical office. A handwritten record is created and the patient's demographic details are registered, a full medical history is filled in onto a form and any lab test results that the patient may bring along are entered in other forms. Later on, this record is entered in the hospital's electronic system and each patient is given a registration number that characterizes the patient in this healthcare institute and the said unit.

Then, each time the patient visits the hepatology center, this unique number will help retrieve his/her record, which will be enriched with new data from the hepatologists who attend the course of his/her hepatic disease. More specifically, a brief history is filled in, which outlines signs and symptoms related to the hepatic disease, its course, any medication required, medical instructions, any lab and imaging tests to be done and also the date of the patient's next visit. Due to lack of time, most medical decisions must be based on rapid judgments of the case relying on the physician's unaided memory. Only in rare situations can a literature search or other extended investigation be undertaken to assure the doctor (and the patient) that the latest knowledge is brought to bear on any particular case.

The Proposed system

The required software will constitute an essential aid for the physician, providing each time help with the diagnosis through a tree of decisions, which will lead on one side to the suggested diagnosis and on the other side will follow the course of the patient's health and will display those data that the physician needs that given moment of the patient's follow-up. Such a software will retrieve data from the servers were details are saved, such as medication, test results'

patient's history even the medical instruction, based on which the physician will be able to appropriate action for his/her patient.

The system will achieve this goal mainly by efficiently combining a wide range of technologies and methodologies. At first digitization technologies for medical data and the patient's files will be used. International technological standards and good practices for digitization aiming at the development of an interoperable digital medical content will be also used.

In addition, for each digital object created, metadata will be assigned so as to assist further elaboration and treatment. The metadata used are based on international metadata standards for bio and medical informatics. The metadata already collected or that are begin collected in an everyday basis will be mapped to the international metadata standards. The mapping process is being implemented as a fully automated process within the databases used.In parallel, expert systems' technologies which facilitate decision support during the diagnosis and treatment of hepatitis are used.

The system is using both current and history patient data to support doctor's decisions. Depending on the data flow analyzed above the system may use:

1. A neural network algorithm based on a Bumptree Network which combines the advantages of a binary tree with an advanced classification method using hyper ellipsoids in the pattern space instead of lines, planes or curves. The arrangement of the nodes in a binary tree greatly improves both learning complexity and retrieval time.
2. A fuzzy logic algorithm, which if necessary, is used to determine or predict the maximum or minimum values of certain biometric data under examination.

Both neural network and fuzzy logic algorithms are being implemented as black boxes for input data and output results. They are transformed from programming languages to dynamic link libraries which can be integrated to the information system.Finally, the system will provide to the doctor and medical personnel web user interfaces, which allow data insertion, search, editing and support through the diagnosis and treatment stages of the hepatitis.

The services can be offered through the internet, at a distributed and geographically dispersed way. The web user interfaces which are implemented in web scripting languages are able to call and execute the neural network and fuzzy logic algorithms based on the data inserted by the final user. The results are also integrated to the web applications. The integrated system support doctors and medical personnel to at first diagnose effectively the hepatitis and at a second stage to offer personalized treatment to the patient.

The system is in the phase of its mid-implementation. The two algorithms have been completed and evaluated, the database on which the overall system relies has been designed and implemented and the web user interfaces are at their early implementation stages. Evidently, the system will be tested and set, by using a series of details from at least 100 patient record cases, which will be searched and chosen to constitute the representative sample of a patient record, who started with the first examination and the confirmation of the hepatic disease till the final treatment or the development of the disease into more severe condition or even to complications that led to the patient's death.

The Data Flow Diagram

The data flow diagram below (figures 1-3) consists of the resources (which are not others than the physician and the patient that will play a definitive role in diagnosis), the stock rooms (which include all appropriate lab and imaging tests that shall be performed depending on the type of hepatitis) and the record with the treatment proposed each time. Moreover, it also includes the "patient record" file, where all new data from a visit of the patient will be entered and it will constitute the reference point for the system in any new visit of the patient to the center.

Finally, it includes that basic transformation that will collect data from the resources and records and will generate the proposed diagnosis and treatment, which evidently can only be effective if validated also by the physician.

This diagram analyzes the first two levels (0, 1).Level 0 (figure 1) shows the resources, the stock houses and a transform that will be the diagnosis and treatment of the hepatic diseases.

On level 1, the basic transform of the diagnosis (figure 2) and treatment (figure 3) is specialized per type of disease met and the link to the

resources that provide different details per disease are displayed.

In brief, we would say that every time the patient visits the hepatology center, s/he mentions the clinical symptoms and his course to the physician. Then, depending on the type of the hepatitis, a series of blood and imaging tests are ordered. So, based on the test results and the patient's clinical symptoms, the system will proceed to the diagnosis that will then be validated or not by the physician.

