

**A. M. KARIM**

**SOFTWARE DEVELOPMENT FOR BLOOD DISEASE EXPERT  
SYSTEM**

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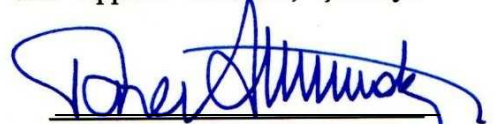
**ÇANKAYA UNIVERSITY**

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Title of the Thesis : **Software Development For Blood Disease Expert System**

Submitted by **Ahmad Mozaffer Karim**


Approval of the Graduate School of Natural and Applied Sciences, Çankaya University

  
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## ABSTRACT

### SOFTWARE DEVELOPMENT FOR BLOOD DISEASE EXPERT SYSTEM

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In this thesis, an expert system that evaluates the Software Development for Blood Disease is studied. The system asks some critical questions about the blood tests after answers these questions the system concludes the type of the blood disease.

Theses information's that uses in Software Development for Blood Disease Expert System is acquired from Kirkuk General Hospital and the system is tested in the Kirkuk University School of Medicine students and Department of Hematology in Kirkuk General Hospital and it's gave the expected results after it's tested with 11 cases.

The rules and parameters are determined due to a predefined knowledgebase and utilized in the expert system called, Software development for blood disease Expert Systems prepared by the software **EXSYS CORVID**. This expert system may be used in determining the blood disease and can uses in hospitals and universities by the doctors and medical students etc.

**Keywords:** Blood disease, Expert system, software development.

## ÖZET

### UZMAN KAN HASTALIKLARI İÇİN YAZILIM GELİŞTİRME

KARIM, Ahmad

Yükseklisans, Bilgisayar Mühendisliği Anabilim Dalı

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Bu tezde, Kan Hastalığı için Yazılım Geliştirme konusunu değerlendiren uzman bir sistem çalışılmıştır. Sistem kan testleri ile ilgili kritik sorular sormakta; bu sorulardan sonra kan hastalığının çeşidine karar vermektedir.

Kan Hastalığı Uzman Sistemi için Yazılım Geliştirme ile ilgili tez bilgileri Kerkük Genel Hastanesi 'nden elde edilmiş, sistem Kerkük Üniversitesi Tıp Fakültesi öğrencileri ve Kerkük Genel Hastanesi Hematoloji Bölümü tarafından test edilmiş ve 11 ayrı durum için test edildikten sonra beklenen sonuçlar elde edilmiştir.

Kurallar ve parametreler daha önce tanımlanmış bilgi tabanlarına göre belirlenmiş ve **EXSYS CORVID** yazılımı tarafından hazırlanan kan hastalığı Uzman Sistemleri için Yazılım geliştirme olarak isimlendirilen uzman sistem tarafından kullanılmıştır. Bu uzman sistem kan hastalığını belirlemek için hastanelerde ve üniversitelerde doktorlar ve öğrenciler, vs., tarafından kullanılabilir.

**Anahtar Kelimeler:** Kan hastalığı, Uzman sistem, yazılım geliştirme.

## **ACKNOWLEDGMENTS**

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## TABLE OF CONTENTS

|                                   |      |
|-----------------------------------|------|
| STATEMENT OF NON PLAGIARISM ..... | iii  |
| ABSTRACT .....                    | iv   |
| ÖZET .....                        | v    |
| ACKNOWLEDGMENTS.....              | vi   |
| TABLE OF CONTENTS .....           | viii |
| LIST OF FIGURES .....             | xii  |
| LIST OF ABBREVIATION .....        | xiii |

### CHAPTERS:

|                                       |   |
|---------------------------------------|---|
| 1. INTRODUCTION .....                 | 1 |
| 2. EXPERT SYSTEM STRUCTURE.....       | 3 |
| 2.1 Knowledge Base.....               | 3 |
| 2.2 Inference engine.....             | 4 |
| 2.3 Explanation.....                  | 6 |
| 2.4 User interface.....               | 6 |
| 2.5 Application of expert system..... | 6 |
| 2.5.1 Medical expert system.....      | 7 |

|   |    |
|---|----|
| 3. SYSTEM DEVELOPMENT.....                            | 9  |
| 3.1 Knowledge Acquisition.....                        | 11 |
| 3.1.1 Blood disease expert system (BDES).....         | 14 |
| 3.2 Expert system development tools.....              | 17 |
| 3.2.1 EXSYS CORVID .....                              | 17 |
| 3.2.1.1 EXSYS CORVID Variables.....                   | 17 |
| 3.2.1.2 CORVID Logic block.....                       | 23 |
| 3.2.1.3 CORVID Command Blocks.....                    | 24 |
| 4. IMPLEMENTATION OF BLOOD DISEASE EXPERT SYSTEM..... | 27 |
| 5. CONCLUSION.....                                    | 73 |
| REFERENCES .....                                      | R1 |
| APPENDICES:   |    |
| APPENDIX A : QUESTIONNAIRE.....                       | A1 |
| APPENDIX B : CURRICULUM VITAE.....                    | A4 |



## LIST OF FIGURES

|             |   |    |
|-------------|---|----|
| Figure 2.1  | Expert system structure.....  | 3  |
| Figure 3.1  | System development.....   | 10 |
| Figure 3.2  | Blood disease expert system tree part1.....                                   | 15 |
| Figure 3.3  | Blood disease expert system tree part2.....                                   | 16 |
| Figure 3.4  | Blood disease expert system tree part3.....                                   | 16 |
| Figure 3.5  | EXSYS CORVID Variables icon.....  | 18 |
| Figure 3.6  | EXSYS CORVID Variables definition.....  | 18 |
| Figure 3.7  | Adding the static variable.....   | 19 |
| Figure 3.8  | Assigning values for static variable_<br>What is the result of blood fil..... | 20 |
| Figure 3.9  | The confidence variable.....  | 21 |
| Figure 3.10 | Assigning values for confidence variable_<br>Anemia of chronic disease.....   | 22 |
| Figure 3.11 | Logic block window.....   | 23 |
| Figure 3.12 | Rules displayed on logic block.....   | 24 |
| Figure 3.13 | Command Blocks icon.....  | 24 |
| Figure 3.14 | Command Blocks windows.....   | 25 |
| Figure 3.15 | Command block with tabs.....  | 25 |
| Figure 3.16 | Display of command block after all settings.....                              | 26 |

|             |                               |    |
|-------------|-------------------------------|----|
| Figure 4.1  | First Window in Run Time..... | 27 |
| Figure 4.2  | First question.....           | 28 |
| Figure 4.3  | Second question.....          | 29 |
| Figure 4.4  | Third question .....          | 30 |
| Figure 4.5  | Result of first case.....     | 31 |
| Figure 4.6  | First question case2.....     | 32 |
| Figure 4.7  | Second question case2.....    | 33 |
| Figure 4.8  | Third question case2.....     | 34 |
| Figure 4.9  | Result of case2.....          | 35 |
| Figure 4.10 | First question case3.....     | 36 |
| Figure 4.11 | Second question case3.....    | 37 |
| Figure 4.12 | Third question case3.....     | 38 |
| Figure 4.13 | Result of case3.....          | 39 |
| Figure 4.14 | First question case4.....     | 40 |
| Figure 4.15 | Second question case4.....    | 41 |
| Figure 4.16 | Third question case4.....     | 42 |
| Figure 4.17 | Fourth question case4.....    | 43 |
| Figure 4.18 | First question case5.....     | 44 |
| Figure 4.19 | Second question case5.....    | 45 |
| Figure 4.20 | Third question case5.....     | 46 |
| Figure 4.21 | Result of case5.....          | 47 |
| Figure 4.22 | First question case6.....     | 48 |
| Figure 4.23 | Second question case6.....    | 49 |
| Figure 4.24 | Third question case6.....     | 50 |
| Figure 4.25 | Result of case6.....          | 50 |
| Figure 4.26 | First question case7.....     | 51 |
| Figure 4.27 | Second question case7.....    | 52 |

|   |    |
|---|----|
| Figure 4.28 Third question case7.....   | 53 |
| Figure 4.29 Result of case7.....        | 53 |
| Figure 4.30 First question case8.....   | 54 |
| Figure 4.31 Second question case8.....  | 55 |
| Figure 4.32 Third question case8.....   | 56 |
| Figure 4.33 Result of case8.....        | 56 |
| Figure 4.34 First question case9.....   | 57 |
| Figure 4.35 Second question case9.....  | 58 |
| Figure 4.36 Third question case9.....   | 59 |
| Figure 4.37 Fourth question case9.....  | 60 |
| Figure 4.38 Result of case9.....        | 60 |
| Figure 4.39 First question case10.....  | 61 |
| Figure 4.40 Second question case10..... | 62 |
| Figure 4.41 Third question case10.....  | 63 |
| Figure 4.42 Fourth question case10..... | 64 |
| Figure 4.43 Fifth question case10.....  | 65 |
| Figure 4.44 Sixth question case10.....  | 66 |
| Figure 4.45 Result of case10.....       | 66 |
| Figure 4.46 First question case11.....  | 67 |
| Figure 4.47 Second question case11..... | 68 |
| Figure 4.48 Third question case11.....  | 69 |
| Figure 4.49 Fourth question case11..... | 70 |
| Figure 4.50 Fifth question case11.....  | 71 |
| Figure 4.51 Sixth question case11.....  | 72 |
| Figure 4.52 Result of case11.....       | 72 |

## LIST OF ABBREVIATION

|       |                             |
|-------|-----------------------------|
| ES    | Expert system               |
| MCV   | Mean carpasular volume      |
| W.B.C | White blood cell            |
| RBC   | Red blood cell              |
| B.M   | Bone marrow                 |
| B.F   | Blood film                  |
| BDES  | Blood Disease Expert System |



## CHAPTER 1

### INTRODUCTION

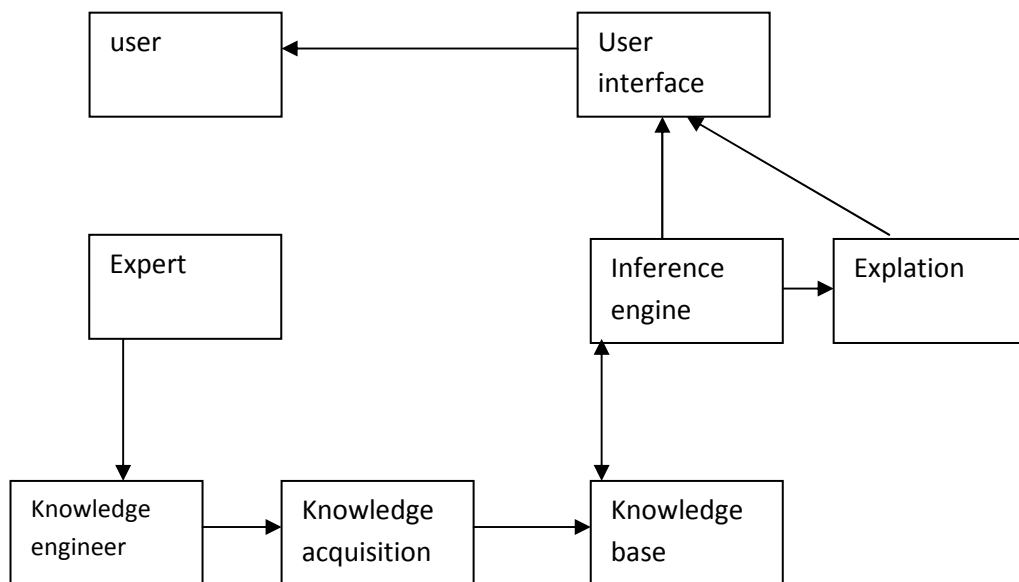
It's not easy to give a precise definition of an expert system, because, among other reasons, the concept of expert system is a changing one. As time passes, new progress is made and new tasks are incorporated in to the old ones. But generally, an expert system (ES) is a computer program that uses knowledge and interface procedures of an expert to solve problem. Expertise is the extensive, task-specific knowledge acquired from training, reading, and experience. The expert systems include Theories about the problem area, Rules, global strategies and facts. The first expert system called DENDRAL was developed at Stanford in 1964 Task of this system Chemical analysis of unknown compounds. The MYCIN (Stanford, 1972) mainly used for diagnosis of infectious blood diseases and providing appropriate treatment. It was the first expert system in the field of medicine and proved the viability of the approach. Medicine was an apt area for the application of Expert Systems since the human body has been a subject of research for a long time though we still don't understand its functioning completely (Fulya, 2007). One of the expert system types is the Medical expert systems have evolved to provide physicians with both structured questions and structured responses within medical domains of specialized knowledge or experience . The structure is embodied in the program on the advice of one or more medical experts, who also suggest the optimal questions to consider, and provide the most accurate conclusions to be drawn from the answers the physician chooses. This knowledge is collected in two phases. In the first phase, the medical background of eye diseases is recorded through the creation of personal interview with doctors and patients. In the second phase, a set of rules is created where each rule contains in IF part that has the symptoms and in THEN part that has the disease that should be realized (Samy S. Abu Naser, Abu Zaiter A. Ola, 2008). Although the physician is free to select any one of the

choices offered in each clause, the physician is limited to the choices offered by the expert in writing the program. The program is thus limited by the fixed input from the expert at the particular time of formulation. If the physician has new questions or new data, a medical expert system program will not be able to accommodate the physician. It is for this basic reason that open system programs have been developed to meet the new needs of the user. There are many medical expert systems built in various medical specialties such as PUFF (diagnosis lung disease), VM (monitors intensive-care patients), ABEL (diagnosis acid-base/electrolytes). In this thesis, an expert system for blood disease diagnosis has been developed and implemented using **CORVID EXSYS** expert system development tool. The system identifies number of diseases such as Acute myeloid leukemia, acute lymphocytic leukemia, chronic lymphocytic leukemia, chronic myeloid leukemia bleeding & haemolysis, myeloid splasia, sideroblastic anemia, iron store adequate, anemia of chronic disease, Fe deficient, alpha thalassaemia trait, beta thalassaemia trait and liver disease after it asked some questions about the results of blood tests the system is diagnosis the type of disease the patient was injured by. At last years, the blood disease and other disease like cancer is increased. Clearly so that it's Necessary for Building this type of systems for the treatment of these diseases. The determination the type of the blood disease early is important for the doctors for the treatment of these diseases and save the lives of patients. These information that uses in Software development for blood disease expert system are acquired from Kirkuk General Hospital and the system are tested from the Kirkuk University School of Medicine students and Department of Hematology in Kirkuk General Hospital and it's gave the expected results after it's tested with 11 cases.

## CHAPTER 2

### EXPERT SYSTEM STRUCTURE

Expert system structure is shown in the Figure 2.1. The main components of an expert system are knowledge base, inference mechanism (engine) and user interface, knowledge acquisition.



**Figure 2.1:** Expert system structure

#### 2.1 Knowledge base

Knowledge base is contains the facts together with information about the relationships between them and a set of rules for solving a problem.



## 2.2 Inference engine

Its job like the engine, directs the search in different directions in the knowledge base up to answer to the question. An inference engine can be either simple or complicated, depending on the structure of the knowledge base. For example, if the knowledge base consists of simple rules (no rules classes structured) and facts, forward chaining suffices.

IF

The result of blood film decrease W.B.C

Then

Bleeding & haemolysis

However, for a knowledge base that consists of structured frames and rules and unstructured logic (facts, data, and variables), both forward and backward chaining with a well thought-out search strategy may be required.

IF

The result of blood film increase W.B.C

Presence of blast cell in P.B + B.M failure presence of blast cell+ B.M failure

Age more then 5 year

THEN

Acute myeloid leukemia.

The main elements of an inference engine are forward chaining, backward chaining, and search strategy. Control strategies, or reasoning strategies as they are sometime called, are used to decide what operators to apply at each stage of the search. The most common control strategies used in expert systems are forward chaining and backward chaining. Forward chaining also known as data-driven process, this method involves checking the condition part of a rule to determine whether it is true or false. If the condition is true, it then concludes the 'THEN' clause and adds this information to its data. It would continue to perform this operation until a goal is attained.

For example:

IF

It's sunny

THEN

Wearing sunglasses

Backward chaining goal-driven process. Backward chaining is the reverse of forward chaining. It is used to backtrack from a goal to the paths that lead to the goal. Backward chaining is very good when all results and facts are known and the number of possible results and facts is not large. In this case, a goal is known and the expert system tries to determine the conditions of the goals. For example:

IF

Wearing sunglasses

THEN

It's sunny

Bi-directional: strategies use a combination of both forward and backward chaining to try to arrive at a solution more quickly. General search methods can be divided into two categories: blind searches and heuristic searches. Blind searches are a search that has no information about its domain, the only thing that a blind search can do is distinguish a non-goal state from a goal state. Example of blind search techniques breadth-first and depth first. Heuristic generally guide the search process towards the region where the acceptable solutions lie. Heuristics to be adopted in a search generally depend on the problem being solved searches are more efficient than blind searches because they attempt to identify the pathway which will most likely lead to solution. Example for heuristic searches include hill-climbing and best-first.

### **2.3 Explanation**

This mode allows the system to explain its conclusions and its reasoning process. This part is very important for users because it explains the results that the system concludes. As a result, most expert systems can answer the following why and how questions.

### **2.4 User interface**

The initial development of an expert system is performed by the expert and the knowledge engineer. The user interface is communicated between the user and the system. Success of any expert system depends on the quality and the ease of implementation of the user interface. As interfaces become easier to use, they become harder to create. Today, direct manipulation interfaces (also called "GUIs" for Graphical User Interfaces) are almost universal. These interfaces require that the programmer deal with elaborate graphics. The user can enter commands and respond to questions. The system responds to commands, and asks questions during the inference process.

### **2.5 Application of expert system**

- **Social and public sector application**

An expert systems technology is used in a number of social applications such as:

1. Assist with car maintenance.
2. Provide assistance to control home appliances.
3. Assist with raising children

- **Staff Management**

Expert systems can be used in Employment, promoting and placement of the staff. By using criteria such as qualifications required for the job and experience, an expert system could be used to assist in the Employment process.

- **Expert Systems in medical diagnosis**

An expert system is used to diagnose Disease in various disciplines such as DENDRAL was developed at Stanford in 1964. Task of this system: Chemical analysis of unknown compounds. The MYCIN (Stanford, 1972) mainly used for diagnosis of infectious blood diseases and providing appropriate treatment.

- **Design and Manufacturing**

These systems assist in the design of physical devices and processes, ranging from high-level conceptual design of abstract entities all the way to factory floor configuration of manufacturing processes (Robert S. Englemore Edward Feigenbaum).

- **Financial**

Expert system application is uses in many financial organizations, such as banks, insurance companies and finance house.

- **Aviation**

Air lines use expert systems in planes to monitor atmospheric conditions and system status. The plane can be put on auto pilot once a course is set for the destination.

### **2.5.1 Medical expert system**

Medical Expert systems are the common type of Artificial Intelligence in medical in routine clinical use. They contain medical knowledge, usually about a very specifically defined task, and are able to reason with data from individual patients to come up with reasoned conclusions. First computer based medical expert systems have been developed in the early 1970th. Since then a great number of such systems has been implemented, including classical approaches as

- INTERNIST its an internal medicine expert system was started in the early 1970s, and continues today under the name CADUCEUS [pople,1984]. The developers are Harry E. pole, Jr., and Jack D. Myers of the University of Pittsburgh.

The goal of this system to perform a diagnosis of the majority of disease associated with the filed of internal medicine.

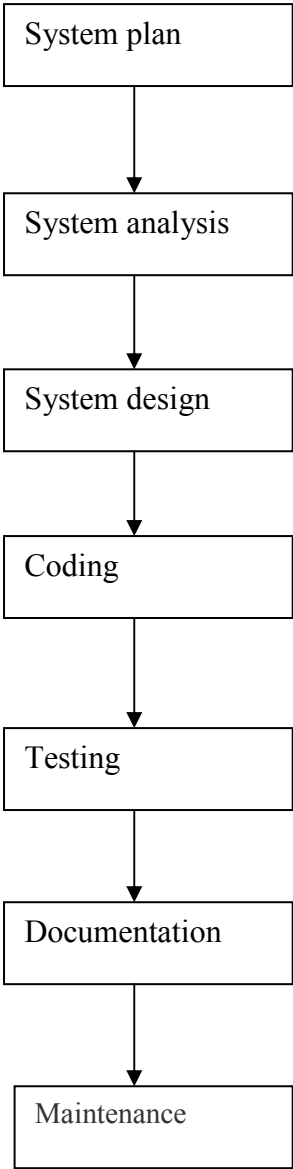
- MYCIN is a blood infection expert system, and it's developed at Stanford University in the mid-1970s. Probably it's the most widely known of all expert systems thus far developed [Shortliffe, 1976].
- PUFF its pulmonary disorders expert system was developed in 1976, using the EMYCIN shell [Alikens, 1984]. The purpose of PUFF is to interpret measurements related to respiratory tests and identify pulmonary disorders.

This knowledge is collected in two phases. In the first phase, the medical background of any diseases that the system built about it is recorded through the creation of personal interview with doctors and patients. In the second phase, a set of rules is created where each rule contains in IF part that has the symptoms and in THEN part that has the disease that should be realized. When faced with a patient who may or may not suffer from a particular illness, a doctor cannot usually give a definite and unique identification of illness. This does not indicate a lack of ability or intelligence on the doctor's part. It is more because the only evidence which a doctor has to go on is what symptoms are observed, and this is often insufficient to identify the illness uniquely. Several illnesses may produce similar symptoms, in the earlier stages at least and some illnesses do not produce all the symptoms in the early stages. So when working backwards from all the symptoms, a doctor must consider several possibilities. It may be, of course, that some of these possibilities are more likely than others and so the result of diagnosis could well be a list of possible illnesses, with some indication of how likely each is. For instance, a quick examination of a patient might result in the following diagnosis Diabetes mellitus - very likely, renal failure – possible, Gout – doubtful Expert The process is certainly a complex one but a doctor will make considerable use of established medical knowledge about illnesses, their symptoms, how common each illness is, how significant a symptom is, and so on. All this medical knowledge we can call a knowledge base (Saad Alshaban and Alyaa K. Taher 2009).

## **CHAPTER 3**

### **SYSTEM DEVELOPMENT**

1. **System Planning:** The first major activity is the planning for the System Development Process. In this section explained why a system should be developed and determining how the project team will build the system.
2. **System analysis:** The next major activity in the development process is defining the system analysis. In this section explained where the system will be used and who use the system and what is the system will do or what is the purpose of system.
3. **System design:** is simply the design of systems is to create a technical solution that satisfies the functional requirements for the system.
4. **Coding:** after design the system the programmer will be programming the system.
5. **Testing:** to ensure that the System gives the required results.
6. **Documentation:** Which is an important stage of the stages of building the system software where the internal construction of the program are documented, For the purpose of maintenance and development.
7. **Maintenance:** This stage is the longest in the life of the system software, for the survival of the system is able to keep up with developments and modern equipment, Part of this stage is to correct errors, and the other part is in development and new technologies.



**Figure 3.1** System development

### **3.1 knowledge acquisition**

Knowledge acquisition means getting knowledge of a particular domain from some source, usually human, and building it into a computer system. And it's one of the difficult tasks facing expert system developer. Transferring expert expertise is not an easy task. To understand the problem of knowledge transferring, it is important to understand how expert deals with his expertise. Also the domain expert has an amount of knowledge (facts and rules) which usually not aware and so he does not know exactly what is needed for the expert system. Acquisition is usually associated with some purpose such as expanding the capabilities of a system or improving its performance at some specified task. Therefore, we will think of acquisition as goal oriented creation and refinement of knowledge we take a broad view of the definition here and include autonomous acquisition, contrary to many workers in the field who regard acquisition solely as the process of knowledge elicitation from expert. Also the aim of knowledge acquisition is to reduce the communication gap between expert or knowledge worker and the knowledge engineer. The knowledge acquisition process primarily involves a discussion between the knowledge engineer and human expert. Clearly, a knowledge acquisition session should not be like a visit to dentist. The knowledge engineer should aim to be as friendly as possible .Acquired knowledge may consist of facts, rules, relationships, statistics, formulas, or other useful information. Sources of this knowledge may include one or more of the following: textbooks, database, reports, and expert in the domain of interest. Knowledge acquisition can be extremely slow and costly as well as difficult and justly earns the reputation of being the main bottleneck in the development of an expert system. To reduce the tedium and improve the effectiveness of knowledge acquisition, a variety of techniques has been developed.



### 3.1.1 Knowledge acquisition methods:

The knowledge acquisition methods can be classified into three categories: manual, Semiautomatic and automatic.