Following, the system moves on to the appropriate treatment depending on the type of hepatitis, will select the appropriate treatment scheme for the patient and further medical instructions will be provided. Finally, all this new information will be saved in the file "patient's record".

The flowchart

The Data Flow Diagram (DFD) is followed by a flowchart (figure 4), which helps identify the individual hepatic diseases through a logical series of steps and by taking into account the main parameters arising from the lab, imaging or histopathology tests that the patient undergoes. Two of the most significant tests for all hepatic diseases are ALT and AST, which many times are 10 to 100 times more elevated that the normal range. These parameters are a first indication of whether the patient suffers from hepatitis or not and in the event that these values are indeed elevated to that point, then a series of other parameters shall be examined.

Then, in combination with the physical examination and the symptoms of the patient, they lead us to the identification of the specific hepatic disease. The parameters examined are the types of antibodies that the patient manifests, and which are different in each form of hepatitis. For example, in hepatitis A we use a control condition that includes Anti HAV-IgM and Anti HAV-IgG antibodies.

If the patient has Anti HAV-IgM, then s/he suffers from hepatitis A, while if s/he has Anti HAV-IgG, then s/he is immune to hepatitis A.

Another more complicated case is that of hepatitis B.

Many times the disease does not appear alone, but acts parallel to other infections or assists the further appearance of other forms of the hepatic disease.

At first, a control condition is used again here, which includes HBsAg, Anti-HBc and Anti-HBs antibodies.

If the patient is positive for Anti-HBs and negative for Anti-HBc and Anti-HBs, then s/he suffers from hepatitis B, while a positive Anti-HBs and negative HBsAg and Anti-HBc, then s/he is immune to hepatitis B thanks to a vaccine.

Then, in the event that the patient is diagnosed as suffering from hepatitis B, a control condition is used to examine the presence or not of Anti-HBc-IgM and HDV-RNA and in the event these are positive, the patient manifests secondary infection, which means that while suffering from chronic hepatitis B, s/he also developed hepatitis D.

Then, another control condition helps us take into account the biopsy results which may lead us to liver cirrhosis, while the combination of the biopsy results with elevated a-fetoprotein indicates hepatocellular carcinoma.
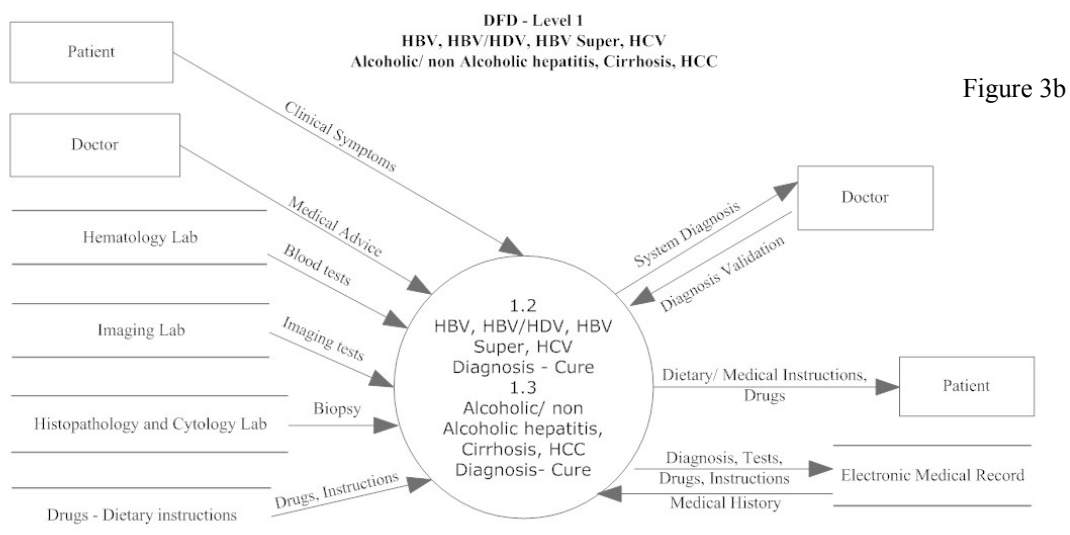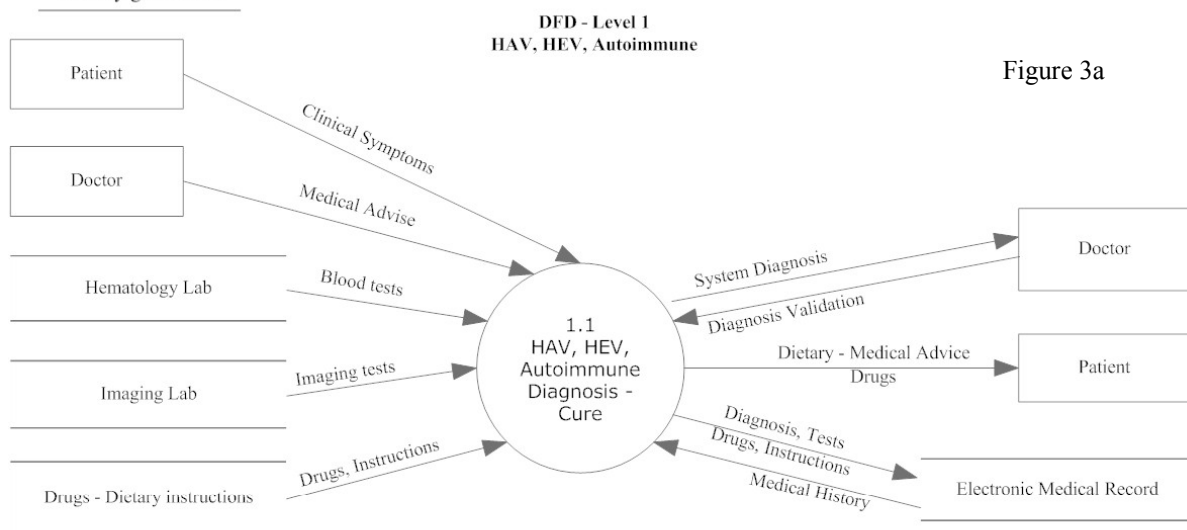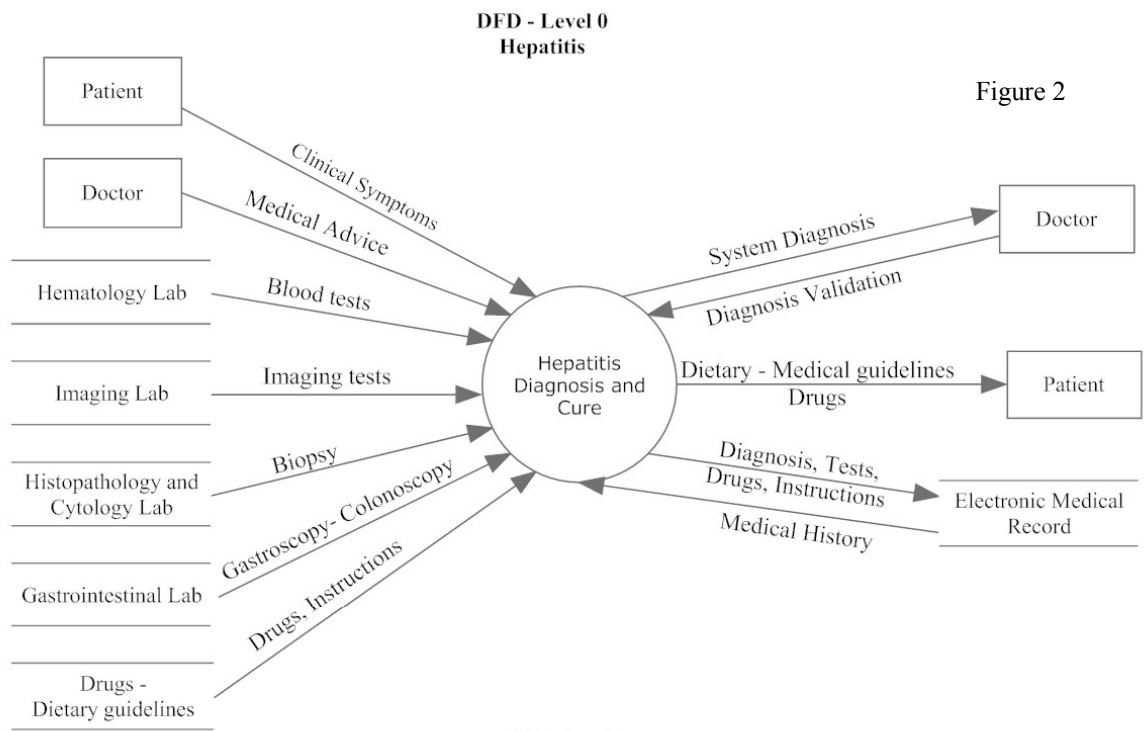
Discussion - Conclusions

The organization and classification of the medical information mainly in digital form is not enough to spectacularly improve the health care service provision in public hospitals.

The appropriate software must be in place, specialized for each clinic, as the one we investigate in the hepatology center.