1. **Manual methods** in this method the knowledge engineer extracts expert knowledge and then codes it in a suitable format. There are many known manual methods like interviewing, protocol analysis, observation; Manual methods are slow, expensive, and sometimes inaccurate. Therefore, there are efforts for automating the process as possible.

➤ Interviewing:

Interviewing is the most common of knowledge acquisition. It involves a direct dialog between the expert and the knowledge engineer. The knowledge engineer controls the direction of the interview by asking questions about selected topics.

➤ Protocol analysis

Protocol analysis is a technique which attempts to record and analyses an expert step-by-step information processing and decision-making behavior. It basically involves asking the expert to think aloud while solving a problem. Protocol analysis is unpopular because most of knowledge engineer that benefit from Protocol analysis dose not justifies the effort required and large variations in expert behavior.

➤ Observation

Observation is similar to protocol analysis except that expert not required to think aloud, generally it's expensive and time-consuming. It's more effective than protocol analysis in the field of medical diagnosis. The Recording consists of natural dialogue and video image have been taken the expert in action.

2. **Semiautomatic** methods some of the knowledge acquisition process are acquired automatically without some process. It allows the experts to build their own knowledge bases with or without the assistance from the knowledge engineers.
  - **Repertory Grid Analysis (RGA)** RGA is based on Kelly's model of human thinking called personal construct, theory Repertory Grid Analysis (RGA) was originally developed in clinical psychology, the technique has been adapted for use in a diverse range of fields. The repertory grid is a technique in which an expert makes distinctions between terms in the domain on chosen dimensions.
  - **Expert transfer system (ETS)** is a computer program that interviews experts and helps them build ES. The goal in building the Expertise Transfer System (ETS) is to provide a tool set to significantly shorten the knowledge acquisition process, and improve the quality of the elicited problem-solving knowledge. To do this, ETS automatically interviews the expert, and helps construct and analyze an initial set of heuristics and parameters for the problem.
  - **Card Sorting Data** Among the knowledge elicitation techniques card sorting is notable for its simplicity of use, the card sort is a simple but surprisingly effective technique in which an expert categories cards which represent terms from the knowledge domain.
3. **Automatic methods**, in this method the roles of both the expert and the knowledge engineer are minimized or even eliminated. Knowledge acquisition is made by the plan architect analyst. The process of using computers to extract knowledge from data is called knowledge discovery. There are two major reasons for the use of automated knowledge acquisition:
  - Good knowledge engineers are highly paid and difficult to find.
  - Domain experts are usually busy and sometimes uncooperative.

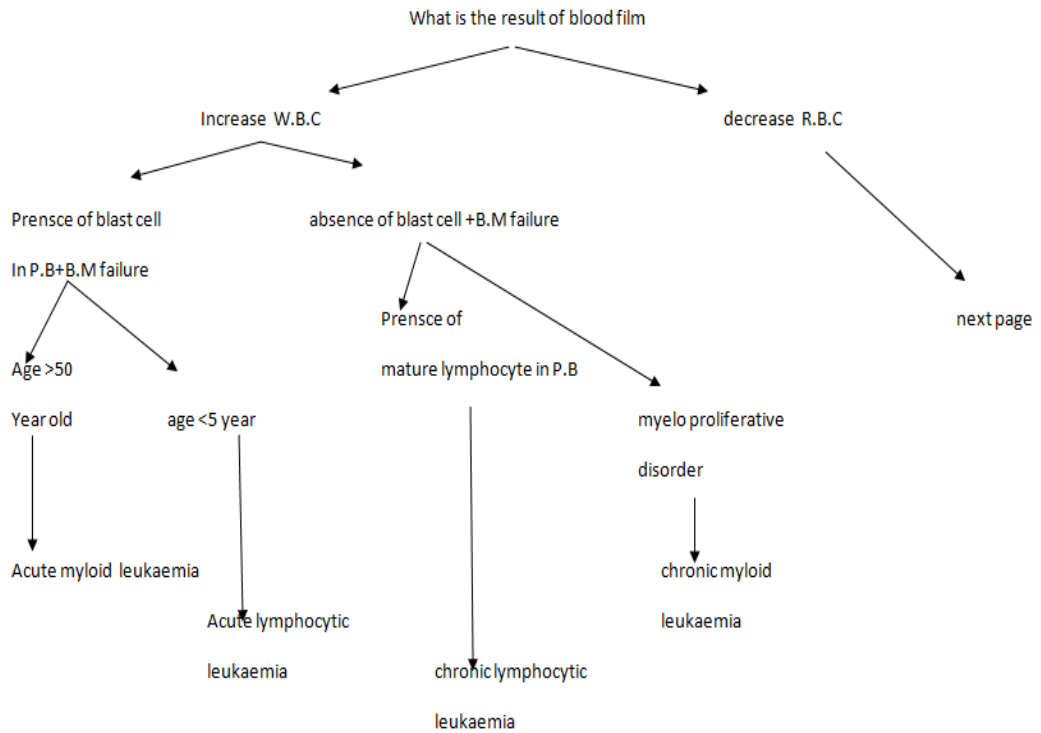
The typical methods for knowledge discovery include the following:

- Genetic algorithms: Is a subset of reproductive population algorithms, This algorithm is find step by step the best combination of knowledge from known cases by using the natural selection standard. As in the natural process of development, the basic operations for discovering knowledge are reproduction, crossover, and mutation.
- Inductive learning: This involves the process of *learning by example* -- where a system tries to induce a general rule from a set of observed instances. The induced rules can then be stored in a knowledge base for consultation.

### **3.1.2 Blood disease expert system (BDES):**

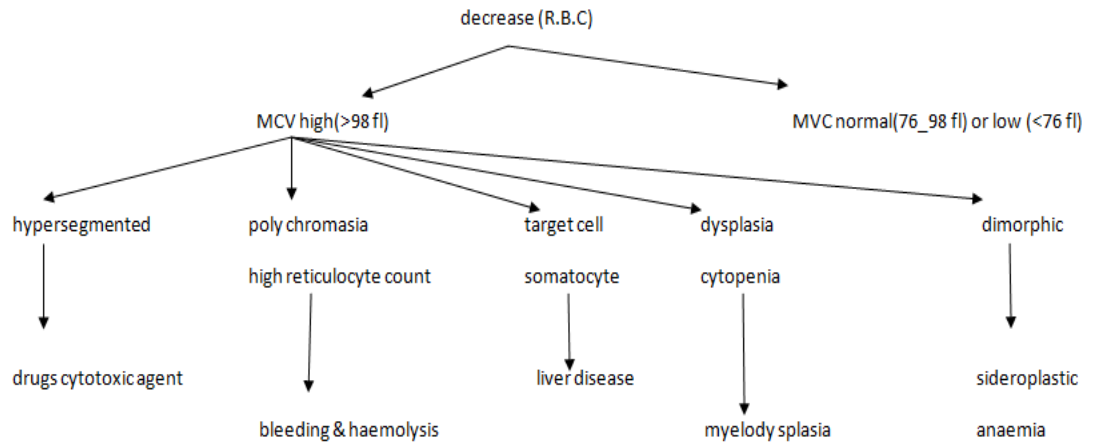
The Blood Disease Expert System (BDES) is a large diagnostic program covering must areas of blood disease. The physician can enter patient information about the history, physical examination, and laboratory tests, and then the program generates detailed explanations of differential diagnoses indicating the clinical data items which support each diagnosis. This system includes 13 questions and 16 Disease. The first step in building a CORVID application is to select a problem that can be broken into logical steps or pieces. The problem should be able to be solved using logic that can be explained to a person using statements in the form: "IF .... THEN". The blood disease system tree is divided in to three parts.

The first questions is what the result of blood film if the result is increase W.B.C then the system implement figure 3.2 blood disease expert system tree part1.

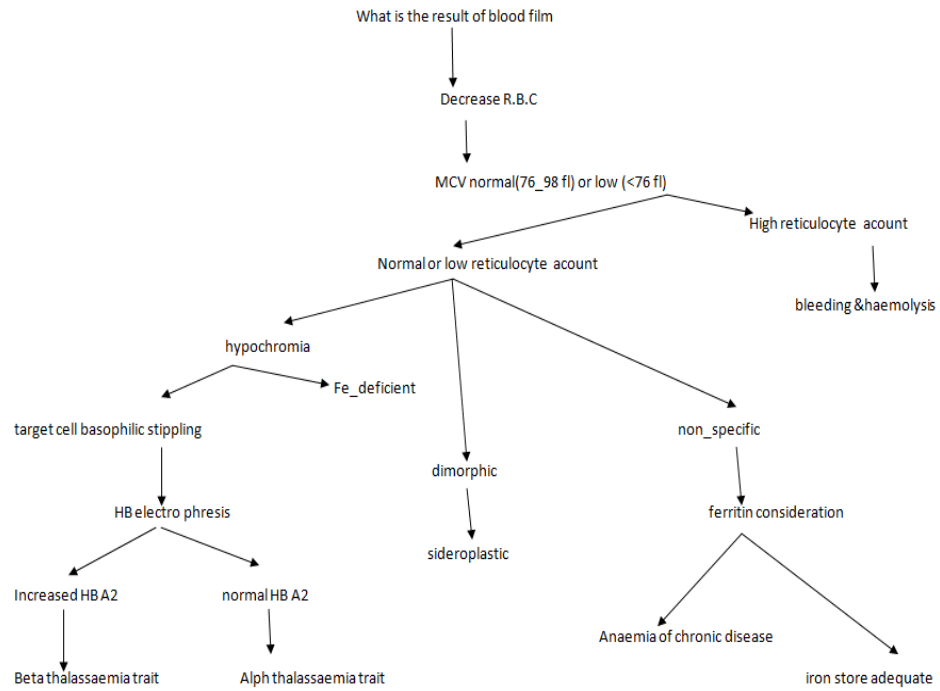


**Figure 3.2** Blood disease expert system tree part1.

If the result is decrease (R.B.C) then system asked second question what is the result of MCV if the MCV high then the system implemented the figure 3.3 blood disease expert system tree part2 or it's implemented the figure 3.4 blood disease expert system tree part3.



**Figure 3.3** Blood disease expert system tree part2



**Figure 3.4** Blood disease expert system tree part3

### 3.2 Expert system development tools:

Expert systems are typically written in special programming languages. The two most common AI languages are LISP and PROLOG in the development of an expert system simplifies the coding process. That they have facilities for symbol handling and dealing with dynamic structures. Most expert systems are developed via specialized software tools called shells, because learning AI languages can take months but in shells the systems can be built quickly. These shells come equipped with an inference mechanism (backward chaining, forward chaining, or both), provide graphic windowing facilities.

#### 3.2.1 EXSYS CORVID

EXSYS CORVID is easy to learn and use, and very powerful. The purpose of EXSYS CORVID is development of any type expert system project. EXSYS CORVID has many options and controls that are used for advanced systems and special situations. This chapter displays some controls that are used in this thesis.

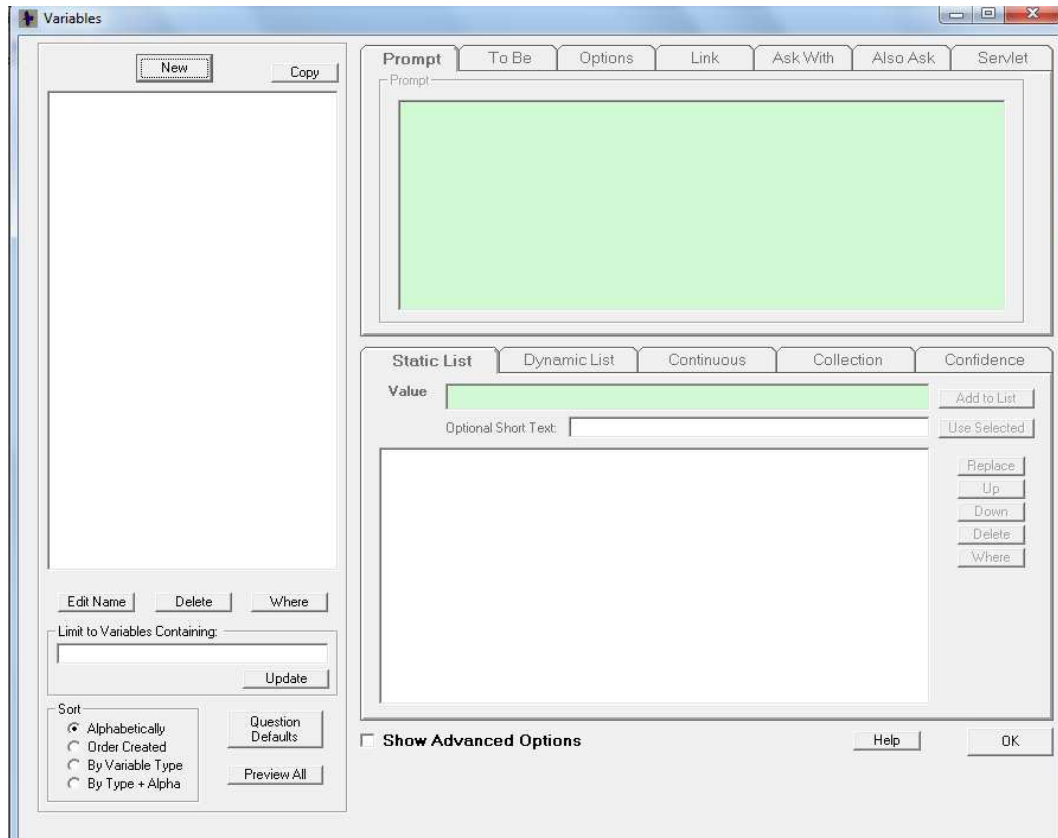
##### 3.2.1.1 EXSYS CORVID Variables

EXSYS CORVID variables are the basis of everything you will build with EXSYS CORVID. Variable are used to build the rules and logic blocks in a system, but before they can be used they must be created in the variables window. The variables window can displays by clicking the variables icon Figure 3.5.



**Figure 3.5** EXSYS CORVID Variables icon(EXSYS CORVID,2011)

To add a new variable, click the “New” button at the top left of the Variables window Figure 3.6, above the variable list. This will open the “New Variable” window..

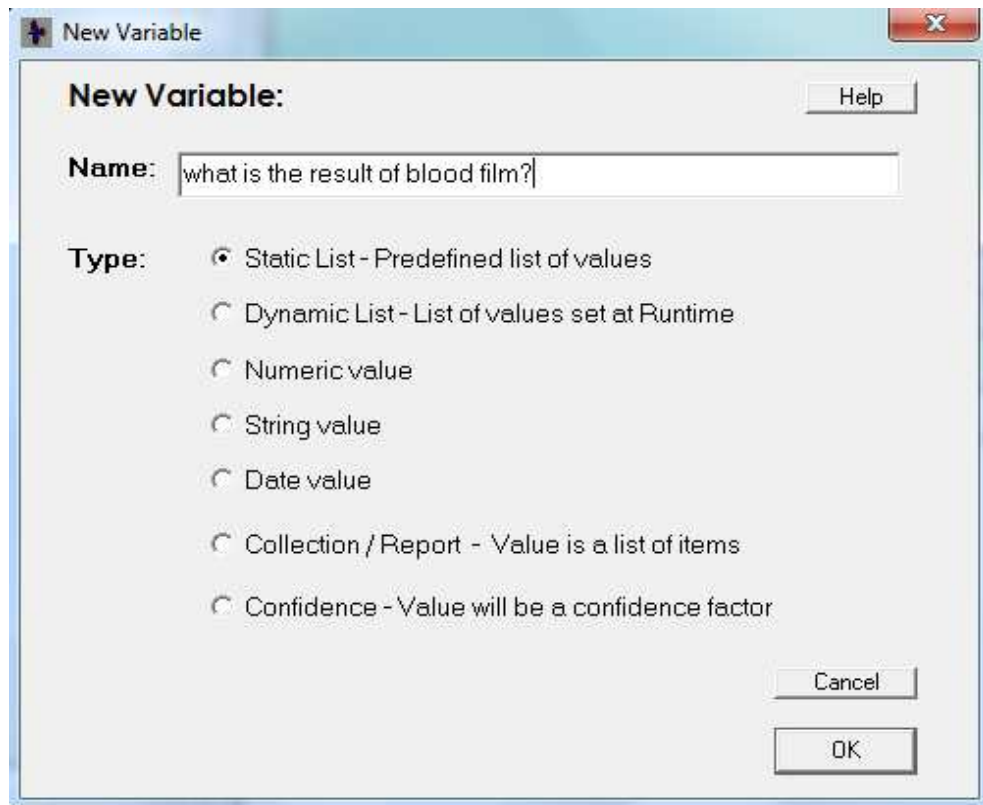


**Figure 3.6** EXSYS CORVID Variables definition

The new variables require need a name and selecting the type of variable it will be. There are 7 types of Variables in EXSYS CORVID: Static list, dynamic list, numeric, string, Date, Collection, confidence. The first 5 are typically used to build the Boolean expression used in the IF parts of the rules in the system. The end user of the system may be asked to provide the value for these variables, although they can also be used in the THEN part of rules which set the value of variables.

## Static List

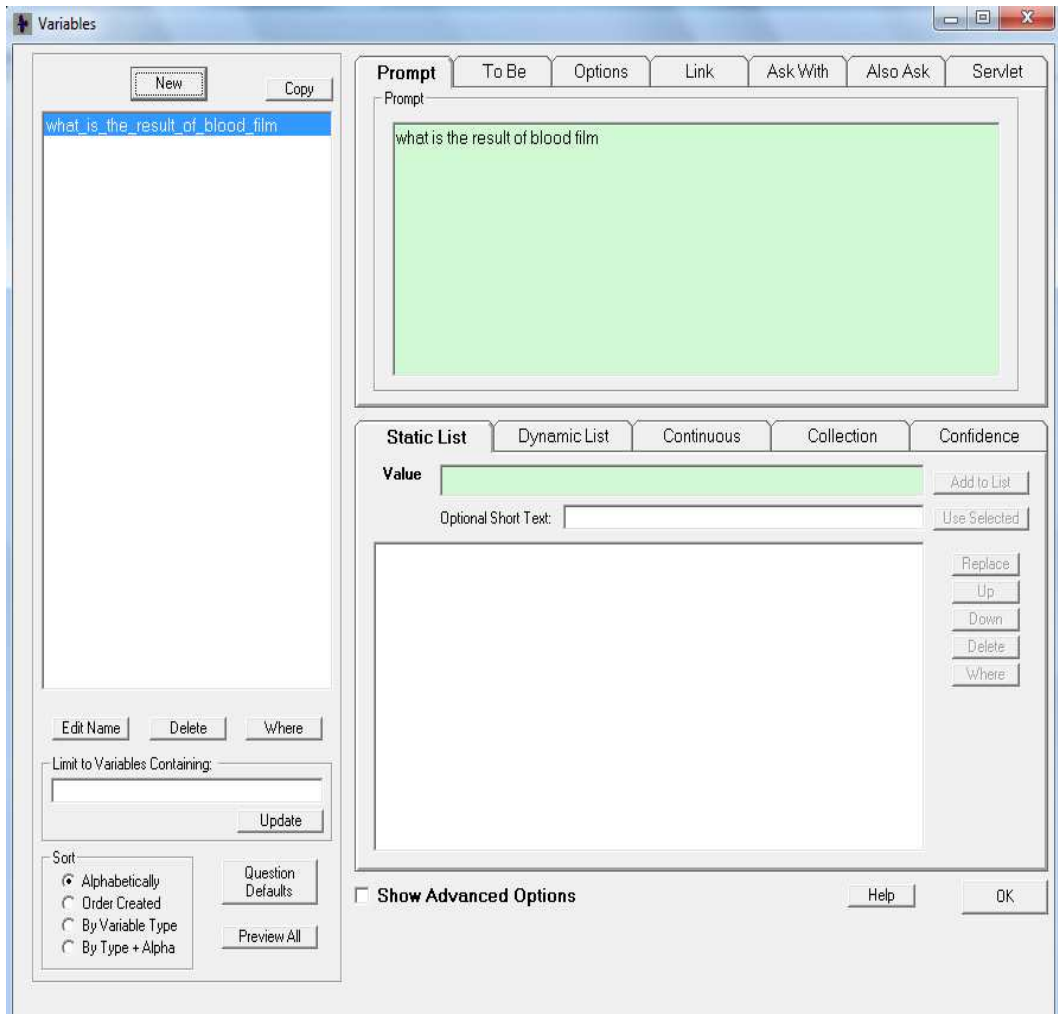
To add the Static List variable on "Driving conditions". In the new Variable Window figure 3.7, In the Name edit box, enter "what is the result of blood film? ". After that select the "Static List" radio button at last click the "OK" button. Static list variables are simply a multiple choice question.



**Figure 3.7** Adding the static variable

After Click the "OK" button, display the new windows figure 3.8 and the value of static list will be inserting in the value box.

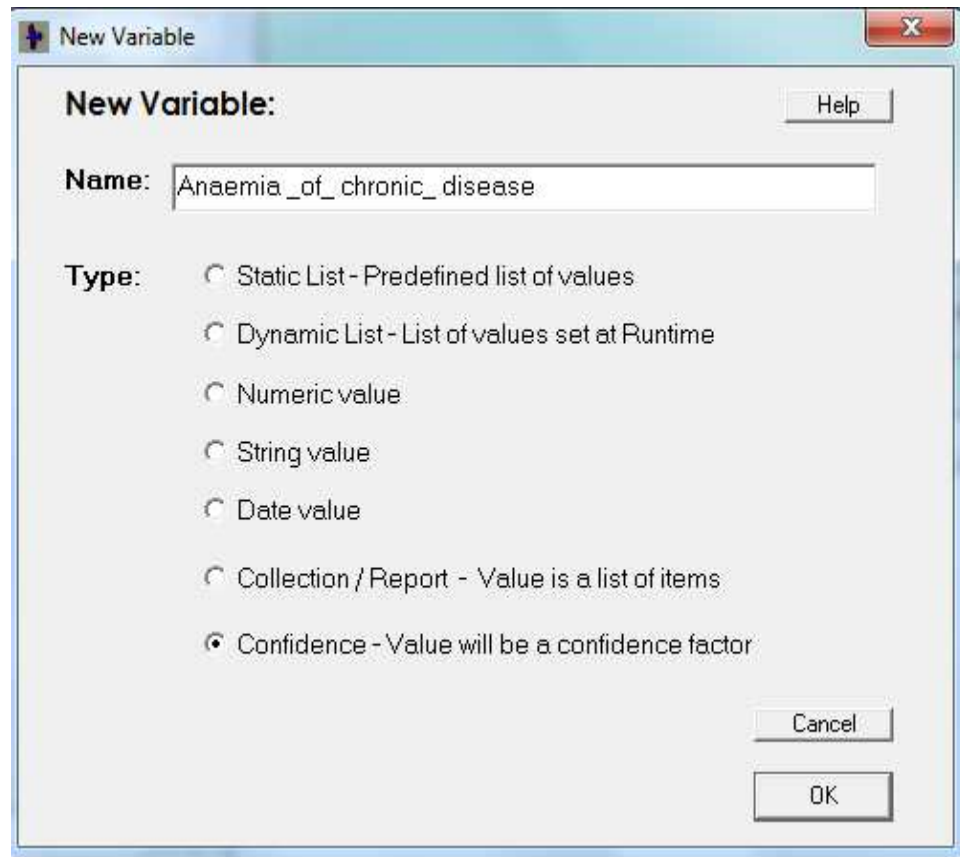




**Figure 3.8** Values for static variable\_ what is the result of blood film

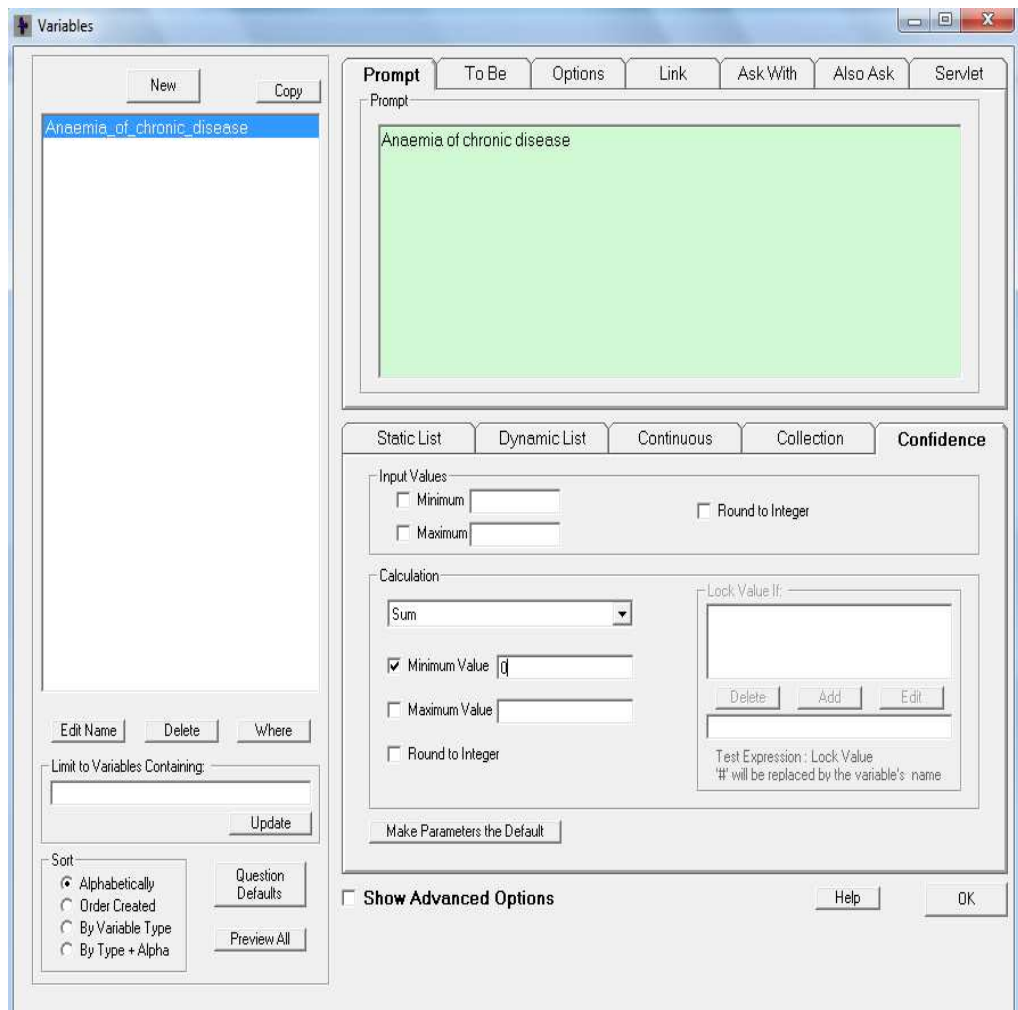
## Confidence

In the New Variable window figure 3.9, enter the name of the Confidence Variable in The "Name" edit box. After that Click on the Confidence Value will be a confidence factor" radio button. At last click the "OK" button.



**Figure 3.9** The confidence variable

After click to the "OK" button, display the new windows figure 3.10 Also click "OK" button.



**Figure 3.10** Assigning values for confidence variable `_anemia of chronic disease`

Confidence variables are variables whose value is Confidence. The Confidence value is calculated from multiple values assigned to the variable by various rules. It is a very useful type of variables and allows building systems that incorporate the more complex logic and reasoning of an expert in selecting among various competing options, when there is no obvious single best solution.

### 3.2.1.2 CORVID Logic block

Click on the logic block icon to open a new logic block window figure 3.11. The top of window display the name of the logic block, in this case “logic block1”, the name can be changed to name that hold meaning of the block. The lower left buttons for adding IF and THEN nodes to the structure. For example:

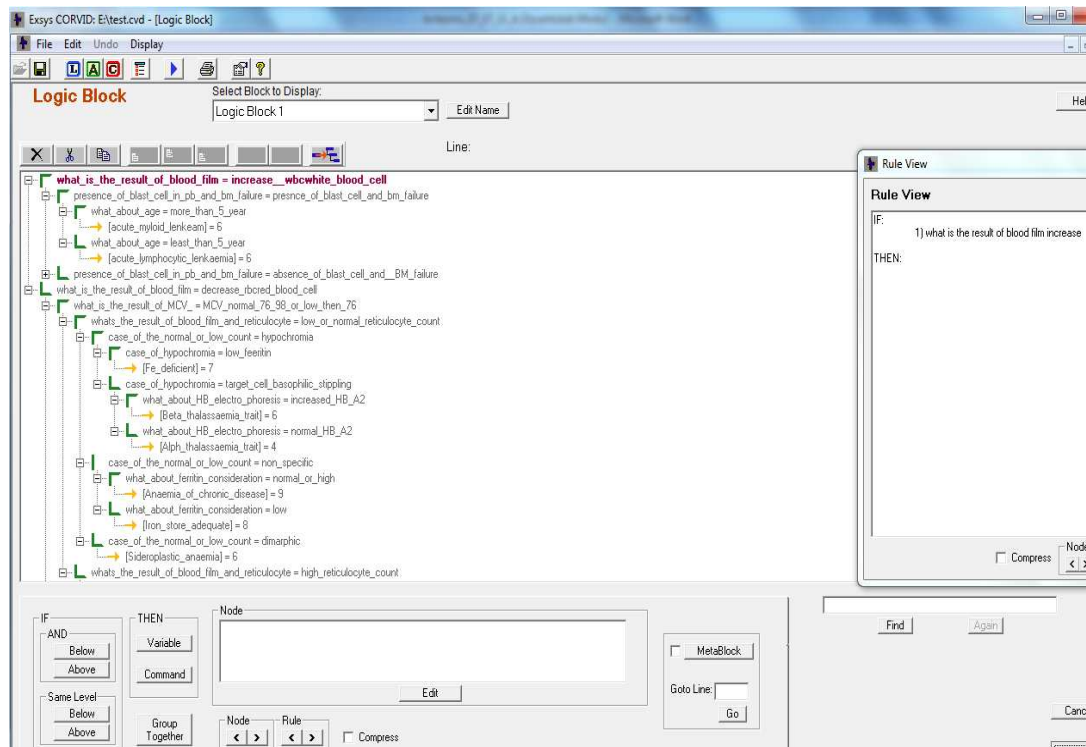


Figure 3.11 Logic block window

The IF condition is represented in corved exsys as this example:

IF

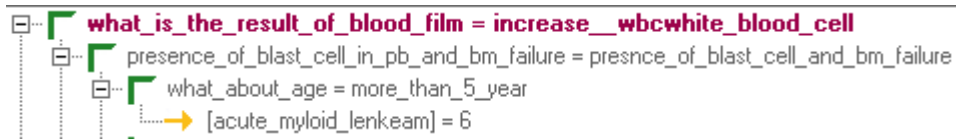
The result of blood film increase W.B.C

Presence of blast cell in P.B+B.M failure \_presence of blast CELL+B.M failure

Age -more then 5 year

THEN

Acute myeloid leukemia



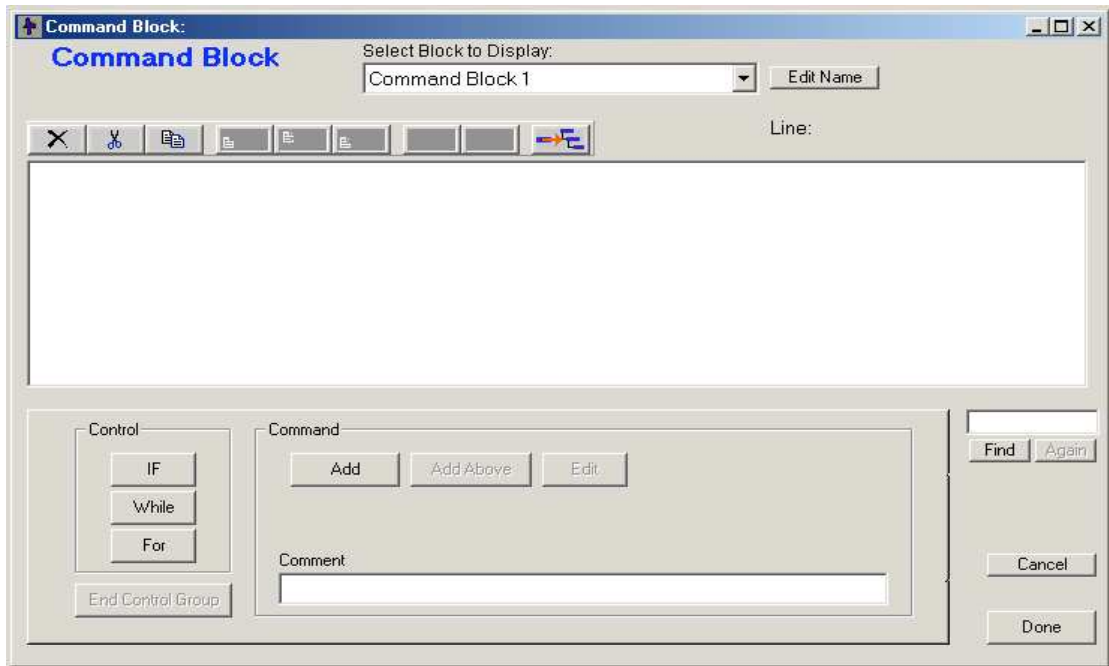
**Figure 3.12** Rules displayed on logic block

### 3.2.1.3 CORVID Command Blocks

To run the CORVID EXSYS systems require a command block, the command block contain many commands, including looping commands, or its may be simple with only a few commands. The goal of the command block is to separate the logical flow of the system. Typical Command Blocks simply tell the system what variable, to derive values for, and then display the results. This can be done with two commands. Command Blocks are added by clicking on the Command Block button like in the figure 3.13 this will display the Command Block window like figure 3.14.

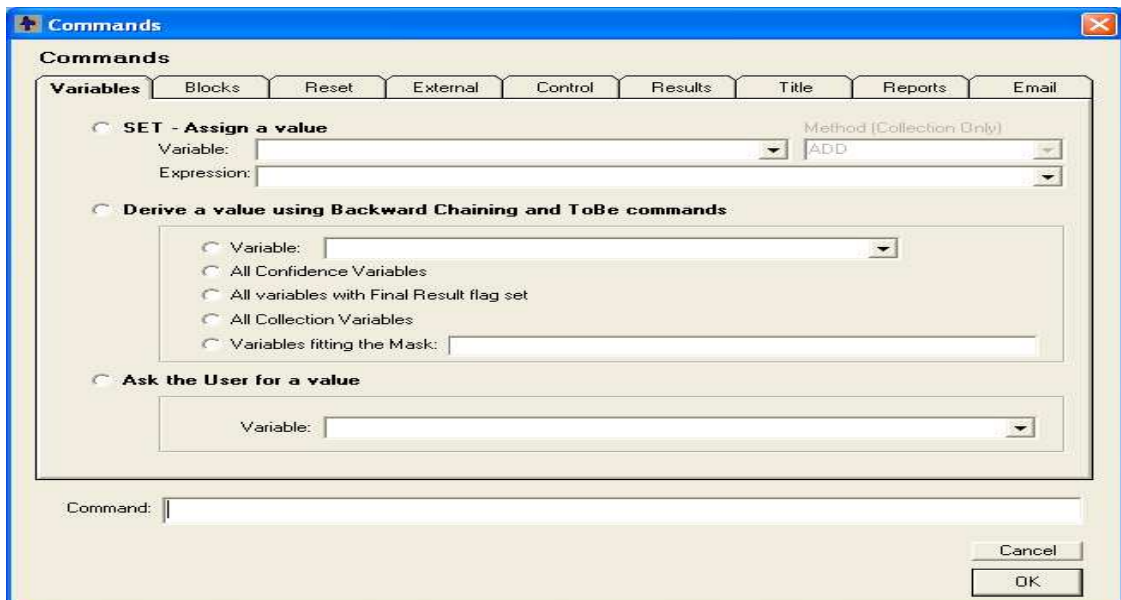


**Figure 3.13** Command Blocks icon(CORVID EXSYS, 2012)



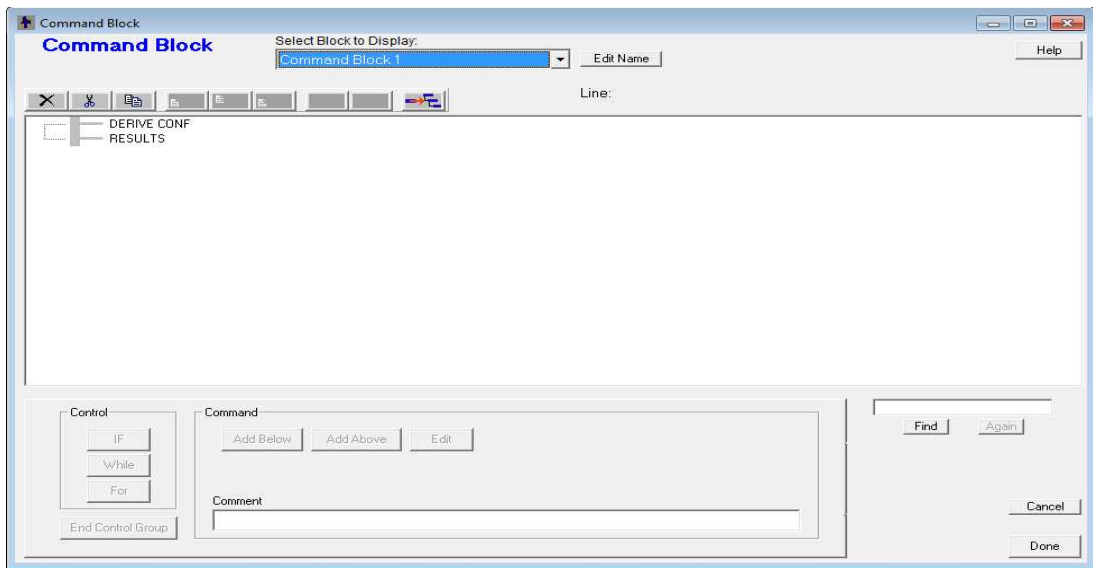
**Figure 3.14** Command Blocks windows

After that click to the "add" icon this lead to display the figure 3.15



**Figure 3.15** Command block with tabs

After that choice the "All confidence variables" click "ok" button display the windows like 3.16



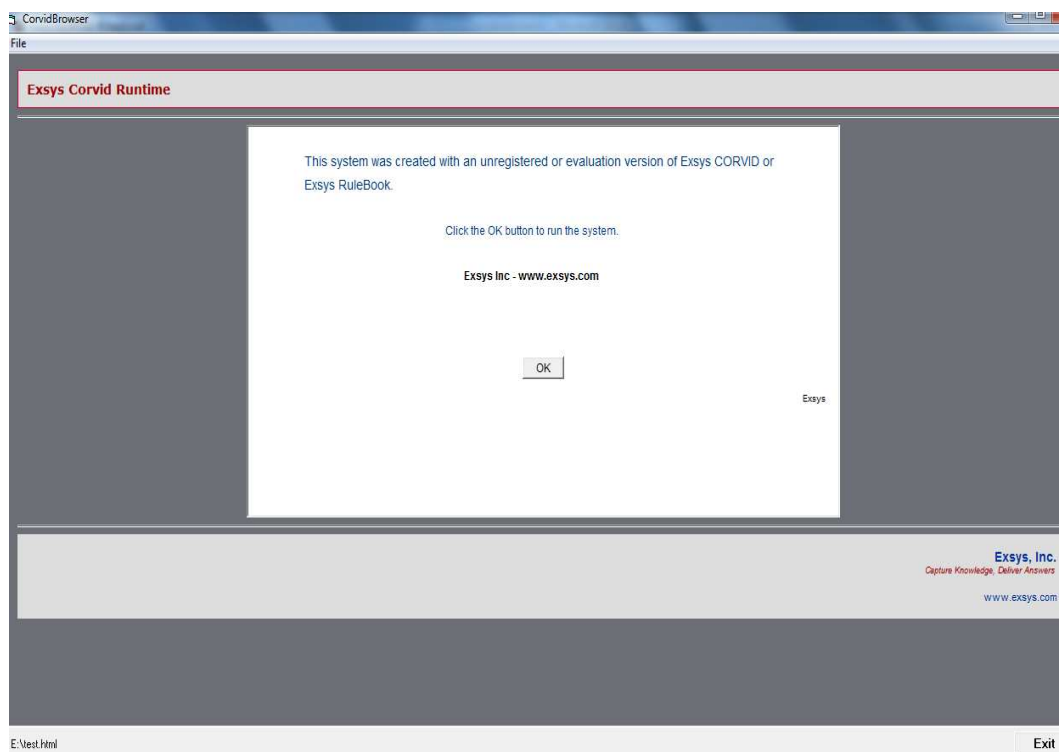
**Figure 3.16** Display of command block after all settings

After that click to the "done" button and the command block is built and the system become ready to execute by the end user.

## CHAPTER 4

### IMPLEMENTATION OF BLOOD DISEASE EXPERT SYSTEM

As shown in Figure 4.1, the first screen consists of the definition goal of the system.

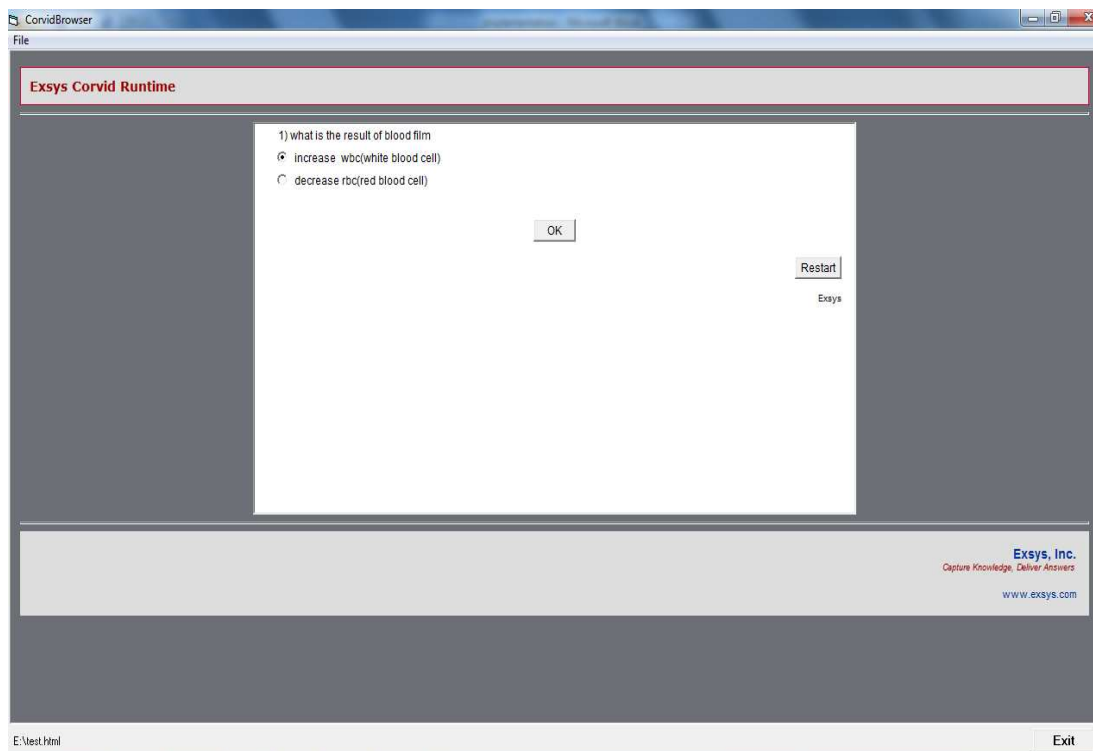


**Figure 4.1** The first Window in Run Time

Then the first question after clicking “OK” button is as seen in Figure 4.2

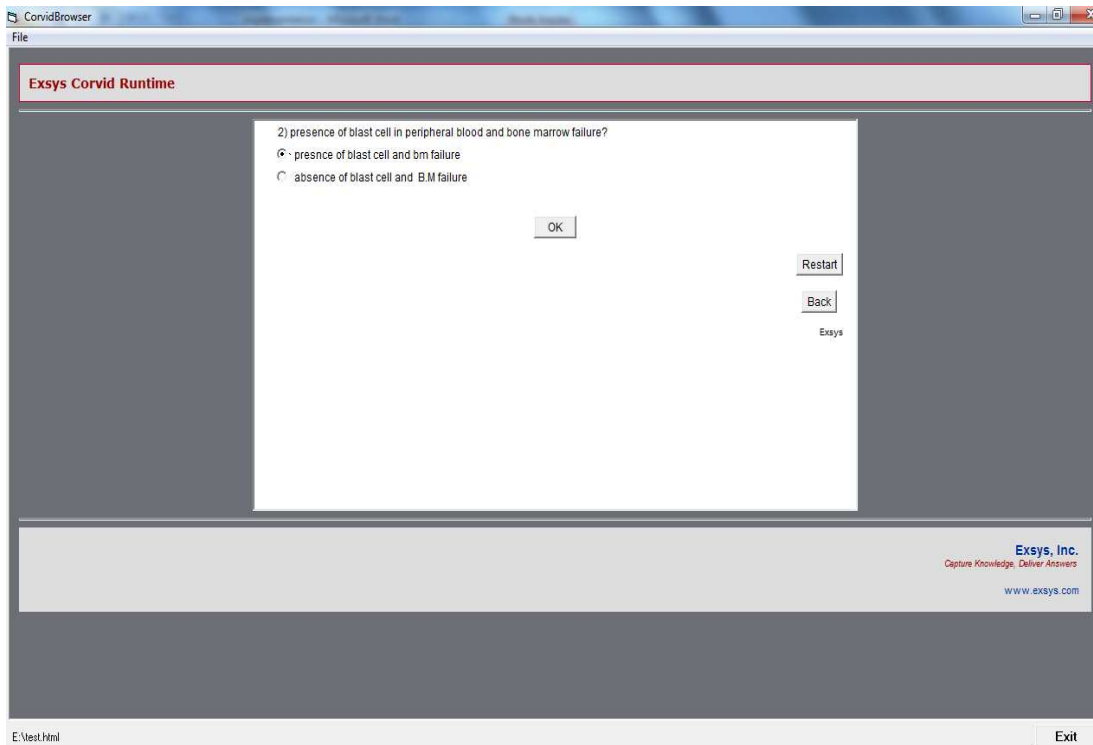


Case1: The blood film increase and Presence of blast cell in B.F+B.M failure and the age is 50 years.



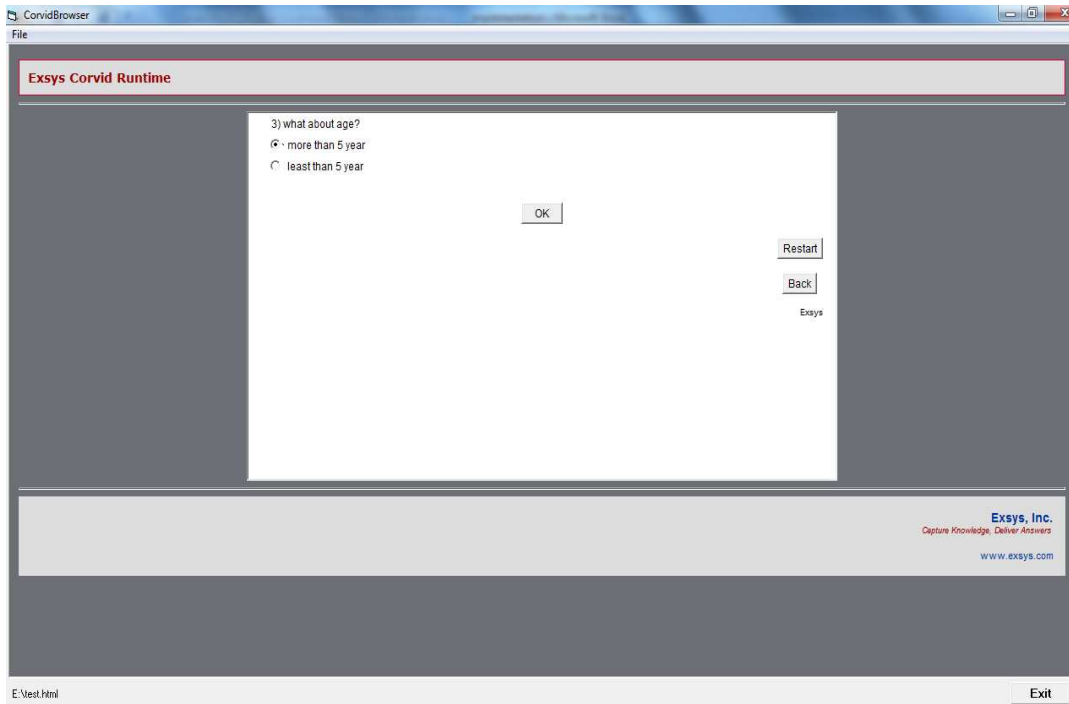
**Figure 4.2** First question

A first question of the system is what is the result of blood film? And it's consist two answers: increase W.B.C and decrease R.B.C. In this case the first answer is chosen according to the patient information the system is displayed the second questions. After clicking "OK" button the **Figure 4.3** displayed.