It must take into consideration the course of the patient's health and it must rapidly give the physician a safe guidance, both regarding the diagnosis and the treatment of the disease.

Based on that, we searched for the main components of the appropriate information system, we identified the critical points of transactions and the information sources, from where we are to retrieve or save the information required.

Then, we identified the crucial parameters that we examine in hepatic diseases and how these affect the diagnosis or treatment of each disease.
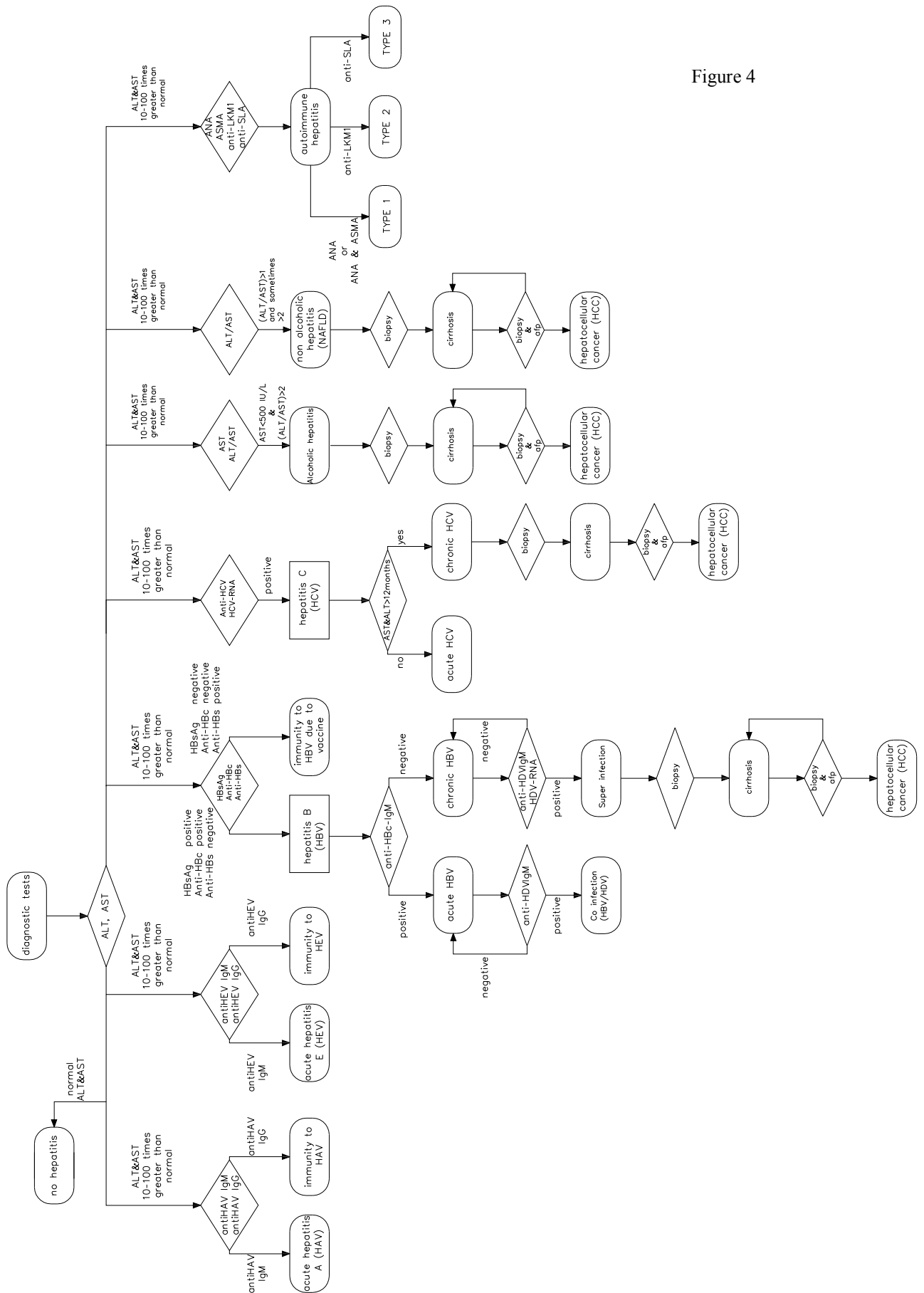
DFD - Level 0
Hepatitis

Figure 2

DFD - Level 1
HAV, HEV, Autoimmune

Figure 3a

DFD - Level 1
HBV, HBV/HDV, HBV Super, HCV
Alcoholic/ non Alcoholic hepatitis, Cirrhosis, HCC

Figure 3b

Figure 4

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