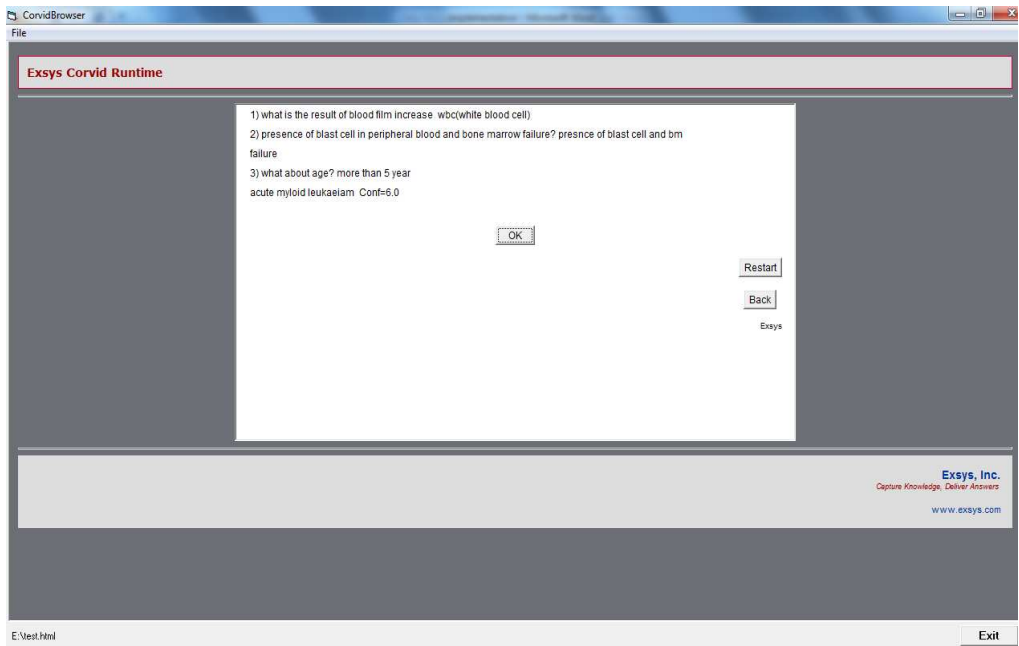
**Figure 4.3** Second question

The second questions about Presence of blast cell In B.F+B.M failure and absence of blast cell +B.M failure. In this case first answer is chosen according to patient information as seen **Figure 4.4**. After clicking “OK” button the **Figure 4.4** displayed.



**Figure 4.4** Third question

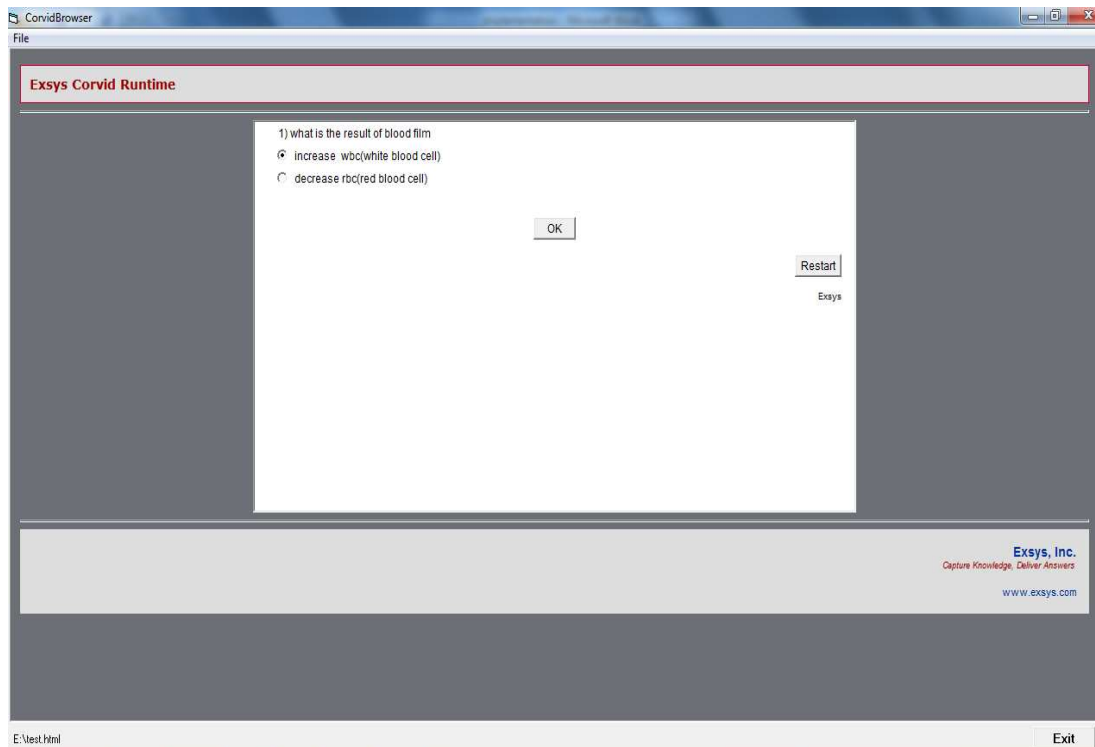
The Third question about the age and there is two answer more than 5 and less than 5. In this case the first answer is chosen according to the patient information. The result is Acute myeloid leukemia is displayed after clicking "OK" button is as seen in Figure 4.5.



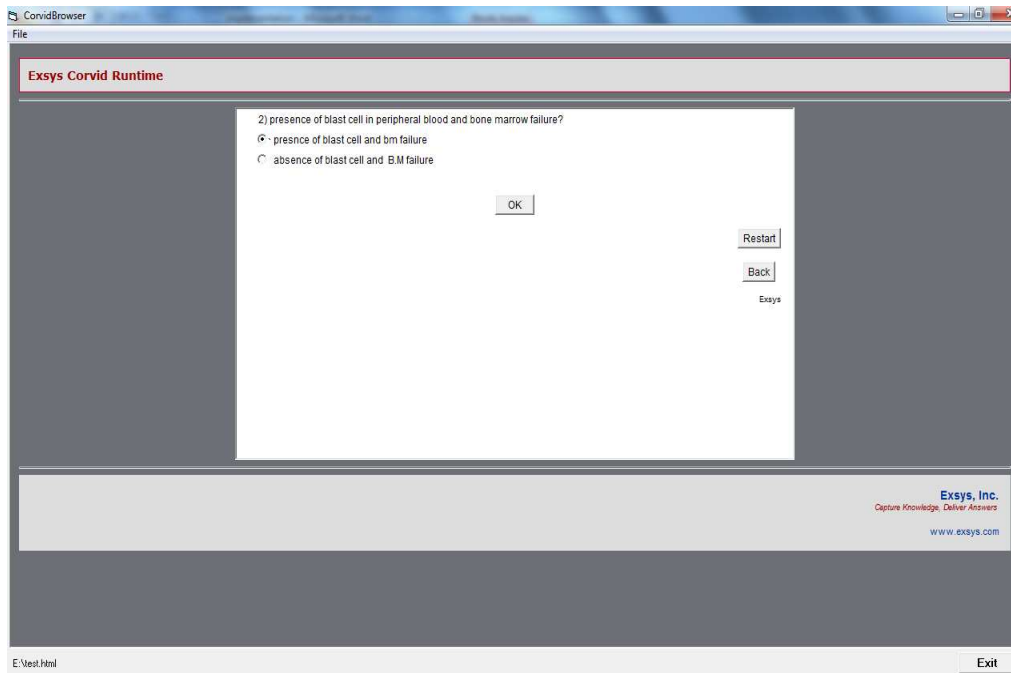
**Figure 4.5** Result of first case

Case2: The blood film is increase and Presence of blast cell In B.F+B.M failure and the age is 4 year.

First question is about blood film and there is two answer displayed by system as seen in Figure 4.6. In this case the first answer is chosen according to the patient information. After clicking “OK” button the **Figure 4.7** displayed.

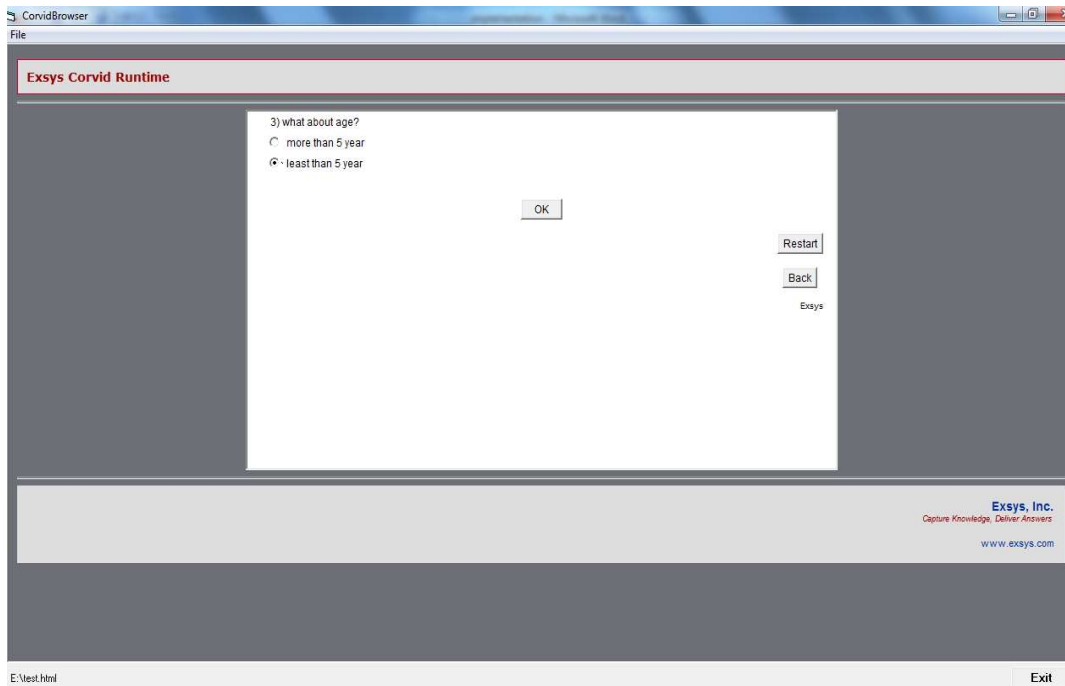


**Figure 4.6** First question case2



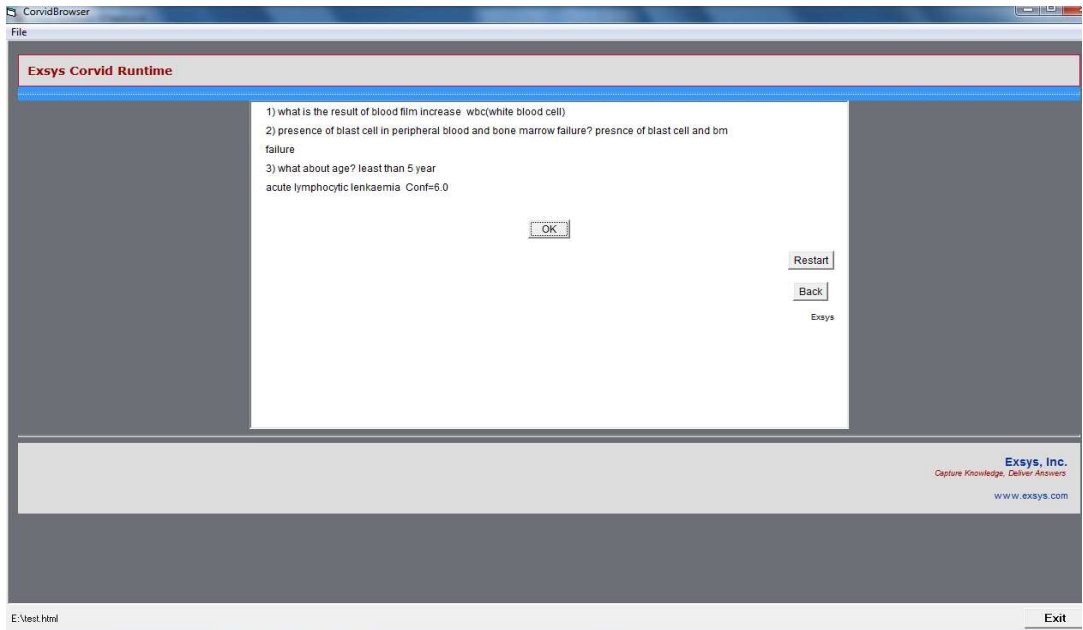
**Figure 4.7** Second question case2

The second question about Presence of blast cell In B.F+B.M failure and absence of blast cell +B.M failure is also include two answers? In this case the first answer is chosen according to the patient information. After clicking “OK” button the **Figure 4.8** displayed.



**Figure 4.8** Third question case2

The Third question about the age and there is two answer more than 5 and less than 5. In this case the second answer is chosen according to the patient information. The result is Acute myeloid leukemia is displayed after clicking “OK” button is as seen in Figure 4.9.

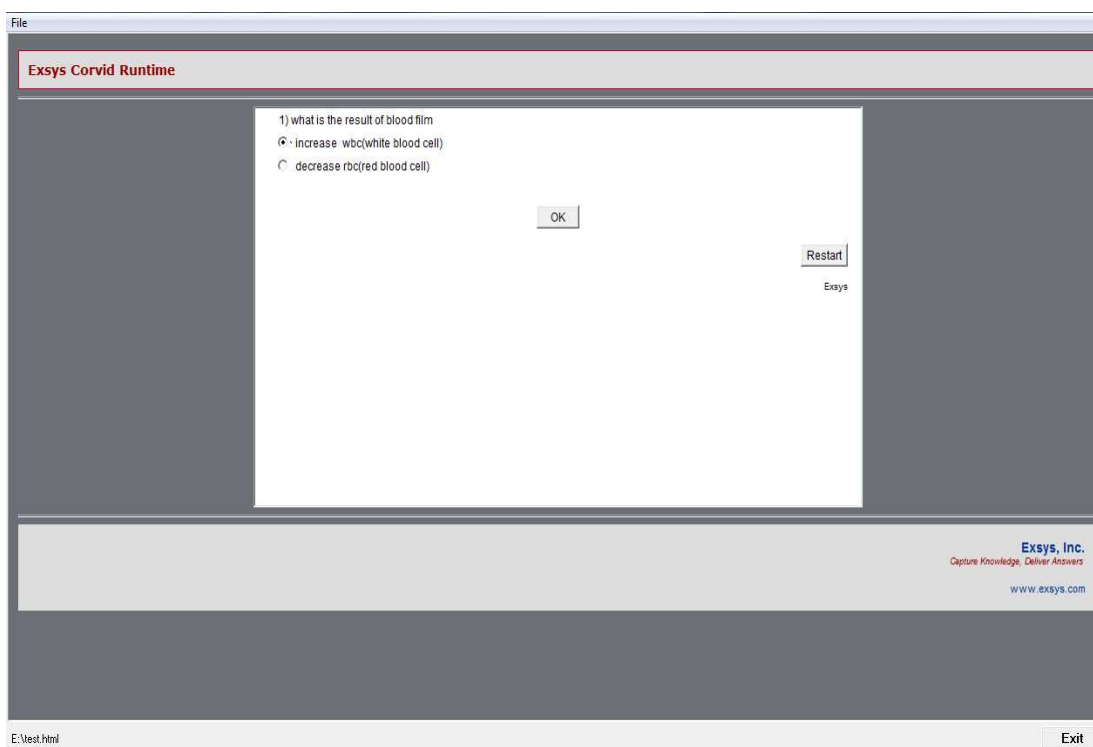


**Figure 4.9** Result of case2

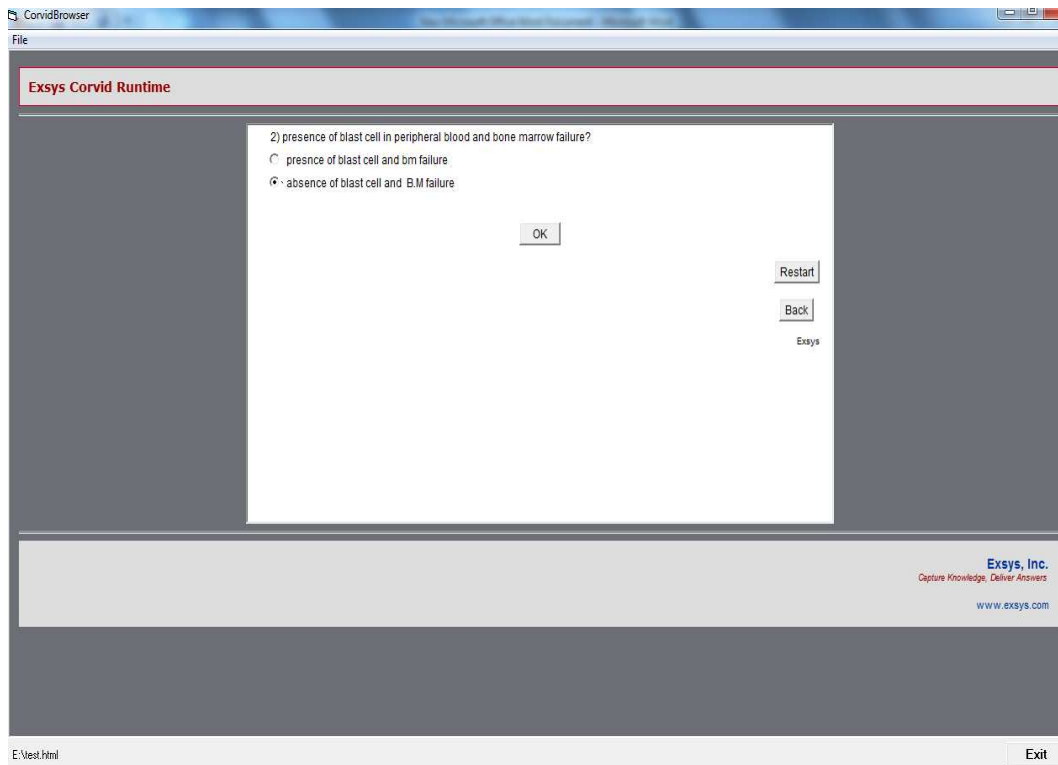


Case3: The blood film is Increase W.B.C, absence of blast cell +B.M failure, and Prance of mature lymphocyte in B.F?

The First question of the system is what is the result of blood film? It's consist from two answer increase W.B.C and decrease R.B.C. In this case the first answer is chosen according to the patient information. After clicking "OK" button the Figure 4.11 is displayed.

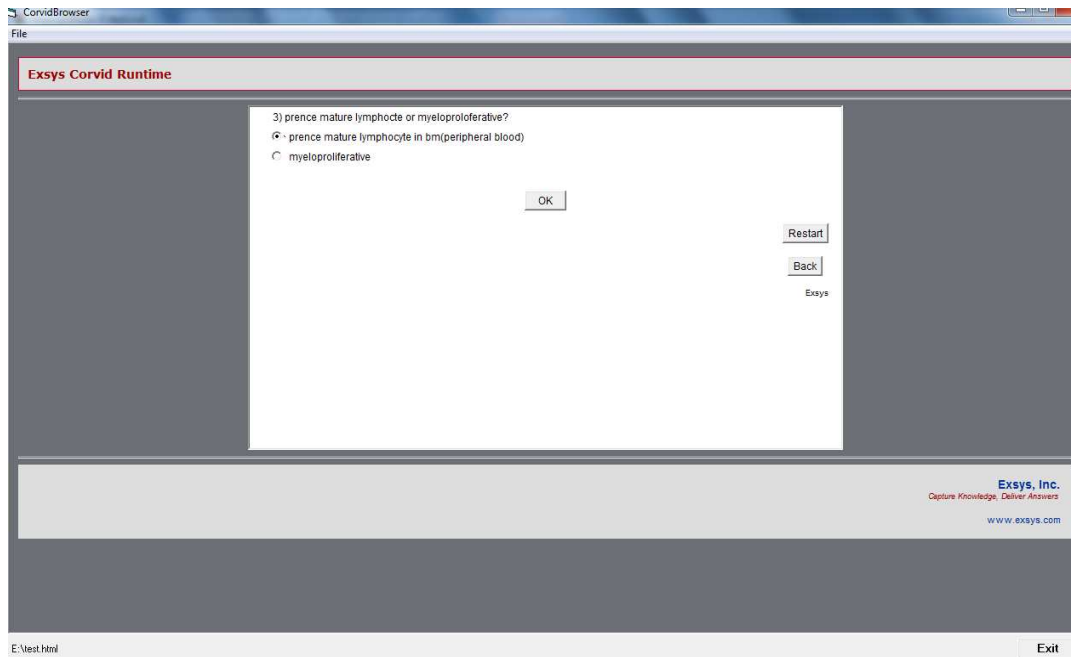


**Figure 4.10** First question case3



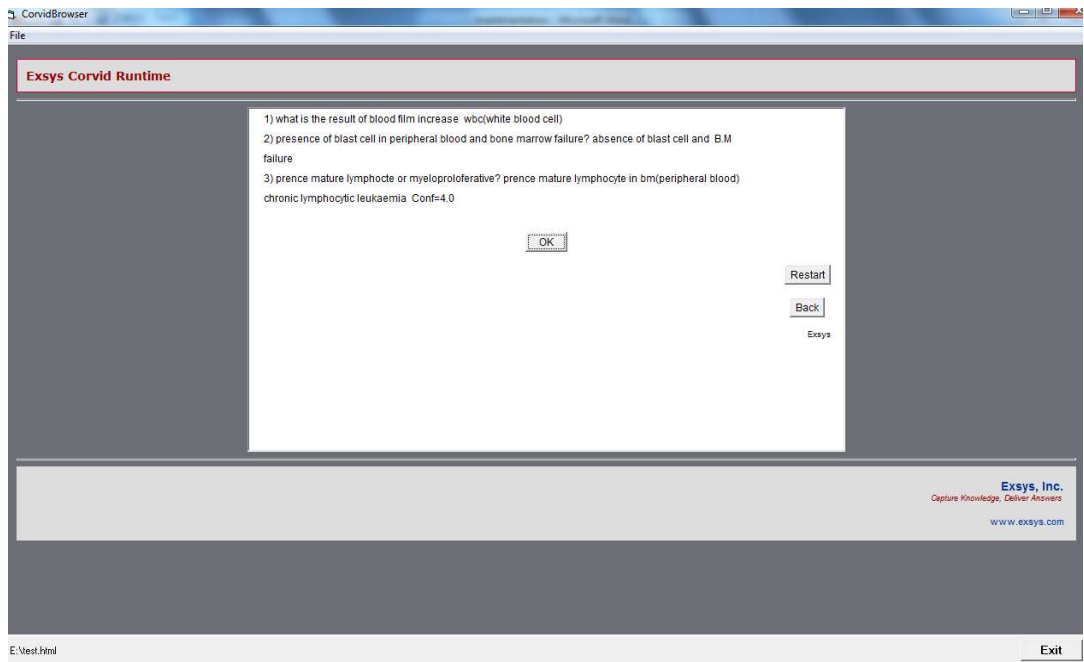
**Figure 4.11** Second question case3

The second question about Presence of blast cell In B.F+B.M failure and absence of blast cell +B.M failure? In this case the second answer is chosen according to the patient information. After clicking “OK” button the Figure 4.12 is displayed.



**Figure 4.12** Third question case3

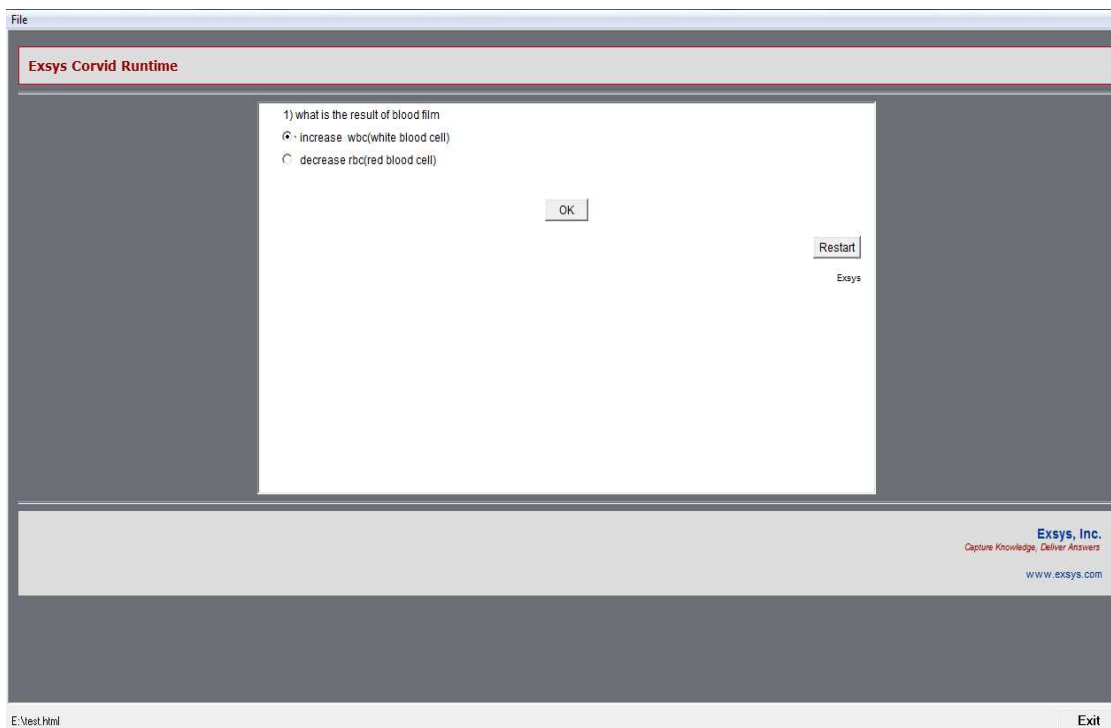
The third question is about prances of mature lymphocyte in p.b and myeloid proliferative disorder? In this case the first answer is chosen according to the patient information. The result is chronic lymphocytic leukemia is displayed after clicking “OK” button is as seen in Figure 4.13.



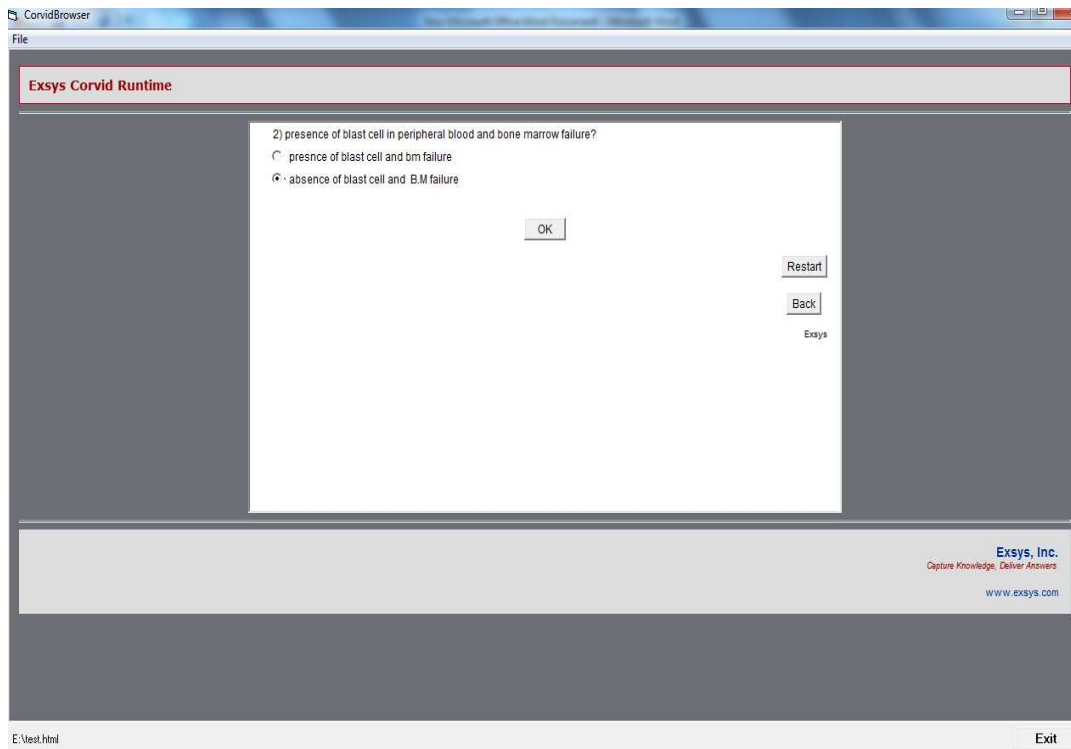
**Figure 4.13** Result of case3

Case 4: The blood film is Increase W.B.C, absence of blast cell +B.M failure, and Prance of mature lymphocyte in B.F?

The First question of the system is what is the result of blood film? Its consist from two answer increase W.B.C and decrease R.B.C. In this case the first answer is chosen according to the patient information. After clicking “OK” button the Figure 4.15 is displayed.

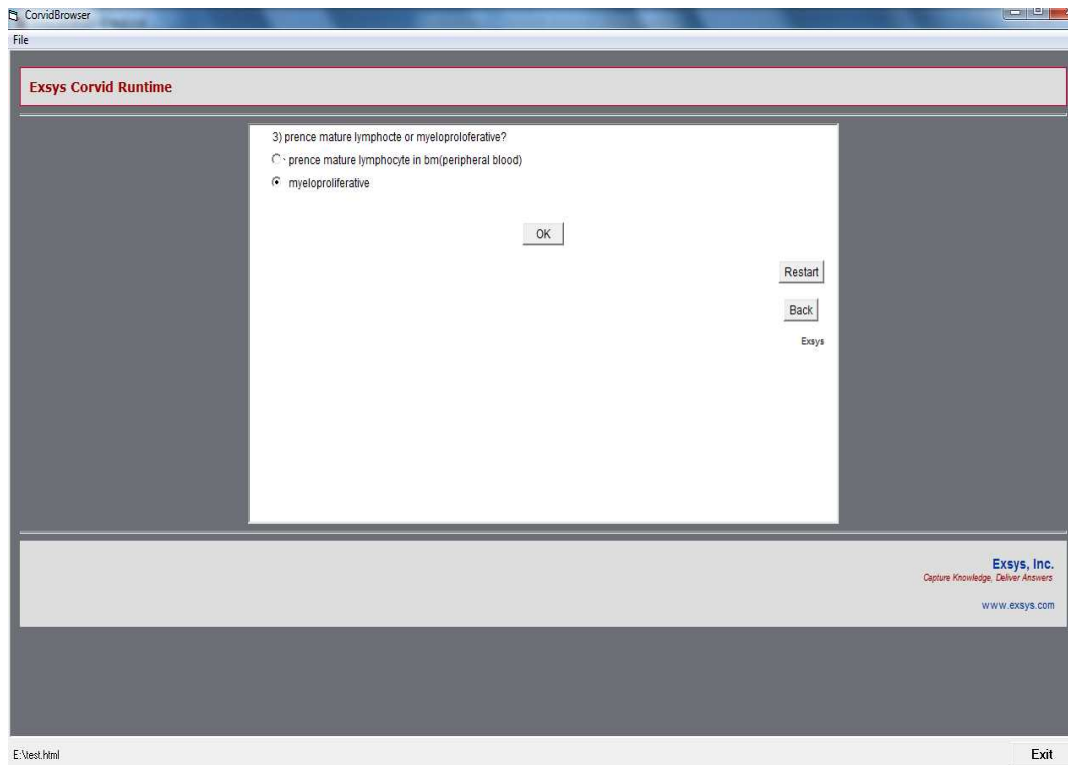


**Figure 4.14** First question case4



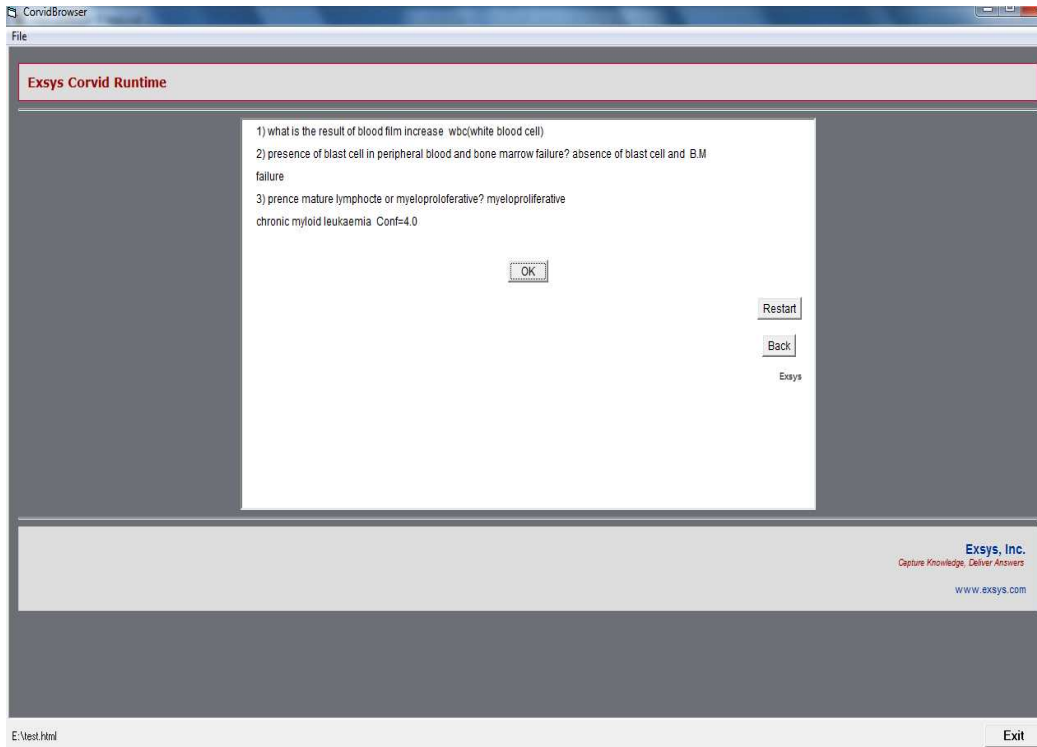
**Figure 4.15** Second question case4

The second question about Presence of blast cell In B.F+B.M failure and absence of blast cell +B.M failure? In this case the second answer is chosen according to the patient information. After clicking “OK” button the Figure 4.16 is displayed.



**Figure 4.16** Third question case4

The third question is about prance of mature lymphocyte in B.F and myeloid proliferative disorder? In this case the second answer is chosen according to the patient information. The result is chronic myeloid leukemia is displayed after clicking “OK” button is as seen in Figure 4.16.

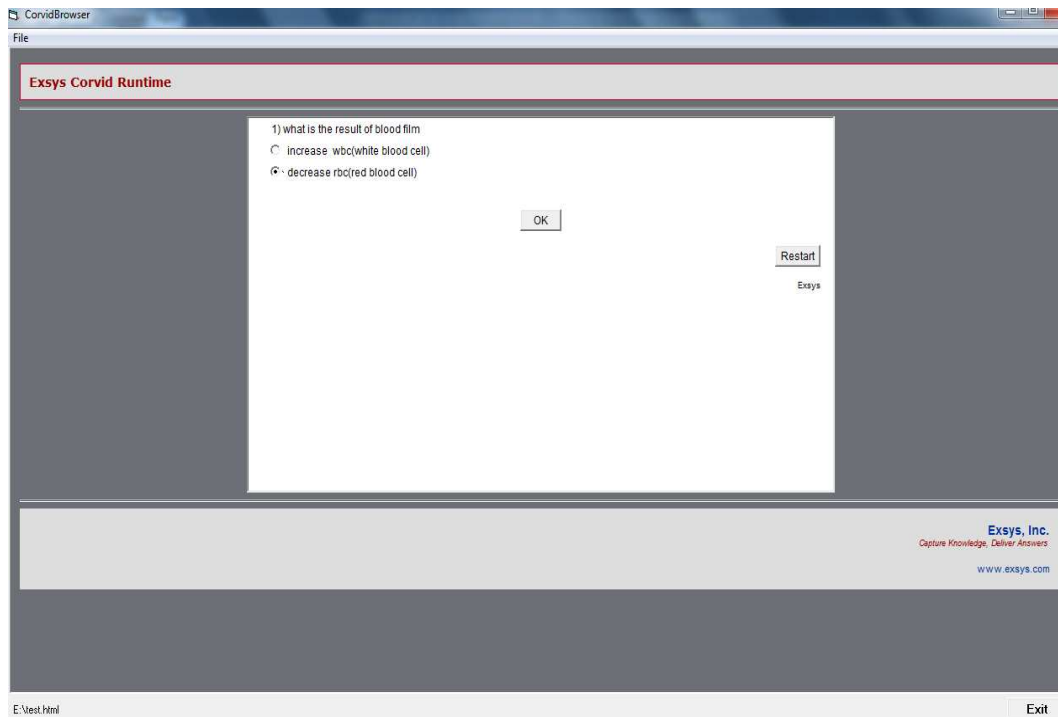


**Figure 4.17** Fourth question case4



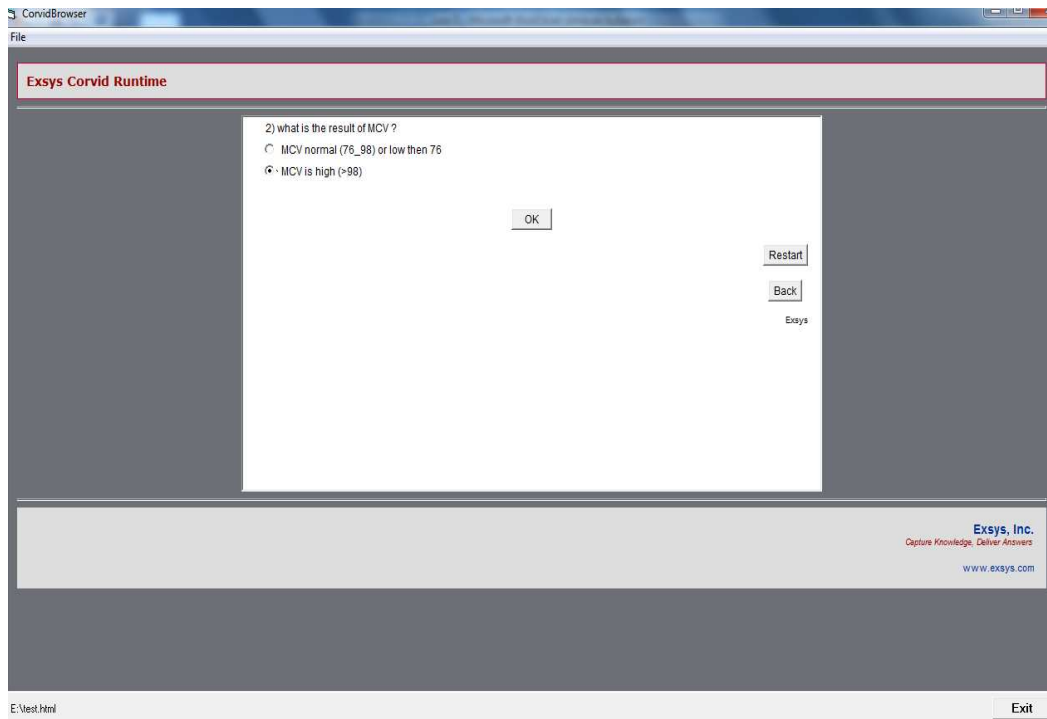
Case5: The result of blood film is decrease, MCV is high>98 and poly chromatic high reticulocyte count?

First question is about blood film and the second answer chosen according to the patient information Figure 4.18



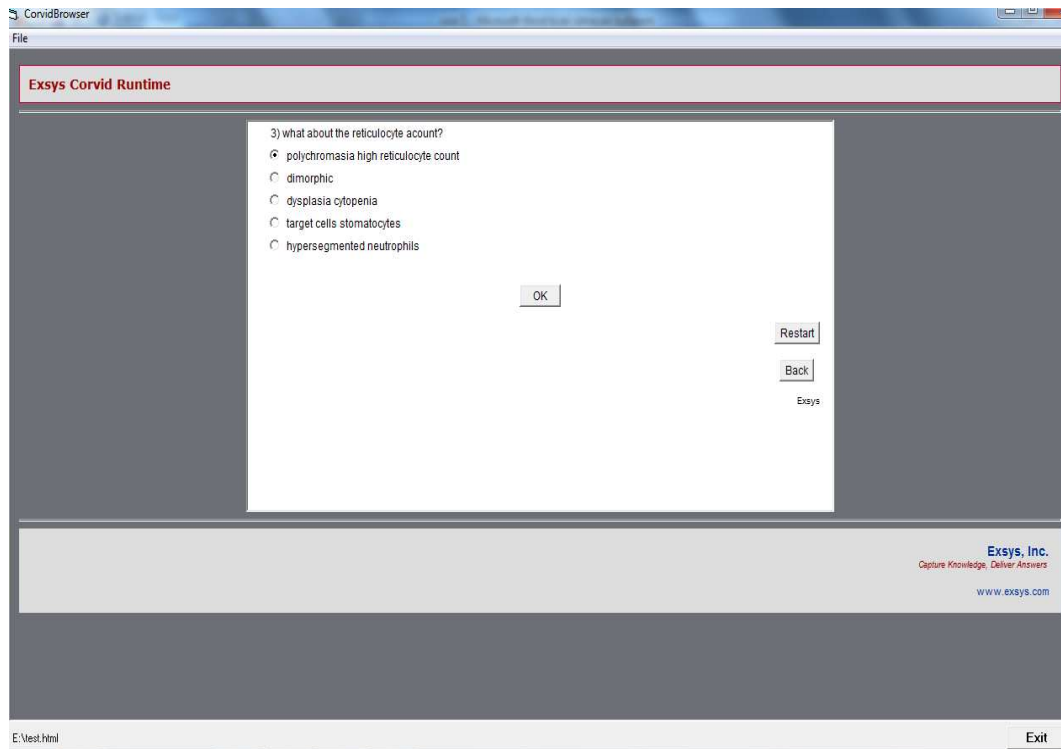
**Figure 4.18** First question case5

The second question is about the result of MCV and the second answer is chosen MCV is high (>98) Figure 4.19.

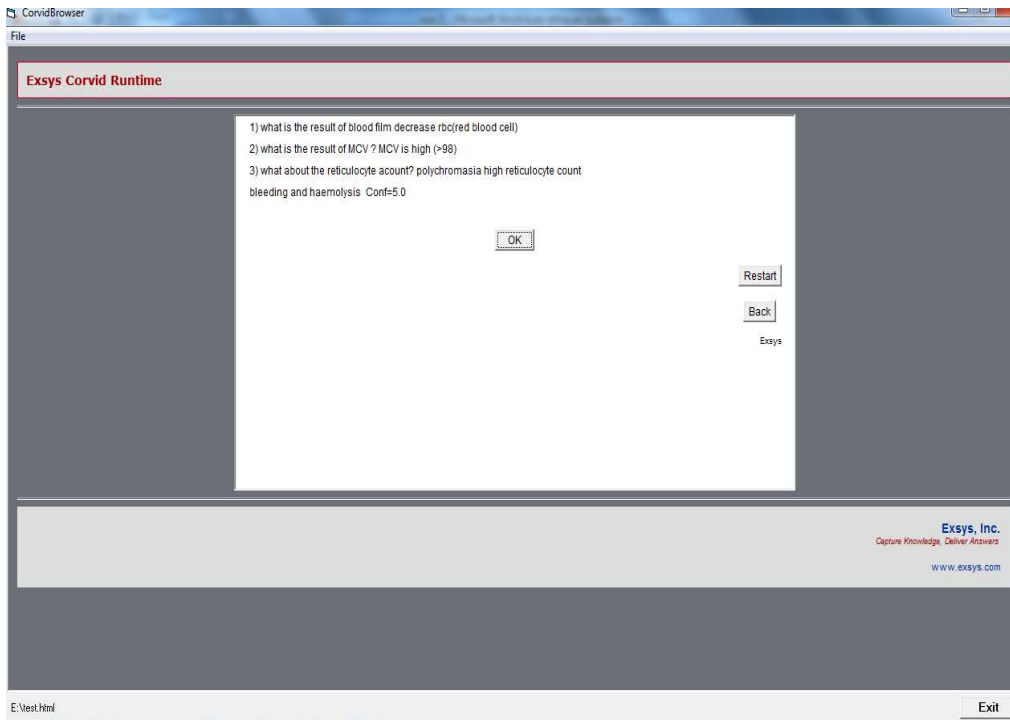


**Figure 4.19** Second question case5

The third question is about the reticulocyte count and the first answer is chosen polychromasia high reticulocyte count Figure 4.20. The system conclusion is bleeding & haemolysis figure 4.21.



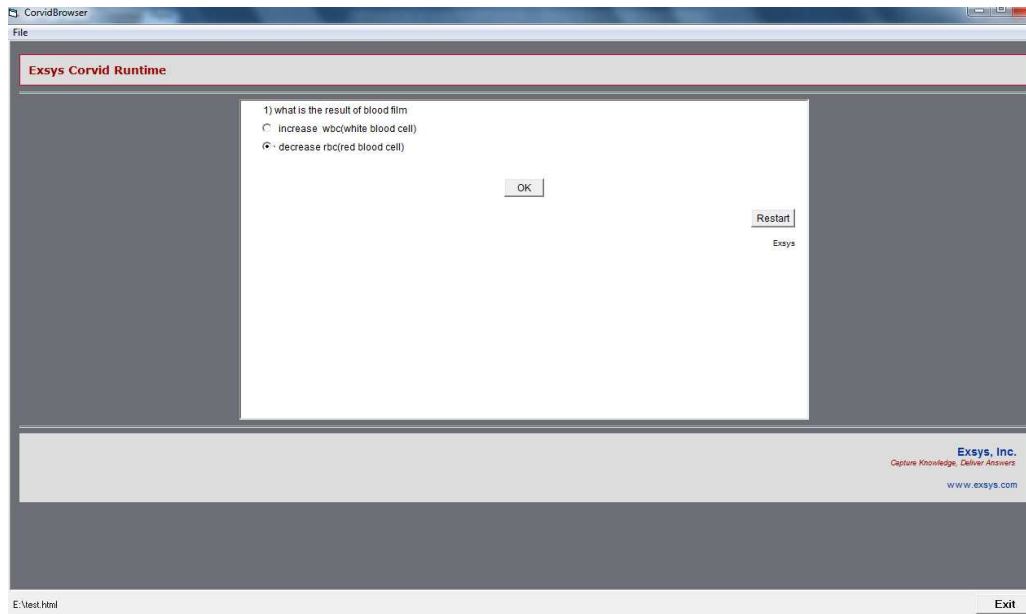
**Figure 4.20** Third question case5



**Figure 4.21** Result of case5

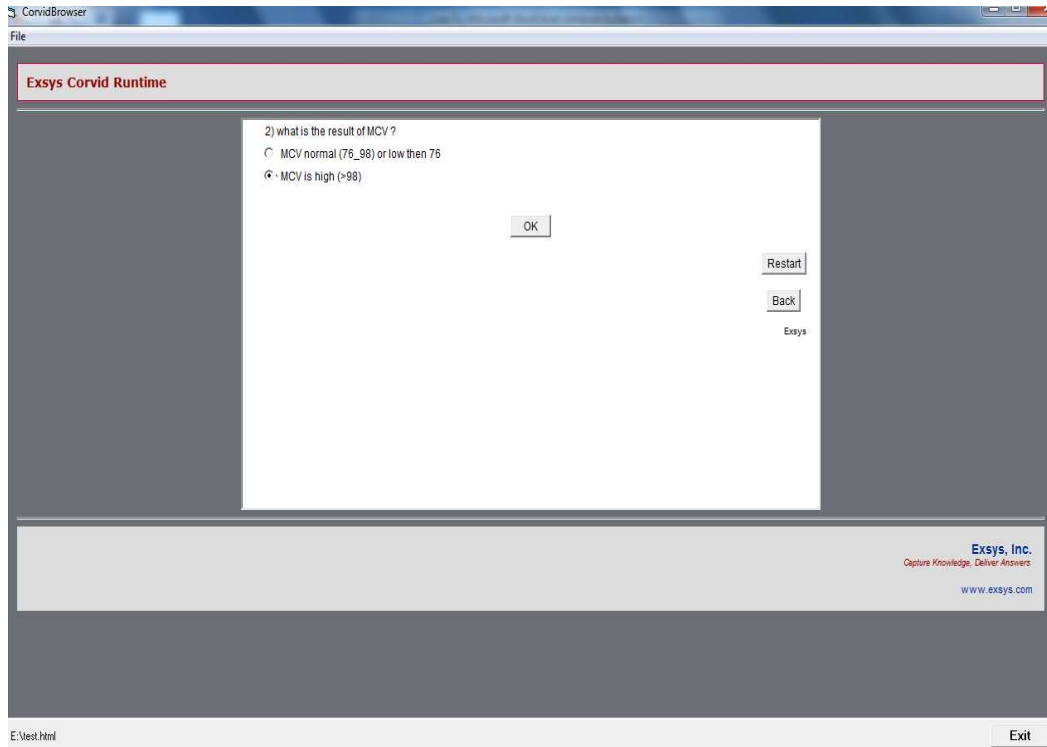
Case6: The result of blood film is decrease, MCV is high>98 and high reticulocyte count is dimorphic?

First question is about blood film and the second answer chosen according to the patient information Figure 4.22.



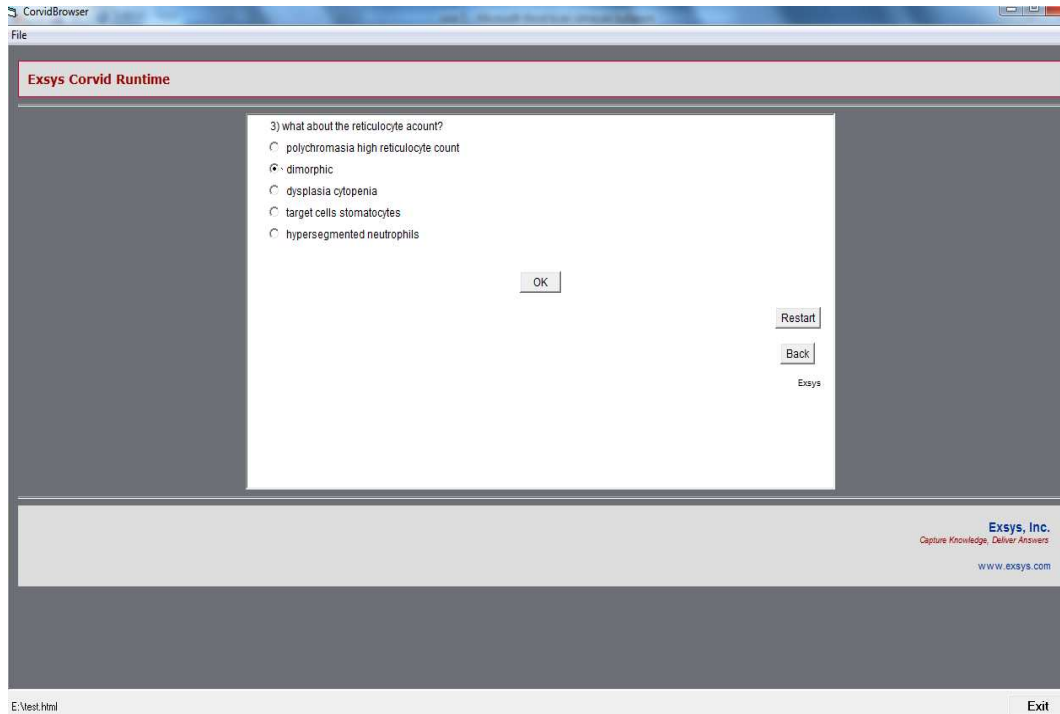
**Figure 4.22** The first question case6

The second question is about the result of MCV and the second answer is chosen MCV is high (>98) Figure 4.23.

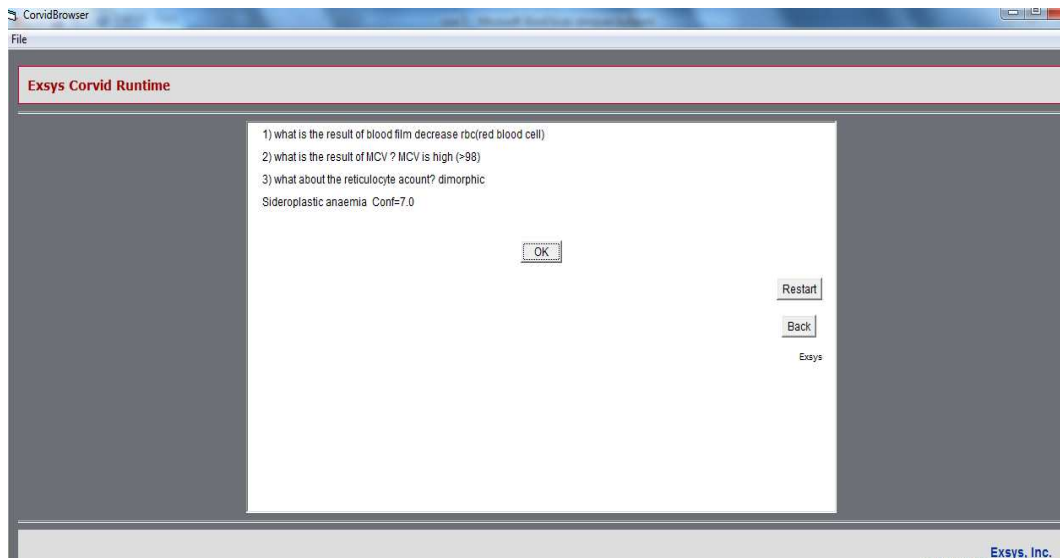


**Figure 4.23** Second question case6

The third question is about the reticulocyte count and the second answer is chosen dimorphic high reticulocyte count Figure 4.24. The system conclusion is sidero plastic anemia figure 4.25.



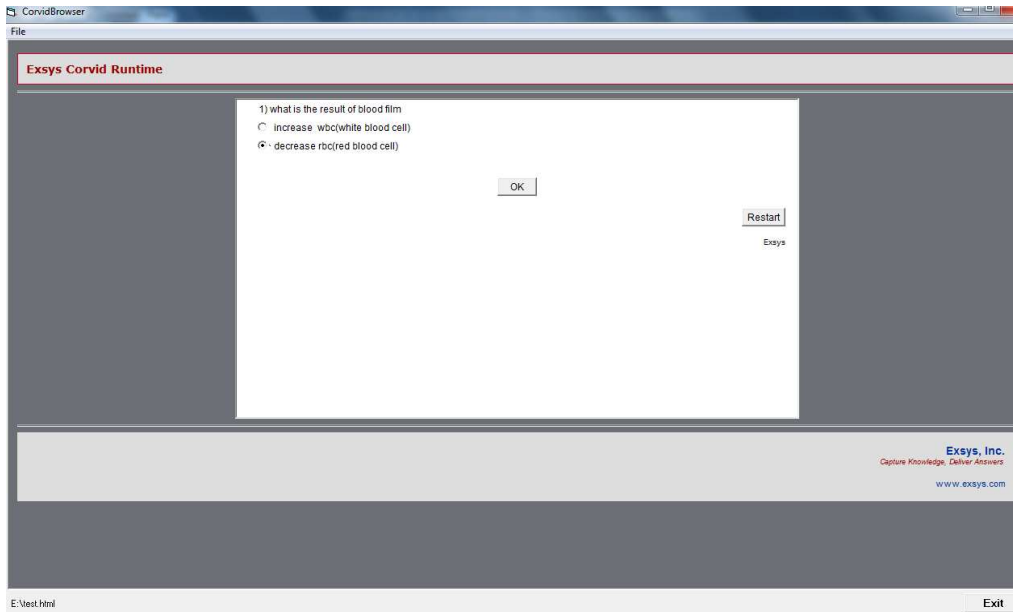
**Figure 4.24** Third question case6



**Figure 4.25** Result of case6

Case7: The result of blood film is decrease, MCV is high>98 and high reticulocyte count is dimorphic?

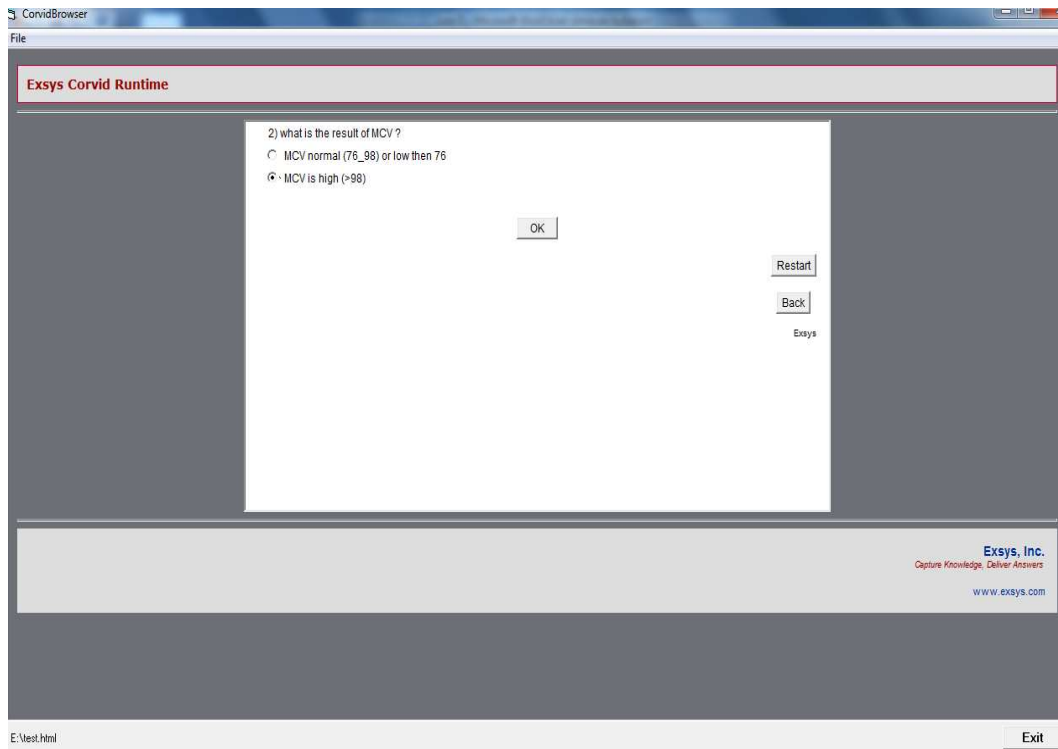
First question is about blood film and the second answer chosen according to the patient information Figure 4.26.



**Figure 4.26** First question case7



The second question is about the result of MCV and the second answer is chosen MCV is high (>98) Figure 4.27.



**Figure 4.27** Second question case7

The third question is about the reticulocyte count and the third answer is chosen cytopenia dysplasia high reticulocyte count Figure 4.28. The system conclusion is myeloid splasia figure 4.29.

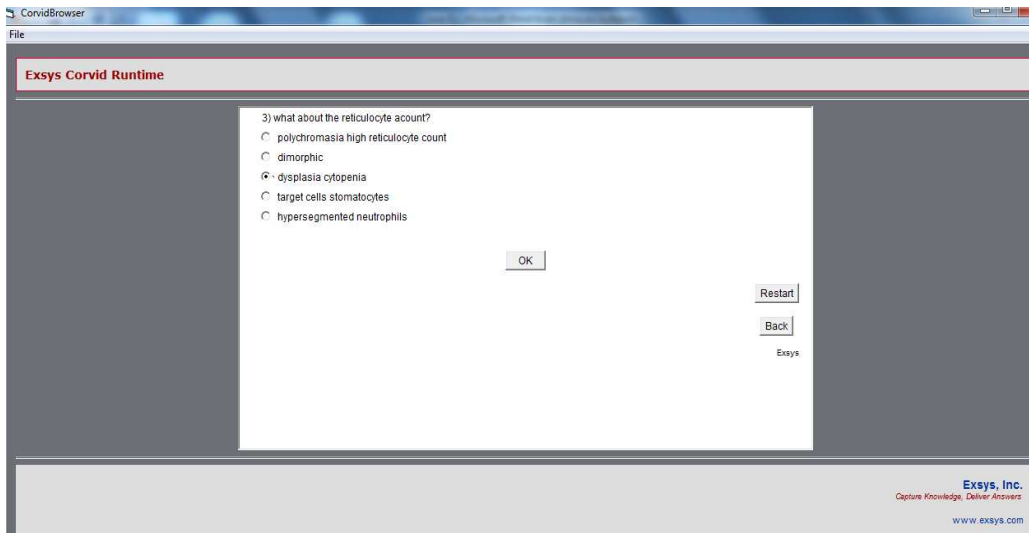


Figure 4.28 Third question case7

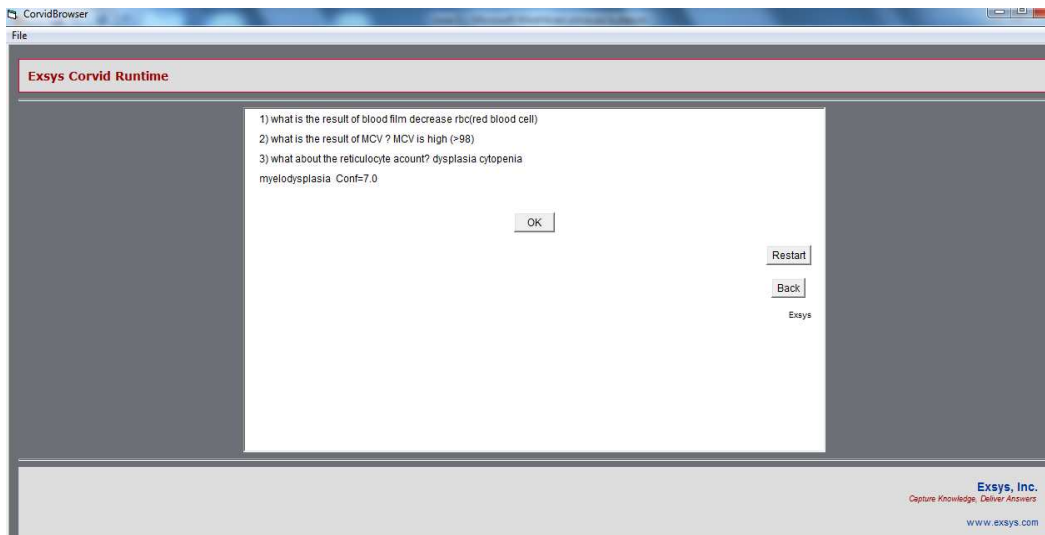
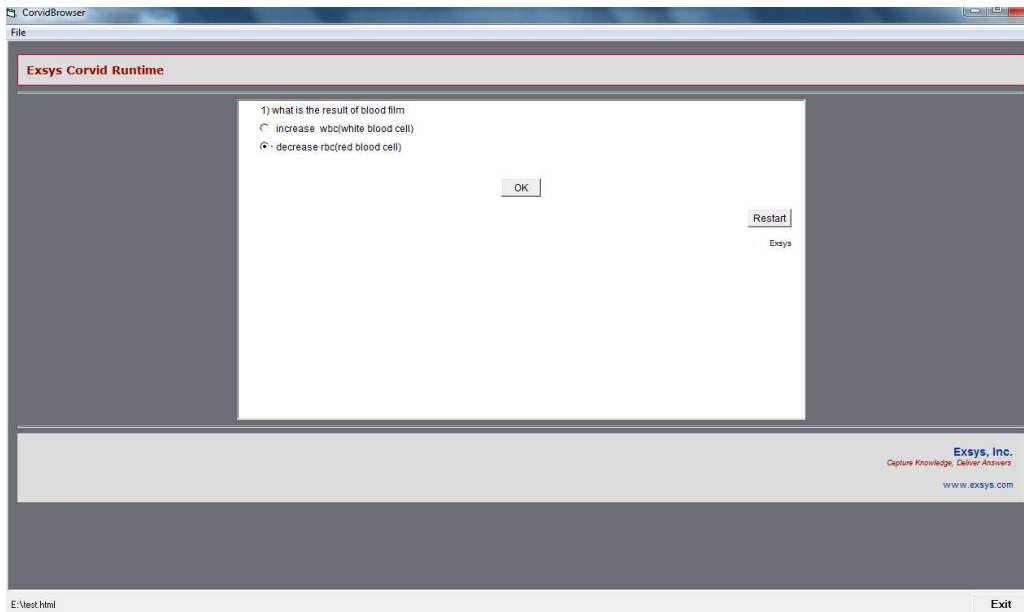


Figure 4.29 Result of case7

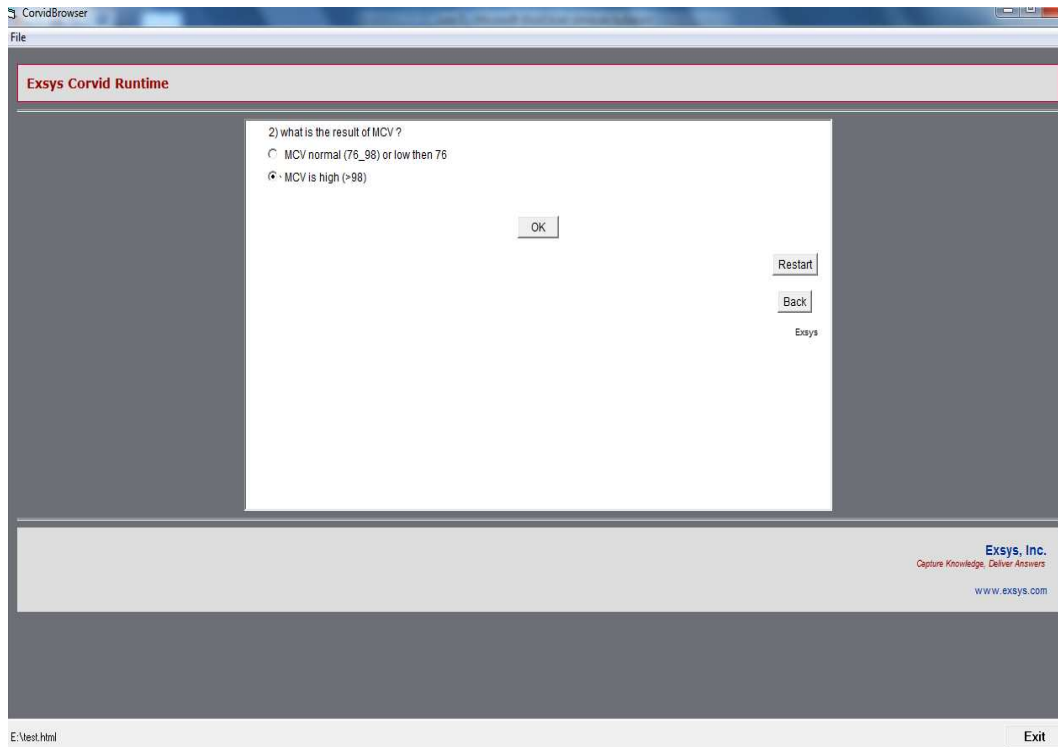
Case8: The result of blood film is decrease, MCV is high>98 and high reticulocyte count is target cell somatocyte?

First question is about blood film and the second answer chosen according to the patient information Figure 4.30.



**Figure 4.30** First question case8

The second question is about the result of MCV and the second answer is chosen MCV is high (>98) Figure 4.31.



**Figure 4.31** Second question case8

The third question is about the reticulocyte count and the fourth answer is chosen target cell stomatocyte high reticulocyte count Figure 4.32. The system conclusion is liver disease figure 4.33.

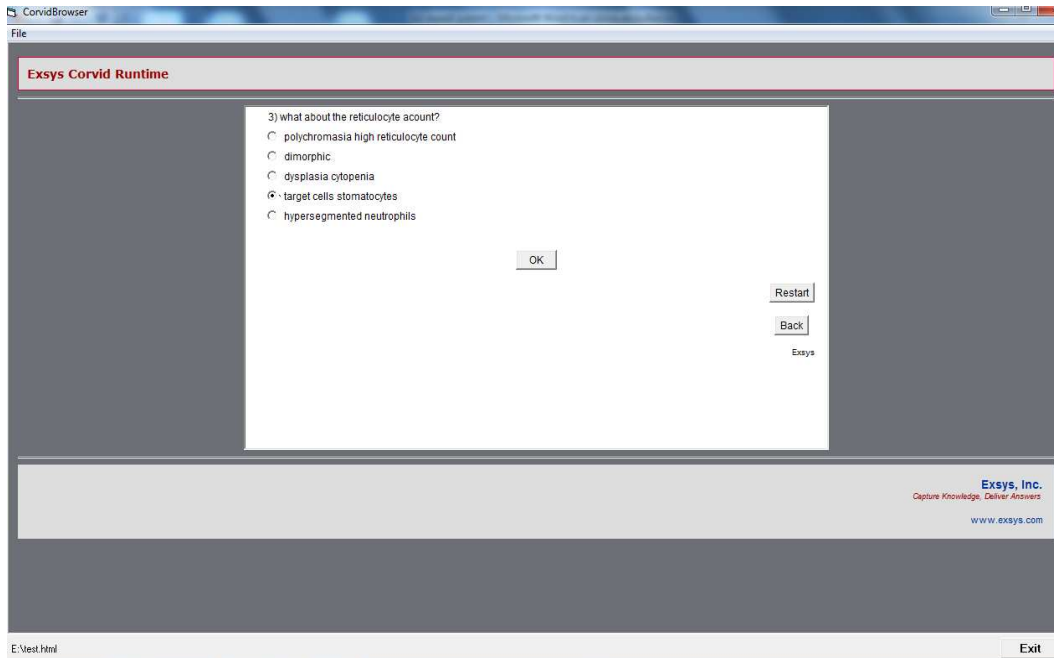


Figure 4.32 Third question case8

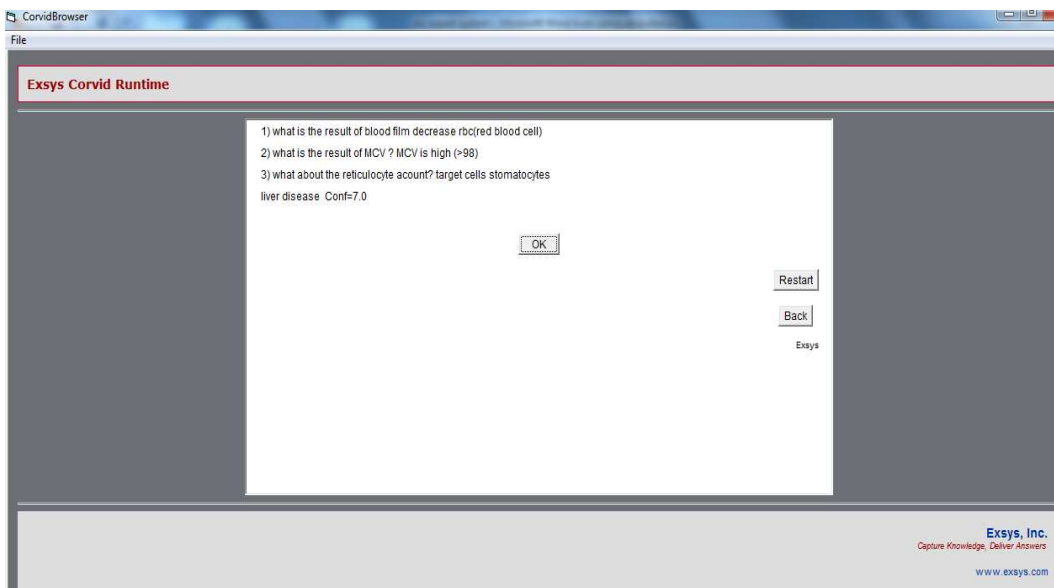
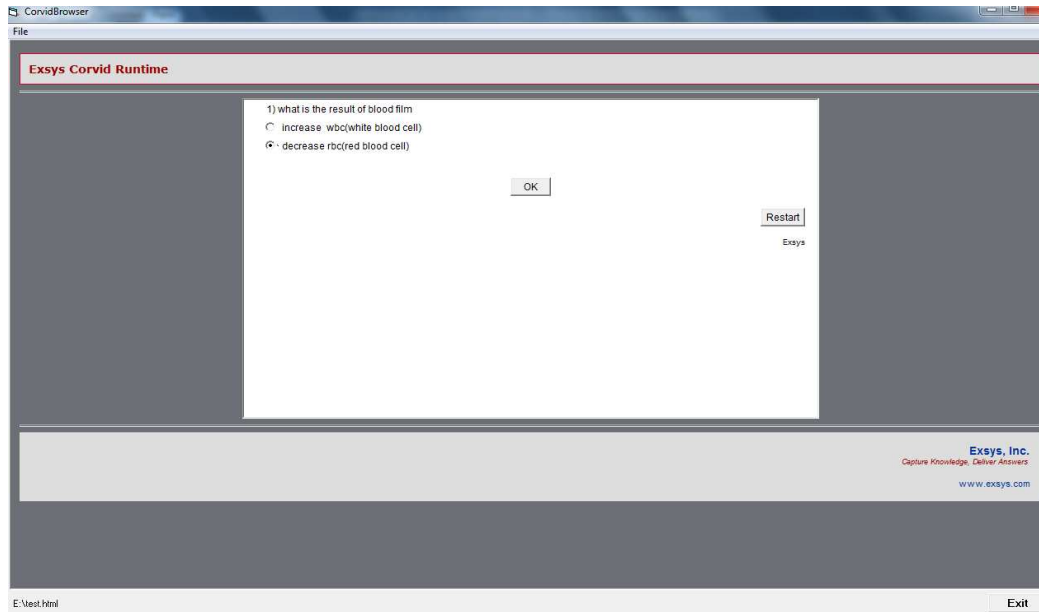


Figure 4.33 Result of case8

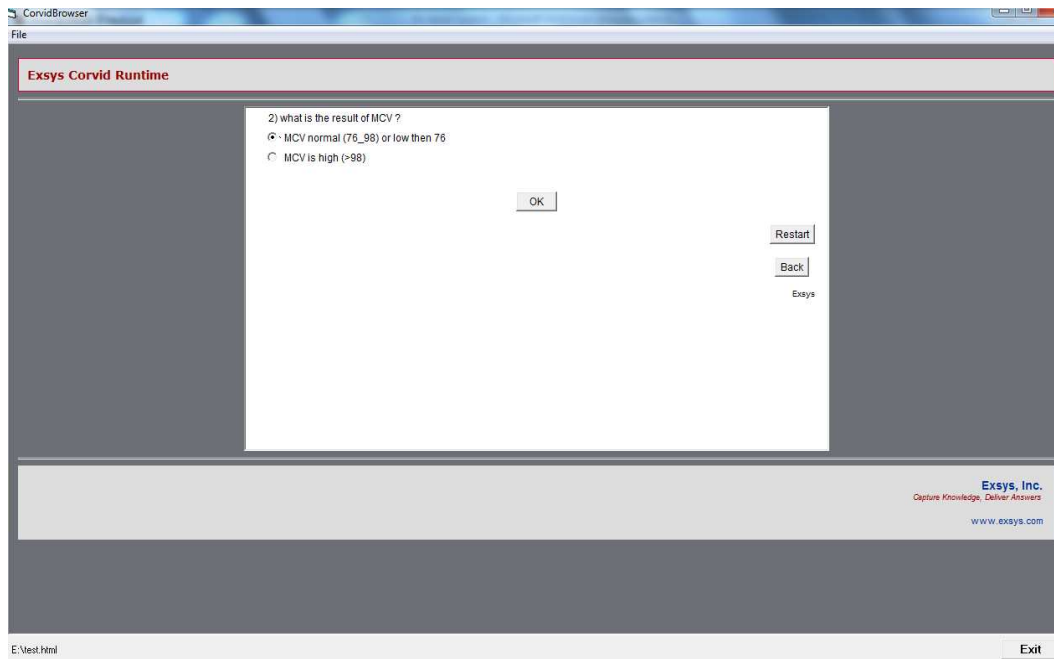
Case 9: The result of blood film is decrease, MCV is normal (76\_98) or low then 76 and high reticulocyte count is target cell somatocyte case of the normal or low reticulocyte count?

First question is about blood film and the second answer chosen according to the patient information Figure 4.34.



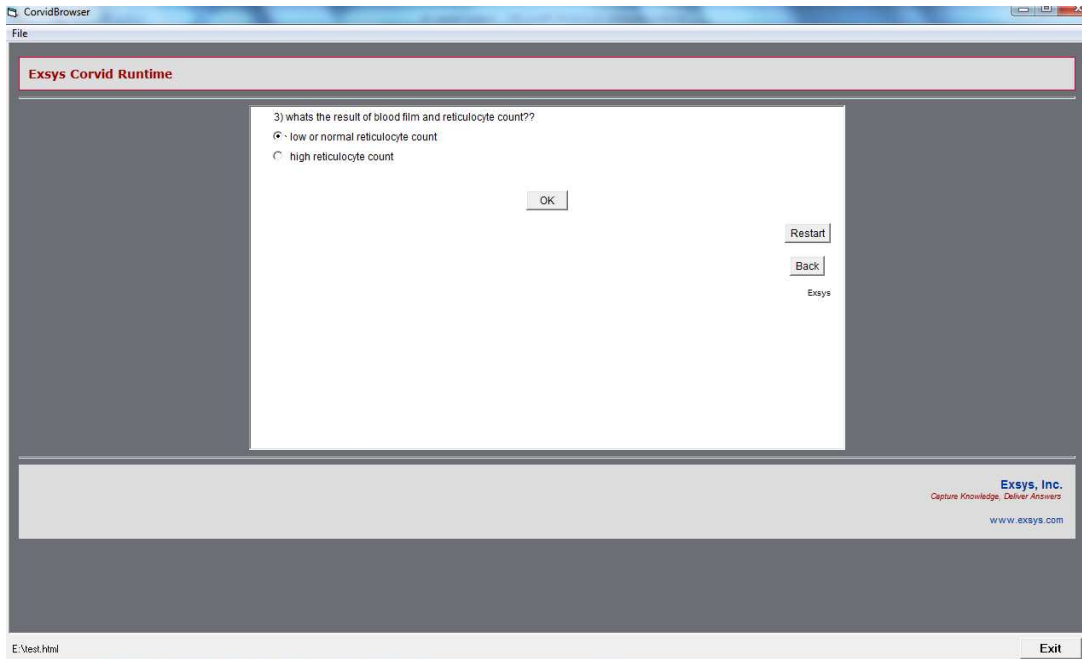
**Figure 4.34** First question case9

The second question is about the result of MCV and the first answer is chosen MCV is normal (76\_98) or low then 76 Figure 4.35.



**Figure 4.35** Second question case9

The third question is about the result of blood film and reticulocyte count and the first answer is chosen figure 4.36.



**Figure 4.36** Third question case9



The fourth question is about the case of the normal or low reticulocyte count and the third answer is chosen figure 4.37. The system conclusion is sidero plastic anemia figure 4.38.

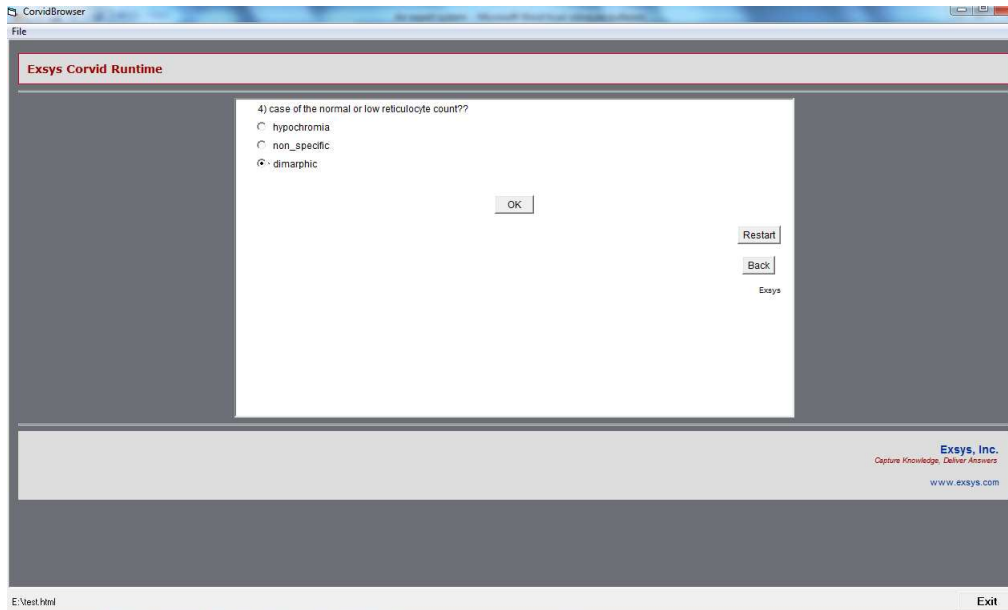


Figure 4.37 Fourth question case9

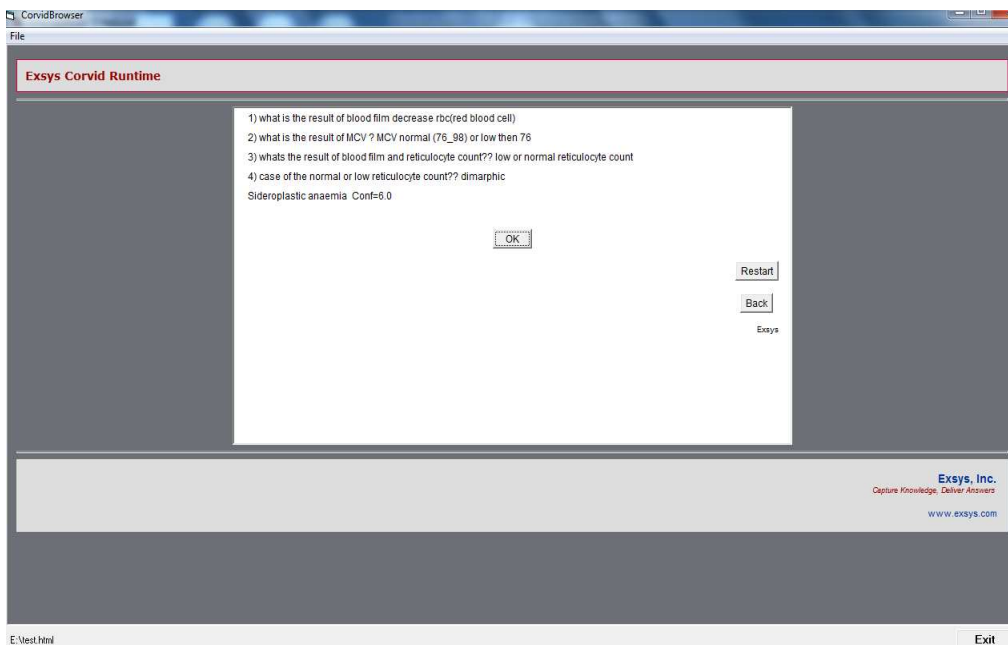
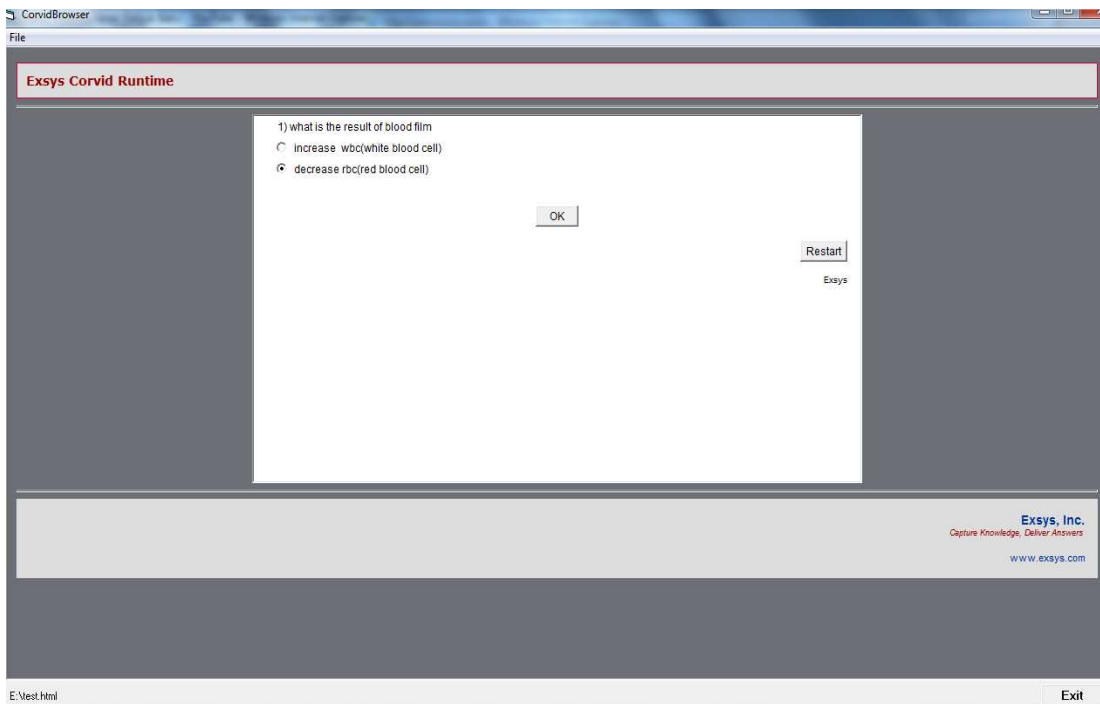


Figure 4.38 The result of case9

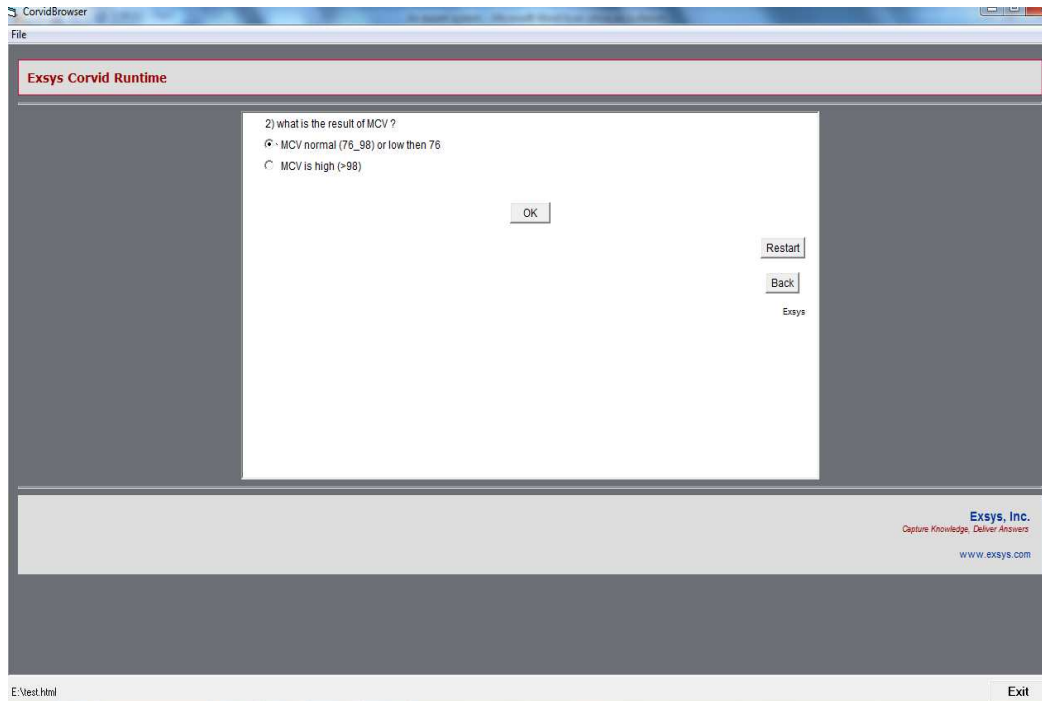
Case10: The result of blood film is decrease, MCV is normal (76\_98) or low than 76, the result of blood film and reticulocyte count is low or normal reticulocyte count, the HB electro phoresis is increased HB A2.

First question is about blood film and the second answer chosen according to the patient information Figure 4.39.



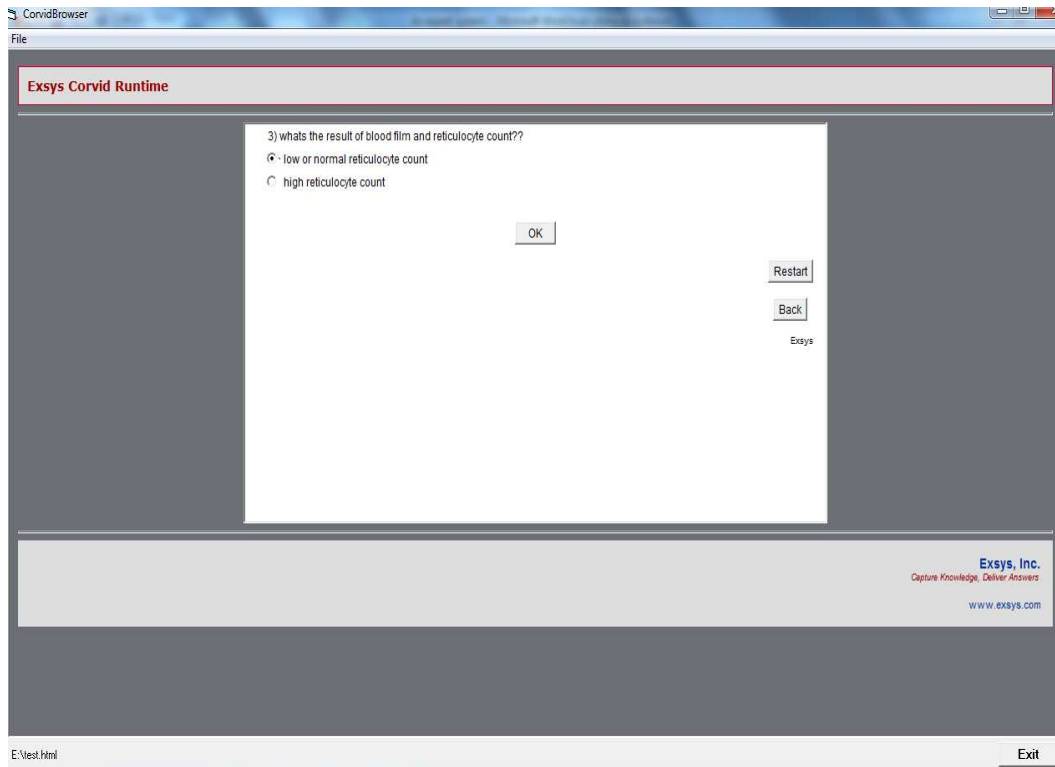
**Figure 4.39** First question case10

The second question is about the result of MCV and the first answer is chosen MCV is normal (76\_98) or low then 76 Figure 4.40.



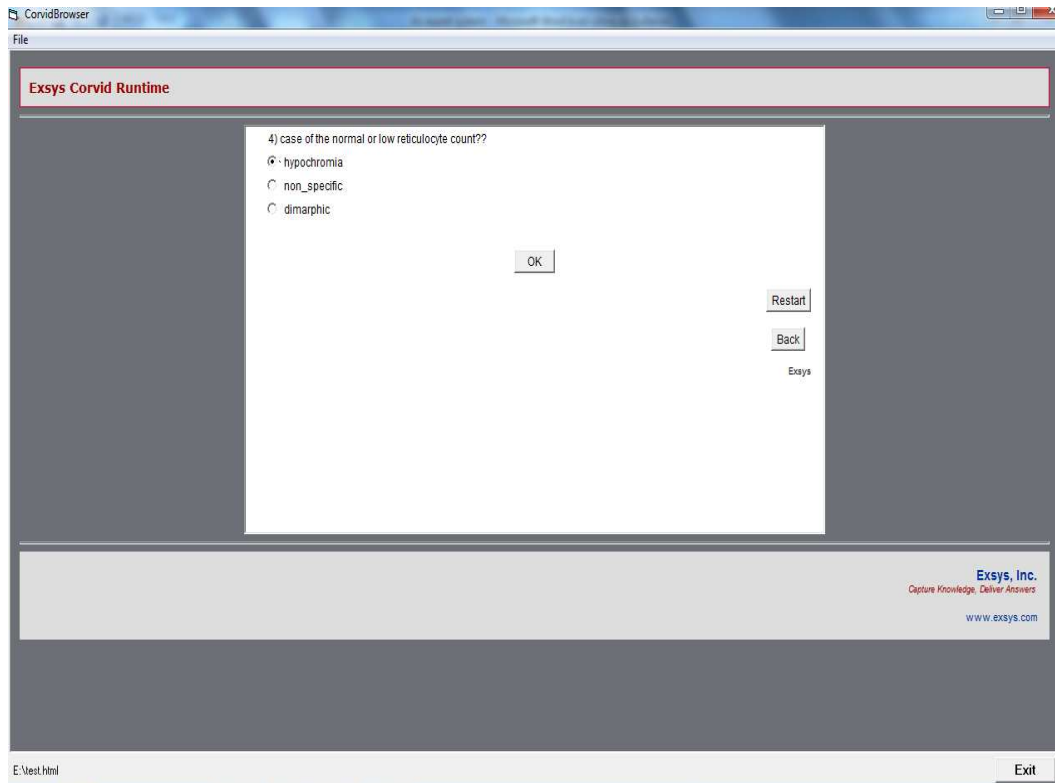
**Figure 4.40** Second question case10

The third question is about the result of blood film and reticulocyte count and the first answer is chosen figure 4.41.



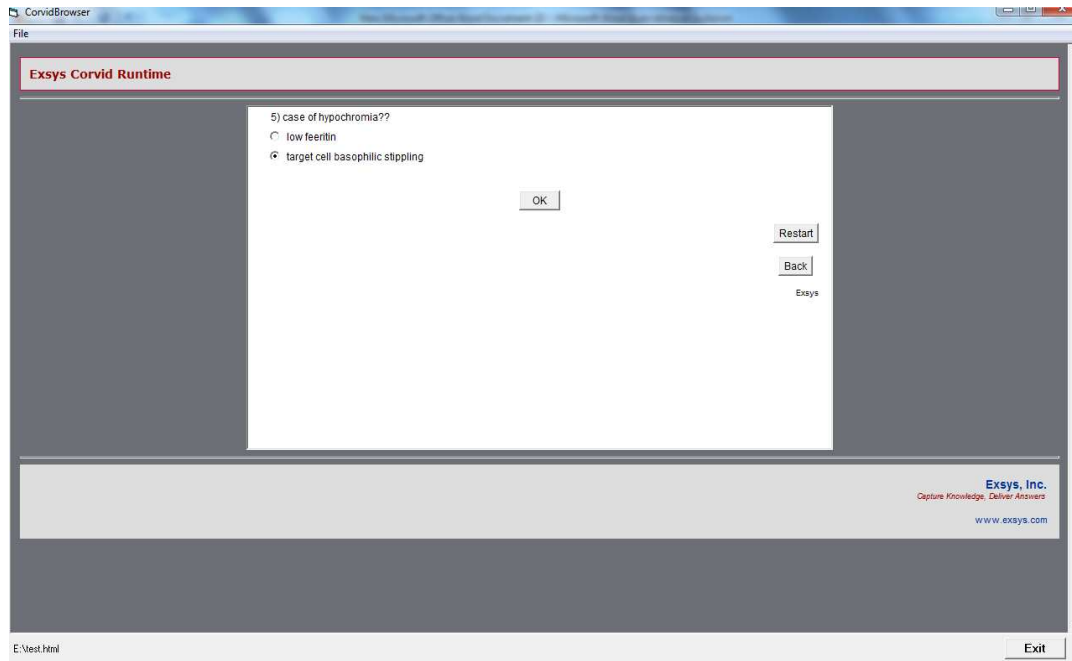
**Figure 4.41** Third question case10

The fourth question is about the case of the normal or low reticulocyte count and the third answer is chosen figure 4.42.



**Figure 4.42** Fourth question case10

The fifth question is about the case of the case of hypochromia and the second answer is chosen figure 4.43



**Figure 4.43** Fifth question case10

The sixth question is about HB electro phoresis and the first answer is chosen figure 4.44. The system conclusion is Beta thalassaemia trait figure 4.45.

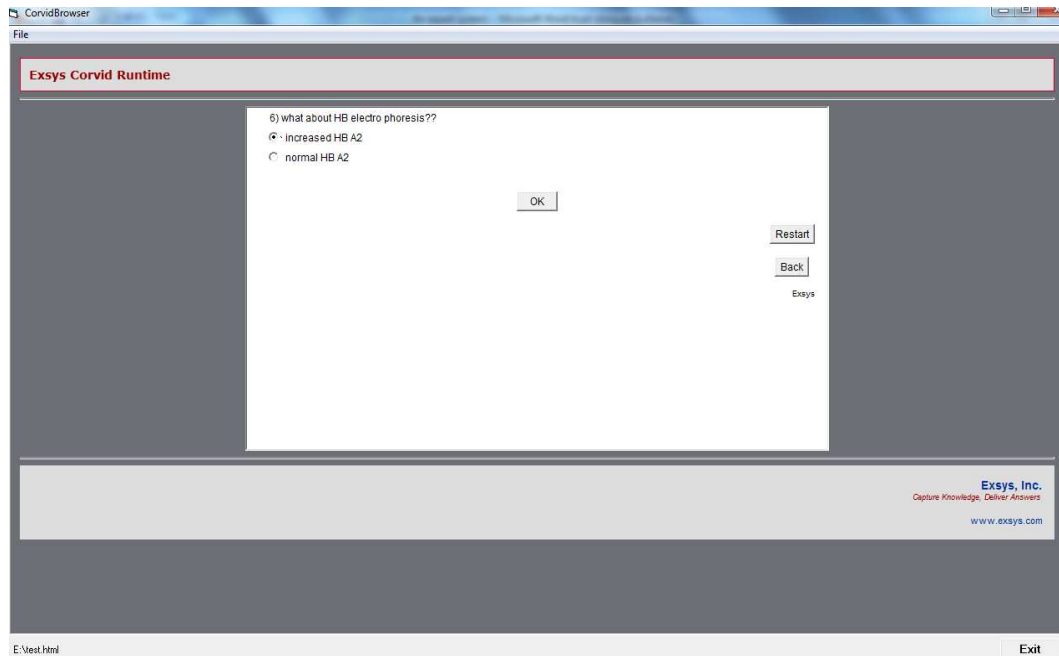


Figure 4.44 Sixth question case10

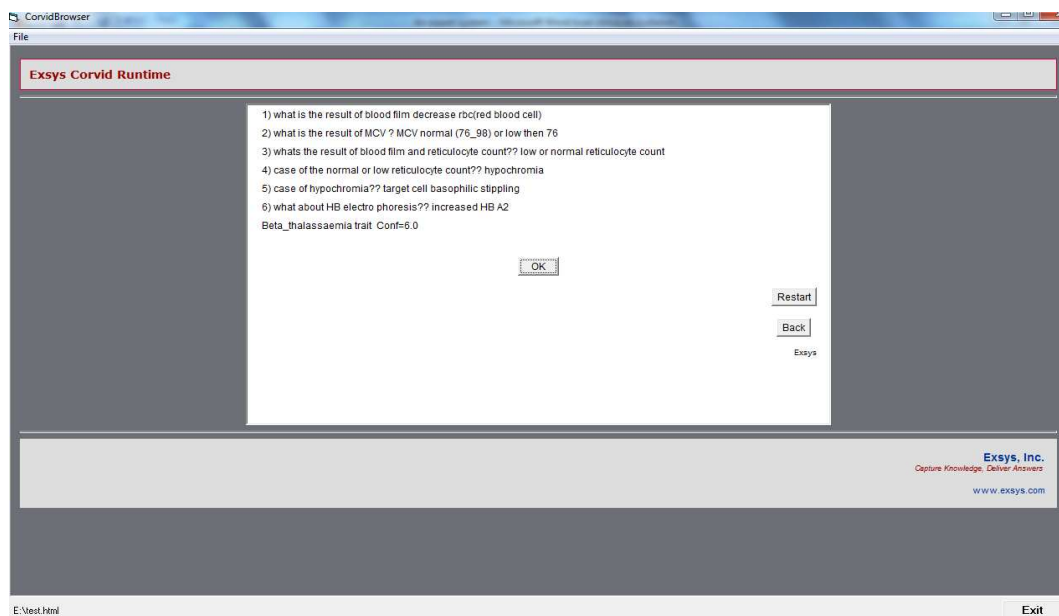
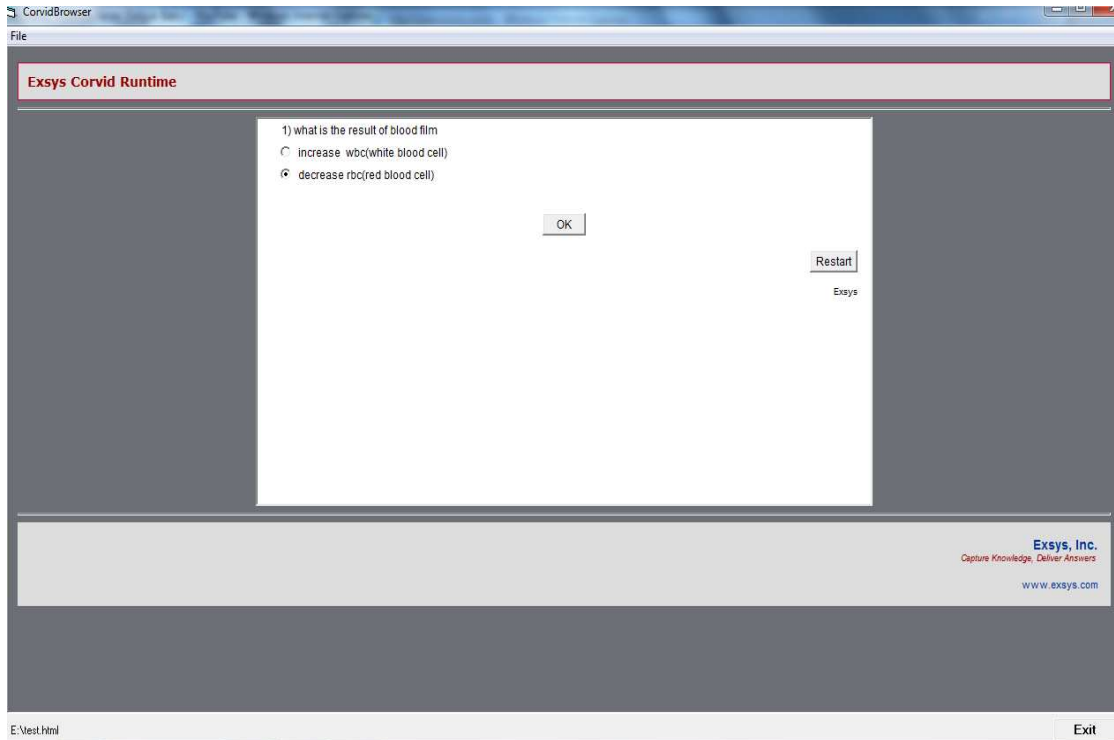


Figure 4.45 Result of case10

Case11: The result of blood film is decrease, MCV is normal (76\_98) or low than 76, the result of blood film and reticulocyte count is low or normal reticulocyte count?

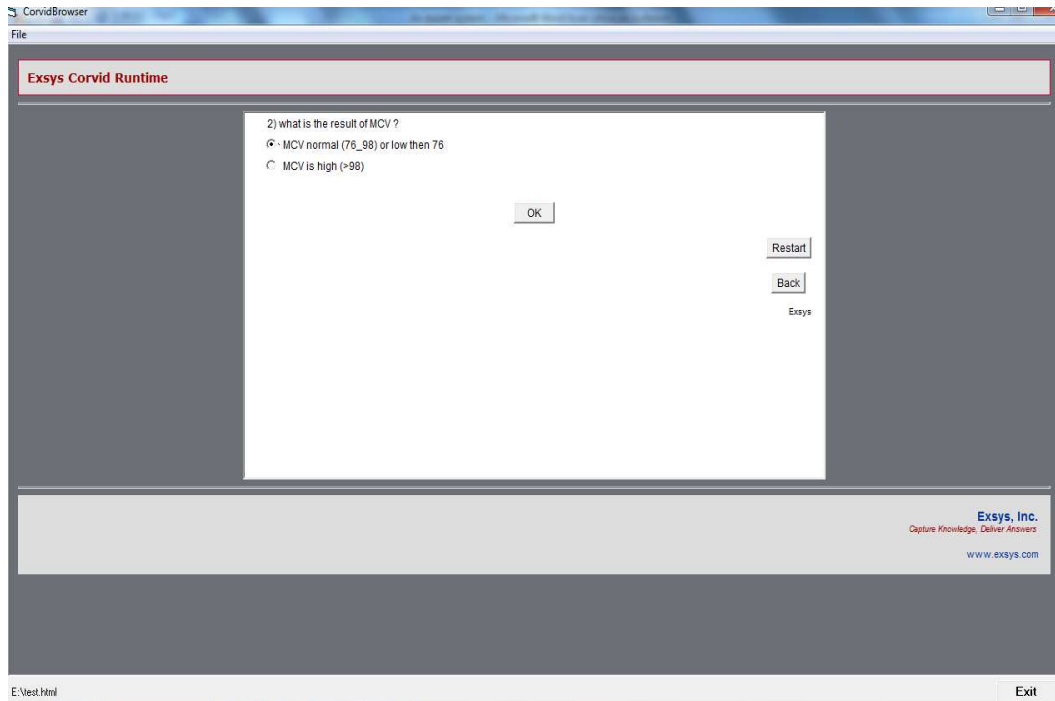
First question is about blood film and the second answer chosen according to the patient information Figure 4.46.



**Figure 4.46** First question case11

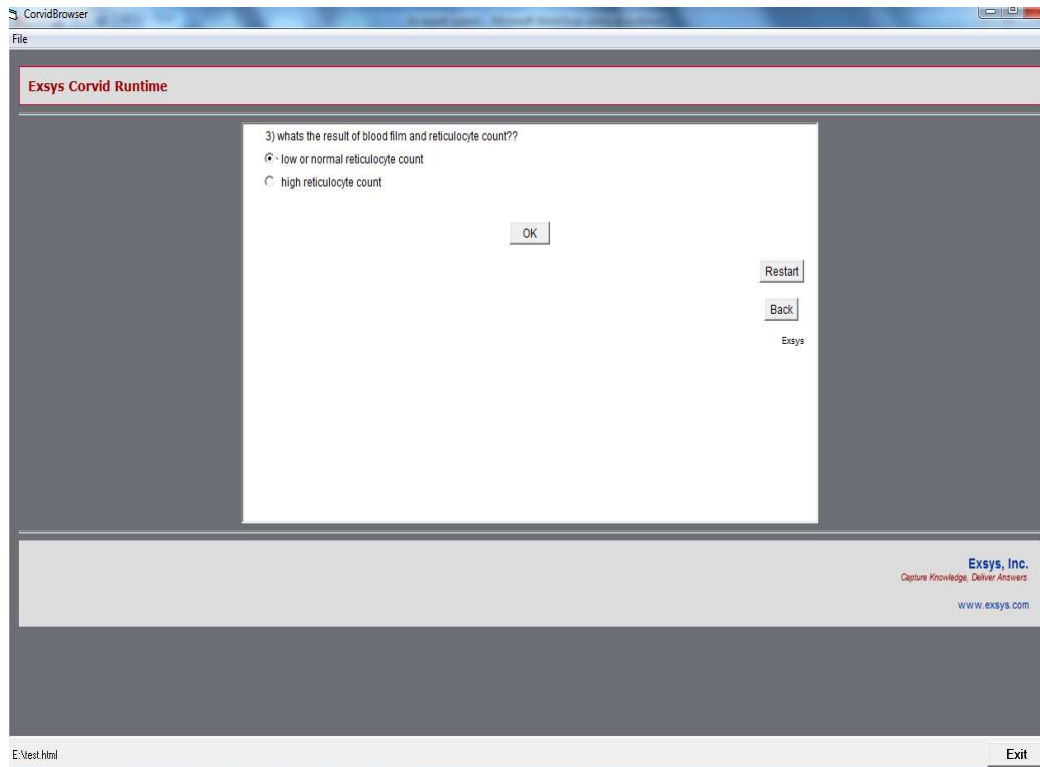


The second question is about the result of MCV and the first answer is chosen MCV is normal (76\_98) or low then 76 Figure 4.47.



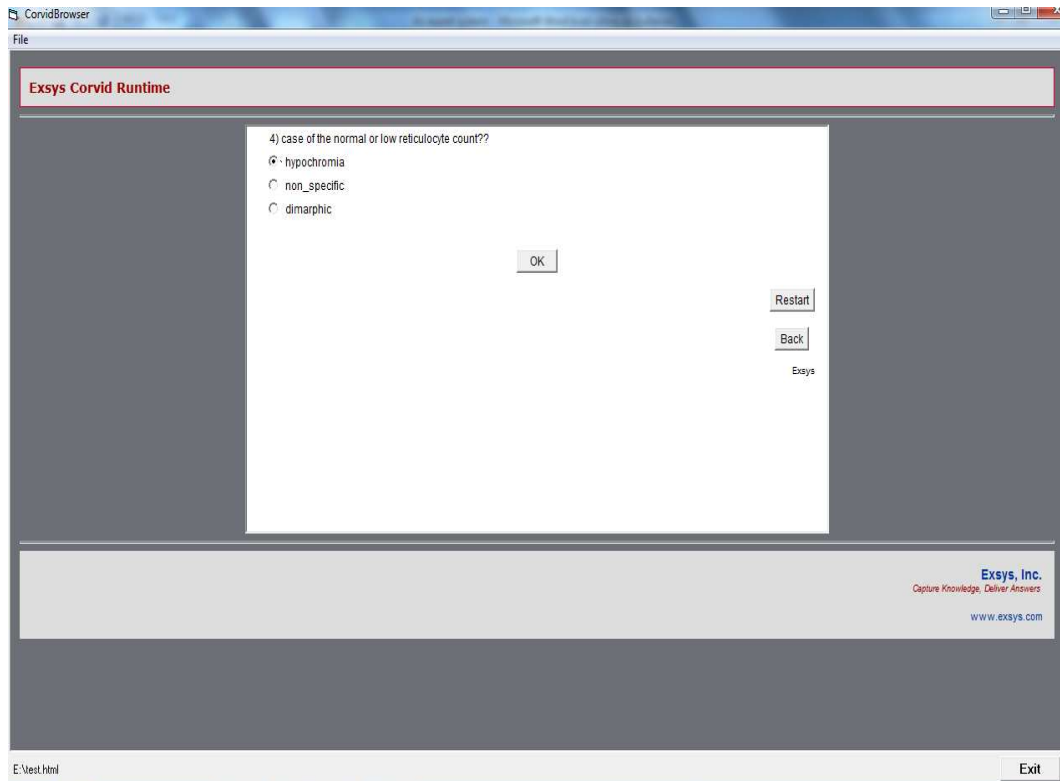
**Figure 4.47** Second question case11

The third question is about the result of blood film and reticulocyte count and the first answer is chosen figure 4.48.



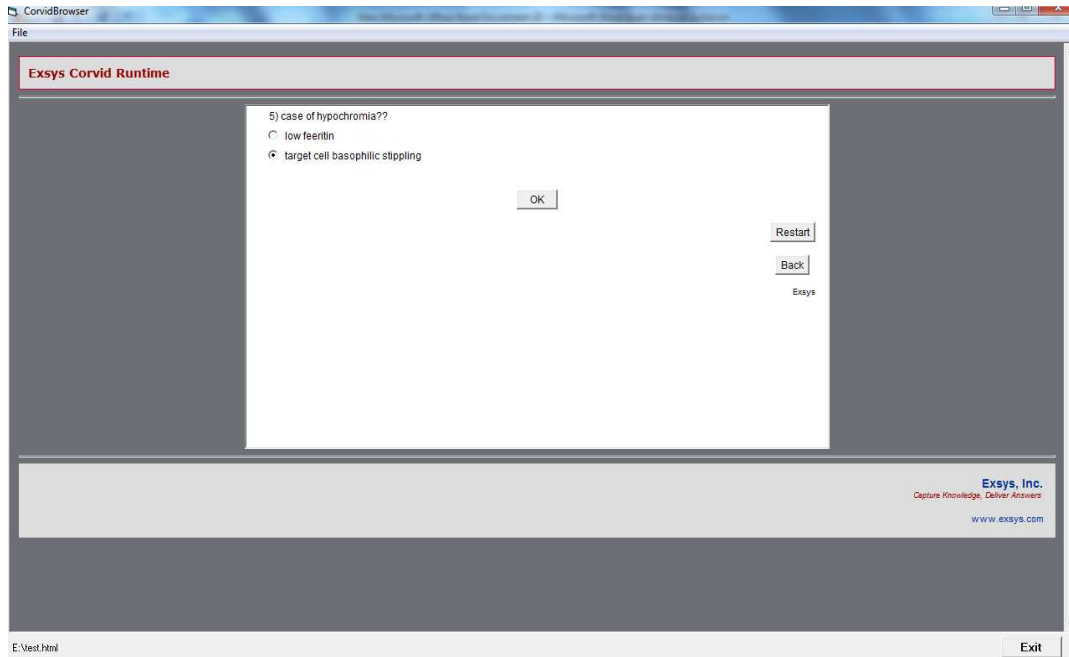
**Figure 4.48** Third question case 1

The fourth question is about the case of the normal or low reticulocyte count and the third answer is chosen figure 4.49.



**Figure 4.49** Fourth question case11

The fifth question is about the case of the case of hypochromia and the second answer is chosen figure 4.50.



**Figure 4.50** Fifth question case11

The sixth question is about HB electro phoresis and the second answer is chosen figure 4.51. The system conclusion is Alpha thalassaemia trait figure 4.52.

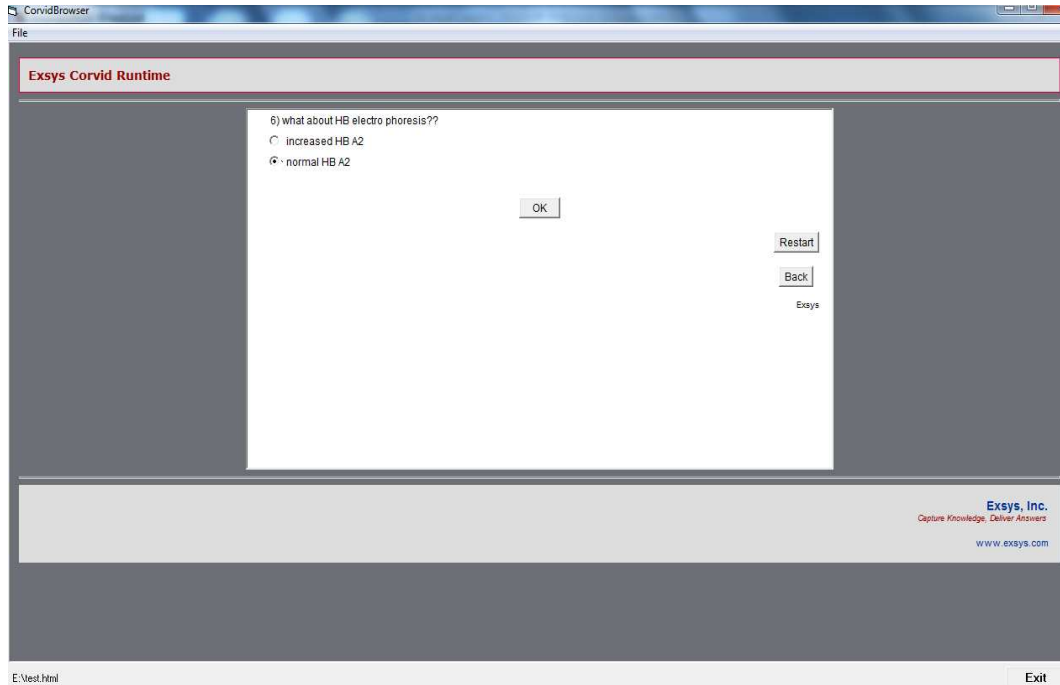


Figure 4.51 Sixth question case 1

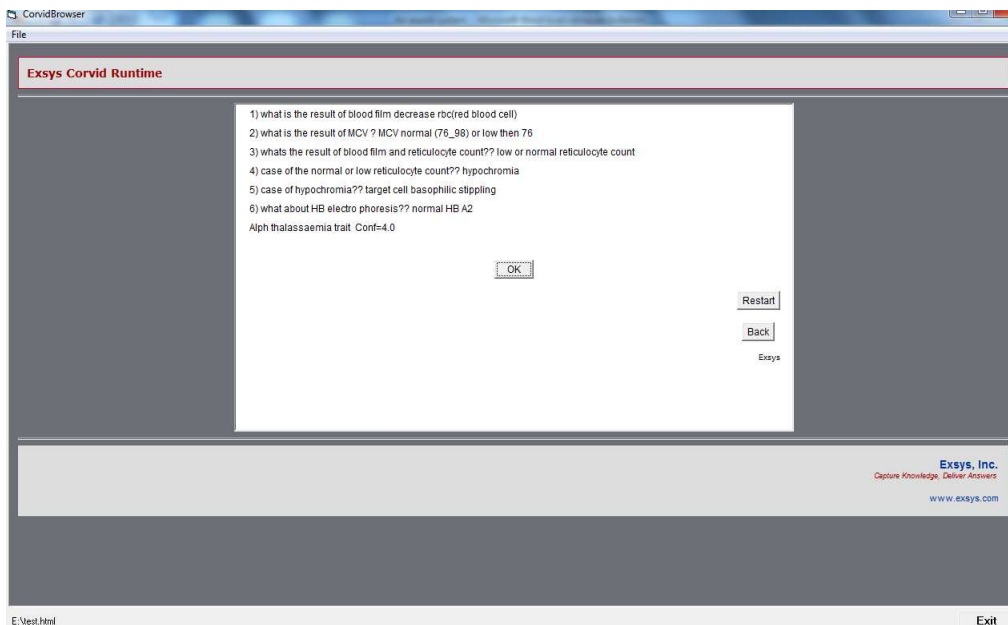


Figure 4.52 The result of case 1

## **CHAPTER 5**

### **CONCLUSION**

In this thesis, an expert system that evaluates the Software development for blood disease expert system is studied. The system asks some critical questions about the blood tests after answers these questions the system concludes the type of the blood disease.

At last years, the blood disease and other disease like cancer is increased Clearly so that it's Necessary for Building this type of systems for the treatment of theses diseases. The determination the type of the blood disease early is important for the doctors for the treatment of theses diseases and save the lives of patients.

These information that uses in Software development for blood disease expert system are acquired from Kirkuk General Hospital and the system are tested from the Kirkuk University School of Medicine students and Department of Hematology in Kirkuk General Hospital and it's gave the expected results after it's tested with 11 cases.

The rules and parameters are determined due to a predefined knowledgebase and utilized in the expert system called, Software development for blood disease expert system prepared by the software EXSYS CORVID. This expert system may be used in determining the blood disease and can uses in hospitals and universities by the doctors and medical students etc.

In addition to this study, the questions may be more detailed and increase the number of diseases to develop the abilities of the expert system.

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## **APPENDIX A**

### **QUESTIONNAIRE**

This section is contain 13 question with its posible answer asked to the user to deteimine the name of blood disease. The english version of questionnaire is shown below:

1)What is the result of blood film?

Increase W.B.C (white blood cell)

Decrease R.B.C (red blood cell)

2)What is the result of MCV?

MCV normal (76\_98) or low then 76

MCV is high (>98)

3)What is the result of blood film and reticulocyte count??

Low or normal reticulocyte count

High reticulocyte count

4)What about the reticulocyte case?

Polychromasia high reticulocyte count

Dimorphic

Dysplasia cytopenia

Target cells stomatocytes

Hyper segmented neutrophils

5)What about the reticulocyte count?

High reticulocyte count

Low reticulocyte count

6)What about morphology of cell?

Hypochromia

Dimorphic

Non specific

7)What about HB electro phoresis??

Increased HB A2

Normal HB A2

8)What about ferritin consideration??

Normal or high

Low

9)What about age?

More than 5 year

Least than 5 year

10)Case of hypochromia?

Low feeritin

Target cell basophilic stippling

11)Case of the normal or low reticulocyte count?

Hypochromia

Dimorphic

Non specific

12)Presence mature lymphocyte or myeloproloferative?

Presence mature lymphocyte in bm(peripheral blood)

Myeloproliferative

13)Presence of blast cell in peripheral blood and bone marrow failure?

Presence of blast cell and B.M failure

Absence of blast cell and B.M failure

**APPENDIX B**  
**CIRRICULUM VITAE**

**PERSONAL INFORMATION**

Surname, Name: Karim, Ahmad

Nationality: Iraq

Date and Place of Birth: 5 April 1987, Kirkuk

Marital Status: Single

Phone: +90531 494 91 39

Email: Ahmedsoft97@yahoo.com

| <b>Degree</b> | <b>institution</b>        | <b>Year of graduation</b> |
|---------------|---------------------------|---------------------------|
| MS            | Cankaya university        | 2012                      |
| BS            | Kirkuk technical colege   | 2009                      |
| High school   | Kirkuk development school | 2005                      |

**EDUCATION**

Advanced English, Advanced Turkish, Advanced Arabic.

**COMPUTER SKILIS**

Office program, Java, CORVID EXSYS, C++.